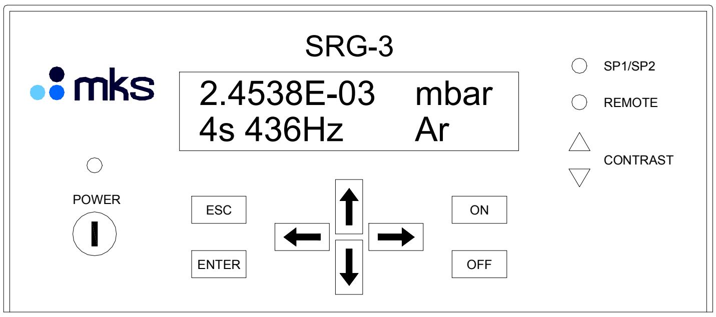
MKS

SRG - 3

Spinning Rotor Vacuum Gauge

Instruction Manual



MKS Instruments
Deutschland GmbH

Edition 2012-08

Printed in the Federal Republic of Germany

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Safety Information

Symbols Used in This Instruction Manual

Definitions of WARNING, CAUTION, and NOTE messages used throughout the manual.

Warning 

The WARNING sign denotes a hazard. It calls attention to a procedure, practice, condition, or the like, which, if not correctly performed or adhered to, could result in injury to personnel.

Caution 

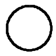
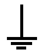
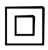
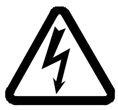
The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of all or part of the product.

Note 

The NOTE sign denotes important information. It calls attention to a procedure, practice, condition, or the like, which is essential to highlight.

Symbols found on the unit

The following table describes symbols that may be found on the unit.

Definition of Symbols found on the unit			
 On (Supply) IEC 417, No. 5007	 Off (Supply) IEC 417, No. 5008	 Earth (ground) IEC 417, No. 5017	 Protective earth (ground) IEC 417, No. 5019
 Frame or chassis IEC 417, No. 5020	 Equipotentiality IEC 417, No. 5021	 Direct current IEC 417, No. 5031	 Alternating current IEC 417, No. 5032
 Both direct and alternating current IEC 417, No. 5033-a	 Class II equipment IEC 417, No. 5172-a	 Three phase Alternating current IEC 617-2 No. 020206	
 Caution, refer to accompanying documents! ISO 3864, No. B.3.1	 Caution! Risk of electric shock! ISO 3864, No. B.3.6	 Caution! Hot surface! IEC 417, No. 5041	

Safety Procedures and Precautions

The following general safety precautions must be observed during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of intended use of the instrument and may impair the protection provided by the equipment. MKS Instruments assumes no liability for the customer's failure to comply with these requirements.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an MKS Calibration and Service Center for service and repair to ensure that all safety features are maintained.

SERVICE BY QUALIFIED PERSONNEL ONLY

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified service personnel only.

GROUND THE PRODUCT AND USE PROPER ELECTRICAL FITTINGS

Dangerous voltages are contained within this instrument. All electrical fittings and cables must be of the type specified, and in good condition. All electrical fittings must be properly connected and grounded.

This product is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting it to the product input or output terminals. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating) can render an electrical shock.

USE THE PROPER POWER CORD

Use only a power cord that is in good condition and which meets the input power requirements specified in the manual.

Use only a detachable cord set with conductors that have a cross-sectional area equal to or greater than 0.75 mm^2. The power cable should be approved by a qualified agency such as VDE, Semko, or SEV.

USE THE PROPER POWER SOURCE

This product is intended to operate from a power source that does not apply more voltage between the supply conductors, or between either of the supply conductors and ground, than that specified in the manual.

USE THE PROPER FUSE

Use only a fuse of the correct type, voltage rating, and current rating, as specified.

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Chapter 1: Description

Delivered Equipment

The basic system consists of:

1 control unit SRG-3 - EL, mounted in a ½ x 19“-housing

1 sensing head SRG - SH 700 with connection cable, length 3 m

1 measuring flange SRG - BF with thimble, mounting rails and retaining screw for measuring head

A measuring stainless steel sphere (sensor, rotor) is located in the thimble, a retaining clip prevents it from falling out. A magnet at the closed end of the tube serves as a fixture for safe transportation (must be removed prior to operation)

1 calibration data sheet for each calibrated measuring sphere

1 set mating connectors

4 rubber feet for tabletop use

2 Replacement fuses

1 Power cord

1 Instruction manual (this document)

1 RS232 Interface manual

Optional:

Extension head cable, lenght 3 m.
Additional flanges with measuring spheres, calibrated / uncalibrated.
Calibration by the German Calibration Service DKD-K-04601

Further options upon request.

Compatible Printer with Centronics Interface (printers not included):

- Epson EPL-5600
- Epson TM-U220PD
- Hewlett Packard HP 400
- Hewlett Packard HP 5652

And others.

Unpacking

MKS has carefully packed the equipment so that it will reach you in perfect operating order. Upon receiving the unit, however, you should check for defects, cracks, broken connectors, etc., to be certain that damage has not occurred during shipment.

Note Do not discard any packing materials until you have completed your inspection and are sure the unit arrived safely.

If you find any damage, notify your carrier and MKS immediately. Please refer to the last page of this manual for a list of MKS calibration and service centers.

Customer Support

Standard maintenance and repair services are available at all of our regional MKS Calibration and Service Centers, listed on the last page. In addition, MKS accepts the instruments of other manufacturers for recalibration using the Primary and Transfer Standard calibration equipment located at all of our regional service centers. Should any difficulties arise in the use of your equipment, or to obtain information about companion products MKS offers, contact any authorized MKS Calibration and Service Center. If it is necessary to return the instrument to MKS, your service center can inform you about the need for an ERA Number (Equipment Return Authorization Number) or a form for declaration of decontamination or any other regulations before shipping. The ERA Number expedites handling and ensures proper servicing of your instrument.

Please refer to the last page of this manual for a list of MKS Calibration and Service Centers.

Warning **All returns to MKS Instruments must be free of harmful, corrosive, radioactive, or toxic materials.**

Intended Use

The spinning rotor gage SRG-3 serves for vacuum pressure measurement only. Any use with explosive or flammable substances ist not allowed.

Combination with electronic controllers and valves for establishing pressure control systems is possible. Please contact MKS Instruments for information about proven configurations and selection of adequate controllers, valves and cables.

About this handbook

1. This handbook describes the manual operation. For operation via the remote interface refer to the extra interface manual.
2. Displays and menues are equally numerized, except those for head control.
3. Appendix C provides complete charts for quick reference.
4. The sensing sphere may also be referred to as ball, rotor or sensor.
5. The arrow → refers to a section, indicated in *italics*, in this manual which gives additional information.
6. *Italics* refer to identically titled sections, figures etc. which may be written, however, in a different format.
7. Connectors are shown in fat letters, e.g. **AUXCH1**.
   Switches, button key etc. Are shown in brackets, e.g. [ENTER]
8. Special versions are not described in this document.

Technical Data

Measuring Range:	5 x 10^{-5} to 100 Pa
Accuracy in the range up to 1 Pa:	1 % of measuring value + U U expresses the residual drag variation.
in the range 1 to 100 Pa:	increasing up to 10 % of the measured value(typical).
Long Term Stability:	better than 1 % over 1 year.
Pressure Display:	Pascal, mbar or Torr * (user selectable). Printout according to display.
Measuring Rate:	adjustable from 1 s to 60 s.
Analog Output:	0 - 10 VDC into 2 kΩ min. load; linear or logarithmic scaling; pressure range adjustable.
Limit Switches:	2 SPDT relays, adjustable. nominal switching capacity (resistive load): 1A 30VDC, 0.5A 25VAC eff.
Monitor Output:	BNC-socket for oscilloscope.
Interface:	a. RS – 232 b. USB (USB 2.0 compatible)
Power Supply:	85 - 265 V; 47 - 63 Hz
Line Fuse:	1,25 A (SB)
Housing:	½ x 19“-rack; 2 HE; depth approx. 185 mm incl. cable bend radius.
Measuring Head SRG-SH 700:	Stainless steel housing with coil system and 3 m connecting cable; max. operating temperature: 65°C
Flange SRG - BF:	DN 40 CF, bakeable to 400°C; all components of stainless steel.
Sphere (Ball, Rotor):	Material: stainless steel 1.4034 Diameter: 4,5 mm Density: 7,70 g/cm^3
Wetted Materials:	Flange and rotor
Weight (control unit):	ca. 2,5 kg

The SRG-3 is compliant to the regulations for conformity (CE) of the European Community (EU).

*) displaying mbar and Torr can be disabled in the setup menu.

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Chapter 2: Control Elements and Connectors

Outline dimensions of the control unit are shown in appendix B3.

Front Panel

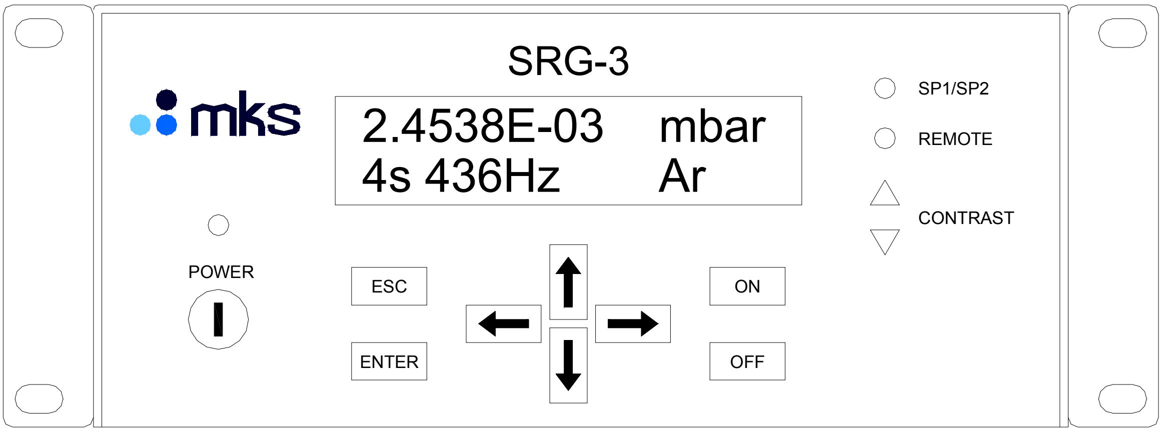


Fig. 1: Front Panel

Display:	Two lines. Readout depending on mode or menu.
POWER	Push button. Switches the unit on and off. To power the unit the line power switch at the rear panel must also be switched on. Configuration will be stored after switching power off.
ENTER	To call up a selection list. To confirm an entered value or selected setting.
ESC	Escape to the previous mode, finally to primary display.
Arrow Keys:	Left / Right to call up and steer the cursor, Up / Down to select and edit parameter.
ON , OFF	Starts / Stopps the rotor (sphere). Starts / Stopps printer. Disables / Enables access to setup menu.
SETPOINT	LED, lit with one or both setpoint/s (setpoint1 or 2) being activated.
REMOTE	LED, lit by operation via RS232 interface.
CONTRAST	Allows adjustment of display contrast.

Rear Panel

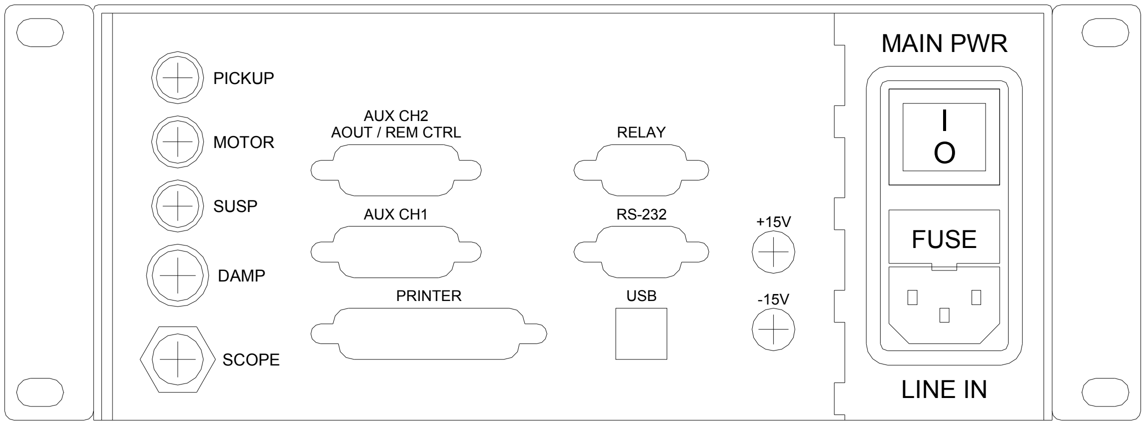


Fig. 2: Rear Panel

Mains Power and Fuses

LINE IN	Receptable for line power cord.
MAIN PWR	I = On; unit can be toggled on and off by front panel button switch. 0 = Off; front panel button switch disabled.
F1, F2	1,6 A for power output ± 15 V or 24 V.
FUSE	Line fuse 1,25 A SB (compartment with replacement fuse).

Connectors

Connectors for Sensing Head SRG-SH700

(all with mechanical latch incorporated)

Name	Pins	Function
PICKUP	2	Measurement signal input from sensing head
MOTOR	4	Ball drive output
SUSP	3	Suspension. Vertical positioning of the ball.
DAMP	6	Damping. Horizontal stabilization of the ball.

SCOPE

Output. To display the sensing signal on an oscilloscope.

AUX CH1 (Channel 1)

15-pins, sub-D, socket

For connection of a pressure transducer, vacuum meter, thermometer etc. with linear (proportional) DC voltage signal output.

Pin	Function
2	Signal Input -11 V to +11 V
5	± 15 V Ground
6	- 15 V ; 1,0 A max.
7	+ 15 V ; 1,0 A max.
12	Ground for Pin 2
15	Chassis Ground

Other pins unused. Pin 6 and 7 can be de-activated (→ Setup 12.4).

AUX CH2 / AOUT / REM CTRL

15-pins, sub-D, socket

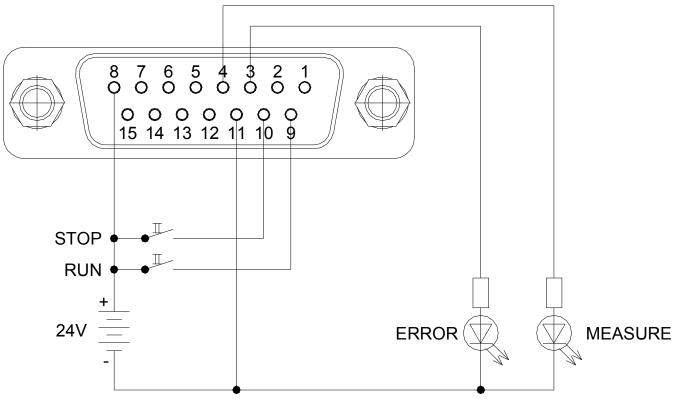
For connection of a pressure transducer etc. as with AUX CH1. Additional control inputs and status outputs plus a scaleable analog DC voltage output (→Setup 11.3).

