

Gas Analyzer Unit CP 4002



OPERATING INSTRUCTIONS

**Serving the Gas
Industry Worldwide**

STATUS JULY 2014



by Honeywell

Note:

Unfortunately, paperwork does not automatically update itself but technical developments are constantly being made. Therefore, we reserve the right to change the descriptions and statements contained in our operating instructions without prior notice. However, you can conveniently download the most recent version of this manual (and those of other devices) from our website www.rmg.com.

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1 MEASURING PRINCIPLE	1
2 CONSTRUCTION OF THE CP 4002	4
2.1 Gas distribution (Figure 2.3)	7
2.2 The gas chromatograph.....	7
2.3 Oxygen sensor OXOS 08	11
2.4 Exhaust gas conduction	11
3 FUNCTIONAL DESCRIPTION.....	12
3.1 Sequence of analysis.....	12
3.2 Separating columns.....	17
4 DATA ACQUISITION AND EVALUATION GAS CHROMATOGRAPH	18
4.1 Fundamentals	18
4.1.1 Fundamentals of analysis.....	18
4.1.2 Fundamentals of evaluation	19
4.2 Calibration in the factory.....	20
4.3 Basic calibration	20
4.3 Recalibration.....	21
5 DATA ACQUISITION AND EVALUATION OXYGEN SENSOR.....	22
5.1 Method of calculation.....	22
5.2 Factory / basic calibration.....	22
5.3 Recalibration.....	23
6 REQUIREMENTS FOR GASES USED / GAS CONSUMPTION	24
6.1 Carrier gas	24
6.2 Internal calibration gas.....	24
6.3 Measuring gas.....	25
7 CONNECTION AND STARTUP	26
7.1 Electrical connections	26
7.2 Gas connections	27
7.2.1 Carrier gas connection.....	27
7.2.2 Measuring gas / calibration gas / reference gas.....	28

CONTENTS

7.3 Column pressure and temperature	28
7.4 Further action	28
7.5 Interruption of carrier gas supply	29
8 OPERATING MODES OF THE CP 4002	30
8.1 Automatic analytical mode / AUTORUN.....	30
8.2 Stop mode / EZCHROM mode	30
8.3 Manual calibration	30
8.4 Reference gas analysis.....	30
8.5 Basic calibration	30
9 OPERATING INSTRUCTIONS FOR THE EXPLOSION-PROTECTED DESIGN... 31	
9.1 General instructions	31
9.2 Explosion-proof enclosure	31
9.3 Increased-safety terminal compartment	31
9.4 Maintenance	32
9.5 Safety measures	32
9.6 Maintenance Work.....	32
9.7 Repairs	32
10 FAULT MESSAGES	33
10.1 Faults occurring during continuous analytical operation	33
10.2 Further faults for devices with oxygen sensor	34
10.3 Faults occurring during recalibration	34
10.4 Power failure of the GC 9000.....	35
11 DATA STORAGE / PRINT REPORTS.....	36
12 INSPECTION AND MAINTENANCE WORK.....	38
12.1 General instructions	38
12.2 Regular maintenance work	38
12.3 Entries into the maintenance book.....	39
13 TECHNICAL DATA OF THE MEASURING ELEMENT	40
13.1 Technical data of the oxygen sensor OXOS 08	40

1 Measuring Principle

A gas sample is taken from the process line by means of a sampling probe. In a gas preconditioning unit the sample is filtered and reduced in pressure before it is conducted into the CP 4002.

Figure 1.1 shows the typical construction of the chromatograph in a block diagram.

In the gas distribution system (1) one of the three inlets is connected to the analyzer via a double block and bleed valve unit. A precisely defined quantity of gas to be analyzed is conducted to the separating columns by means of the injector.

This quantity is conducted through the separating columns representing the so-called mobile phase by means of a carrier gas.

The separation of the gas mixture is based on a reciprocal effect between a stationary phase, the packing or filling of the columns and the components of the gas flowing by. Due to different adsorption forces between the stationary phase and the gas components, the individual components are selectively delayed when they pass through the column, i.e. they pass through it at different speeds.

Therefore, all components appear at different times at the end of the column.

A thermal conductivity detector (TCD) records the components leaving the column. For each component a signal is generated which varies in length and height. This is a so-called peak. The area below the signal curve serves as a measure for the proportion in terms of quantity of the component involved.

Helium is used as carrier gas in the CP 4002 measuring element. Two columns which can be operated in parallel are used for gas separation.

With the two columns it is not possible to separate oxygen from nitrogen, i.e. the nitrogen content in the analysis result is too high to the contents of oxygen. For this reason, there is the option to install an additional sensor which determines the fraction of oxygen with the help of the paramagnetic properties of oxygen. Especially for biogases, it is usually necessary to measure the oxygen contents.

The area proportions determined, as well as the raw signal from the oxygen sensor, are evaluated in the GC 9000 analytical computer. There also the calculation of calorific value and standard density is carried out according to ISO 6976.

Depending on the factory calibration, a distinction is drawn between **calorific value measuring devices**, which determine superior calorific value, standard density and carbon dioxide contents for custody transfer metering (sufficient for the calculation of the compressibility factor according to GERG 88S) and **gas quality measuring devices**, where also the gas components are measured for custody transfer metering (required for AGA 8-92DC).

Functional Diagram Gas Chromatograph
with sensor OXOS 08 (optional)

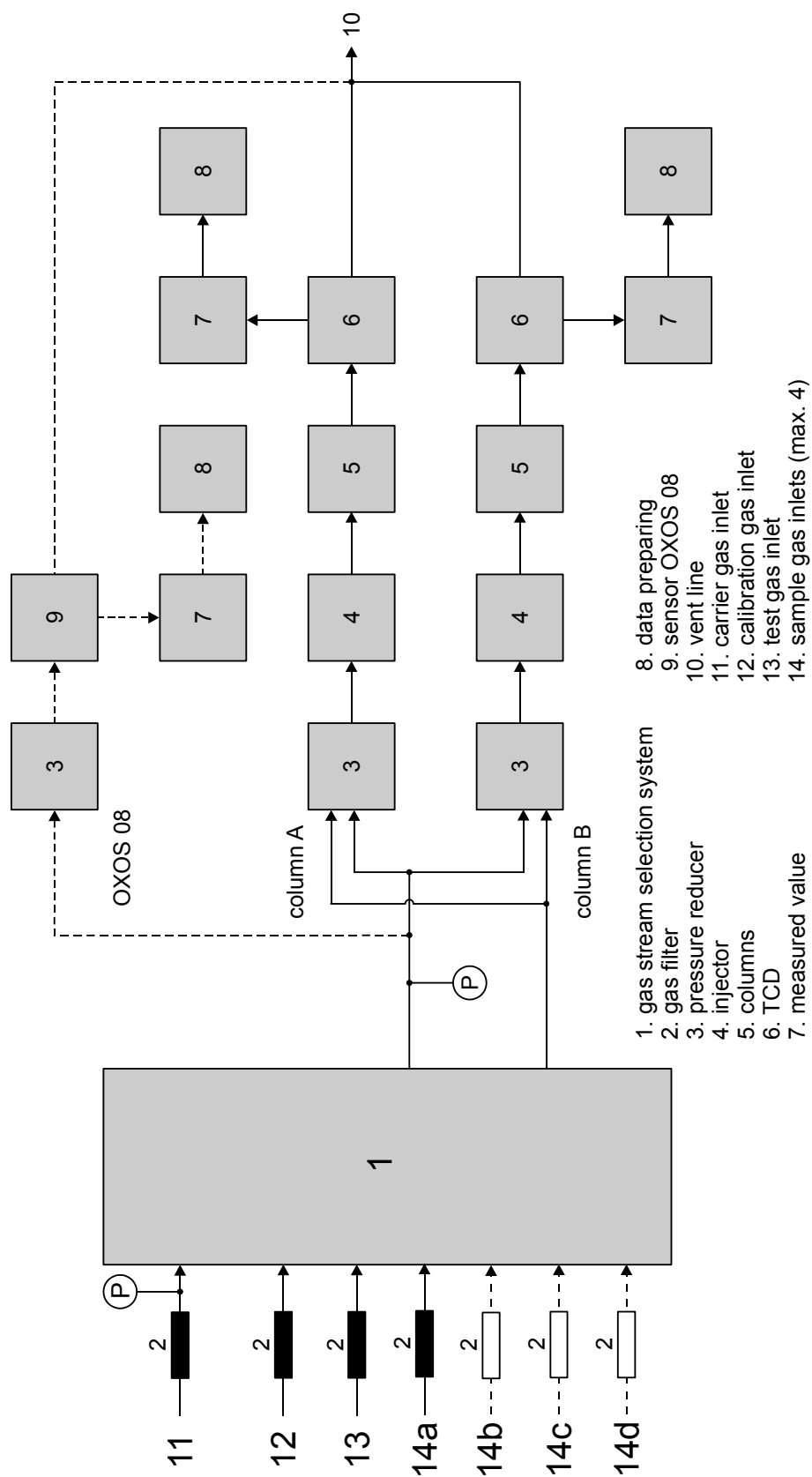


Figure 1.1

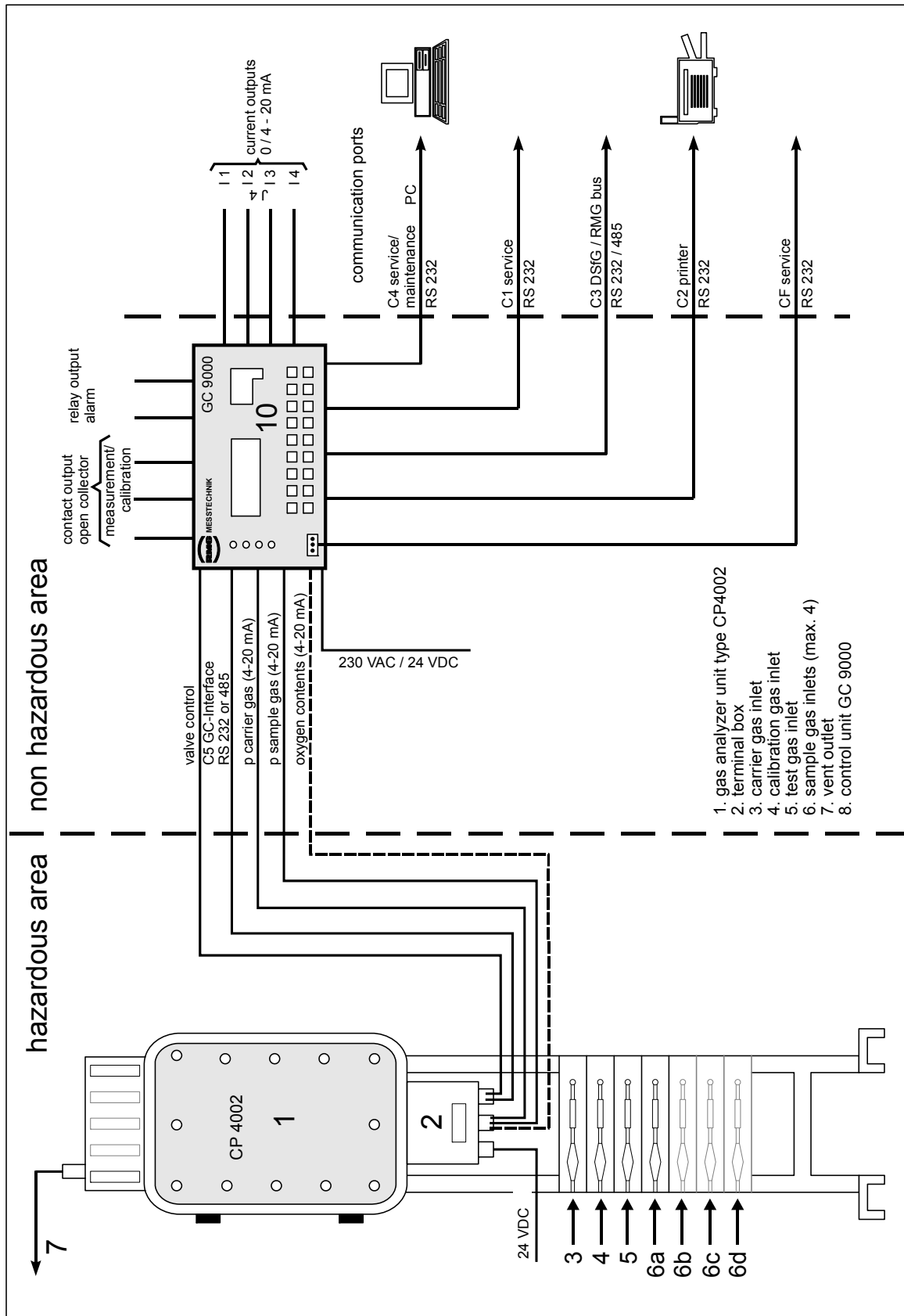


Figure 1.2

2 Construction of the CP 4002

Figure 2.1 shows the CP 4002 measuring element in its non-ex design and Figure 2.2 in its explosion-proof ("Ex-d") design. The unit can be divided into four major constituents:

- The electrical connector box (2) with its connections to the GC 9000 analytical computer. (Data exchange, valve control, power supply)
- An explosion-proof unit (Fig. 2.2) comprising power supply and valve control components.
- The gas distribution system with the carrier gas inlet A and the inlets for different gas streams (B, C, M1,...).

These inlets are connected to the chromatograph via a double block and bleed valve circuit. Switching over is controlled via the GC 9000 analytical computer.

Furthermore, there are two pressure transducers monitoring the carrier gas pressure and the pressure of the gas to be analyzed.

- The chromatograph itself in an explosion-proof enclosure (1).