Pin	Function
2	Signal Input -11 V to +11 V
3	Error (out) status
4	Measure Pulse (out) status
5	± 15 V Ground
6	- 15 V ; 1,0 A max.
7	+ 15 V ; 1,0 A max.
8	+ 24 V (Input)
9	Run Command
10	Stop Command
11	- 24 V (Ground for Pin 8)
12	Ground for Pin 2
13	Signal Output 0 -10 V
14	Ground for Pin 13
15	Chassis Ground

Other pins unused. Pin 6 and 7 can be de-activated (→ Setup 12.4).

Wiring example for connector AUX CH2 /AOUT / REM CTRL

Remote Control Connection



RUN: Starts ball drive with automatic stop at selected operation speed.

STOP: Brakes ball speed to zero.

MEASURE: Indicates activated measurement mode.

ERROR: Indicates failure with ball drive/signal.

RELAY

9-pins, sub-D, pin

Provides access to both trip point relays (configuration →Setup 11.1 and 11.2) and to the status relay READY. The status relay READY will be activated as soon as the SRG has switched to measurement mode, e.g. after drive up to operation speed.

Pin	Function
1	Relay READY N.C.
2	Relay READY N.O.
3	Relay SP2 COM
4	Relay SP1 N.C.
5	Relay SP1 N.O.
6	Relay READY COM
7	Relay SP2 N.C.
8	Relay SP2 N.O.
9	Relay SP1 COM

RS-232

9-pins, sub-D, socket

Pin	Function
2	RXD (out)
3	TXD (in)
5	Ground (isolated)

Other pins unused.

PRINTER

Centronics-Printer Port, 25-pins, sub-D, socket.

Compatible Printer are EPL-5600 (Epson), TM-U210-PAR (Epson), TM-U220PD (Epson), HP 400, HP 5652 (Hewlett Packard) and others.

Pin	Function
1	Strobe (out)
2	D1 (out)
3	D2 (out)
4	D3 (out)
5	D4 (out)
6	D5 (out)
7	D6 (out)
8	D7 (out)
9	D8 (out)
10	Acknowledge (in)
11	Busy (in)
12	Paper out (not used)
13	Select Paper (not used)
14	Autofeed (not used)
15	Error (not used)
16	Reset (not used)
17	Select In (not used)
18 -25	Ground (isolated)

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Chapter 3: Installation

Installation, Mounting

The SRG-3 is designed for use in dry and warm environment with sufficient ventilation. The device must be installed in such a way that air can circulate free. Do not cover the openings at the instrument's housing. If there are heat loss generating devices located next to the unit make sure that no excessive heat is transferred to the unit.

Rack Mounting or Table Top?

The SRG-3 fits to a 19“ half rack or maybe used on top of a table. Three screws on each side allow disassembling of the rack angles. Rubber feet give the device a stable stand on a table. (Screws are TX10)

Fig. 3: Rack angles assembly

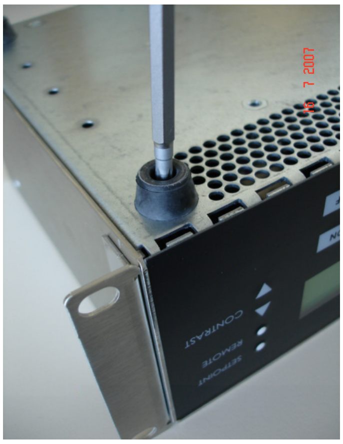

Fig. 4: Rubber feet assembly

Note Position the unit with proper clearance to allow air cooling, so that the unit can operate within the specified temperature range. Do not cover the openings at the instrument's housing.

Note With respect to the guidelines and rules for compliance to the conformity of the European Community (CE) notice must be taken to the following information.

CE related notices for Installation and Operation

To comply with the directives of the European Community (EC) for electrical conformity (CE) it is mandatory to meet the following requirements:

Note The instrument complies to EN61326-2-2 with the requirements for laboratory applications. Braided shielded cables must be used. The compatible sensor head is SRG-SH700-V3.

- The SRG-3 is very sensitive against signals in the frequency range of 300 Hz to 2 kHz. The sensing head should therefore not be located in amplitude modulated RF environment of more than 1 V/m and not be installed close to video monitors, power transformers, induction heaters and other sources of strong electromagnetic fields.

Caution

- In the presence of very high electromagnetic induction, e.g. close to transmitters or heating coils, the sensing head may be damaged.

- Use only shielded cables and connectors to connect to the RS 232 interface with cable shield connected directly to the ground terminal screw (3 mm thread size) on the rear panel.
- Use only shielded cables for connection of the relay and analog outputs. The cable shield should be connected directly to the ground terminal screw (3 mm thread size) on the rear panel.

Warning! **Never use the SRG without proper connection to protective ground potential!**

Line Power

Set the main power switch on the rear panel to the OFF position.

Plug the line power cable into the socket on the rear panel. Check that the plug fits firmly with the socket.

It is recommended to operate the SRG-3 via an uninterruptable power supply (UPS)! Otherwise in case of a power down the sphere will not be kept suspended and its surface may be alterated when hitting the thimble surface at high rotational speed. A new calibration could be necessary!

Mounting of Flange and Measuring Head

Before mounting the flange check that the measuring head can easily slide between the upper and lower bar. If this is not the case then untighten the bars with an 3 mm Allen type wrench and retighten the bars after correct adjusting. The thimble should be in centered position within the hole of the measuring head.

Do not force (press) the head onto the flange and do not turn it on the thimble.

The quality of the measurement results depends to a large extent on the proper installation of the measuring flange and measuring head.

The flange should be mounted in such a position that

a) no disturbances and vibrations occur
b) no interference is to be expected.
c) no mechanical shocks exist as for example caused by pneumatic valves, operating people etc..

Vibrations cause high levels of the residual drag and instability of the pressure measurement.

The measuring sphere should not be touched!

Caution **The measuring sphere should not be touched!**

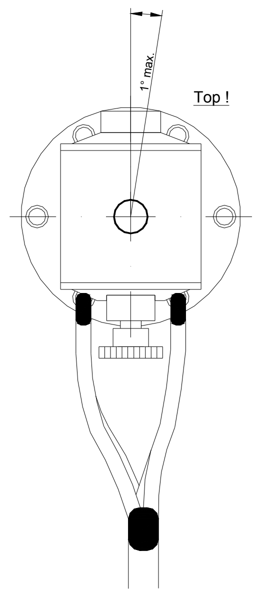

Fig. 5: Mounting the sensing head

With reference to Fig. 5, the axis of the measuring flange should be vertical within max. ± 1° (set for example, using a plumb-line). In this way, it will be ensured that the subsequently mounted measuring head is installed in a vertical position. Incorrectly adjusted flanges can lead to erroneous results, especially under high vacuum at the limits of the resolution. Additionally, the residual drag may increase to even higher values.

The measuring head is pushed forward as far as the rails allow, with the cable outlets pointing downwards. It is then withdrawn until the positioning sphere clicks into place and is secured by the locking screw (finger tight).

This procedure ensures that the sphere in the thimble is easily captured. For example, it can roll forward against the retaining clip if the flange is slightly inclined.

Caution The connecting cables of the measuring head must be kept away from areas of high temperature (pump, heating coil, etc.). The surrounding flexible plastic tubing cannot withstand temperatures greater than 50°C.

Plug in the four connectors of the sensing head cable assembly to the mating connectors PICKUP, DAMP, SUSP and MOTOR on the rear panel of the instrument (Fig. 2).

Please note!

The enclosed Ball/Flange Assembly is supplied with the ball installed in the tube. The tube has a small clip installed to prevent the ball from falling out. Additionally, a small button magnet is applied to the closed end of the tube to restrain the ball from moving and being damaged during shipment. The magnet is hold in place by a shrink tube or tape.

The magnet must be removed from the tube prior to install the sensing head! It is recommended to save the magnet for future use, e.g. for shipping the ball/flange assembly to a calibration laboratory. The magnet may also be used to re-magnetize the ball if its magnetism is too low for generating a useful signal (→chapter 7 *Diagnosis and Tuning*)

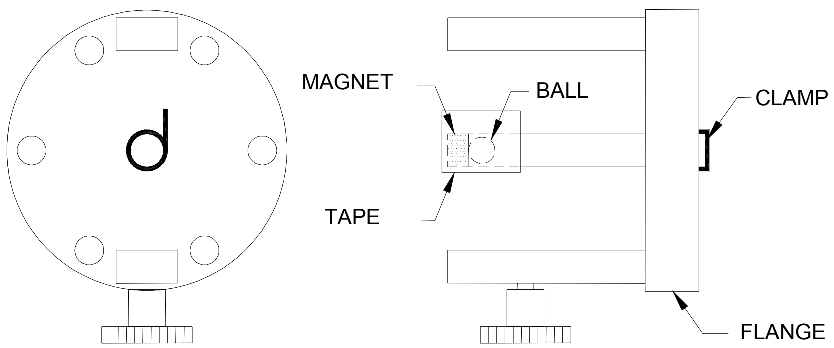

Fig. 6: Ball/Flange Assembly

Note:

Each of the four connecting cables (and extension cable, if used) is separately shielded. The metal braided shields are electrically connected to the housing of the operating electronics. In order to avoid ground loops, and the possible associated inductive currents, the shield is not connected to the measurement head housing. The measurement head housing is connected via the fixing screw to the vacuum system. Optimum shielding of the measuring system can only be achieved when good groundings for the vacuum system and operating electronics are used. The latter usually is given by the power supply cable.

When the measuring head is dismounted (e.g. during bakeout), it should be safely protected against the entry of small metal pieces (small screws, wire-ends, etc.). For a description of bakeout, see section 9.

After installation is completed evacuating of the vacuum system can be started. For best use of the spinning rotor gage performance a base vacuum of $p < 5 \times 10^{-6}$ Pa is recommended.

The following chapter describes how to start and how to end the operation of the SRG.

Chapter 4: Start / End Operation

Initial Switching On

Assuming that the steps of preparation (flange - sensing head – line power - grounding) have been correctly performed and the vacuum chamber has been evacuated (p < 100 Pa), the system can be taken into operation.

The following flow chart shows the sequence of switching on power and drive up of sphere. For a detailed description follow the instructions *Startup Step by Step*.

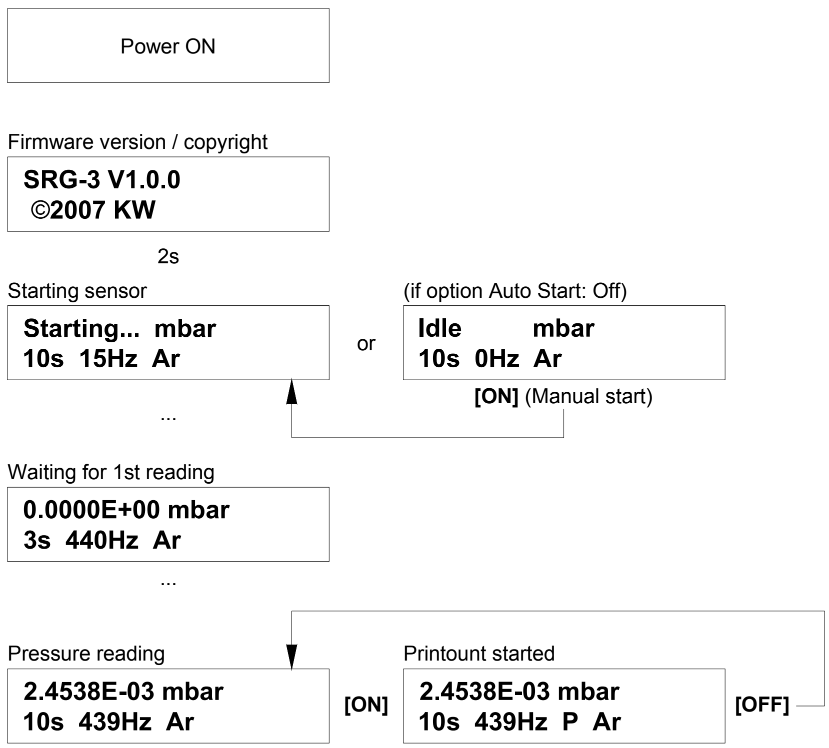

Fig. 7: Startup Sequence

For the first time of operation, it is strongly recommended

- to follow the steps described herein exactly.
- avoid mechanical disturbances during acceleration of the sphere
- to optimize the adaption of head and electronics (→ chapter 7)

If this is disregarded, the sphere and/or the control unit may attain an undefinable condition.

Note

Before starting the system it is strongly recommended to carefully perform the head adjustment procedure (→chapter 7).

Startup step by step:

Action / Display	Comments
• Rear panel line power switch on. For 2-3 s the following readout appears:	If rear panel switch is already switched on then press button key [POWER] at front panel.
SRG-3 V1.0.0 **©2007 KW**	In case of request for assistance please report the firmware version to MKS (here: V1.0.0).
• Then the SRG switches automatically to:	
Starting... mbar **10s 15Hz Ar**	1. The sphere (ball, rotor) is levitated to a centered vertical position. 2. If **Auto Start: On** (→Setup 8.4) has been selected the sphere will automatically be accelerated to the upper limit of the selected operational speed (factory setting: 440 1/s).
• Or displays:	
Idle mbar **10s 0Hz Ar**	If **Auto Start: Off** (→Setup 8.4) has been selected the sphere will just be levitated but the motor drive remains switched off. Press [ON] to accelerate the sphere to the upper limit of the selected operational speed
• After the sphere has reached the upper limit the readout appears:	
0.0000E+00 mbar **3s 440Hz Ar**	In this example an upper limit of 440 Hz was choosen. The SRG switches automatically to the measuring mode and displays seconds to next reading (STNR) in the left corner of the bottom line.
• After completing the first measuring cycle the first measurement value will be displayed:	
2.4538E-03 mbar **10s 439Hz Ar**	Now the SRG-3 continuously measures in intervals as selected in the setup menu (→Setup 8.1, *Meas Time*). Each time the STNR becomes zero the measurement value will be updated.

Now the system is ready for measurement mode but does at this time not necessarily measure precisely. If a printer is connected to the SRG you can now operate it by means of the [ON] and [OFF] keys.

The following chapter 5 describes all processes and inputs necessary to obtain accurate measurement results.

To stop the sphere press [OFF] twice. With the first press the information **Standby** appears, meaning that measuring mode and ball drive are de-activated. After the next press the message **Shutdown...** comes up and the sensor speed display shows the stopping cycle to 0 Hz. To re-start the motor to drive up the sphere press again the [ON] key.

Difficulties at startup?

(also refer to chapter 7, *Diagnosis and Tuning* and chapter 8, *Error Messages and Troubleshooting*)

Error Message	Cause and Remedy
No Sensor	No rotor detected. Ball probably rolled to the clamp at the front end of the thimble. Loose locking screw at lower bar of flange, move head as close as possible to the flange. As soon as the sphere will be recognized the message **Dismount** appears. Move head back and secure it by means of the fixing screw (fingertight!). Press [ON] and the sphere will be accelerated or the message **Idle** appears, depending on the choosen drive control mode.
Err 34	Rotor signal too low or/and sphere has not come to operational speed. Press [ON] and motor drive starts again. Readout: **Starting...**
Unstable	Mechanical disturbances (violent shocks, heavy vibrations etc.). If this just happens once the SRG will re-stabilize the sphere, otherwise the source of influence must be eliminated.

Caution

Do not switch off the SRG via the rear panel switch or remove line power in any other way after a calibrated ball has being accelerated. The sphere will drop down and bounce around in the thimble. This might change the ball's surface thus changing the calibration. It is therefore recommended to operate the SRG-3 via an uninterruptable power supply (UPS)!

Continue with chapter 5, *Operation / Measuring* or with chapter 6 *Setup* or with the section following next if the operation shall be ceased.

Ending Operation / Switching Off

Before you switch off the system the rotor speed must be reduced to ≈ 0. Switching off de-activates the suspension of the rotor and without stopping before the calibration might be alterated by friction of the rotor's surface with the inside wall of the thimble.

Same precaution applies if any work is done on the apparatus, e.g. when heavy shocks or vibrations may cause overload to the suspension circuitry or if the sensing head shall be removed for any reason.

Tipp:

Note the values shown in the diagnosis menus 5.1 and 5.2 as reference data. After restarting the system similar values shall be obtained.

(continued next page)

Switching off from measurement mode

There are two ways to end operation and switch off the unit.

1) <u>Directly switching off</u>

Action / Display	Comments
• Press button [POWER] at front panel. This readout appears:	
Stopping... mbar **10s 423Hz Ar**	And the stopping of the sphere begins.
• After stopping finally to speed ≈ 0 this information appears temporarily:	
Idle mbar **10s 0Hz Ar**	And the unit switches off by itself. Now you can also put the rear panel switch to the Off position.

2) <u>Stopping the sphere to speed ≈ 0</u>

Action / Display	Comments
• Press button [OFF] . This readout appears:	
Standby mbar **10s 438Hz Ar**	The sphere is now in a coasting mode and the selfstarting re-acceleration is de-activated. The display of the actual rotor speed will be continued (as long as the rotor provides a valuable signal). Press [ON] to return to the measurement mode.
• For complete stopping press [OFF] again and the stopping of the sphere begins. • After stopping finally to speed ≈ 0 this information appears temporarily:	
Idle mbar **10s 0Hz Ar**	Now you can switch completely off the SRG.

Status Messages after stopping the sphere

When removing the sensing head with the SRG being powered the following readout temporarily appears:

Dismount mbar
10s 0Hz Ar

and then changes to

No Sensor mbar
10s 0Hz Ar

meaning that the head control circuitry is still active (does not cause any harm to the unit). For de-activating the circuitry press the [OFF] button. The following readout comes up:

Disarmed mbar
10s 0Hz Ar

After the sensing head being re-installed you can start again the measurement mode by pressing the [ON] key.

Note: After the conditions for operation in measurement mode have been attained the zero offset must be checked (and in most cases actualized).

If the sensing head is removed for a longer period (for example in case of system bakout or to change the flange), the SRG should then be switched off completely.

Caution Before switching off make sure that the sphere has stopped to zero speed. Switching off at high rotational speed may change the calibration.

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Chapter 5: Operation / Measuring

Readouts in Measurement Modes

The SRG-3 provides these readouts in the measurement modes:

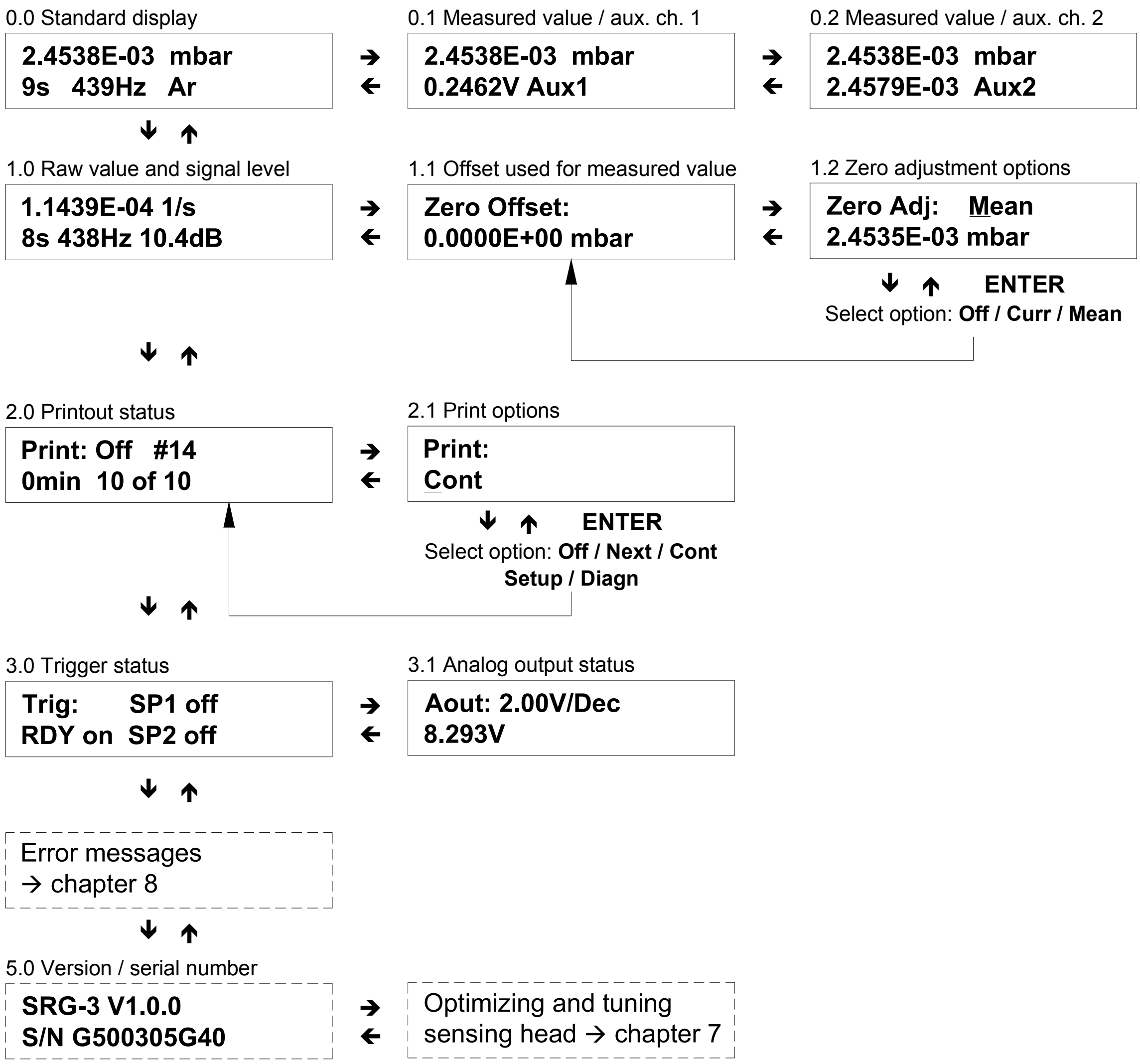
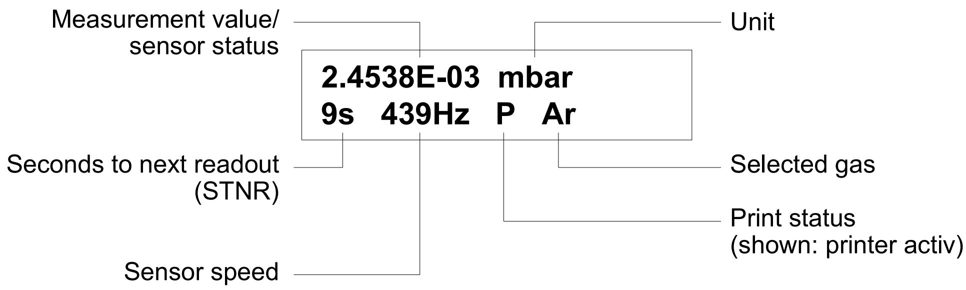


Fig. 8: Readouts in Measurement Modes

How to interpret the displays

(Numbers of titles correspond to those in the overview in appendix C.)

0.0 Standard display



0.1 / 0.2 Measurement value / aux. ch. 1/2

2.4538E-03 mbar
0.2462 V Aux1

Engineering unit as selected in setup menu.

1.0 Raw value and signal level

1.1439E-04 1/s
8s 438Hz 10.4dB

The raw value is the relative change in rotational speed of the sensing sphere, measured in 1/s. This value includes the residual drag which is pressure independent.

The signal level must be at least -10 dB to be accepted by the controller. Good measurement conditions are given with signals between 0 and 6 dB (→chapter 7, *Diagnosis and Tuning*).

1.1 Offset used for measured value

Zero Offset:
0.0000E+00 mbar

Here the actual (manually entered or automatically determined) offset value is displayed.

1.2 Zero adjustment options

Zero Adj: Mean
2.4535E-03 mbar

Value stored with [ENTER].

Zero Adj: **Mean** = stores the mean value of the last n measurement values as offset. (n → Setup 8.5 *Background Average Option*).

Curr = stores the actual measurement value as offset.

Off = no zero adjustment.

2.0 Printout status

Print: Off #14
0min 10 of 10

Shown: Printer is switched off. Last printout was current number #14 with 10 measurement values. Interval = 0 (→Setup 10.1)

For examples of printouts refer to appendix A.

2.1 Print options

Print:
Cont

To select the printout mode and to provide status information. Choose line with ←→ and set mode with ↓↑ keys. Store with [ENTER]. After execution of the choosen mode the setting returns to **Off**.

Upper line:

Print: **Off** = no printing

Next Reading = print next value

Cont = print continuously

Statistics = executes printout of n values with statistical analysis. (n → Setup 10.1 *Max Count*).

Setup File = printout of setup

Error History = prints all stored error messages. (→chapt. 8, *Error Messages a. Troubleshooting*; Apppendix A, *Printouts*)

Diagnostics = data related to sensor and measuring head. Data should be at hand when calling MKS for support in case of troubles.

Page Feed = new sheet (when using single sheet printers)

Bottom line:

0min 10 of 10 = continuous printout. Example shown: 10 values of total 10 printed.

1min usw. = 1 printout per minute

Note: Printing can also be initiated or stopped in the standard display 0.0 by means of the [ON] or [OFF] key, respectively.

3.0 Trigger status

Trig: SP1 off
RDY on SP2 off

Informs about the status of the trip limit relays:

Relay of setpoint 1 (SP1)

Relay of setpoint 2 (SP2)

Relais ‚READY' (RDY)

On = relay activated; Off = relay de-activated.

3.1 Analog output status

Aout: 2.00V/Dec
8.293V

Informs about status of the analog output. Shown here:

Scaling = 2 V per decade (→Setup 11.3)

Actual output = 8293 mV

5.0 Version / serial number

SRG-3 V1.0.0
S/N G500305G40

Shows firmware version and serial number.

Please add these data to any support request.

Further Displays

Additional readouts are

- Error messages (→chapter 8)
- Sensing head adjustment and damping values (→chapter 7, *Diagnosis and Tuning*)
- Setup (→chapter 6, *Setup Menus*)

and will be discussed in the respective chapters.

Measuring Pressure

Prior to measuring

Pressure measurement requires to have provided these actions first:

1. Flange and sensing head installed (→chapter 3; chapter 7).
2. System evacuated to base pressure, ideally to $p < 5 \times 10^{-6}$ Pa.
3. Ball (sphere, rotor, sensor) accelerated to operational speed, readout stabilized.
4. Setup completed.
5. Offset (residual drag) determined, value entered and zero readout checked.

For measuring pressure the following parameters must be determined and stored:

Parameter	**Refer to setup menu, chapter, look at...**
a) Gas specific	
Molecular mass	Setup 7.1
Viscosity	Setup 7.2
Temperature	Setup 7.4
b) System specific	
Surface coefficient of sensing sphere, accomodation factor σ ,	Calibration sheet, Setup 8.1
Ball diameter (in mm)	Calibration sheet, for uncalibrated balls refer to *Specifications*
Density of ball material (in g/cm^3)	
Residual drag	This chapter: *Determination of the Residual Drag (Offset)*
c) Depending from sampling interval	This chapter: Sampling Interval, Setup 8.1 Meas Time

Refer to chapter 6, *Setup Menus* for how to enter parameters and how to configure the system.

Prior to take over any numeric input the SRG-3 checks if the number falls in the acceptable range. If not correct the SRG limits to the lowest or highest numeric value and displays this number. All inputs must be confirmed with the [ENTER] key.

In case of inactivity the display switches about 60 s after the last entering automatically back to the standard display 0.0 .

Sampling Interval

The sampling interval, also called measurement time, determines the cycle of measurement outputs. If in setup 8.1 a measurement time for example of 10 seconds is choosen, you allow the SRG this time to carry out multiperiod measurements to determine the relative deceleration rate and to calculate and display the respective pressure. Then the next cycle of 10 s will start and be shown in the standard display 0.0.

The right choice of an adequate measurement interval depends on:

- Required stability, resolution and accuracy of the measurement.
  The better the reproducibility shall be, the longer is the time required for one interval.
- Pressure range.
  The lower the pressure is the smaller the slowing down of the rotor speed will be and the measurement result becomes more and more inaccurate. Therefore longer intervals for measuring the deceleration rate will be required. In case of higher pressures shorter intervals are necessary.

The user can choose the measurement time from 1– 60 s. In case of high pressure (= high deceleration rate) it is also possible to have the interval automatically adapted by Aut 1 or Aut 2 (→Setup 8.4).