This compact unit comprises separating columns, heating, injectors, detectors, pressure control system, data acquisition and communications hardware. The enclosure is heated in order to ensure that there is a minimum internal temperature of 10°C.

- The optional paramagnetic oxygen sensor OXOS 08 which is flown through parallelly to the sample gas column unit.

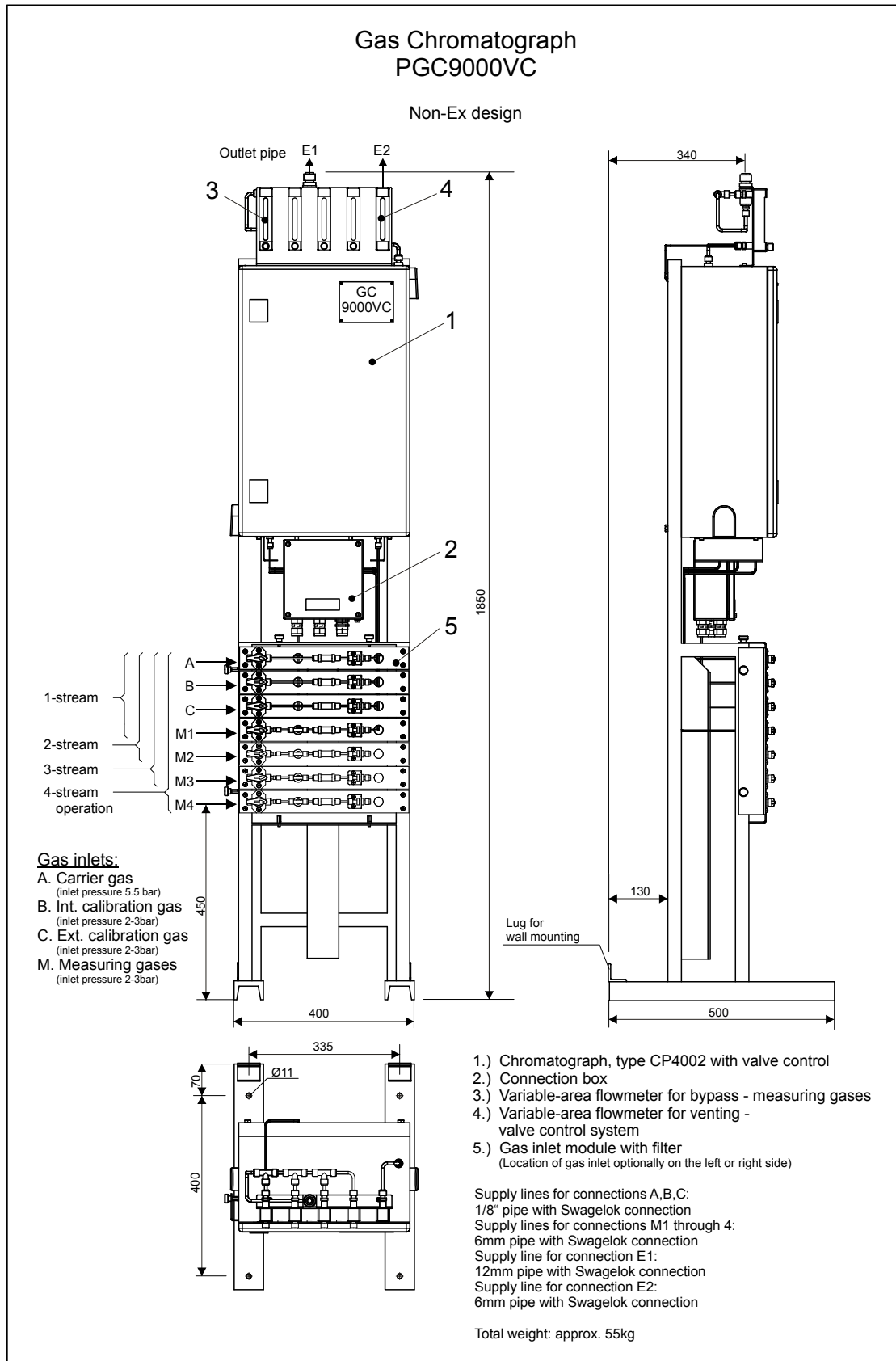


Figure 2.1

2 CONSTRUCTION OF THE CP 4002

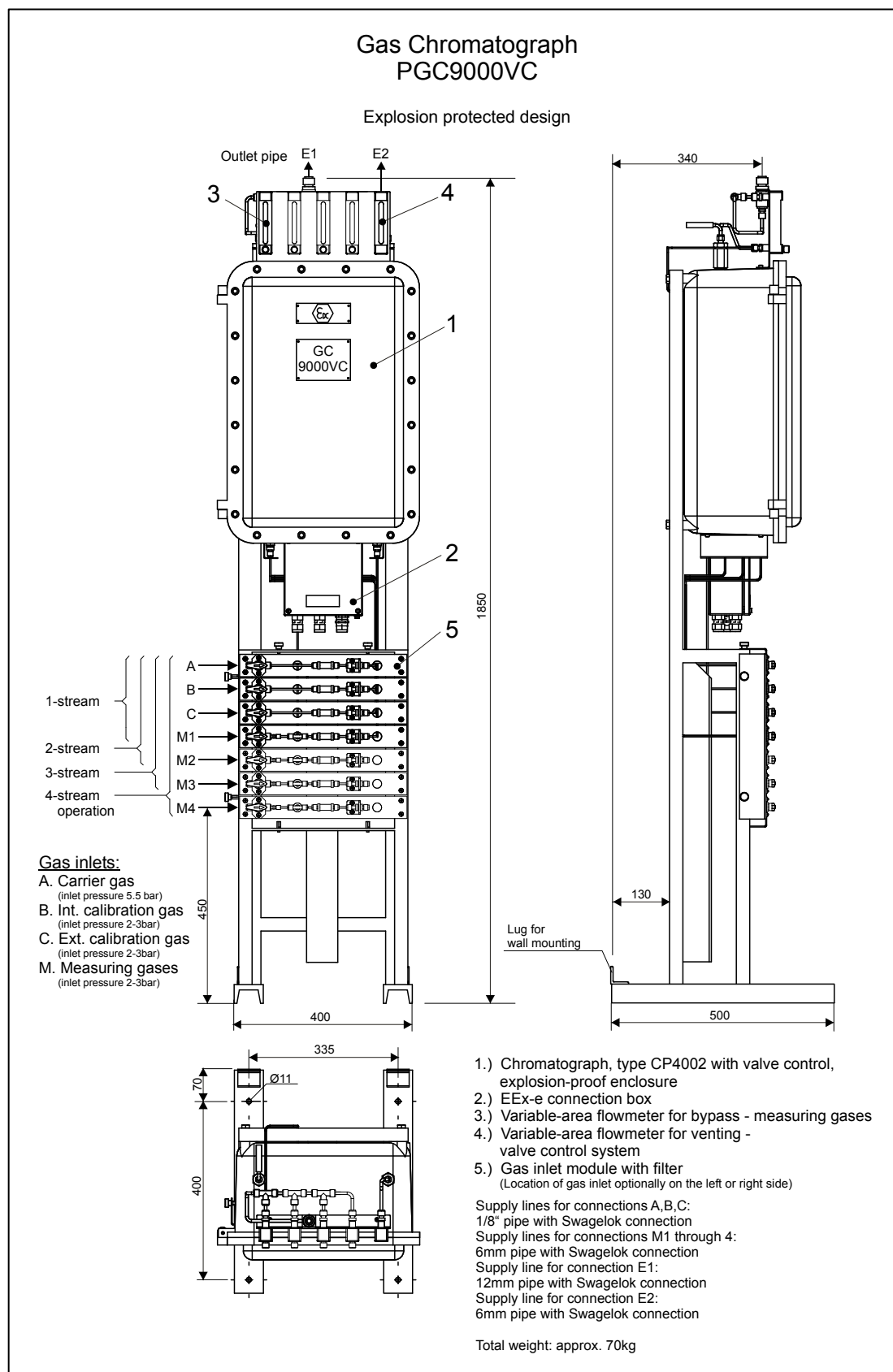


Figure 2.2

2.1 Gas distribution (Figure 2.3)

The gas distribution system serves to conduct one of the three gas streams to the analyzer and add the carrier gas.

In order to prevent any contamination of the selected gas stream by possible valve leakages, a double block and bleed valve configuration was chosen.

Figure 2.3 shows such a configuration with gas stream 2 being selected. It can be seen that the volumes between the valves of the unselected gas streams are open towards the atmosphere. Therefore, leakages occurring cannot contaminate the gas stream to be analyzed.

2.2 The gas chromatograph

Figure 2.4 shows the construction of the analyzing unit accommodated in an explosion-proof enclosure (Figure 2.1 or 2.2, item 1).

The analyzing unit is comprised of three major functional units for each channel:

- Pressure / valve control system (1)

This unit comprises the pressure control and monitoring system for the helium pressure before the columns as well as the control valves for the injector.

Set the pressure by means of the adjusting knobs (2).

The setting is adjusted in the plant when basic calibration of the device is made.

- Column modules (3)

Each column module is comprised of an injector, a reference column, a measuring column, thermal conductivity detectors and a column heating.

- Electronic unit (4)

This unit comprises the power supply, analog section, digital section and communications system.

Here data acquisition and preparation, temperature control and pressure monitoring as well as communication with the GC 9000 analytical computer are performed.

Gas distribution

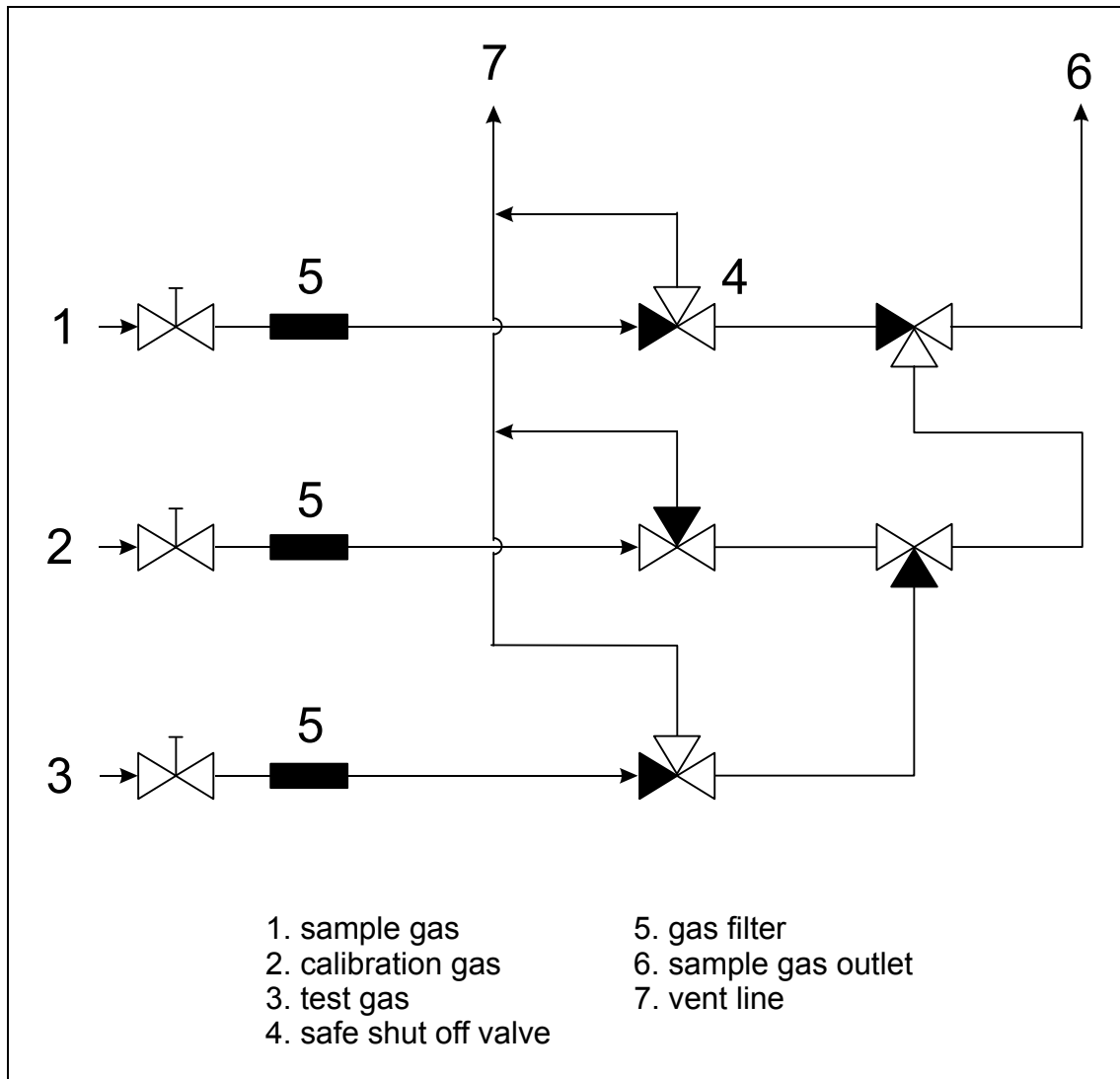


Figure 2.3

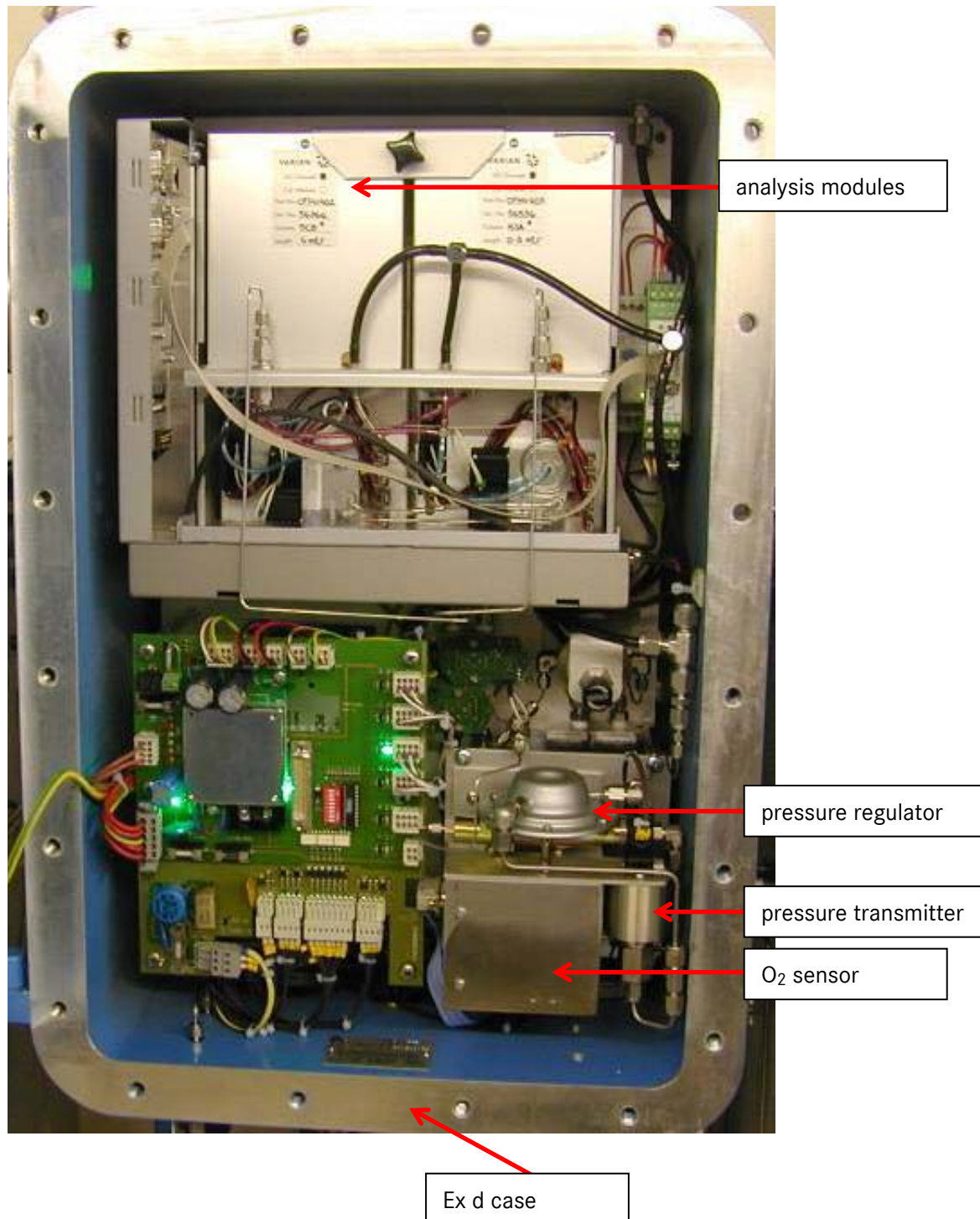


Figure 2.4

2 CONSTRUCTION OF THE CP 4002

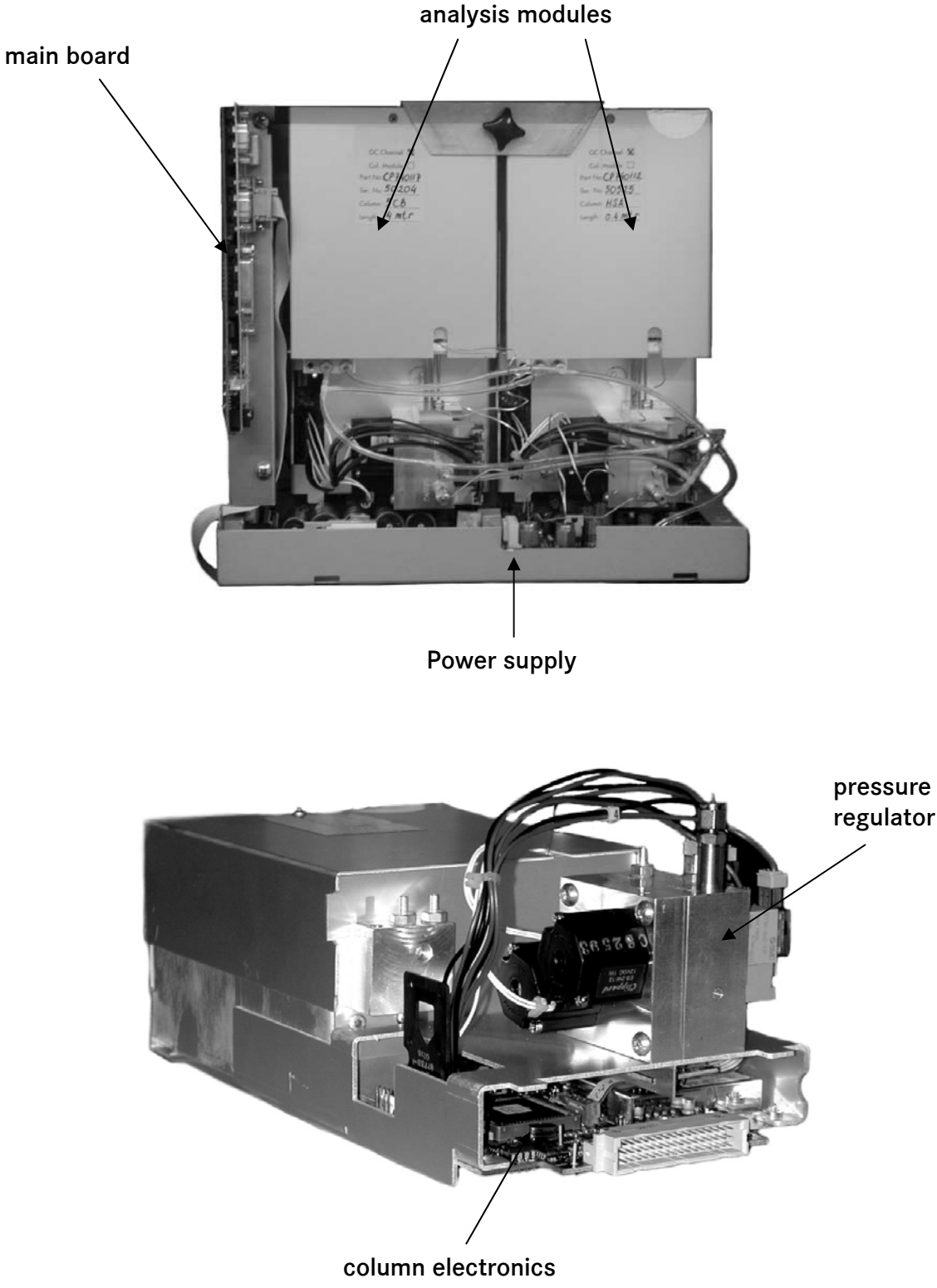


Figure 2.5

2.3 Oxygen sensor OXOS 08

The sensor unit is wrapped in an insulating enclosure and is controlled by a heating element and a PT 100 temperature sensor to a constant temperature of about 50°C. It is controlled by the controller board in the sensor unit.

From the pressure regulator (1), the gas passes through the first capillary (2) into the oxygen sensor (3).

After the oxygen sensor, the absolute pressure is measured via a pressure transmitter (4). The pressure is the sum of the actual atmospheric pressure and the pressure drop across the second capillary tube (5). Via this second capillary tube, which is used to attenuate rapid pressure changes coming from the outlet side, the gas flows to the outlet.

As density and viscosity of the gas change with the changing atmospheric pressure, the measuring results of the oxygen sensor are changed unintentionally. The sensor signals are thus corrected in the analytical computer by the measured absolute pressure.

Functional diagram measuring element OXOS 08

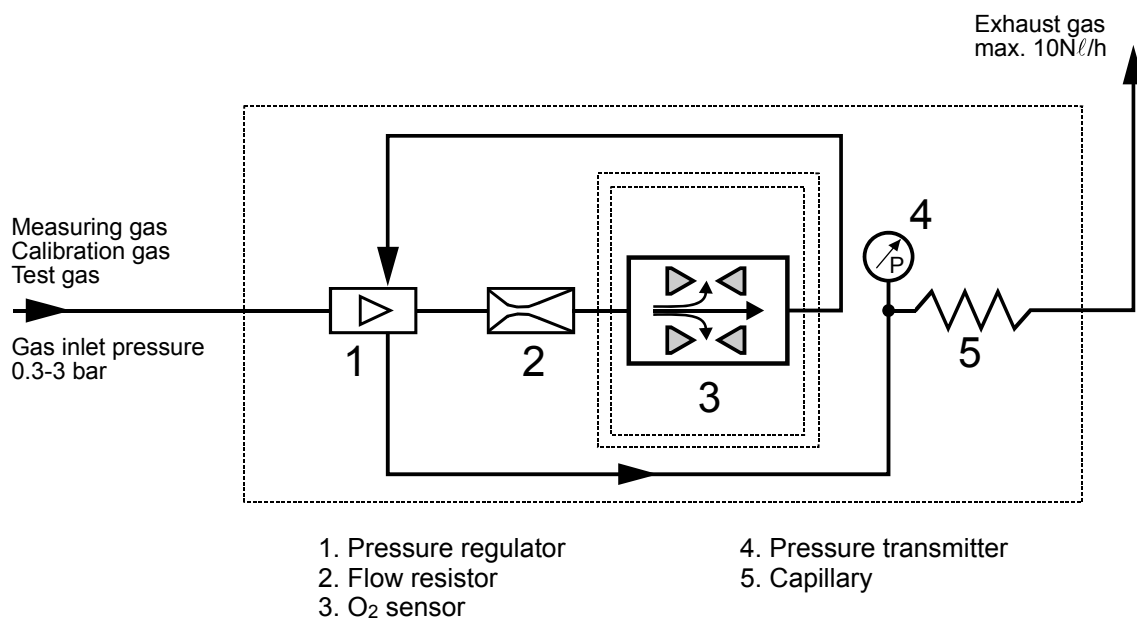


Figure 2.6

2.4 Exhaust gas conduction

The gas mixture leaving the chromatograph is conducted through a flame barrier (Ex d design only) to a variable-area flow meter (figures 2.1 and 2.2, items 3 and 4). This device serves to test the chromatograph for correct functioning. A flow will be shown only during sweeping time. Since new devices are set to continuous sweeping, only during the calibration there will be no flow display at the measuring gas outlet.

3 Functional Description

3.1 Sequence of analysis

The following five diagrams show the basic sequence of analysis. In order to facilitate understanding, the sequence is shown for one channel only.

- Initial position

Carrier gas is connected to the injector at a pressure of 5.5 bar by means of a solenoid valve. It pressurizes the microvalves for injection and gas sampling which then shut. At the same time pressure-controlled carrier gas continuously flows through the flow resistors and the analytical and reference columns.

- Sweeping

Set the solenoid valve for gas sampling to venting. The pressure at the microvalve is reduced and the valve opens. Then the gas stream sweeps the sample loop. The PGC 9000 VC is set to permanent sweeping is switched on permanently.

- Pressurization

The solenoid sampling valve opens and pressurizes the microvalve for gas sampling with helium at a pressure of 5.5bar. The solenoid microvalve is closed and a defined sample gas volume is entrapped in the sample loop.

The solenoid valve pressurizes the sample loop with pressure-controlled carrier gas.