Quite often the measurement time is set much too high than really necessary. Good numbers from experience are

- 10 s for 10^{-5} Pa < p < 10^{-2} Pa
- 5 s for 10^{-2} Pa < p < 1 Pa
- for pressures up to 100 Pa refer to section *Measuring up to 100 Pa*

Determination of the Residual Drag (Offset)

Eddy currents in the measuring sphere are produced by the rotational movement in the suspending magnetic field which leads to a pressure independent additional drag. This system-specific contribution is equivalent to the gas friction in air of some 10^{-6} mbar. The residual drag (offset) must always be determined again when:

a) the sphere suspension was deactivated
b) the measurement head was dismounted
c) the temperature changes considerably
d) the rotor frequency changes considerably

Determining the offset step by step:

(recommended procedure)

a) Evacuate the flange/thimble below the SRG's resolution, preferable to $p \leq 10^{-6}$ Pa
b) Allow the ball/flange-assembly to get in thermal balance with the environment (after drive up of the sphere minimum 30 minutes should be waited)
c) Enter all (valid) parameters or choose the appropriate data set
d) Enter correct temperature value
e) Set *Background Average* (→Setup 8.5) to 10 or higher number. The larger the number the more accurate the resulting mean value for the offset will become

f) Set the measuring interval with respect to the requested resolution and stability

g) Switch to standard display **0.0** by pressing [ESC].

h) Switch to readout **1.1** and check for Zero Offset = Null ?

i) Go to readout **1.2**

0.0 Standard display

2.4538E-03 mbar
9s 439Hz Ar

↓ ↑

1.0 Raw value and signal level		1.1 Offset used for measured value		1.2 Zero adjustment options
1.1439E-04 1/s **8s 438Hz 10.4dB**	→ ←	**Zero Offset:** **0.0000E+00 mbar**	→ ←	**Zero Adj: Mean** **2.4535E-03 mbar**

j) If in **1.1** Zero Offset ≠ Null , then select **Zero Adj: Off** and confirm with [ENTER].

k) Wait until the SRG has stored the number of measurements as entered in section e), which is the result of multiplying *Background Average x Measurement Time* , then confirm in readout **1.2** the input Mean by [ENTER].

Now all pressure measurement readouts will be corrected by the amount of the residual drag, meaning that the SRG is now measuring pressure correctly. The remaining fluctuations of the pressure readout values determine the minimum resolution available. Switch to **1.1** any time you want to read the stored offset.

Repeat steps i) to k) if the offset as determined by the procedure above seems to be not enough accurate. Increase, if necessary the number in the Background Average menu and/or the measuring time in Setup 8.1.

Some advices:

- If just a quick and rough zero setting is requested then switch to readout **1.2** and select **Curr** and the currently displayed measurement value will be taken as offset.
- Another way to determine the offset: Set **Offset** in Setup 8.6 to zero, then measure a reasonable number (ten or more values), calculate the mean value and enter this number in **8.6**. A printer connected to the SRG may be helpful..
- For actual offset see Setup 8.6.
- When operating via computer it will normally be easier to carry out the zero setting by means of this computer.
- Check the zero readout periodically and re-adjust if necessary. The frequency for checking depends on the acceptable uncertainty of measurements and is last not least also a matter of experience.
- By frequent re-accelerations in a short time the ball's temperature can be increased by a significant amount. This leads to a change of the zero offset. When returning to low pressure measurements it is advised to allow the sphere (and thimble) sufficient time to stabilize again.
- When changing the engineering unit for pressure the SRG calculates and changes automatically the stored offset value accordingly.
- Zero setting can also be done when the deceleration rate 1/s is displayed. It is, however, important to know that when then changing to pressure units, the offset must be determined in that pressure unit.

- In the calibration sheet of MKS Instruments you will usually find a value for the offset. This value refers only to the time and conditions of the calibration and shall just give the user an idea of what is realistic. The user, however, must determine the residual drag at the location and under the conditions of use.

Note Check the zero readout periodically and re-adjust if necessary.

Pressure Readout

After all steps as described above have been performed the SRG-3 will correctly display the actual pressure in the thimble, provided that all concerned parameters had been set correctly. Use of the switching keys or data transfer is allowed during measuring, displaying and printing. The measurement interval **Meas Time** should be adjusted with respect to the pressure range and to the expected reproducibility and stability. During a re-acceleration cycle the measurement is stopped.

Measuring up to 100 Pa

The linear measuring range of the SRG typically ends at a few 10^{-2} mbar. With higher pressures, the relation between decrease of rotor frequency and pressure becomes increasingly non-linear (→ Chapter 10, *Theory*).

The SRG-3 is fitted with a program to correct this non-linearity. All pressure measurements are checked by the microcomputer and are corrected before being output. But the higher pressure the lower the accuracy will be (refer to *Specifications*).

In order to initialize the linearization program, it is necessary to input the parameter *Viscosity* (→Setup 7.2). If parameter viscosity is set to zero, the correction factor is constantly = 1.

Because the deceleration rate will be high in the upper pressure range it is necessary to keep the measurement interval sufficiently short to ensure that the measurement cycle will be completed before the re-acceleration cycle starts. Also possible is to select an automatic adaption of either the measurement interval or the speed window of the sphere (→Setup 8.4).

Due the high breaking rate in the upper pressure range it is important to keep the measuring time sufficiently short to prevent excessive heating of the rotor. If the sphere has significantly increased ist temperature, the SRG may display negative pressure values after pumping down. The ball will accelerate then by cooling and contraction (pirouette effect), thus increasing rotational speed. Allow the sphere to accommodate with the ambient temperature.

Note For pressure measurement above 10^{-2} mbar we recommend the use of capacitance manometers Baratron®.

The signal input connectors Aux1 and Aux2 offer the possibility to connect a pressure transducer with linear voltage output, e.g. a capacitance manometer Baratron, to the SRG and have the pressure displayed via the displays 0.1 or 0.2. Refer to Setup 12.0 ff. for more details.

Chapter 6: Setup

General

System configuration and entering parameters is done in the setup menu. Refer to appendix C3 and C4 for schematics showing the complete structure.

Call up the setup menu:

- Select the standard display:

  0.0 Standard display

  2.4538E-03 mbar
  9s 439Hz Ar

- Press cursor ↑ to go to:

  6.0 Current setup no. / timestamp

  Setup #0
  2007-09-06 13:47

- Select with cursor ←→ and ↓↑ a pre-selected setup menu (data set), e.g. setup #5:

  6.0 Current setup no. / timestamp

  Setup #5
  2007-09-06 13:47

or

- enter via [ENTER] the setup menu to read or change settings:

  7.0 Gas parameter menu

  Setup Menu:
  Gas < >

For routine work with standard parameters, e.g. for standard calibration runs, the use of data sets according to section 6.0 is recommended. Section *Operating with Data Sets*, at the end of this chapter provides detailed information about configuring, how to store and activate such data sets.

A schematic of the complete setup menu contains appendix C4. Detailed information to each single setup follow on the next pages in this chapter.

The setup consists of seven parameter sections, each with several sub menus:

Gas – Sensor – Readout – Printout – Output – Input – Interface.

Use cursor ←→ to steer from one section to the next. Access to each sub-menu is achieved by using the [ENTER] key or the ↓↑ cursors.

Editing within the submenus , parameter selection and settings is done using the ←→ and ↓↑ cursors.

Note Any change in the setup will convert the original data set to data set #0. To give the data set back again a specific number you must use the **Save As** command (Menu 6.2).

The setup menu provides a reasonable number of settings. However, for the pure measurement mode with the SRG head (without the Aux.Inputs) and manually operated, only the shade marked fields must be considered. All other settings do not affect the intrinsic SRG measurement.

7.0 Gas Parameter

7.0 Gas parameter menu

Setup Menu:
Gas < >

Press [ENTER] or cursor ↓↑ to proceed to the sub menus 7.1 to 7.4 .

7.1 Gas selection / mass units

Gas: Ar
AMU: 039.944

Select the gas type. The mass can also be changed. Store any changes with [ENTER]! Employ Usr 1 … 8 to store user defined gases or mixtures.

Select:	Gas[1]	Molecular weight (factory settings)	Viscosity [μ Pa s] at 20°C (→ 7.2)	Temp.-coefficient of viscosity [μ Pa s K^{-1}] (→ 7.2)
Air	Air	028.960	018.192	0.0536
Ar	Argon	039.944	022.330	0.0660
C2H2	Acetylen	026.020	018.084	0.0325
CF4	Freon-14	088.010	017.247	0.0550
CH4	Methane	016.043	010.980	0.0330
CO2	Carbon Dioxide	044.010	014.663	0.0450
D2	Deuterium	004.027	012.468	0.0248
H2	Hydrogen	002.016	008.873	0.0210
He	Helium	004.003	019.651	0.0585
HF	Hydrogen Fluorine	020.006	012.269	0.0423
N2	Nitrogen	028.016	017.630	0.0460
N2O	Nitrous Oxide	044.013	014.560	0.0475
Ne	Neon	020.183	031.381	0.0697
O2	Oxygen	032.000	020.386	0.0618
SF6	Sulfur Hexaflouride	146.050	015.147	0.0450
SO2	Sulfur Dioxide	064.063	012.500	0.0400
XE	Xenon	131.300	022.470	0.0725
Usr 1…Usr 8	User defined	028.016	017.630	0.0460

Table 1: Gas Table

Note

It is the user's responsibility to ensure that the used gases or gas mixtures are compatible with the wetted materials of sphere, thimble and flange.

[1] References:
- Walter Blanke, Thermophysikalische Stoffgrößen, Springer Verlag 1989
- ATP Handbook, 1972

7.2 Viscosity / temp. Coefficient

Visc: 022.330
Tco: 0.0660

Refer to table 1 on previous page.

Here the values for the gases as selected in section 7.1 are displayed, factory set or user set data, respectively. The values can be accepted or may be changed.

For values Visc: ≠ 0 the SRG-3 automatically linearizes the calibration curve in the upper pressure range, where the curve becomes more and more non-linear with increasing pressure, thus minimizing the measurement error (→chapter 10: *Measurement Range 1 - 100 Pa*).

In case of Visc: = 0 no correction is done.

7.3 Destination selection

Save As Gas:
Usr1

Stores the gas parameters as defined in 7.1 and 7.2 as gas type „USER#“ and assignes the respective data automatically to the measurement. When operating via the serial interface you can also assign a name of your choice, e.g. MIX3, with four characters maximum.

7.4 Temperature

Temp: +0020.00°C

Enter the temperature of the system. The unit can be selected in menu 9.1.

8.0 Sensor Parameter

8.0 Sensor parameter menu

Setup Menu:
Sensor < >

Press [ENTER] or cursor ↓↑ to proceed to the sub menus 8.1 to 8.6.

8.1 Accomodation / measure time

Accomm: 1.000
Meas Time: 10

The accomodation factor, formula symbol: Sigma **σ,** is determined at the calibration of the sphere (rotor, sensor, ball) and is documented in the calibration sheet. In case of using un-calibrated balls contact MKS for best approach.

Input range: 0,1 – 2 (no unit). Typical values for Sigma are between 0,94 and 1,00.

Measurement Time **(Meas Time):** Sampling interval in seconds used to determine the next displayed measurement value.

Large intervals increase the stability and reproducibilty but increase also the delay time; too small intervals, however, may lead to unuseful measurement values.

Input range: 1 - 60 s. Typical values are 5 s to 10 s.

8.2 Sensor diameter / density

Diameter: 4.500
Density: 7.700

Diameter and density are documented in the calibration sheet. For un-calibrated balls refer to *Specifications* or contact MKS.

Input range:

Diameter: 1 – 6 mm
Density: 6 – 10 g/cm^3

8.3 Speed limits

Upper Speed: 440
Lower Speed: 430

The speed limits determine the ‚window' within the sensing sphere will rotate. The variable adjustment allows to keep the sphere signal free from resonance effects, e.g. induced by rotating pumps. Note that changing the frequency of rotation also changes the residual drag. Therefore the speed window should be kept small, typically 10 s^{-1}. In most applications frequency change of this magnitude are negligible.

Input range: 405 – 810 s^{-1} .

8.4 Control modes

Auto Start: On
Ctrl Mode: Aut1

Auto Start: On After power switched on and test routines executed the rotor will automatically be accelerated to the upper speed limit as entered in 8.3.

Auto Start: Off After power switched on the rotor will be suspended but not accelerated. Press the [ON] key at the front panel to start the motor or send the respective command via the interface.

Ctrl Mode: Aut1 Automatic control with fixed speed limits (sampling interval will be reduced at high pressure). As soon as the rotor has lowered its rotational speed as stored in 8.3 the motor is switched on and drives the sphere again to the upper limit of the speed window.

Ctrl Mode: Aut2 Constant measurement time. At higher pressures the lower limit of the speed window will be reduced if necessary.

Ctrl Mode: Off Switching to standby mode when the rotor speed falls below the lower limit per menu 8.3.

8.5 Background average option

Bgd Average: 10

The SRG executes continuous averaging of the last measurement values. The number of values is selected here (in this example: 10 values). The actual mean value can be used for zero setting at any time without the need of making an extra measurement. The larger the number the more precisely the mean value will be. The actual mean value can then be seen in display 1.1.

Input range: 0 – 50; settings of 0 and 1 de-activate the averaging.

8.6 Zero offset

Offset:
0.0000E+00 mbar

Here the zero offset can be entered manually. If the pressure unit mbar, Pa or Torr is changed, the offset value will automatically be adapted.

Attention: The offset value will not be adapted when it was determined in the unit 1/s or when changing the readout from pressure unit to 1/s !

Zero adjustment can also be done easily in menu 1.2.

9.0 Readout settings

9.0 Readout settings menu

Setup Menu:
Readout < >

Press [ENTER] or cursor ↓↑ to proceed to the sub menus 9.1 to 9.4.

9.1 Display unit / temperature scale

Displ Unit: mbar
Temp Scale: °C

Displ Unit Select pressure units Pa, mbar, Torr or unit 1/s for the deceleration rate. The deceleration rate DCR indicates the change of rotor rotation per one revolution, thus being the basic value of measurement.

Temp Scale Select between degree Celsius °C and Kelvin K.

9.2 Decimal places / display timeout

Dec Places: Aut
Dsp Timeout: 30

Dec Places Decimals of the pressure readout can be set to automatic or fixed number.

Aut (automatic setting):

	Decade of measurement	Number of decimals
$p \geq$	10^{-3} mbar or Torr or 10^{-1} Pa	4
	10^{-4} mbar or Torr or 10^{-2} Pa	3
	10^{-5} mbar or Torr or 10^{-3} Pa	2
$p \leq$	10^{-6} mbar or Torr or 10^{-4} Pa	1

Setting to 1 – 4 generates this fixed number of decimals. In case of a leading negative sign four decimals will be reduced to three.

Dsp Timeout After the time in seconds, as entered here, the SRG-3 will switch back to readout 0.0 or 0.1 or 0.2.

Selecting **Off** disables the display timeout.

Setup menus will always be set back after 60 seconds.

9.3 Set clock / calendar

Date: 2007-09-07 **Time: 16:57**

To enter date and time. These data will be listed on a printout.

9.4 SI units option

SI only: Off

SI only: On Only SI units will be accepted. All readouts in mbar, Torr and ° C are disabled.

10.0 Printout settings

Refer to appendix A for typical examples.

10.0 Printout settings menu

Setup Menu: **Printout < >**

Press [ENTER] or cursor ↓↑ to proceed to the sub-menus 10.1 to 10.4.

10.1 Statistics count / print interval

Max Count: 010 **Interval: 000**

Here you can choose how many measurement values shall be printed and enter the printout intervals. The printer must be activated in readout 0.0 with the [ON] key.

Max Count:	000	Continuous printout.
	001 bis 100	Determines the number of printouts. After printing the last measurement value the printer will stop.
Interval:	000	Each measurement value will be printed.
	≤ 120	Print at selected intervals in minutes. Example: one print every 15 minutes when 15 is selected.
	> 120	Printing sets of consecutive readings, specified by **Max Count** Example for 180 and Max Count = 10: every 3 hours (= 180 minutes) one printout with 10 values plus statistical evaluation.