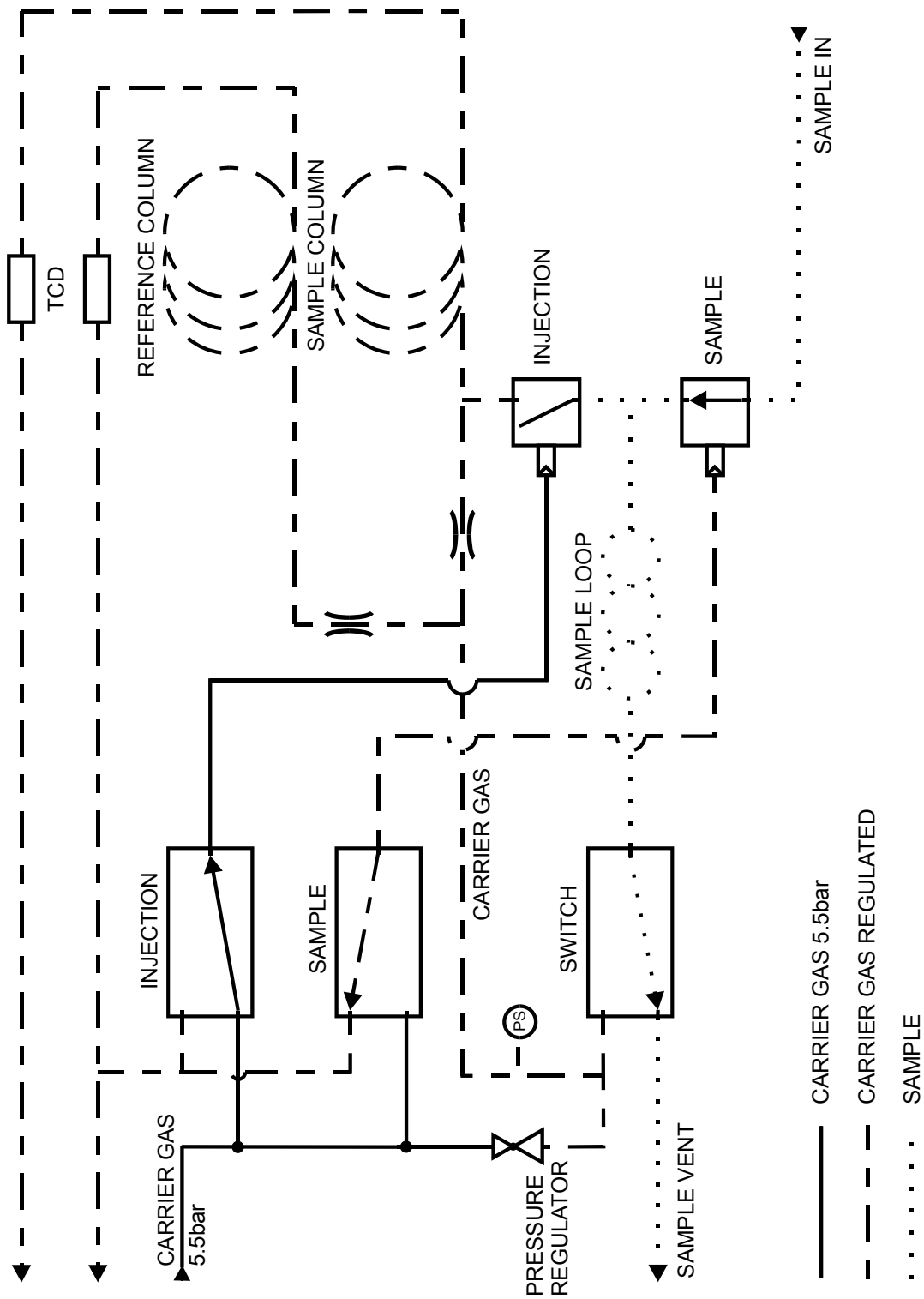
- Injection (1ms - 255ms)

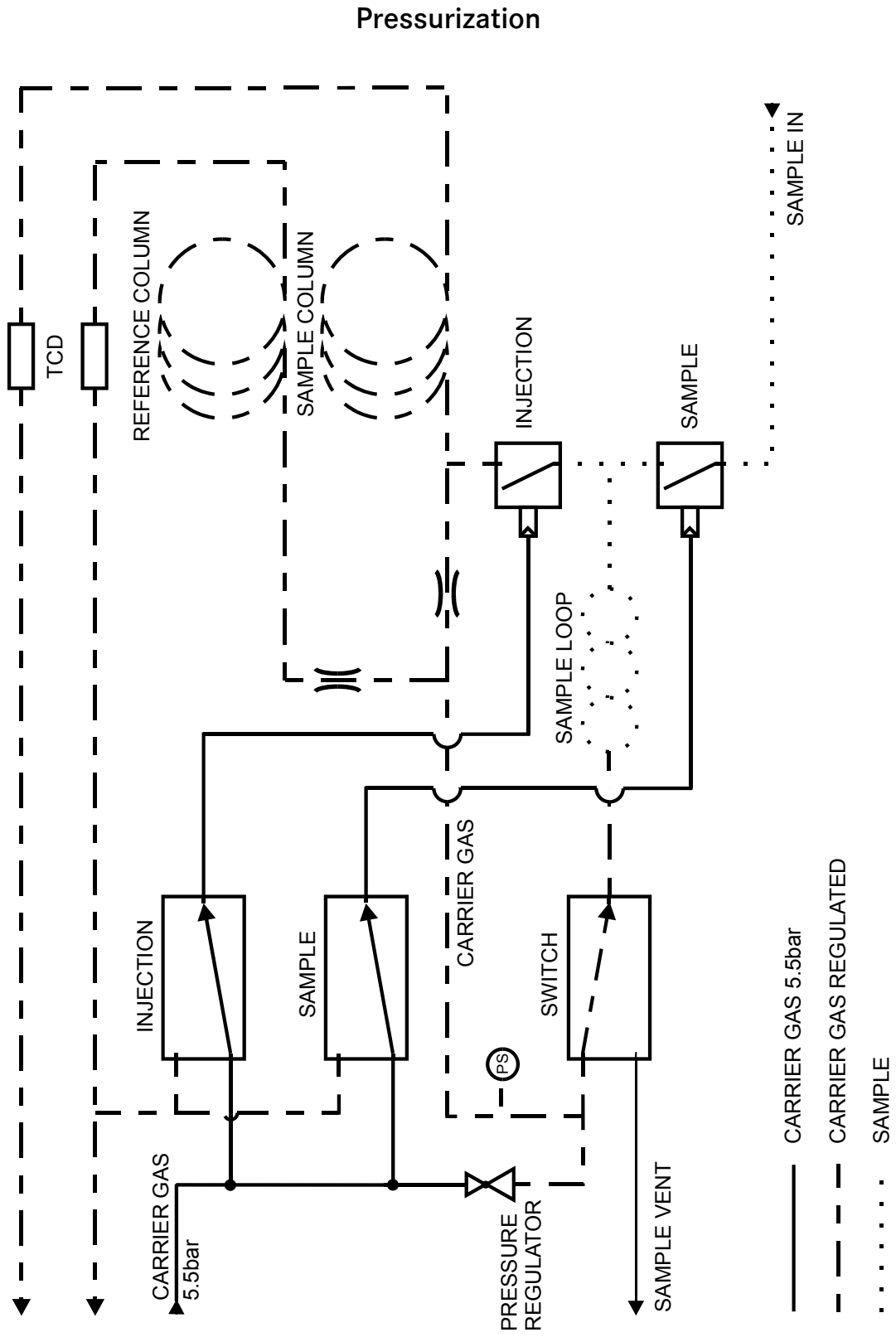
The solenoid injection valve switches to venting and opens the microvalve for injection. The pressure-controlled carrier gas of the solenoid valve forces the gas sample through the injection microvalve into the column. No sample gas is conducted to the reference column.

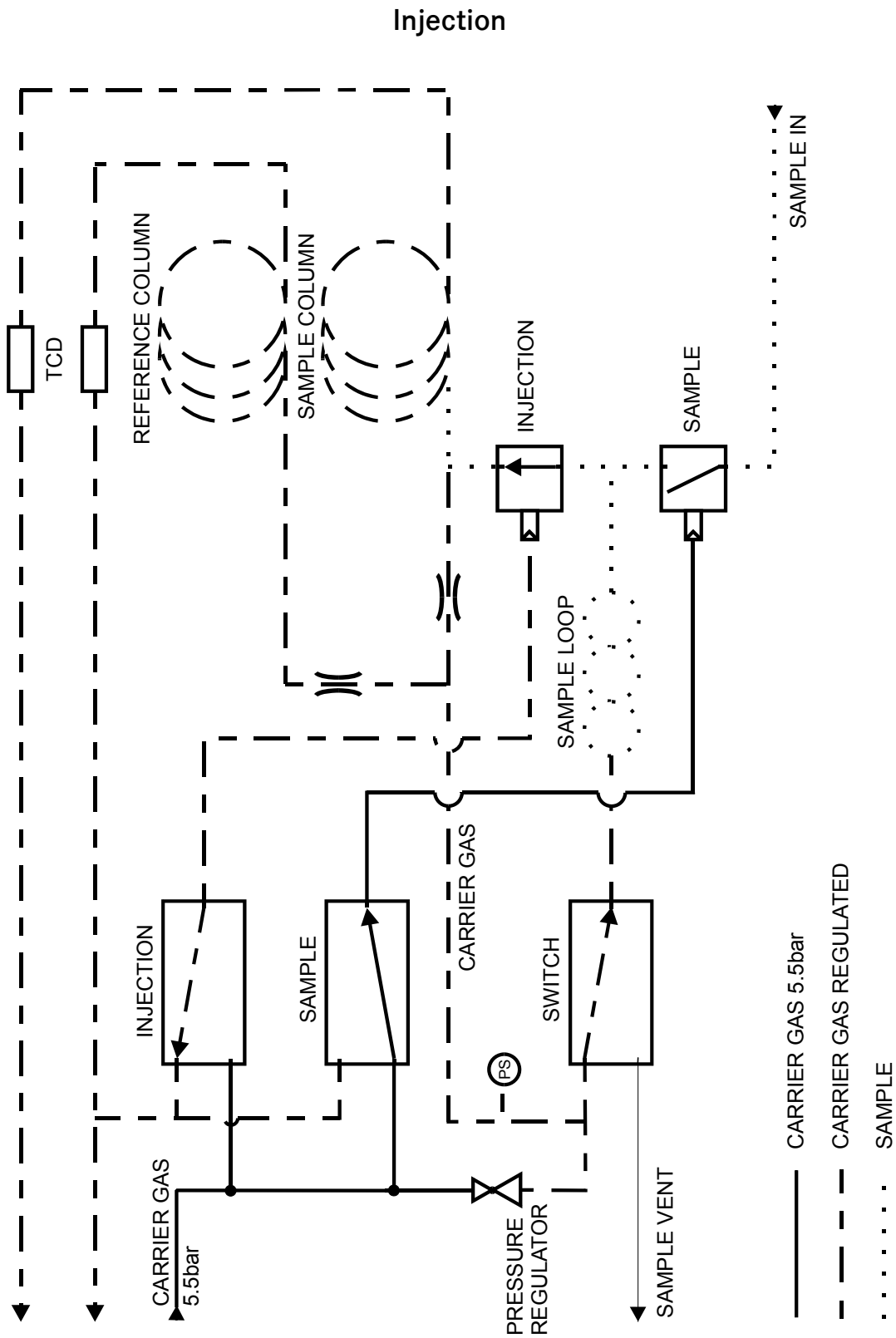
- Analysis

The solenoid injection valve opens and pressurizes the injection microvalve which then shuts. The gas sample is separated in the column and passes the detector.

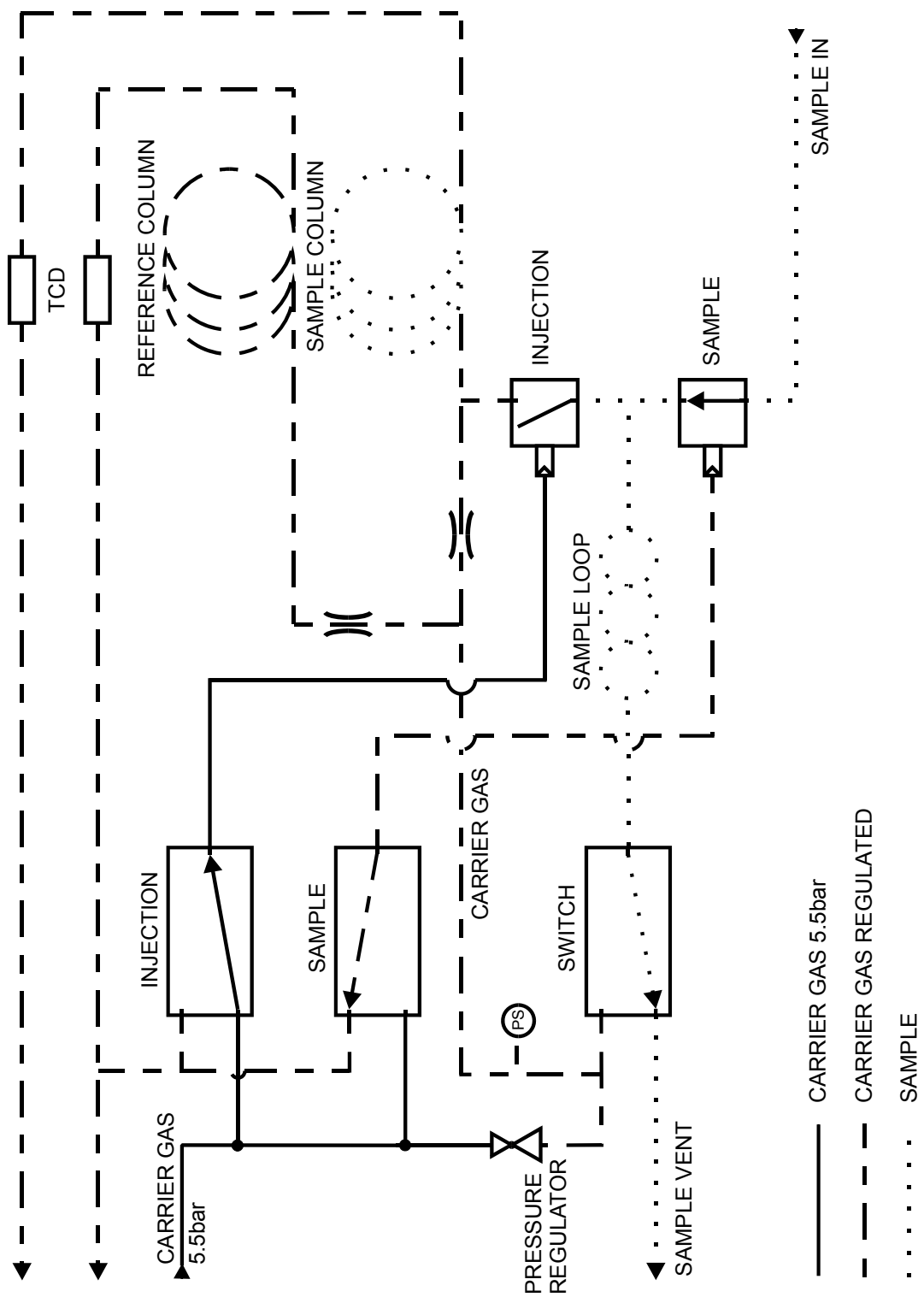
Sweeping (initial position)







Analysis



3.2 Separating columns

As already mentioned above, two separating columns are operated in parallel in the CP 4002. The sequence of analysis described under 3.1 equally applies to both channels.

The following columns are used to separate the listed components. The chronological sequence corresponds to the order of listing.

Channel A

Type: CP-Sil 5 CB
Length: 4m

Component	Operating range (mol %)	
	Calorific value measuring device	Gas quality measuring device
Propane	0 – 5.0	0 – 5.0
iso-Butane	0 – 2.0	0 – 0.9
n-Butane	0 – 2.0	0 – 1.6
neo-Pentane	0 – 0.3	0 – 0.06
iso-Pentane	0 – 0.3	0 – 0.12
n-Pentane	0 – 0.3	0 – 0.12
C ₆ + ¹⁾	0 – 0.3	0 – 0.08

¹⁾ Hexanes and higher hydrocarbons.

Channel B

Type: Haye Sep A
Length: 0.4m

Componente	Operating range (mol %)	
	Calorific value measuring device	Gas quality measuring device
Nitrogen	0 – 20	0 – 22
Methane	70 – 100	65 – 100
Carbon dioxide	0 – 20	0 – 12
Ethane	0 – 20	0 – 14.5

4 Data Acquisition and Evaluation Gas Chromatograph

4.1 Fundamentals

In order to achieve a good separation of elements when they pass through the columns, and make it possible to correctly determine peak areas, it is necessary to define several basic parameters. These are of decisive importance for correct functioning of the device. They are set in the plant and cannot be accessed by the user.

The relevant set of parameters is called method. Some of these settings are displayed and monitored via the analytical computer.

4.1.1 Fundamentals of analysis

Specific physical fundamentals of the analytical procedure which directly affect the analytical result are determined in the method.

These are the following:

- **Column temperatures**

Column temperatures directly affect the separating capacity and duration of analysis. They are monitored by the analytical computer.

- **Development time**

The development time determines the period during which data acquisition and evaluation of TCD signals are performed.

- **Helium gas pressure at the columns**

Here the pressure is determined which serves to pressurize the sample loops prior to injection. The setting is made in the factory directly at the chromatograph, it cannot be changed by the operator. The monitoring is carried out by the analytical computer.

- **Sweeping time**

This is the period during which the sample loops are swept with fresh measuring gas prior to injection. A basic time is firmly preset by the method. Depending on specific analytical conditions, the user can extend the sweeping time by entering a multiplier (not applicable for devices with continuous sweeping). This has no direct effect on the analysis.

- Carrier gas pressure

Because the pneumatically controlled valves of the injector unit are operated by means of the carrier gas, a defined pressure (5.5 bar) is required. The setting is made via the inlet pressure regulation unit.

Monitoring of this pressure is also performed by the GC 9000.

It is not to be confused with the carrier gas pressure in the columns, which is separately adjusted at the chromatograph.

- Measuring gas pressure

The measuring gas pressure can be set between 0.5 bar and 2 bar. Once the precompression at the gas distribution system has been defined, it must be kept within a tolerance band. Measuring and monitoring are also performed by the analytical computer.

4.1.2 Fundamentals of evaluation

Specific parameters are given to evaluate voltage characteristics determined by the TCDs.

Above all, a delimitation of element-specific peaks must be made. For this purpose, specific time zones are determined where the interaction of peak areas takes place.

The CP 4002 works on the principle of autogating, i.e. the relevant time gates are not firmly preset but determined according to the rise of the voltage characteristic.

The appropriate settings and expected retention times for the individual elements are defined by means of the method.

The latter are displayed as "RETENTION TIME AT THE START" and shown in the calibration report.

New retention times are determined with each recalibration.

The deviation between the retention times as defined in the method and the new retention times is monitored by the GC 9000.

4.2 Calibration in the factory

After a method has been defined and programmed, the first calibration of the device is made in the plant. It serves to assign peak areas to the corresponding proportions in terms of quantity of the components concerned. For this purpose, a number of calibration gases defined with sufficient precision are used which contain all elements to be determined. The individual proportions in terms of quantity of the components involved cover the range of concentrations to be expected.

After determination of the appropriate data record an approximation is made by a polynomial of the 3rd order:

$$\text{Concentration}[n] = A + B \cdot (\text{area}[n]) + C \cdot (\text{area}[n])^2 + D \cdot (\text{area}[n])^3$$

The values of the polynomial coefficients are stored in the GC 9000. They are outputted in the calibration report.

4.3 Basic calibration

During the initial start-up of the device a basic calibration is started at the analytical computer.

A calibration gas (internal calibration gas) with precisely defined composition is used. The corresponding concentrations of the components, as well as superior calorific value and standard density of the mixture are stored in the analytical computer.

A calibration cycle includes a selectable number of analyses of the calibration gas. Furthermore the number of analyses used for the averaging can be specified.

So for example it is possible to specify that in a calibration cycle 10 analyses are performed, where the last 5 are used for the averaging.

A concentration is calculated from the averaged peak areas for the respective component using the polynomial of the calibration in the factory.

$$\text{Actual Concentration}[n] = A + B \cdot (\text{area}[n]) + C \cdot (\text{area}[n])^2 + D \cdot (\text{area}[n])^3$$

A response factor for the basic calibration is calculated using the stored specified concentrations.

$$\text{RFZ}[n] = \frac{\text{Specified concentration}[n](\%)}{\text{Actual concentration}[n](\%)}$$

Then the calculated concentration results in:

$$\text{Concentration}[n] = \text{RFZ}[n] \cdot (A + B \cdot (\text{area}[n]) + C \cdot (\text{area}[n])^2 + D \cdot (\text{area}[n])^3)$$

These factors are stored in the analytical computer and are compared with the values obtained in the recalibration (see 4.4).

4.3 Recalibration

Automatic recalibration can be initiated by the analytical computer at certain intervals. Apart from this, the user can initiate such recalibration by hand at any time. Here also the internal calibration gas is used. The procedure corresponds to the basic calibration.

A concentration is calculated from the averaged peak areas for the respective component using the polynomial of the calibration in the factory.

$$\text{Actual Concentration}[n] = A + B \cdot (\text{area}[n]) + C \cdot (\text{area}[n])^2 + D \cdot (\text{area}[n])^3$$

A response factor for the basic calibration is calculated using the stored specified concentrations.

$$\text{RF}[n] = \frac{\text{Specified concentration}[n](\%)}{\text{Actual concentration}[n](\%)}$$

These factors are used for calculating proportions in terms of quantity of the components involved until the next calibration is made. They are stored in the analytical computer.

As already mentioned above, new retention times (RT) which are compared with the original values in the method (RTZ) are determined each time recalibration is performed.

5 Data Acquisition and Evaluation Oxygen Sensor

5.1 Method of calculation

The following calculations are performed with the measured values in this sequence in the analytical computer:

Correction of the sensor signals by the change of the atmospheric pressure

$$O_{2a} = O_2 + (p_{cal} - p_1) \cdot G1 + G2 \quad [\%]$$

O_{2a}	corrected oxygen contents
O_2	measured value of oxygen contents
p_{cal}	average reference pressure (always the same)
p_1	measured value of atmospheric pressure
$G1$	correction value factor
$G2$	correction value offset

5.2 Factory / basic calibration

After switching on and after the end of the warm-up time (approx. 1 h), zero gas (methane) is fed to the sensor for about 3 minutes.

The output signal is set to the zero point of the sensor via the corresponding potentiometer. Then test gas with a concentration of at least 75% of the measuring range is fed to the sensor for about 3 minutes. The output signal is adjusted with the second potentiometer on the concentration of the test gas.

Then zero gas is fed the sensor again, to verify the zero-point and to recalibrate if necessary.

During the calibration in the factory, all device-specific constants are determined in a test. All constants are stored in the analytical computer and are to be read on the display.

Determination of the pressure correction parameters G1 and G2

The two flow sensor signals are recorded in dependance on the atmospheric pressure.

For the measurement, any constant gas within the operating range of the device can be used.

The change of the atmospheric pressure is simulated by immersion of the exhaust pipe into a water column in a fixture.

The calculated slope in % O_2 /mbar results in the respective pressure correction parameters G1 and G2.

Example: OXOS 08 pressure correction

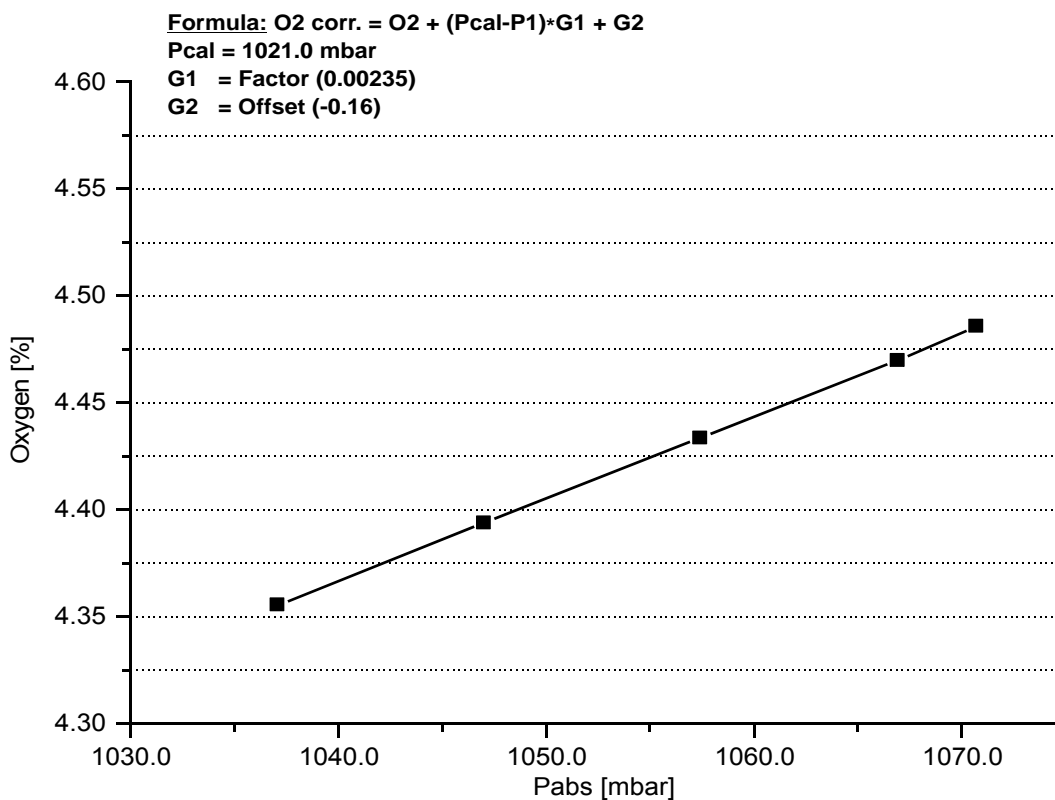


Figure 5.1

5.3 Recalibration

The calibration on site can be initiated manually at any time.

A calibration starts with a sweeping time for the calibration gas, which ensures that the device is completely swept.

The sweeping time is about 2-3 minutes.

A recalibration is only possible together with the recalibration of the PGC and takes 30 minutes including the sweeping time.

A PGC calibration gas (11M), which contains oxygen (as described in the type-approval 7.614/00.42) is used as calibration gas.

The offset correction value is stored in the analytical computer and determined again with any recalibration.

An appropriate calibration report is created in the analytical computer during each calibration.

6 Requirements for Gases used / Gas Consumption

6.1 Carrier gas

Helium which is used as carrier gas must comply with class 5.0 (99.999%).
The inlet pressure must be

$$P_{\text{He}} = 5.5 \text{ bar } (\pm 10\%)$$

to ensure correct functioning of the CP 4002.

Pressure monitoring is carried out by a pressure transducer installed in the gas distribution system.
Its output signal is monitored by the GC 9000.

Helium consumption is (depending on the column precompression selected)

$$Q_{\text{He}} = (4 - 10) \text{ ml/min}$$

A built-in oxygen sensor OXOS 08 is not flowed through by the carrier gas and thus not increasing the consumption of helium.

Helium easily tends to leak out and, therefore, it is important to carefully seal off and monitor the system.

6.2 Internal calibration gas

The following composition is proposed for the internal calibration gas:

Component	Concentration (mol%)	
	without oxygen sensor	with oxygen sensor
Nitrogen	4.00	4.00
Methane	88.90	88.45
Carbon dioxide	1.50	1.50
Ethane	4.00	4.00
Propane	1.00	1.00
iso-Butane	0.20	0.20
n-Butane	0.20	0.20
neo-Pentane	0.05	0.00
iso-Pentane	0.05	0.05
n-Pentane	0.05	0.05
n-Hexane	0.05	0.05
Oxygen	0.00	0.50

At a maximum filling pressure of 120 bar, the minimum storage temperature of this mixture is 0°C.

Inlet pressure may be defined within the range of

$$P_i = (0.5 - 2.0) \text{ bar}$$

It must already be determined prior to basic calibration. Any subsequent changes are not allowed.

Permissible deviations during operation are as follows:

$$dP_i = \pm 10\%$$

During calibration gas is only consumed during the calibration time.

At a precompression of $P_i = 1.0$ bar, there is a flow rate of

$$Q = 40 \text{ nml/min}$$

25

6.3 Measuring gas

The sample to be analyzed must be in gaseous condition of aggregation. Liquid components and other impurities are not permitted.

As to the inlet pressure and gas consumption, the values mentioned under 5.2 apply.