Readout/Display 2.0 shows the actual status of the printouts.

10.2 Header / footer options

Header Opt: Std
Footer Opt: Std

To configure head and foot lines of printouts.

Header Opt:	Std	Standard format (statistics)
	Col	Only column headers
	Off	No headers
Footer Opt:	Std	Standard format (statistics)
	Cnt	Count statement only
	Off	No footers

10.3 Data column options

Data Opt: Std

Here you can select what shall be printed in addition to the measurement values.

Std	Prints an asterisk * when Unstable' was displayed during a measurement cycle Setp Prints an asterisk * when a trip limit (Setpoint) was activated
Aux1	Prints data of signal input Aux CH1 in the left column instead of time
Aux2	Prints data of signal input Aux CH2 in the left column instead of time

10.4 Printer port / auto page eject

Print Port: Par
Page Eject: On

Print Port:	Par	Printer on parallel interface (Centronics)
	Ser	Printer connected to RS232 interface
	Off	Printer ports de-activated

Page Eject: On / Off enables or disables the automatic paper eject on a single sheet printer.

11.0 Configuring outputs

This menu serves to configure and set the setpoints and the analog output.

11.0 Output configuration menu

Setup Menu: **Outputs < >**

Press [ENTER] or cursor ↓↑ to proceed to the sub-menus 11.1 bis 11.3.

11.1 Setpoints

Setp1: 1.000E-01 **Setp2: 1.000E-02**

To set the setpoints for the trip limit relays Setp1 and Setp2.

Range (each setpoint): 10^{-5} – 10^{3} Pa
10^{-7} – 10 mbar
7,5*10^{-8} – 7,5 Torr
10^{-8} – 0,1 s^{-1}

11.2 Setpoint hysteresis

Hys1: -5.000E-02 **Hys2: -5.000E-02**

To set the hysteresis for the trip limit relays Setp.1 and Setp.2.

Range:
-0,5 - 1

<0	lowers OFF trip point by fraction of setpoint level
0	no hysteresis
>0	raises ON trip point by fraction of setpoint level

11.3 Analog output full scale / span

Full: 1.000E-02 **Span: 5**

The parameter **Full** determines the pressure associated with the full scale of the analog output U_{out} = 0 – 10 V .

Range: 10^{-5} – 10^{3} Pa
10^{-7} – 10 mbar
7,5*10^{-8} – 7,5 Torr
10^{-8} – 0,1 1/s

The parameter **Span** sets the scaling:

Lin	linear scale
1 - 10	logarithmic, number of decades

Conversions:

a) Linear scale: $p = \frac{U_{out}}{10\,V} \cdot p(Full)$

Example: U_{out} = 10 mV ; p(Full) = 100 Pa

$P = \frac{0{,}01V}{10V} \cdot 100$ Pa = 0,1 Pa

b) Logarithmic Scale $p = p(Full) \cdot 10^{(Span(\frac{U_{out}}{10V}-1))}$

Example: U_{out} = 7,40 V ; p(Full) = 1 Pa ; Span = 5

P = 1 Pa $\cdot 10^{(5\cdot(\frac{7{,}40V}{10V}-1))}$ = 0,05 Pa

Note

The voltage range of the analog output is always 0 – 10 V, independent of the selected scaling!

The analog output is refreshed in the rhythm of the sampling interval **(Meas Time)**, e.g. every 5 seconds or up, thus not being suitable for most pressure control applications.

Interfering effects like shocks caused from pneumatic valves can generate violent amplitudes with unintended responses of the trip limit relays.

12.0 Configuring auxiliary inputs

12.0 Aux. input configuration menu

Setup Menu:
Aux Inputs < >

There are two analog input ports on the SRG-3 which support external pressure transducers with linear signal voltage or can be used with temperature sensors. The respective readout is provided in the displays 0.1. and 0.2.

Press [ENTER] or cursor ↓↑ to proceed to the sub-menus 12.1 bis 12.4.

12.1 Aux. input modes

Mode1: Raw
Mode2: Raw

Choose the engineering unit for each channel:

Raw	raw value without scaling. Incoming signal will be displayed in volts.
Temp	display of temperature in °C or K , as defined in sub-menu 9.1.
Press	display in units of pressure, as defined in sub-menu 9.1.
Spcl	special. User defined displaying without units.

12.2 Aux. input scales

Scal1: 1.000E+00
Scal2: 1.000E+00

Scaling of the inputs is always 1/V and always refers to pressure unit Pascal Pa or to temperature unit Kelvin K, independent from the display unit selected in 9.1. The voltage range is fixed to 0 – 10 V.

<u>Example # 1 for pressure:</u>

Scale (**Scal1** ; **Scal2**) is set to 1.000E+01 meaning 10 Pa/V.

An input signal of 5 V will be displayed as 50 Pa or 0,5 mbar or 0,375 Torr.

<u>Example # 2 for pressure:</u>

An absolute pressure transducer with full scale range 1 Torr and linear output 0-10 V is connected.

1st conversion: 1 Torr = 133,322 Pa

2nd conversion: 1,33322 Pa = 1V

Scaling: 1.333E+00

An input signal of 4,5 V will be displayed as 6 Pa or 0,06 mbar or 0,045 Torr. The conversion can be easily verified using mode **Raw** in 12.1.

<u>Example for a temperature sensor:</u>

Scale (**Scal1** ; **Scal2**) is set to 2.000E+02 meaning 200 K /V.

An input signal of 1,00 Volt will be displayed as 200 K or – 73,2 °C.

An input signal of 1,45 Volt will be displayed as 290 K or 16,8 °C.

Note The auxiliary inputs accept negative signals. Check for correct polarity when connecting a gage otherwise negative pressures or temperatures will be displayed.

12.3 Aux. input offsets

Ofs1: +0.000E+00
Ofs2: +0.000E+00

This sub-menu serves for zeroing the signal inputs of Aux1 and Aux2. The values always refers to pressure unit Pascal Pa or to temperature unit Kelvin K, independent from the display unit selected in 9.1.

<u>Example for an absolute pressure transducer:</u>

The pressure transducer's full scale range is 10 mbar with linear output 0 – 10 V. The resolution is specified as 10^{-5} mbar, meaning that at a pressure of p ≤ 10^{-5} mbar the value 0 (Null) shall be displayed.

After evacuating below 10^{-5} mbar and sufficient warm up (follow manufacturer's instruction) the remaining output signal is + 65 mV.

Conversion:	10 mbar = 1000 Pa = 10 V.
Scale (**Scal1** or **Scal2**):	1.000E+02 (100 Pa per 1 Volt).
Conversion:	65 mV = 6,5 Pa.
Enter (**Ofs1** or **Ofs2**):	-6.500E+00 (negative because a positive offset has to be compensated).

12.4 Aux. input power supply

Aux Power: Off

Via internal relays the supply voltage output ± 15 V can be switched on and off.

13.0 Configuring the serial interface

Detailed instructions for operation via the standard RS232 interface are given in the extra handbook RS 232 INTERFACE (included in the shipment).

13.0 Serial comm settings menu

Setup Menu:
Serial Comm < >

Press [ENTER] or cursor ↓↑ to proceed to the sub-menus 13.1 to 13.2.

13.1 Baud rate / promt option

Baud: 9600
Prompt: Std

Available settings:

Baud(rate): 1200, 2400, 4800, 9600, 19200

Prompt: Std, User, Off

For more information refer to handbook RS 232 INTERFACE.

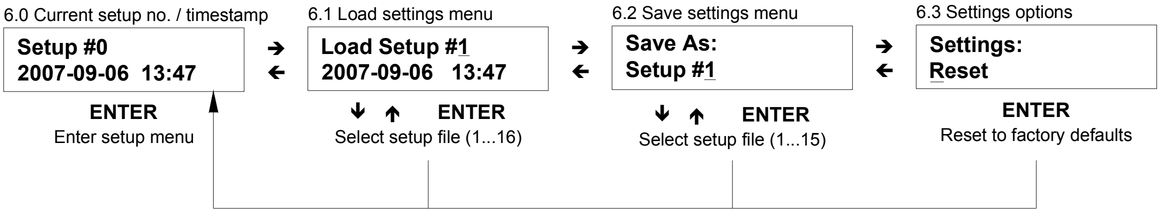
13.2 Prompt characters

Ackn: 62 (>)
Nack: 63 (?)

Described in the handbook RS 232 INTERFACE.

Operating with Data Sets

Structure



Storage

Up to 15 individually defined data sets can be stored by the user. Setup #16 instead is a fixed stored factory set default and serves besides factory and service related purposes to provide the operator a means to have a complete data set ready for use with which a system will work if there is no serious fault.

Create a data set

Example:

The following parameter data shall be stored as Setup# 3 :

- Argon
- Sensor (sphere, rotor) with 4,5 mm diameter and 7,9 g / cm^3 density
- Accommodation factor 0,997
- Temperature 24,5 °C
- Measuring time / sample interval 8 s
- Speed window 420 – 430 Hz
- Offset 3,8 x 10^{-4} Pa
- Display in Pa

other parameters arbitrary.

(continued next page)

Proceed as follows:

Action / Display	Comments
• Select standard display:	
0.0 Standard display **2.4538E-03 mbar** **9s 439Hz Ar**	
• Press cursor ↑ to display:	
6.0 Current setup no. / timestamp **Setup #0** **2007-09-06 13:47**	In this example the current data set was Setup# 5
• Press [ENTER] to enter the setup menu:	
7.0 Gas parameter menu **Setup Menu:** **Gas < >**	
• Set parameters in menus 7.0., 8.0, 9.0	
• Press [ESC] to return to standard display:	Press [ESC] several times, if necessary
0.0 Standard display **6.1109E-04 Pa** **9s 439Hz Ar**	
• Press cursor ↑ to display:	
6.0 Current setup no. / timestamp **Setup #0** **2008-11-06 15:01**	Because of changing parameters now Setup#0 appears (the original Setup #5 is still unchanged and stored)
• Press cursor key → twice to display:	
6.2 Save settings menu **Save As:** **Setup #x**	x = actually stored data set
• Press cursor ↓↑ to select the desired number for the new data set (#3 in our example) and store with [ENTER]:	
6.2 Save settings menu **Save As:** **Setup #3**	Setup #0 is now being stored as Setup #3

Establishing or changing data sets can be carry out very comfortable when operating the SRG remotely by a computer.

Select a data set

Action / Display	Comments
• Select standard display:	
0.0 Standard display **2.4538E-03 mbar** **9s 439Hz Ar**	
• Press cursor ↑ to display:	
6.0 Current setup no. / timestamp **Setup #3** **2008-11-06 15:25**	In this example the current data set was Setup#3
• Press cursor key → to display:	
6.1 Load settings menu **Load Setup #x** **2008-11-06 15:27**	x = actually stored data set
• Press cursor ↓↑ to select the number of the desired data set and confirm with [ENTER]:	
• Press [ESC] to return to standard display	Press [ESC] several times, if necessary

Setup reset

Action / Display	Comments
• Select standard display:	
0.0 Standard display **2.4538E-03 mbar** **9s 439Hz Ar**	
• Press cursor ↑ to display:	
6.0 Current setup no. / timestamp **Setup #3** **2008-11-06 15:25**	In this example the current data set was Setup#3
• Press ←→ to enter menu 6.3 :	
6.3 Setting options **Settings:** **Reset**	
• Confirm with [ENTER]	All data sets will be reset to factory default (= Setup#16).
• Press [ESC] to return to standard display	Press [ESC] several times, if necessary. Measurement values will now base upon Setup#16 data (except auxiliary inputs).

Lockout setup menu

Switch to menu 6.0 Current setup no. / timestamp and press the [ON] key. In the upper right corner an asterisk * appears and the SRG will not accept any inputs to the setup menu.

To disable press the [OFF] key. The asterisk * disappears.

Note There is no manual access to the setup menu when operating via the RS232 interface.

Chapter 7: Diagnosis and Tuning

Optimizing the sensing head adaption

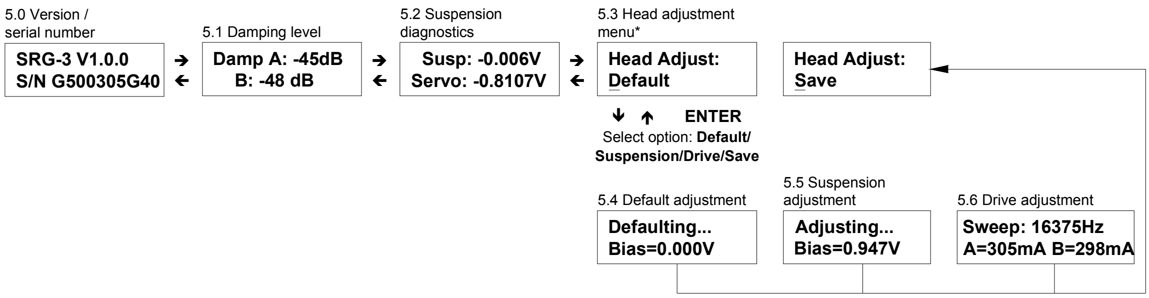
With new delivered units or when for example the sensing head was replaced, it may happen that the rotor drive or the ball suspension are not optimally aligned to the electronic circuitry.

This can be identified already on installation of the head onto the measuring flange by the message **No Sensor**, even if the sphere is captured in the sensing head's magnetic field.

Note Before starting the system it is strongly recommended to carefully perform the head adjustment procedure as described in the following.

Diagnosis and tuning

The SRG provides two adjustments: Suspension and Drive (Motor). The following chart gives an overview, for a detailed procedure see next page.



Tuning procedure

- Dismount the sensing head and place it on an isolating, non magnetic plate. (e.g. wooden table)
- Switch with cursor ↓↑ to readout 5.0 *Version/serial number*.
- Select with cursor ←→ menu 5.3.
- Select with cursor ↓↑ the adjustment mode **Suspension** for adjusting the magnetic suspension of the sphere and press the [ENTER] key.
  The menu 5.4 *Default adjustment* will appear, then for a moment the last stored bias value, e.g. **Bias =0.000V.**
  The system now performs automatically the optimum adaption of the suspension circuitry, followed by displaying the new bias value, e.g. **BIAS = – 2.032 V**.
- The readout switches automatically back to menu 5.1 *Damping Level* (menu explained in the next section).
- Select again with cursor ←→ menu 5.3.
- Select with cursor ↓↑ the adjustment mode **Drive** for adjusting the motor drive and press the [ENTER] key.
  The menu 5.6 *Drive adjustment* appears. Now the SRG-3 optimizes the adaption of the motor drive circuitry to the head coil inductivities and stores the new values of **Sweep**.
- The readout switches automatically back to menu 5.1
- Switch again to menu 5.3
- Select **Save** and store with [ENTER] the actual tuning values. Without storing the adjustment settings will be lost after power down.
- The SRG switches automatically back to the standard display 0.0
- Mount the sensing head onto the flange
- Repeat procedure if necessary
- Before starting measurement check the zero readout. Correct zero offset if necessary.