The operating ranges of the modules are within the following limits:

Component	Concentration (mol%)	
	Calorific value measuring device	Gas quality measuring device
Nitrogen	0 - 20	0 - 22
Methane	70 - 100	65 - 100
Carbon dioxide	0 - 20	0 - 12
Ethane	0 - 20	0 - 14.5
Propane	0 - 5	0 - 5
iso-Butane	0 - 2	0 - 0.9
n-Butane	0 - 2	0 - 1.6
neo-Pentane	0 - 0.3	0 - 0.06
iso-Pentane	0 - 0.3	0 - 0.12
n-Pentane	0 - 0.3	0 - 0.12
C6+	0 - 0.3	0 - 0.08
Oxygen	0 - 3	0 - 3

Without oxygen sensor, oxygen is recognized and shown together with nitrogen.

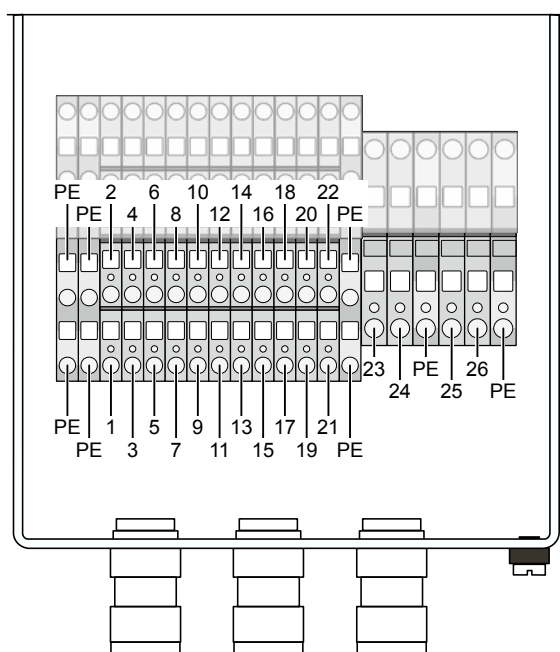
The limits are monitored by the analytical computer.

7 Connection and Startup

7.1 Electrical connections

The electrical connections must be made in compliance with the enclosed circuit manual for both the analytical computer and the CP 4002 measuring element. If no separate documentation for this purpose is available, the following pin assignment applies (from 07/2011).

Attention: The power supply to the CP 4002 measuring element must not be made before the carrier gas flow has been ensured!



Range of the cable glands (permissible cable diameters):

number	inner coating	outer coating
<i>Ex PGC</i>		
3	3.1 – 8.6 mm	6.0 – 13.4 mm
3	6.1 – 11.6 mm	9.5 – 15.9 mm
<i>Non-Ex PGC</i>		
4	-	4.5 – 10 mm
1	-	7.0 – 13 mm

Pin assignment:

CP 4002	Signal	GC 9000
1	p sample gas +	J5 / 1
2	p sample gas -	J5 / 4
3	p carrier gas +	J5 / 1
4	p carrier gas -	J5 / 2
5	T-	R+ *)
6	S1-	R- *)
7	R+	T- *)
8	R-	S1- *)
11	int. cal.gas	J2 / 1
12	ext. cal.gas	J2 / 3
13	stream 1	J3 / 1
14	stream 2	J3 / 3
15	stream 3	J3 / 5
16	stream 4	J3 / 7
17	GND	J2 / 2, 4 J3 / 2, 4, 6, 8
18	O ₂ pressure +	J5 / 6
19	O ₂ pressure -	J5 / 9
20	O ₂ meas. value +	J5 / 7
21	O ₂ meas. value -	J5 / 8
22	+ 24 V heater	
23	- 24 V heater	
24	+ 24 V meas. elem.	
25	- 24 V meas. elem.	

*) Connection to interface converter
Phoenix PSM EG RS 232 / TTY, from there to
interface C5 of the GC 9000

After switching on the analytical computer for the first time, certain parameters are set to specified values. These values should be monitored and changed, if necessary (see GC 9000 Operating Manual). The changed values will remain stored in a buffer store and will even be available after switching off the device another time.

7.2 Gas connections

The incoming lines for the connections A to M (see figures 2.1 and 2.2) are made of 1/8" pipes with Swagelock joints.

Appropriate micro-filters are installed upstream of the analytical unit. The lines should be made of stainless steel and should be free from impurities, grease, solvents, etc. In order to avoid any contamination with dirt or atmospheric air, the incoming lines in the relevant pressure area must be gas-tight. If it is necessary to seal off threads or joints, use only teflon tape for this purpose. You must absolutely avoid using liquid leakage detecting agents.

The tightness of all connections is of utmost importance for correct analyses.

The gases are to be connected to the process gas chromatograph by observing the rules for handling high-purity gases (VDI 3490 Sheet 3, Dec. 1980).

Prior to startup you must make sure that the gases used fulfill the specified requirements.

The exhaust-gas line must have a minimum inside diameter of 4 mm. A 6 mm Swagelock joint has been planned for this connection. No other devices should be connected to the line.

No overpressure is allowed to built up in the line.

7.2.1 Carrier gas connection

The connection of the carrier gas in accordance with the a.m. guidelines should first be made with the ball valve being closed (Figure 2.1/D). Make sure that there is a gauge pressure of 5.5bar. After connecting is finished, the gas pipes must be swept by opening the clamp ring connections at the input filters. After opening of the ball valve a waiting time of approx. 15 min is required before the power supply to the CP 4002 measuring element is switched on.

Then the carrier gas pressure is monitored via the internal pressure transducer and the analytical computer.

The pressure applied can be displayed by pressing the "Input" function key, and while monitoring the value displayed it is possible to precisely adjust it.

Connected pressure values: 5.5bar ($\pm 10\%$)

7.2.2 Measuring gas / calibration gas / reference gas

Connection of these gases should be made in the same way as with the carrier gas. Inlet pressure can be defined between 0.5 - 2bar.

Such definition of a specific inlet pressure must be made prior to basic calibration of the device. Once the pressure has been defined, no more changes are allowed. The pressure must be identical for all three inlets. The permissible tolerance is $\pm 10\%$.

Pressure monitoring is made in a similar way as with the carrier gas by means of an integrated pressure transducer. The assigned measured values can be accessed in column U. To adjust the pressure of the measuring gas inlet, you must select the appropriate inlet in the manual mode under GC Mode (see GC 9000 Operating Manual). When the pressure adjustment for measuring gas has been performed, the setting is also suitable for calibration gas and reference gas.

7.3 Column pressure and temperature

The column temperatures and helium pressure at the injectors are determined during factory calibration of the device.

During operation these values are continuously monitored by the analytical computer. When the permissible limiting values are exceeded, a fault message is outputted and no more analysis is made. The appropriate specified values are stored in the computer under the "GC- Status" key.

7.4 Further action

After the measuring gas pressure has been adjusted in accordance with the a.m. description, the PGC is in the holding mode, i.e. no automatic analysis is made. Then select the operating mode "NORM-CAL" in the manual mode. The chromatograph will perform one calibration run according to the specified parameters.

It is possible that the first calibration is shown as being faulty. In this case, the PGC will start a further calibration after some minutes. If also the second calibration is faulty, the PGC automatically switches to the operating mode "STOP".

If the result of a faulty calibration shows a too high amount of nitrogen, then the reason could be insufficient sweeping of the gas pipes.

After successful calibration, the PGC automatically switches to the "AUTORUN" mode.

7.5 Interruption of carrier gas supply

If carrier gas supply is interrupted for a short period of time, when cylinders are changed, for example, the analysis has to be interrupted by selecting the mode "STOP" at the analytical computer.

If the analytical computer is set to the mode "STOP", the power supply at the CP 4002 measuring element must be switched off. All inlet valves at the gas distribution system (Fig. 2.1 / A,B,C,M) have to be closed.

If the carrier gas supply is ensured again (correct sweeping of pressure regulators and pipes!) the inlet pressure should be checked (inlet pressure regulation unit).

After the inlet valve has been opened (Fig. 2.1 / A) carrier gas one more check at the analytical computer ("Input" key) should be made. The device should remain in this status for about 15 min. Now the power supply for the CP 4002 measuring element may be switched on again. After a waiting time of 5-10 minutes all inlet valves (Fig. 2.1 / B,C,M) may be opened again.

Now the analytical computer must be set to the mode "NORM-CAL". After successful calibration the mode of the analytical computer changes automatically to "AUTORUN".

If the power supply has been switched off for longer than 0.5 h, one more manual calibration should be started after 1-2 h.

If fault messages happen then in most cases this is due to residual amounts of foreign gases. Not later than after about 2 h operation time also these messages should be cleared.

If carrier gas supply is interrupted for a prolonged period of time, the device should be shut down. After the pressure has fallen to 0.5 bar ("Input" key) the outlet of the device has to be closed. For this purpose close the outlet of the rotameter in the exhaust gas pipe with a dummy plug. Then switch off the power supply of the measuring element.

Then a restart has to be made in accordance with the sequence of operations described above.

Attention: non-observance may lead to the destruction of the measuring element!

8 Operating Modes of the CP 4002

The operating modes of the CP 4002 can be set via the "GC-Mode" column of the analytical computer (see GC 9000 Operating Manual; column A).

8.1 Automatic analytical mode / AUTORUN

The automatic analytical mode of the CP 4002 ("AUTORUN") is the normal operating mode of the CP 4002. In this mode, cyclic sampling and analysis of the measuring gas are performed.

This sequence is only interrupted by the activated automatic recalibration function (column D "Calibration data").

8.2 Stop mode / EZCHROM mode

These modes are activated to make communication with an external computer possible. After the current analysis has been completed. The device can then be addressed by the external computer with specific programs (C4 data interface).

These modes are only used for in-plant calibration or in the event of servicing.

8.3 Manual calibration

In this mode it is switched over to the calibration gas inlet. One calibration cycle is performed using the specified data (coordinates D/6 thru D/7). After calibration has been completed, the valves are again connected to the measuring gas inlet and a continuous analysis is made. The time of the next automatic recalibration is not changed.

8.4 Reference gas analysis

The reference gas inlet is connected and a continuous analysis is made. Independent of the settings in the print menu a printout will be started for each analysis.

For the annual check the external calibration gas is analyzed over the reference gas inlet. This is a normal analysis and the response factors from the last automatic or manual calibration keep unchanged.

8.5 Basic calibration

One calibration cycle is performed and the determined factors are stored in the analytical computer (see 4.3). To avoid unintentional releasing a key request is carried out. After the calibration cycle the analytical computer switches back to "AUTORUN".

9 Operating Instructions for the Explosion-Protected Design

9.1 General instructions

The explosion-protected design of the PGC 9000 VC process gas chromatograph is an explosion-protected electrical apparatus of the “explosion-proof encapsulation” type of protection with a terminal compartment of the “increased-safety” type of protection.

Code: II2 G Ex de IIB T5 (up to 40°C)
II2 G Ex de IIB T4 (up to 60°C)

The device complies with the provisions of Guideline 94/9/EG (ATEX 100a).

It can be installed in areas subject to explosion hazards in zone 1 which are endangered by gases and vapours classified under danger class IIB and temperature class T4 resp. T5.

For installation and operation, the appropriate ordinances and regulations must always be observed.

With regard to explosion protection, the device has been approved for the following ambient temperature range:

Ambient temperature range	Temperature class
$-20^{\circ}\text{C} \leq T_{\text{amp}} \leq 40^{\circ}\text{C}$	T5
$-20^{\circ}\text{C} \leq T_{\text{amp}} \leq 60^{\circ}\text{C}$	T4

For measuring purposes, however, the ambient temperature must be between -10 to +55°C!
The device has to be protected against the weather.

9.2 Explosion-proof enclosure

The explosion-proof enclosure has no interlocking switch.

Before you open the enclosure, make sure that the voltage is switched off and then wait for one minute.

(See information on the data plate.)

9.3 Increased-safety terminal compartment

For the electrical connection of the device, make sure that the correct voltage is supplied (see information on the data plate).

The cable diameters of the supply lines must be within the clamping range of the cable feed-through.

Unused openings of wire feed-throughs must be plugged by impact-resistant stoppers which cannot become loose and are secured against distortion.

When these openings are closed, make sure that the seals remain effective in order to guarantee that the degree of protection IP 54 is maintained.

9.4 Maintenance

Explosion-protected electrical control systems must be subjected to maintenance at regular intervals. These intervals depend on the operating and environmental conditions. We recommend that you check the system at least once a year (possibly in conjunction with the annual official verification of the PGC).

9.5 Safety measures

In areas subject to explosion hazards, work is generally prohibited on voltage-carrying electrical apparatus (except for intrinsically safe circuits).

In special cases, it is possible to carry out work if it is guaranteed that there is no explosive atmosphere.

This can only be done if there are explosion-protected and approved measuring instruments involved.

9.6 Maintenance Work

Since explosion-proof enclosures are protected against water only to a limited extent due to the flameproof joint (IP 54), you must check for water collecting inside the enclosure.

Rusted joints must not be cleaned using abrasives or wire brushes, but should only be cleaned chemically, for example with reducing oils.

Then joints must be protected thoroughly with acid-free anticorrosive agents, e. g. ESSO RUST BAN 397, Mobil Oil Tecrex 39 or equivalent agents.

The seal of the intrinsically safe (Ex-e) enclosure must be checked for damage and replaced, if necessary.

Check cable glands and stoppers for tight fit.

Damage to the enclosures can terminate the explosion protection!

9.7 Repairs

If repairs are done to components of the device which are essential for explosion protection, such components must first be checked by an acknowledged expert before you can put them into service again.

If repairs are done by the manufacturer, they need not be approved by an expert.

10 Fault Messages

Any fault occurring is outputted by the analytical computer as a text message with a specific number. Fault numbers are shown in the print reports.

A complete list of fault messages is included in annex E of the GC 9000 Operating Manual. In the following, only directly analysis-related fault messages are explained.

10.1 Faults occurring during continuous analytical operation

No.	Text	Description	Cause
33	CP temperature	The column temperature of one or both channels exceeds the permissible deviation (coordinates N/6 thru N/10; "GC STATUS"). When this fault occurs, no analysis is made until the specified temperature is reached.	<ul style="list-style-type: none"> - Device is in the heating-up phase after it has been out of service - Defective heating/ faulty regulation
34	CP pressure	Column precompression of one or both channels exceeds the permissible deviation (coordinates N/11 thru N/16; "GC STATUS"). No analysis is made.	<ul style="list-style-type: none"> - Carrier gas pressure too low (at the same time fault 51) - Faulty setting of pressure controllers - Defective pressure controllers
41	RT fault	The retention time of one or more gas components shows an unacceptable deviation from the basic values. (Coordinates B/26 thru B/37, N/23)	<ul style="list-style-type: none"> - Faulty pressure/temperature values (with faults 33, 34) - Non-permissible gas composition (with fault 42) - Defective module
42	Unnormalized sum	When normalization is made for 100% the limiting value is exceeded (K/18; N/25).	<ul style="list-style-type: none"> - Non-permissible gas composition - Fault of pressure /temperature (33, 34) - Defective module
47/48/ 55/56	Hs min/max CO2 min/max Wo min/max Rho,n min/max	Measuring range violated	<ul style="list-style-type: none"> - Check of limiting values in M/8 thru M/19
49	Comp. min/max	Operating range of the modules violated	<ul style="list-style-type: none"> - Non-permissible gas composition
84 - 87	I(n)-Out Min/Max	Current < 0/2mA or > 21mA	<ul style="list-style-type: none"> - Check of limiting values in F thru I/2 - 9
51	Carrier gas	The inlet pressure of carrier gas is outside the tolerance band.	<ul style="list-style-type: none"> - Incorrect setting - Cylinder pressure - Check of column T ("Input")
52	Gas for analysis	Depending on the inlet connected, the inlet pressure of measuring/calibration or reference gas is outside the tolerance band.	<ul style="list-style-type: none"> - Incorrect setting - Cylinder pressure - Check of column U

10.2 Further faults for devices with oxygen sensor

No.	Text	Description	Cause
59	O2 min_max	min/max limits O2 of measuring gas violated	- O2 value of measuring gas is outside the measuring range
60	Pabs. min_max	min/max limits Pabs of measuring gas violated	- Measuring gas inlet pressure is outside the specified limits - Defective pressure controller
86	I3-Out min/max	Current < 0/2 mA or > 21mA	- Check of limiting values in E 4 - 9
87	I4-Out min/max	Current < 0/2 mA or > 21mA	- Check of limiting values in E 12 - 16

10.3 Faults occurring during recalibration

The following faults are only outputted during recalibration or basic calibration. If such faults occur, calibration will be invalid. Previous response factors will be maintained. All the following measured values will be marked as faulty.

These faults cannot be acknowledged and are only reset by valid recalibration.

No.	Text	Description	Cause
40	RW fault	The newly calculated response factors show an unacceptable deviation (N/24).	- Fault of pressure/temperature during recalibration - Faulty specified value for calibration gas concentration (D/11 thru 24) - Defective module
53	Area deviation	The total area for calibration deviates by more than 30% from value for basic calibration.	- See 40
43/44/45	Calib. Hs Calib. rhon Calib. CO2	The specified superior calorific value, standard density or carbon dioxide concentration is not reached during calibration.	- See 40
39	Cal. RT fault	The newly determined retention times deviate in an unacceptable way from the specified values (B/26 thru 37; N/23).	- See 40
38	Cal. unnormalized sum	During calibration the limiting value of 100% normalization is exceeded (N/26).	- See 40

10.4 Power failure of the GC 9000

After a power failure of the analytical computer (fault 02 - power failure), first of all a self-check of the device is performed when it is restarted.

After completion of this self-check, calibration is automatically initiated. After such calibration, the analytical operation is continued.

11 Data Storage / Print Reports

Apart from storing the a.m. quantities, there is the option of outputting different print reports.

Print reports can be activated and formatted via the "Print" selection key of the GC 9000 (see GC 9000 Operating Manual).

There are the following reports available (identification by means of a prefixed letter on the printout):

- Automatic print (A)

Continuous output of mean values of the last completed hour. To be activated via 0/10.

- Manual print (M)

Single printout of the last current analysis. To be activated via 0/9.

- Test print (T)

Cyclic output of the current analysis. You can define in 0/4 after how many analyses a printout should be made.

- Reference gas (R)

If the reference gas inlet is selected, data are printed after each current analysis.

- Fault print (F)

This printout is automatically activated when a fault message is pending. All analytical data are printed together with the fault number.

If a fault has occurred, all subsequent data printed are marked with an asterisk (" * ").

- Fault acknowledged print (K)

A printout is made when the fault is acknowledged. Refer to Chapter 10 for fault treatment during calibration.

- Calibration print (C)

Here the user can choose between a complete and a condensed printout of calibration data (0/11).

Calibration data will remain stored until the next calibration is performed and can be retrieved during this period.

Condensed printout: Analytical values of components
actual/specified values and difference of calorific value, standard density,
CO₂ concentration, relative density and Wobbe index.

Complete printout
with additional data: Response factors
new retention times
retention times of the method
unnormalized sum
permissible deviations
graphical printout of chromatograms

37

- Graphical print calibration/measuring gas

The chromatograms of the last calibration or the last current analysis are printed. The graphical printout can be scaled via the coordinates 0/5 thru 8.

Here a factor of

1000000

corresponds to a representation of 1V (measuring amplifier output voltage) on the ordinate. The abscissa always represents a duration of analysis of 70 seconds.

- Channel report

Coordinates of the GC 9000 and values from the analytical method are printed.

Up to software version 4.10:

- Hourly values
- Daily values
- Monthly values

Printout of all completely formed mean values for the following quantities:

Calorific value
Standard density
CO₂ concentration
Relative density
Wobbe index

12 Inspection and Maintenance Work

12.1 General instructions

If it is necessary to open an explosion-proof enclosure when carrying out maintenance work or repairs, it must be ensured by appropriate measures that the enclosure is not exposed to an explosive atmosphere.

If it is necessary to provide access to the electrical units of the analytical computer or the measuring element, the following precautions must be observed:

- The entire device must be disconnected from the power supply.
- When work is carried out on electronic units, a connection must be established between an earthed object and the body of the person concerned.

See Chapter 7.5 for interruption of the carrier gas supply.

12.2 Regular maintenance work

- **Replacement of inlet filters (Figures 2.1 and 2.2, item 4)**

Inlet filters must be replaced once a year or even more frequently, if necessary.

The analysis operation is to be interrupted by programming the mode "STOP" on the analytical computer.

To replace the filters, interrupt the gas supply of the appropriate incoming line and close the cock downstream of the filter.

Dismantling and replacement of the filter element is to be made according to the description of the manufacturer of the filter.

After installation, the pipes should be swept with closed inlet valves for a short time by opening the clamp ring fittings at the filters.

After the inlet valves have been opened again, the device should remain in this state for about 15 minutes. Pending error messages should be acknowledged now.

You can then switch to automatic analysis (mode "AUTURUN"). If error messages occur in analysis mode, this is mostly due to remaining amounts of foreign gases. Finally also these messages should be acknowledged after an operation time of approximately 2 hours.

When working on the carrier gas supply observe the instructions in Chapter 7.5.

- **Inspection of the flame barrier (Figure 2.2)**

The flame barrier located in the outlet is to be checked every six months for proper condition.

To do this, close all four cocks of the gas supply system.

Then inspect the flame barrier as described in the annex.

12.3 Entries into the maintenance book

The following data and measured values must be entered at appropriate intervals into the maintenance book prepared for this purpose:

- Column pressure and temperature of both columns;
- Cylinder pressure of the carrier gas and internal calibration gas;
- Cylinder pressure difference as against that of the last entry;
- Carrier and measuring gas pressure at the measuring transducer;
- Quantity of exhaust gas during sweeping.

39

For manual recalibration of the CP 4002, the measured calorific value of the internal calibration gas, the corresponding specified value and the calculated error are to be entered in the maintenance book.

Furthermore, the chromatogram has to be compared with that of the previous calibration. The printout is to be filed in the maintenance book.

After the measured calorific value, the specified value and the corresponding error have subsequently been checked against external calibration gases, they are to be entered in the maintenance book.

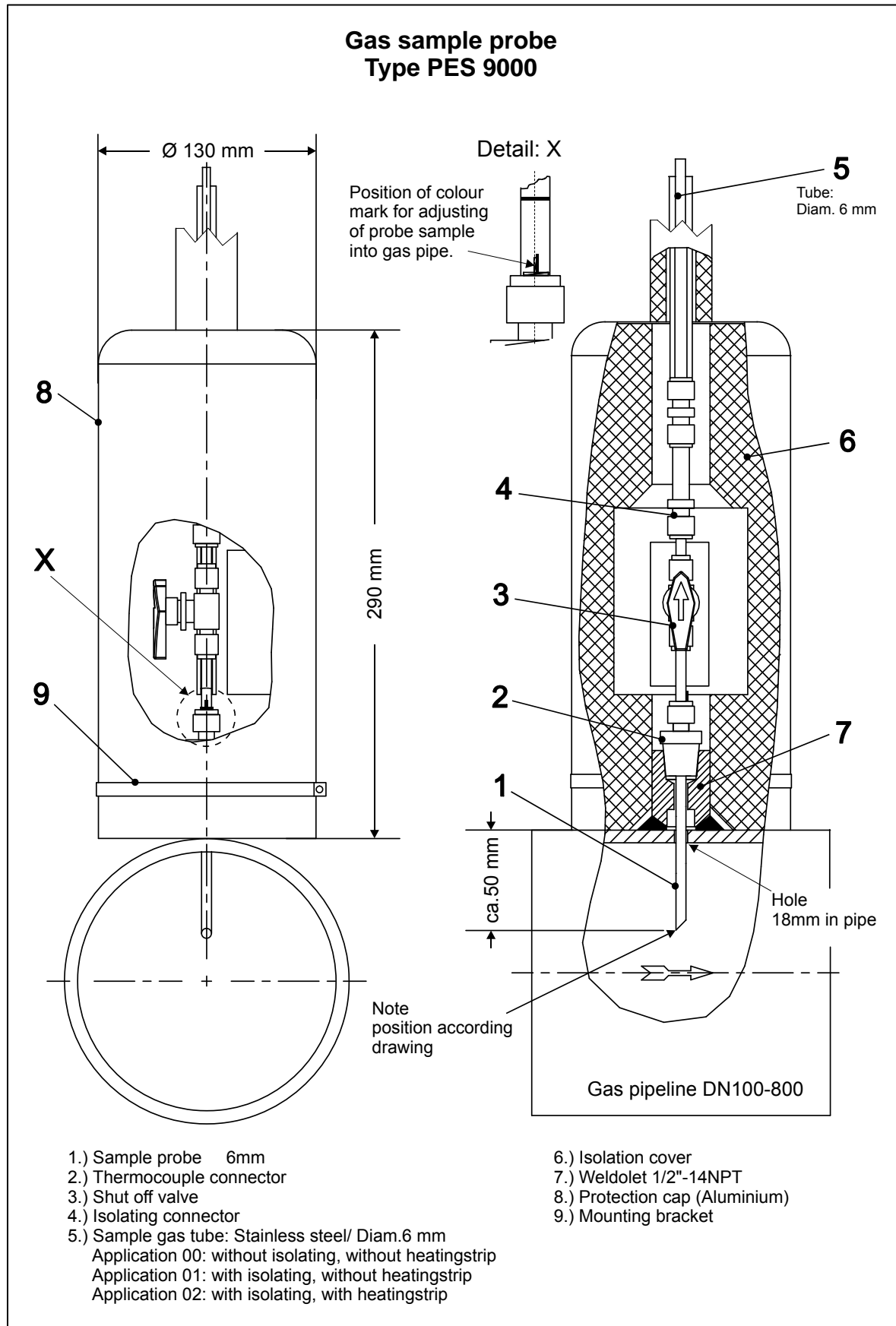
When work is carried out on the carrier gas supply the instructions on page 24 must always be observed!