To reset the adjustment settings to factory defaults switch to menu 5.3 and select **Default**, confirmed with [ENTER].

<u>Note:</u>

- Adjustment does only match the sensing head that was connected to the SRG.
- When switching off the SRG the stored setting will be safely kept in memory. It will be deleted with a new **Save** or a default command.
- After each tuning the zero pressure readout must be checked.

Diagnosis

5.1 Damping level

Damp A: -45dB **B: -48dB**

Provides information about the lateral stabilization of the sphere. The more negative values are the less intervening of the electronics is necessary as the sensing system is inherently symmetric and stable.

Display	indicates	Improvement/Remedy
-35 dB....-60 dB	Good values, stable system	--
-80 dB	Lowest achievable value. May appear randomly but not continuously.	--
> -12 dB **Unstable**	Poor stability. No measurement values will be displayed.	Eliminate sources of vibrations, shocks etc. Change the speed window to avoid resonance effects with pumps, electric drives etc. Change location of head/flange.
A=B= -80 dB (constantly)	Sensing head dismounted. Cable ‚Suspension' not connected	--- Connect cable to the 6-pole mating connector on rear panel.

5.2 Suspension diagnostics

Susp: -0.006V **Servo: -0.8107V**

Specific sensing head data, derived from the head-to-electronics adaption and also depending from the vertical symmetry head-sphere-thimble.

Tipp: Document these numbers after having successfully completed the adjustment procedure. They may serve as reference data when the measuring system will be re-started after a shutdown.

Pickup signal

To fulfill the condition that resolution, reproducibility and accuracy of the pressure measurement meet the specifications the pickup signal must be sufficient high and stable.

Indication on display

Action / Display
• Starting from standard display:
0.0 Standard display **2.4538E-03 mbar** **9s 439Hz Ar**
• Press cursor ↓ to switch to:
1.0 Raw value and signal level **1.1439E-04 1/s** **8s 438Hz 10.4dB**

The signal level in above example is 10,4 dB. The SRG requires a minimum level of -10 dB, otherwise no pressure measurement is done. For good measurement results values of about 6 dB are recommended. Higher signal level can (but not must) improve stability and thus reproducibility, but can also increase the residual drag, thus increasing the zero offset.

Diagnose with oscilloscope

On the rear panel you will find the connector **SCOPE**. This output provides the same conditioned and amplified pickup signal as it is fed into the unit´s counter electronics.

The signal there should be a stable and clear sinus wave of about 6 Vpp magnitude. The stability, however, is more significant than a sinus form and the signal’s magnitude.

Magnetizing the sphere

If the signal's amplitude is too low the magnetism of the rotor (ball, sphere) can be increased. This is done through the thimble's wall, with sensing head dismounted, using a permanent magnet. The small button magnet that originally was located at the end of the thimble (→chapter 3, Fig. 6) is well suited for this procedure. Slide the magnet along the thimble until you feel the rotor.

Caution: The flux of the magnet is high and the level of magnetization normally does increase the offset and should be kept as low as possible. Therefore use first a few sheets of paper between magnet and thimble.

It is difficult to reduce too high magnetism can be reduced. A proven method is baking. Do not use a de-magnetizing coil in case of calibrated balls!

Check the signal again after the sphere has been accelerated to the operation speed. Repeat the procedure of magnetizing if necessary. Sometimes it turns out to be sufficient just to re-install the sensing head. With the following suspension the sphere may be lifted to a different axial position, producing now a good signal.

The main source of interference leading to unacceptable instability is quite often the transfer of vibrations from the pumps or cycles of pneumatic gate valves. These can be reduced by anti-vibration mounts, bellows etc. but also by choosing a different place for installation of the ball/flange assembly.

Rotor sphere, thimble and head are carefully selected at the factory prior to calibration and delivery to provide optimum performance. Appropriate care is given by MKS Instruments on the adjustment of the measuring head and the stabilization electronics.

Note

In order to improve the signal level and stability and/or to reduce the zero offset it takes sometimes not more than to stop the sphere, remove the sensing head, re-mount it and start the system again. By a randomly taken different axial position the sphere may provide then a useful signal.

Adaption of the Rotor Frequency

The factory set default value for the rotor frequency limits is 430 - 440 Hz. To avoid interference with harmonic frequencies (e.g. from a turbo pump) the low and high limits can be changed. As the residual drag generated by eddy currents changes with the rotor speed the window size given by the limits however, should be kept small (typically 10 Hertz).

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Chapter 8: Error Messages and Troubleshooting

If an operation is ceased because of exceeding the allowable execution time limit one of the following error messages will be displayed. In the standard display 0.0 the blinking error message is shown until the message is confirmed with [ESC] or until a respective command, e.g. MSG, is received via the serial interface.

Error messages are also transferred through the serial interface. There is a number of requests and commands available to handle these alerts. Detailed instructions are given in the extra handbook RS 232 INTERFACE (included in shipment).

The following handles only the manual operation. The listing of possible causes and their remedies does not necessarily claim to be absolutely complete.

Error message	Problem /	Possible cause and remedy
Err 07	MLC not recognized The levitation controller (MLC) could not be recognized during power-up.	A hardware problem is likely. Contact MKS service for assistance.
Err 13	Motor current failure The motor output is not capable of providing the required drive current.	1. The MOTOR plug is not in place. Make sure that the gauge head is connected properly and try again. 2. The motor circuit is not tuned to its resonant frequency. Dismount the gauge head and start the tuning procedure ‘Drive’ (→chapter 7). Then reinstall the head and try again
Err 14	Adjusting head failed	The adjustment procedure has been started with the sensor fitted. Dismount the gauge head and try again.
Err 15	Tuning motor failed The tuning procedure was terminated unsuccessfully.	1. The MOTOR plug is not in place. Make sure that the gauge head is connected properly and try again. 2. The resonant frequency of the motor circuit could not be found within the predefined range. Make sure that both gauge head and unit have assumed room temperature and try again. If the error persists, a hardware problem is likely. In this case, contact service for assistance.
Err 21	No rotor detected No sensor (sphere, ball) was detected.	Make sure that the sensor is fitted and the gauge head is mounted properly (→ chapter 3), then try again.

Err 22	Mounting rotor failed The instrument is unable to levitate the sensor.	1. The suspension circuit of the gauge head shows significant zero error. Dismount the gauge head and perform a zero adjustment (→chapter 8), then reinstall the head and try again. 2. The sensor is of a non-supported size or type or the gauge head is mounted in a way as to prevent the sensor from reaching its levitated position. Make sure that you are using the correct type of sensor and that the gauge head is mounted properly (→ chapter 3).
Err 23	Rotor touched down A persistent overload caused a safety shutdown of the levitation controller while the rotor was spinning.	1. A DMT command was sent before the sensor had been stopped (RCS > 3). Mind to stop the sensor before issuing the DMT command (see commands RCS and STP). 2. The gauge head was dismounted before the sensor had been stopped (RCS > 3). Mind to stop the sensor before dismounting the head (see commands RCS and STP). 3. The gauge head was bumped or exposed to vibration causing levitation control excitation. Mount the gauge head in a way as to avoid mechanical disturbance.
Err 31	Drive test failed The sensor speed did not increase during acceleration test.	The sensor signal is most likely interfered by stray signals or by vibration picked up by the gauge head. Such interference may originate from vacuum pumps operating in close vicinity. Monitor the sensor signal at the SCOPE output with a spectrum analyzer or an oscilloscope to identify the problem (→ chapter 7). Make sure that the signal path is free from interference. If this is not possible, try shifting the speed window
Err 32	Brake test failed The sensor speed did not decrease during deceleration test. See Err 31.	
Err 33	Controlling speed failed The sensor could not reach its initial speed with the allowed number of tries.	This may occur if the sensor signal is interfered or too noisy to obtain a useful speed indication. Monitor the sensor signal at the SCOPE output with a spectrum analyzer or an oscilloscope to identify the problem (→ chapter 7). Make sure that the signal path is free from interference. In case of a weak signal, dismount the gauge head, magnetize the sensor, then reinstall the head and try again.

Err 34	Bad signal level The sensor signal did not gain the minimum level (-10dB) required for measurement.	1. The PICKUP plug is not in place. Make sure that the gauge head is connected properly and try again. 2. The remanent magnetization of the sensor is too small to produce a sufficient signal. Dismount the gauge head, magnetize the sensor, then reinstall the head and try again (→chapter 7). 3. The sensor may experience excessive friction due to (a) high pressure, (b) touching the tube wall (excentric suspension) or (c) electrostatic fields (if the sensor is contained in a glass tube). Make sure the gauge head is mounted properly, the pressure is in the specified range, and, if a glass tube is used, take measures to prevent electrostatic charging.
Err 35	Speed window too small The measurement could not be completed within the speed limits.	The window is too small to attain a reading at the current pressure. Either increase the window by adjusting the speed limits or change to automatic mode Aut 2 (chapter 6: *Setup, 8.3, 8.4*), then try again.
Err 36	Spurious signal The measured signal is not the sensor signal.	1. The measured sensor speed seems to increase due to interfering signals picked up by the gauge head. 2. An internal overflow occurred due to interfering signals picked up by the gauge head. 3. The measured sensor acceleration is out of range, so the speed control is very likely locked to a harmonic of the sensor signal. Monitor the sensor signal at the SCOPE output with a spectrum analyzer or an oscilloscope to identify the problem. Make sure the signal path is free from interference and try again.

Err 61	Printer data overrun Data overrun occurred in continuous print mode because the printer is not ready to accept data. The print job has been aborted.	1. The printer is stopped by paper out or another error. Make sure that the printer is ready and has sufficient paper, then try again. 2. The printer is not online. Make sure the printer is online and ready, then try again. 3. The printer may have received a spurious command during hot plugging. Reset the printer by cycling the power switch, then try again. 4. The printer cable is not connected properly. Check the connection, then try again.

Table 2: Error Messages

Display and print error messages

Error messages will always be stored. They can be read and printed out later as well as being read via the RS232 interface. More information for remote operation with RS232 is given in the extra handbook INTERFACE (included in delivery). The following instructions refer to the manual operation only.

Starting from the standard display 0.0 switch with cursor ↓↑ readout 4.0. Continue according to the following chart:

4.0 Date / error count / oper. hours		4.1 Error history		4.2 Error history options
2007-09-07 12:36 **4 Errs 398h**	→ ←	**Last: Err 13** **2007-09-07 10:23**	→ ←	**Error History:** **Print**
		↓ ↑ Scroll through error history		↓ ↑ **ENTER** Select option: **Print/Erase**
		3: Err 21 **2007-09-05 14:17**		

Display 4.0: Date and time (here: 7.September 2007, 12:36); 4 error messages in memory; 398 hours of operation.

Display 4.1: Latest detected failure (here: Err 13, problem with rotor drive); use cursor ↓↑to get all stored error messages displayed with date and time of occurrence (here: error number 3 = Err 21, rotor not detected).

Display 4.2: Select Print for printing or Erase to clear the error memory. After emptying the readout 4.0 displays **0 Errs**.

Appendix A contains an example for a error listing printout.

Chapter 9: Bakeout

The measuring flange (or only the measuring cylinder, the thimble) can be heated up to 400 °C. The bakeout temperature should be at least 200 °C.

The calibrated rotor spheres are always baked before calibration in the measuring flange system. From experience, this results in the best long term stability. The heating should be repeated at the place of measurement to give the best stability. The measurement head must be removed before the ball/flange assembly is baked.

After bakeout, the flange system must be cooled down to the surrounding temperature before the system is operated. If the rotor sphere is not in thermal equilibrium with its ambience, it experiences an accelerating component by contraction upon cooling. This can lead to a negative pressure display; a positive drift of the pressure display is observed until a temperature equilibrium has been attained.

Note The inherent remanent magnetic field of the rotor can be reduced during bakeout. A remagnetization is recommended before starting again operation.

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Chapter 10: Theory

Principle of Measurement

The central component of the spinning rotor gauge is a freely rotating steel sphere in a vacuum, which is decelerated by friction with gas molecules. The relative deceleration is proportional to the pressure.

Fig. 9 shows details of the measurement head.

The drawing shows the rotor sphere (R) in the measurement cylinder (thimble) of the flange. Two permanent magnets (M) create a strong homogenous magnetic field in the region of the measurement cylinder. When the rotor is in the working position i. e. with its center on the cylinder axis, an unstable vertical position is attained. Stabilization is achieved by two opposing coils (S) which amplify the upper and lower field of the permanent magnets according to the deviation of the rotor. Horizontal deviations of the rotor are prevented by four coils (L). The rotor is driven by a two-phase motor consisting of four coils (D). The signal pick-up is performed by two coils (P) which are placed opposed from each other and are switched in series.

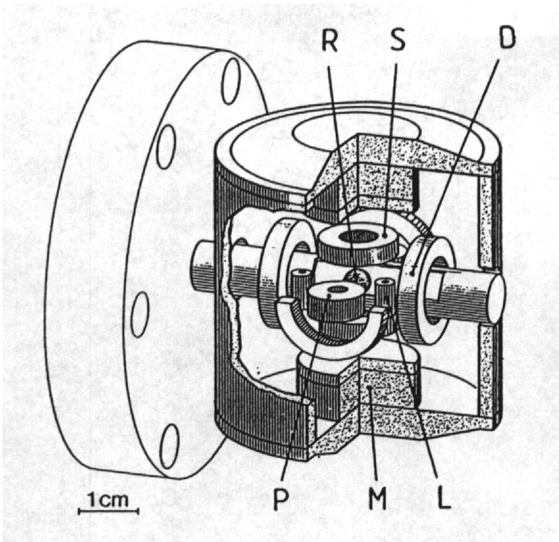

Fig. 9: Sensing Head SRG-SH

Measurement

The spinning rotor gauge determines the pressure by measuring the relative rate of deacceleration of a metal sphere which is freely rotating in a vacuum ambience. The formula used for this relationship is:

$$p = (- d\omega / d\omega t) \cdot (1/\sigma) \cdot (\pi / 10) \cdot (a \cdot \rho) \cdot \bar{c} \quad - [OFS]$$

with:

$- d\omega / d\omega t$ = relative retardation of the sphere per unit time

$\bar{c} = \sqrt{(8 \cdot R \cdot T) / (\pi \cdot M)}$ = average molecular speed

R = gas constant $8{,}314 \cdot 10^3$ (Nm/kmol • K)

T = absolute temperature in Kelvin (K)

M = molecular weight

a = radius of sphere

ρ = density of sphere

[OFS] = residual drag

σ = accommodation factor, surface coefficient, sigma factor etc.

Accomodation Factor σ

The accomodation factor is dependent on the surface conditions of the sphere and can (theoretically) be 0 in case of an ideal smooth surface and 1,27 (= $4/\pi$) in case of a “technically roughened” surface.

Standard spheres as provided by MKS are of stainless steel and are the same as used in ball bearings. The surface is not threatened to provide best corrosion resistance and the real accomodation factors are between 0,95 and 1,05. The exact value is documented in the calibration sheet.

The accomodation factor σ is determined for each rotor sphere. This is done in the calibration laboratority of MKS Instruments Germany by calibration against a gas friction manometer which serves as a transfer standard. This reference is routinely checked by the Physikalisch-Technische Bundesanstalt (PTB).

Gas Mixtures

For the pressure measurement of gas mixtures, it is necessary to know the resulting relative molecular mass. For n gases in a mixture:

$$M_{res} = (a_1 \cdot \sigma_1 \cdot \sqrt{M(1)} + a_2 \cdot \sigma_2 \cdot \sqrt{M(2)} + ...a_n \cdot \sigma_n \sqrt{M(n)})^2$$

with a(n) = fractional part of gas(n).

The friction coefficient of each individual gas generally differs only slightly from that of other gases so that the use of the coefficient of the dominant gas in general is sufficient for an exact measurement.

Measurement Range 1 - 100 Pa

In the pressure range p $\geq$ 1 Pa (0,01 mbar) the ratio of retardation to pressure becomes increasingly non-linear.

Fig. 10 demonstrates that the retardation ratio reaches a saturation level. This corresponds to a pressure of about 100 Pa and is particularly determined by the viscosity of the gas and by the free space between the rotor and measurement cylinder (thimble).

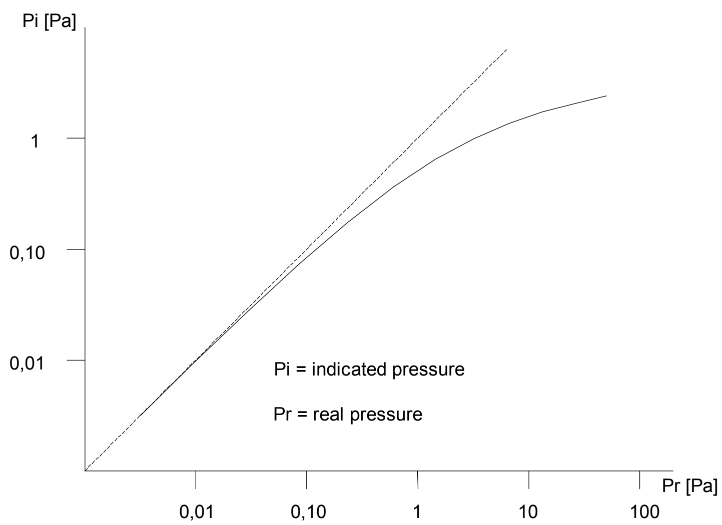

Fig. 10: Saturation by influence of Viscosity

The linearization program of the SRG - 3 corrects the deviation in this pressure range, however an increase in the measurement uncertainty of up to 10 % must be considered, caused by an increased heating up of the rotor and gas according to the continuous repetition of the sphere drive.

The correction factor can be read via the RS232 interface (read only)!

Note If the value for viscosity is entered as zero (no viscosity), no linearization will be done.

Note For most accurate pressure measurement above 10^{-2} mbar we recommend the use of a capacitance manometer Baratron® with 100 Pa full scale range.

Appendix A: Printout Examples

The following examples were created with 9-pin matrix printer TM-U220PD (Epson) connected to the rear panel Centronics printer port.

Measurement Data

a)

```
SRG-3  VACUUM GAUGE  1.0.4
Serial no.      G500307G40
Setup 0   from  2008-11-08
Date 2008-11-08         #2

Time           Press [Pa]

17:17:57        1.0450E-02
17:18:02        1.2170E-02
17:18:07        1.0860E-02
17:18:12        1.0910E-02
17:18:17        1.1950E-02
17:18:22        1.0510E-02
17:18:27        1.1740E-02
17:18:32        1.1280E-02
17:18:37        1.0680E-02
17:18:42        1.1830E-02

Count                   10
Mean value      1.1240E-02
Max. dev.       9.3200E-04
Std. dev.       6.4000E-04
Mean std.       2.0000E-04
```

Printout of 10 single measurement values, completed with statistical evaluation.

b)

```
SRG-3  VACUUM GAUGE  1.0.4
Serial no.      G500307G40
Setup 0   from  2008-11-08
Date 2008-11-08         #8

Time              Press [Pa]

17:28:49          1.1030E-02
17:28:54          9.9760E-03
17:28:59          1.1970E-02
17:29:04          1.0500E-02
17:29:09          1.0830E-02
17:29:14        * 1.1990E-02
17:29:19          1.0200E-02
17:29:24          1.1310E-02
17:29:29          1.1560E-02

Count                      9
Mean value        1.1040E-02
Max. dev.        -1.0700E-03
Std. dev.         7.3300E-04
Mean std.         2.4000E-04
```

The asterisk * preceeding the 6th measurement value indicates that the measurement was disturbed (→ error message UNSTABLE, OVERLOAD etc).

Any printout with three or more measurement data will be closed with statistical evaluation.

Definition of the statistical terms:

MEAN VAL: Average $\overline{X}$ of the measurements

$$\overline{X} = 1/N \bullet \sum_{i=1}^{N} Xi$$

MEAN STD: Average standard deviation. This is the quotient derived from the standard deviation and the square root of the number of measurements

$$\text{MEAN STD} = \text{STD DEV} / \sqrt{N}$$

According to the rules of statistical analyses of measured results, this average standard deviation - standard deviation of a test sample - represents the measurement error of the average value. It must not be overseen that the accuracy of the measurement system is specified by 1% + U (see Technical Data).

STD DEV: Standard deviation calculated from

$$\sqrt{\sum_{i=1}^{N} (Xi - \overline{X})^2 / (N-1)}$$

MAX. DEV: Difference between the average value and the maximum differing measurement values.

Setup/Data Set

```
SRG-3  VACUUM GAUGE  1.0.4
Serial no.      G500307G40
Setup 0   from  2008-11-08
Date 2008-11-08   17:34:18
```

```
Gas:
Gas type               Air
Mol mass [u]        28.960
Visc [uPas]         18.192
Tco [uPas/K]        0.0536
Gas temp [°C]         20.0
Sensor:
Accommodation        1.000
Meas Time [s]            5
Ball diam [mm]      4.5000
Ball dens [g/cm^3]   7.700
Upper limit [Hz]       440
Lower limit [Hz]       430
Auto start             Off
Speed control         Aut1
Backgnd average          5
Offset [Pa]     2.3447E-01
Readout:
Unit                    Pa
Temp scale              °C
Dec places            Auto
Displ timeout [s]       30
Printout:
Count                    0
Interval [min]           0
Header option          Std
Footer option          Std
Data option            Std
Page eject              On
Outputs:
Setp1 [Pa]      1.0000E+00
Setp2 [Pa]      1.0000E+00
Hyst1                -0.05
Hyst2                -0.05
Full [Pa]       1.0000E+00
Span (decades)           5
Aux inputs:
Mode1                  Raw
Mode2                  Raw
Scale1          1.0000E+00
Scale2          1.0000E+00
Offst1          0.0000E+00
Offst2          0.0000E+00
Aux power              Off
Serial com:
Baud rate (8N1)       9600
Promt option           Std
Pos ackn char       62 (>)
Neg ackn char       63 (?)
```

(→ chapter 5: *2.1 Print options*)

Error Messages

```
SRG-3  VACUUM GAUGE  1.0.4
Serial no.      G500307G40
Operating hrs          541
Date 2008-11-08   17:12:44
--------------------------
Logged messages:
2008-11-08  17:10   Err 23
2008-11-08  17:10   Err 36
2008-11-08  17:08   Err 36
2008-11-08  17:07   Err 61
```

(→ chapter 5: *2.1 Print options*)

Diagnostics

Printout for diagnose and service support.

```
SRG-3  VACUUM GAUGE  1.0.4
Serial no.      G500307G40
Operating hrs          541
Date 2008-11-08   17:35:59
--------------------------
Sensor:
Head power              On
Status               Ready
Rotor speed [Hz]     437.9
Signal level [dB]      7.1
Damp level A [dB]    -31.6
Damp level B [dB]    -32.9
Data processing:
Sample time       17:35:56
Sampl intvl [s]       5.00
Packets                136
DCR [1/s]       9.6578E-05
Mean speed [Hz]     438.07
Actual temp [K]     239.15
Cal factor
  [Pa s]        2.5197E+03
Corr factor     1.0027E+00
Table index              8
Levitation:
Control             Active
Detect [V]          -0.086
Det offset [V]       2.337
Bias [V]            -2.889
Damping A [V]        0.077
Damping B [V]        0.075
Speed Control:
Drive                  Off
Drive curr A [A]     0.334
Drive curr B [A]     0.329
Accel coeff
  [s^-2 A^-2]         91.3
Drag [1/s]      9.6578E-05
I/O status:
Switch state           -2-
Analog out [V]      5.9581
Aux inp 1 [V]       0.0012
Aux inp 2 [V]       0.0020
Aux power              Off
```

(→ chapter 5: *2.1 Print options*)

This printout contains, amongst others, information about sensing head tuning)

MKS may ask you for this printout in case of troubles with your SRG.

System Parameters

Contains settings of the SRG controller.

(→ chapter 5: *2.1 Print options*)

```
SRG-3  VACUUM GAUGE  1.0.4
Serial no.      G500307G40
Operating hrs          541
Date 2008-11-08   17:27:15
--------------------------
Scale factors:
Bias             6544.7798
Aout             5705.5322
Aux1               25.0000
Aux2               25.0000
Vdet               25.1200
Vsens              25.1200
Vserv              25.1200
Vsig                8.2580
VdmpA               7.7000
VdmpB               7.7000
IdrvA               1.0600
IdrvB               1.0600
Offsets:
Bias                 32823
Aout                  1711
Aux1                     0
Aux2                     0
Vdet                  2048
Vsens                 2048
Vserv                 2048
Vsig                     0
VdmpA                    0
VdmpB                    0
IdrvA                    0
IdrvB                    0
Levitation params:
Bias [V]            -2.889
Detect level [V]     2.500
Overld level [V]     1.000
Unstbl level [V]     0.250
Speed control params:
Motor freq [Hz]      15625
Min current [A]      0.150
Init accel coeff
    [s^-2 A^-2]      180.0
Init drag [1/s]      0.010
Drive timo [ms]      20000
Signl holdoff           70
Max trials               5
Signal params:
Timebase [Hz]     60000000
Min speed [Hz]         390
Min signal [V]       0.316
Min packet size         24
Other params:
Start sweep [Hz]     17026
Stop sweep [Hz]      14895
Options                  0
Created 2008-09-15   12:30
Changed 2008-11-04   14:59
```

Appendix B: Dimensions

B1 Flange

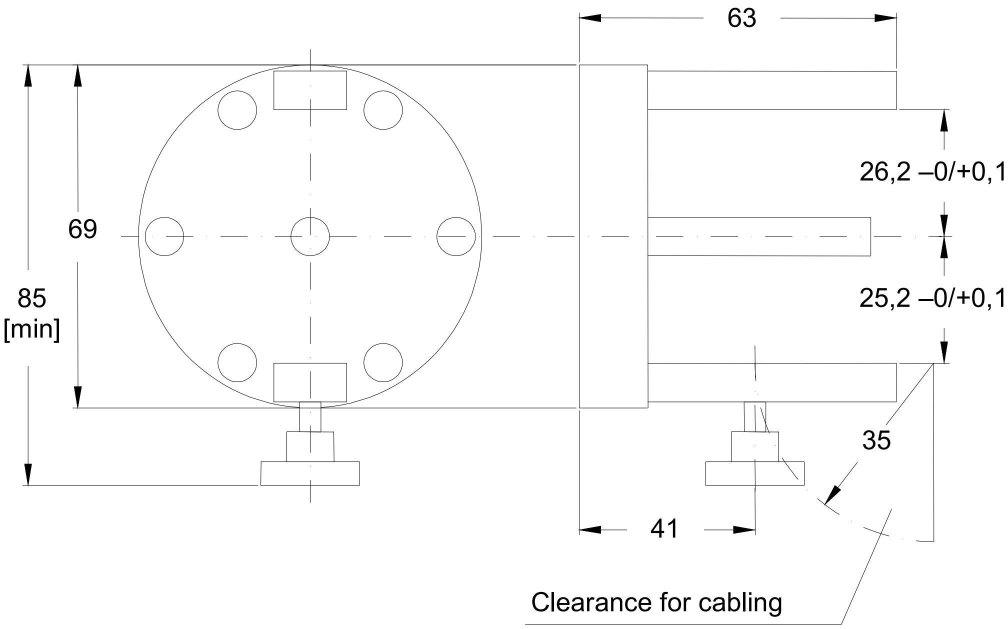

Fig. 11: Flange

B2 Sensing Head

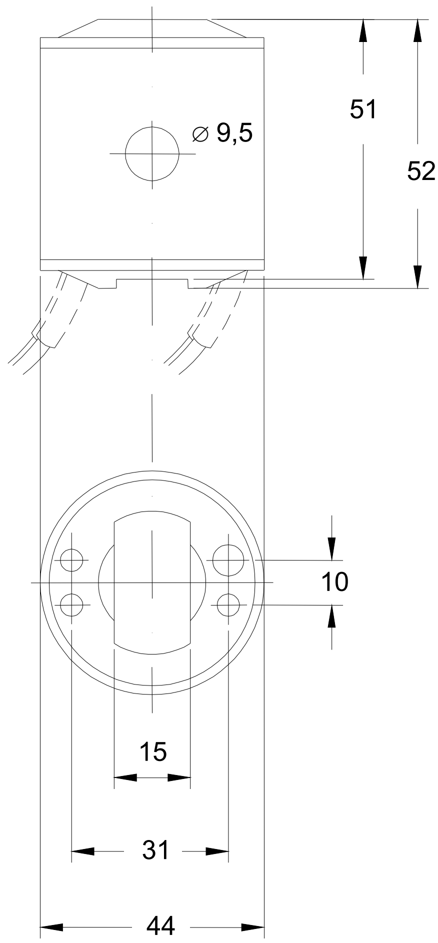

Fig. 12: Sensing Head

B3 Electronic Unit

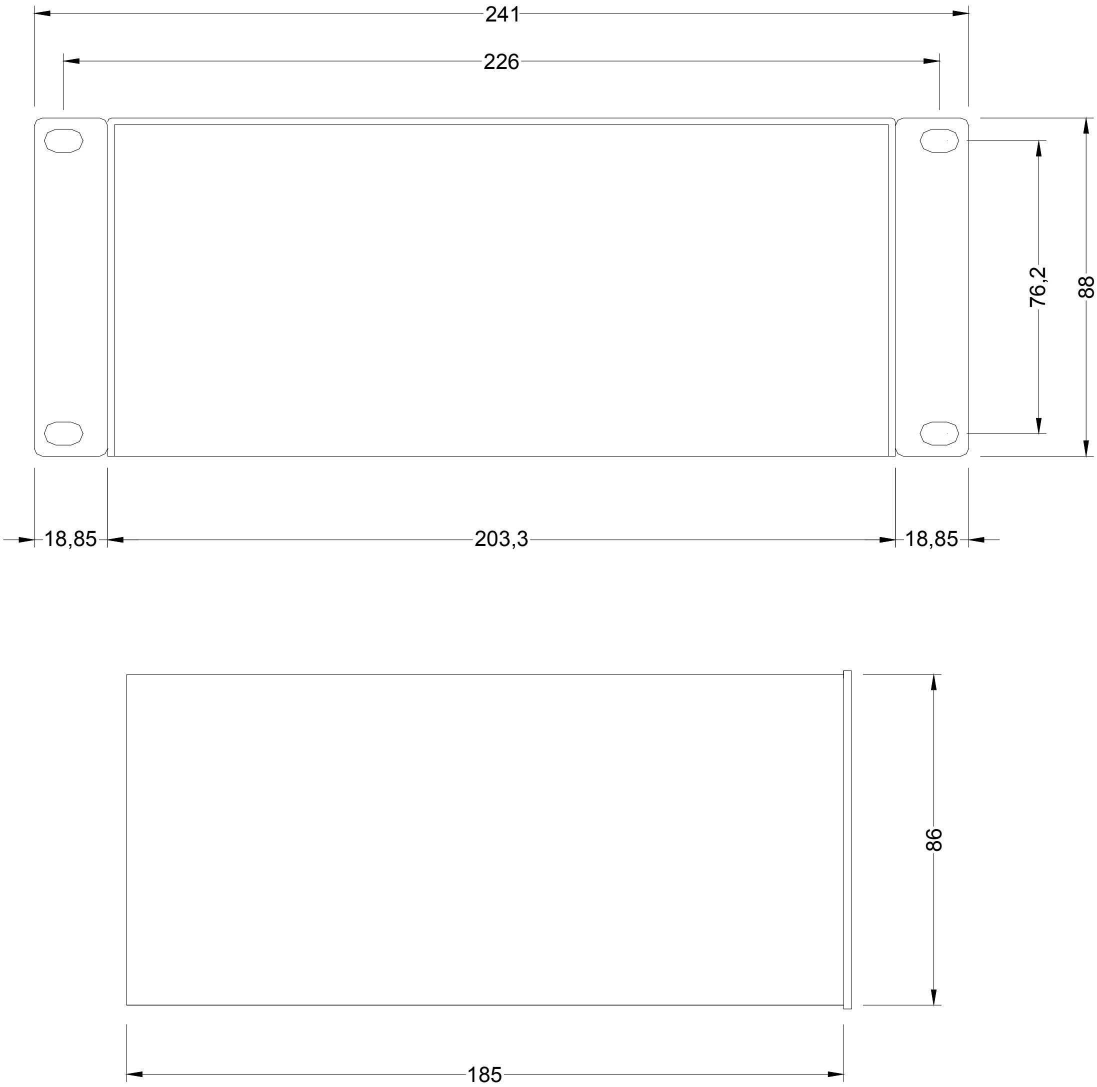

Fig. 13: Electronic Unit

(top: front and rear panel; bottom: side view)

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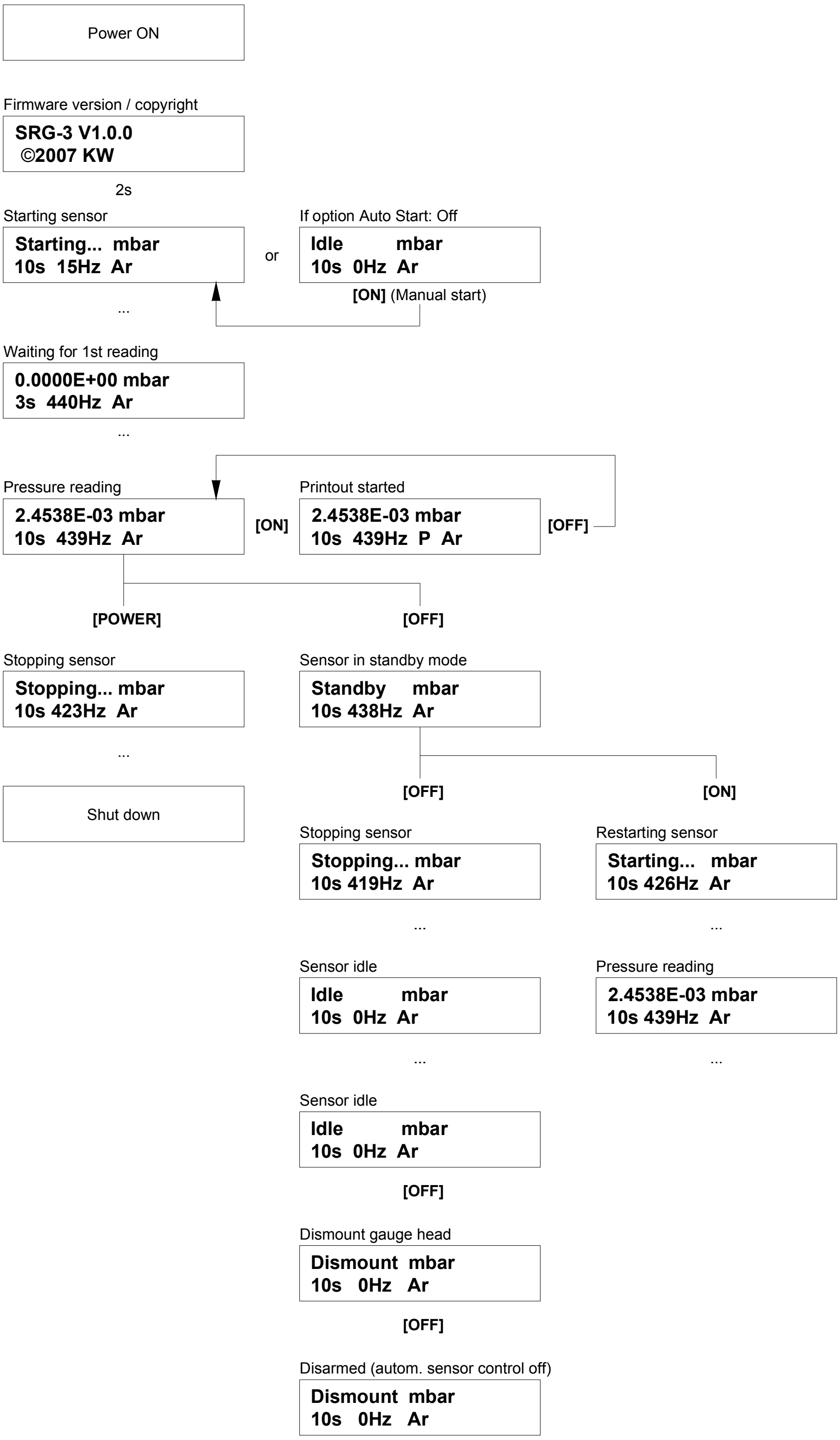
Appendix C: Overview of all Readouts and Menus

C1 Control Displays



C2 Measurement modes

0.0 Standard display
2.4538E-03 mbar
9s 439Hz Ar

0.1 Measured value / aux. ch.1
2.4538E-03 mbar
0.2462V Aux1

0.2 Measured value / aux. ch.2
2.4538E-03 mbar
2.4579E-03 Aux2

1.0 Raw value and signal level
1.1439E-04 1/s
8s 438Hz 10.4dB

1.1 Offset used for measured value
Zero Offset:
0.0000E+00 mbar

1.2 Zero adjustment options
Zero Adj: Mean
2.4535E-03 mbar

↓ ↑ **ENTER**
Select option: **Off / Curr / Mean**

2.0 Printout status
Print: Off #14
0min 10 of 10

2.1 Print options
Print:
Cont

↓ ↑ **ENTER**
Select option: **Off / Next / Cont**
Setup / Diagn

3.0 Trigger status
Trig: SP1 off
RDY on SP2 off

3.1 Analog output status
Aout: 2.00V/Dec
8.293V

4.0 Date / error count / oper. hours
2007-09-07 12:36
4 Errs 398h

4.1 Error history
Last: Err 11
2007-09-07 10:23

↓ ↑
Scroll through error history
3: Err 21
2007-09-05 14:17

4.2 Error history options
Error History:
Print

↓ ↑ **ENTER**
Select option: **Print / Erase**

5.0 Version / serial number
SRG-3 V1.0.0
S/N G500305G40

5.1 Damping level
Damp A: -45dB
B: -48dB

5.2 Suspension diagnostics
Susp: -0.006V
Servo: -0.8107V

5.3 Head adjustment menu
Head Adjust:
Default

↓ ↑ **ENTER**
Select option: **Default /**
Suspension / Drive / Save

5.4 Default adjustment
Defaulting...
Bias=0.000V

5.5 Suspension adjustment
Adjusting...
Bias=0.947V

5.6 Drive adjustment
Sweep: 16375Hz
A=305mA B=298mA

Head Adjust:
Save

C3 Data sets

6.0 Current setup no. / timestamp
Setup #0
2007-09-06 13:47

ENTER
Enter setup menu

6.1 Load settings menu
Load Setup #1
2007-09-06 13:47

↓ ↑ **ENTER**
Select setup file (1..16)

6.2 Save settings menu
Save As:
Setup #1

↓ ↑ **ENTER**
Select setup file (1..15)

6.3 Setting options
Settings:
Reset

ENTER
Reset to factory defaults

C4 Setup

Navigation: The windows in the head line represent the seven menu sections, each with several sub menus.

7.0 Gas parameter menu	8.0 Sensor parameter menu	9.0 Readout settings menu	10.0 Printout settings menu	11.0 Output configuration menu	12.0 Aux input configuration menu	13.0 Serial comm settings menu
Setup Menu: Gas < >	**Setup Menu: Sensor < >**	**Setup Menu: Readout < >**	**Setup Menu: Printout < >**	**Setup Menu: Outputs < >**	**Setup Menu: Aux Inputs < >**	**Setup Menu: Serial Comm < >**
7.1 Gas selection/mass units **Gas: Ar AMU: 039.944**	8.1 Accommodation/measure time **Accomm: 1.000 Meas Time: 10**	9.1 Display unit/temperature scale **Displ Unit: mbar Temp Scale: °C**	10.1 Statistics count/print interval **Max Count: 010 Interval: 000**	11.1 Setpoints **Setp1: 1.000E-01 Setp2: 1.000E-02**	12.1 Aux. input modes **Mode1: Raw Mode2: Raw**	13.1 Baud rate/prompt option **Baud: 9600 Prompt: Std**
7.2 Viscosity/temp. coefficient **Visc: 022.330 Tco: 0.0660**	8.2 Sensor diameter/density **Diameter: 4.500 Density: 7.700**	9.2 Decimal places/display timeout **Dec Places: Aut Dsp Timeout: 30**	10.2 Header/footer options **Header Opt: Std Footer Opt: Std**	11.2 Setpoint hysteresis **Hys1: -5.000E-02 Hys2: -5.000E-02**	12.2 Aux. input scales **Scal1: 1.000E+00 Scal2: 1.000E+00**	13.2 Prompt characters **Ackn: 62 (>) Nack: 63 (?)**
7.3 Destination selection **Save As Gas: Usr1**	8.3 Control modes **Upper Speed: 440 Lower Speed: 430**	9.3 Set clock/calendar **Date: 2007-09-07 Time: 16:57**	10.3 Data column options **Data Opt: Std**	11.3 Analog output full scale/span **Full: 1.000E-02 Span: 5**	12.3 Aux. input offsets **Ofs1: +0.000E+00 Ofs2: +0.000E+00**	
7.4 Temperature **Temp: +0020.00°C**	8.4 Control modes **Auto Start: On Ctrl Mode: Aut1**	9.4 SI units option **SI only: Off**	10.4 Printer port/auto page eject **Print Port: Par Page Eject: On**		12.4 Aux. input power supply **Aux Power: Off**	
	8.5 Background average option **Bgd Average: 10**					
	8.6 Zero offset **Offset: 0.0000E+00 mbar**					

Only the shade marked fields have an influence to the measurement result.

MKS Worldwide Calibration & Service Centers

UNITED STATES

MKS Instruments, Inc.
Corporate Service Center
90 Industrial Way
Wilmington, MA 01887-4610
Tel (978) 284-4000
Fax (978) 284-4303

MKS Instruments, Inc.
HPS Division,
Vacuum Components,
Valves & Gauging
5330 Sterling Drive
Boulder, CO 80301
Tel (303) 449-9861
Fax (303) 449-2003

CANADA

MKS Instruments, Canada Ltd.
30 Concourse Gate
Nepean, Ontario, Canada K2E 7V7
(613) 723-3386
Tel (800) 267-3551 (CAN only)
Fax (613) 723-9160

FRANCE

MKS Instruments, France s.a.
43, Rue du Commandant Rolland
B.P. 41
F-93352 Le Bourget, Cedex,
France
Tel 33(1)48.35.39.39
Telex 233817 F
Fax 33(1)48.35.32.52

DENMARK

MKS Denmark ApS
Ndr. Strandvej 119G
DK-3150 Hellebæk
Tel 45-44 92 92 99
Fax 45-44 92 94 99
Email: mksdenmark@mksinst.com

TAIWAN

MKS Instruments, Taiwan
10F, No.93, Shoei-Yuan Street
Hsinchu City 300
Taiwan, R.O.C.
Tel 886-3-575 3040
Fax 886-3-575 3048

GERMANY/BENELUX

MKS Instruments,
Deutschland GmbH
Schatzbogen 43
D-81829 München
Tel 49-89-420008-0
Fax 49-89-42-41-06
Email: mks-germany@mksinst.com

ITALY

G. Gambetti Kenologia Srl.
Via A. Volta No. 2
20082 Binasco (MI), Italy
Tel 39-2-90093082
Fax 39-2-905.2778

JAPAN

MKS Japan, Inc.
Harmonize Building
5-17-13, Narita-Higashi
Suginami-Ku, Tokyo 166, Japan
Tel 81-3-3398-8219
Fax 81-3-3398-8984

KOREA

MKS Korea Co., Ltd.
1st Floor DK Plaza-I
375-1 Geumgok-dong
Bundang-gu,Seongnam Kyonggi-do
Korea 463-805
Tel 82-31-717-9244
Fax 82-31-714-9244

UNITED KINGDOM

MKS Instruments, U.K. Ltd.
1 Anchorage Court
Caspian Road
Altrincham, Cheshire
WA14 5HH, England
Tel 44-161-929-5500
Fax 44-161-929-5511

SINGAPUR

MKS Instruments, Inc.
BLK 4010 Techplace I
#01-08/09 Ang Mo Kio Avenue 10
Singapore 569623
Tel (65) 6451 1062
Fax (65) 6451 0172