13 Technical Data of the Measuring element

Power supply:	21V DC - 27V DC
Power input:	110 W 125 W with oxygen sensor
Starting current:	10 A in the first 3 minutes
Ambient temperature range:	-5°C - 40°C optional: -10°C - 55°C with additional heating and isolation.
Air humidity:	0% - 95% R.H. Moisture condensation is not permitted.
Safety classification:	II2 G Ex de IIB T5 (up to 40°C) II2 G Ex de IIB T4 (up to 60°C)
Dimensions:	See figures 2.1 and 2.2
Weight:	75 kg (Ex design), 55 kg (Non-Ex design)

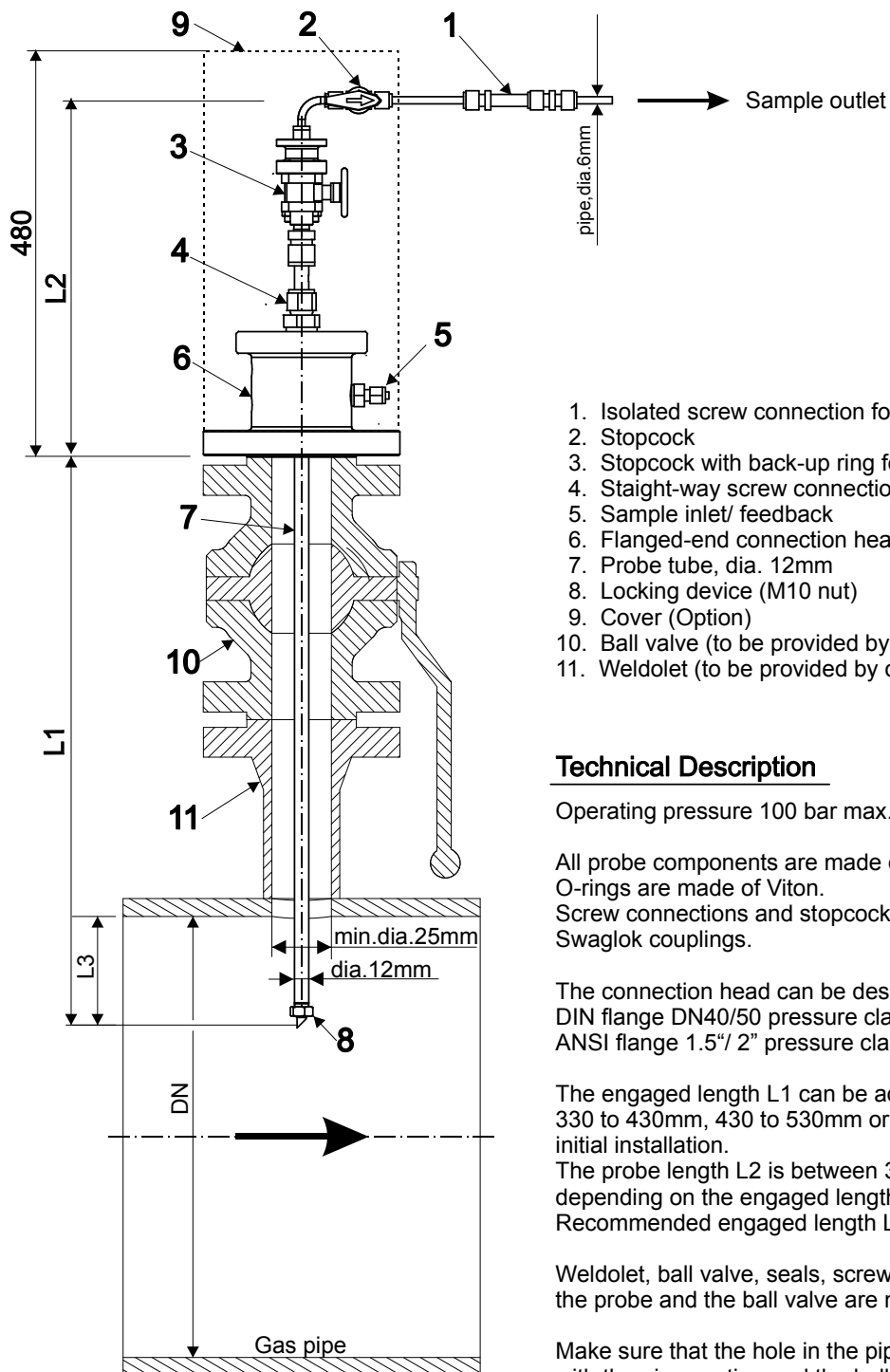
13.1 Technical data of the oxygen sensor OXOS 08

Inlet pressure:	0.3 - 3 bar
Power supply:	20 - 28 V DC
Power input:	15 W
Analog output:	4 - 20 mA
Response time T90:	≤ 60 s
Gas consumption:	max. 10NI/h
Ambient temperature:	-10 - +55°C
Transmitter temperature:	60°C
Warm-up time:	approx. 30 min.
Ambient temperature influence:	negligible within -10 to +55°C ambient temperature
Ambient pressure influence:	no influence
Linearity:	≤ ± 0.1 Vol %
Zero point drift:	≤ ± 0.05 Vol % per month
Reproducibility:	≤ ± 0.02 Vol %
Tilt angle influence:	≤ ± 0.05 Vol % / °



Sampling Probe Type PPS 02-R

extendable under pressure



Technical Description

Operating pressure 100 bar max.

All probe components are made of high-quality steel.
O-rings are made of Viton.
Screw connections and stopcocks are desinged for Swagelok couplings.

The connection head can be designed as follows:
DIN flange DN40/50 pressure class PN10-100
ANSI flange 1.5"/ 2" pressure class ANSI 150-600

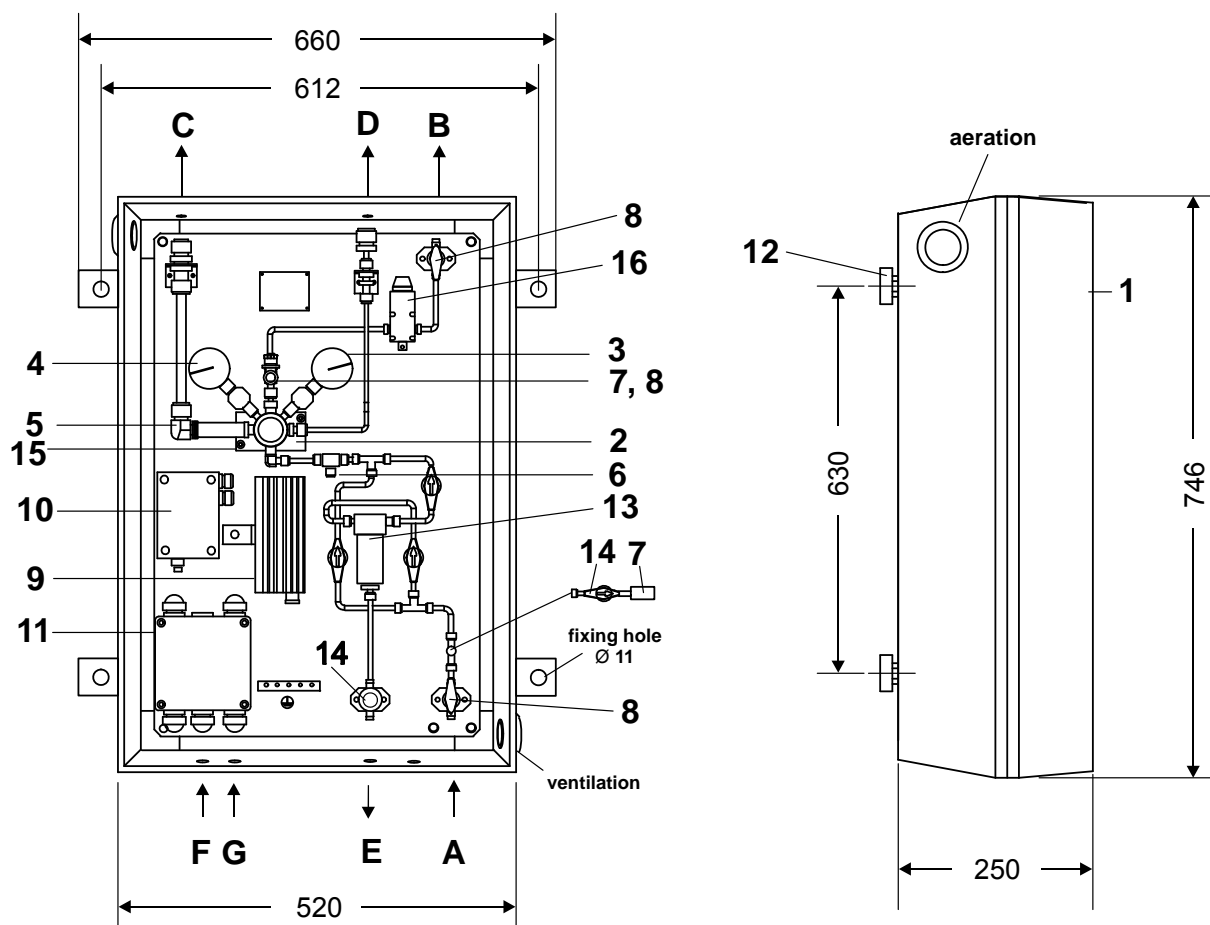
The engaged length L1 can be adjusted between
330 to 430mm, 430 to 530mm or 585 to 685mm during
initial installation.

The probe length L2 is between 300mm and 400mm
depending on the engaged length L1.
Recommended engaged length L3=1/3 DN (50mm min.)

Weldolet, ball valve, seals, screw bolt and nut between
the probe and the ball valve are not included in the delivery.

Make sure that the hole in the piping is centrally adjusted
with the pipe section and the ball valve and has a
minimum diameter of 25mm.

Pressure Reducing Unit Type DRS 200 (wall installation)



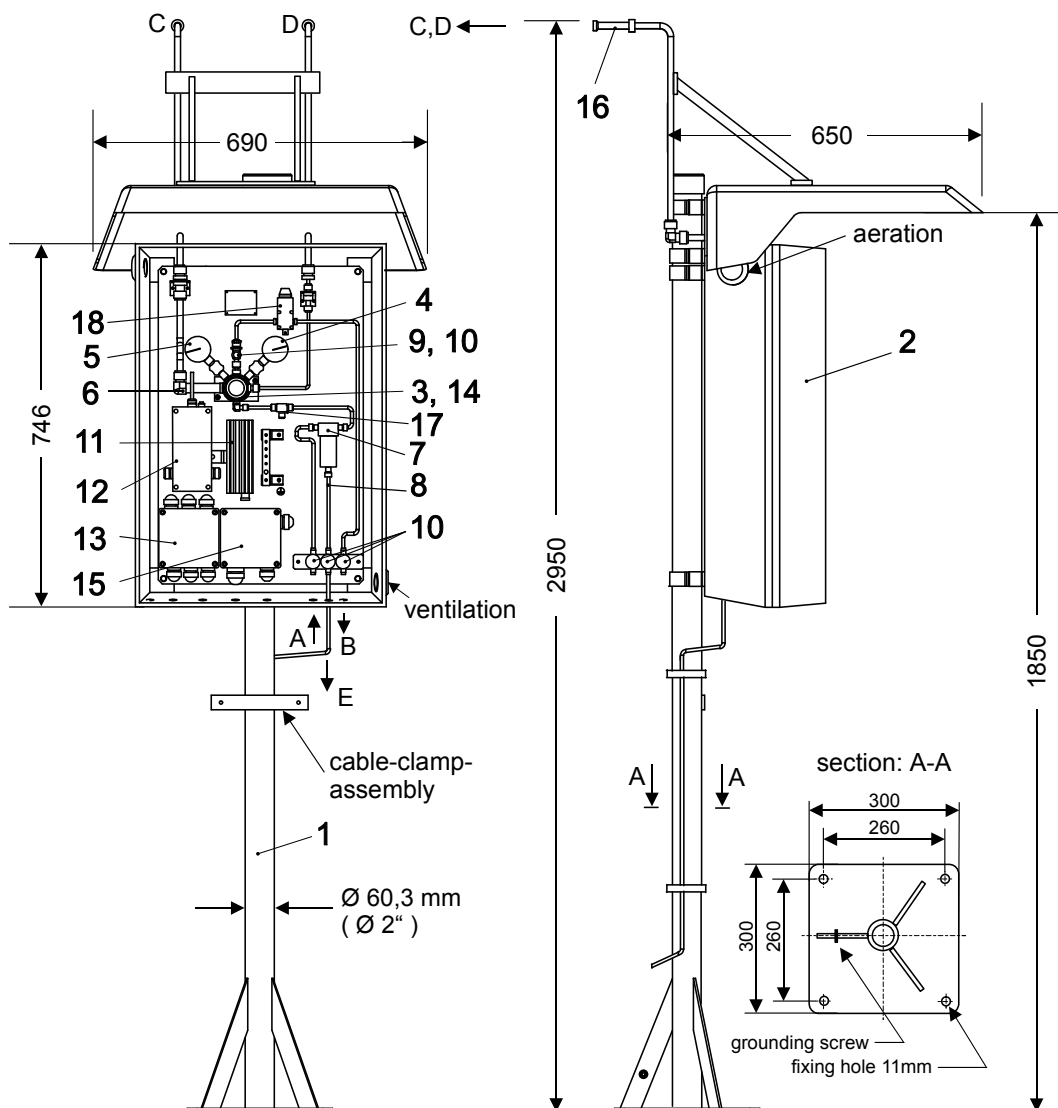
- 1.) isolation cabinet with window
- 2.) pressure reducer 100/2.5 bar
- 3.) pressure gauge 0-100 bar
- 4.) pressure gauge 0-6 bar
with max. contact, limiting values set below
the opening pressure of the relief valve
- 5.) relief valve (4 bar)
- 6.) filter (sintered metal filter)
- 7.) test port
- 8.) shut-off valve
- 9.) heating (ex), 60W
- 10.) thermostat (ex)
- 11.) connection box (ex) for pos. 4, 9, 10
- 12.) holder for wall installation
- 13.) coalescence filter / liquid separator
(option)

- 14.) regulating / shut-off valve
- 15.) restrictor
- 16.) solenoid valve (ex) 24 V/DC (option)

- A. measuring gas inlet (max. pressure 100 bar)
- B. measuring gas outlet (min/max. pressure 2.5-3.5 bar)
- C. vent line of relief valve (12mm pipe)
- D. vent line of pressure reducer (12mm pipe)
- E. outlet for condensate (6mm pipe)
- F. power supply 230VAC
- G. connection for pipe heating

6mm pipe for connections A,B:
all tube fittings and connections in Swagelok system
tube and connection material: stainless steel

Pressure Reducing Unit Type DRS 200 (installation on rack)

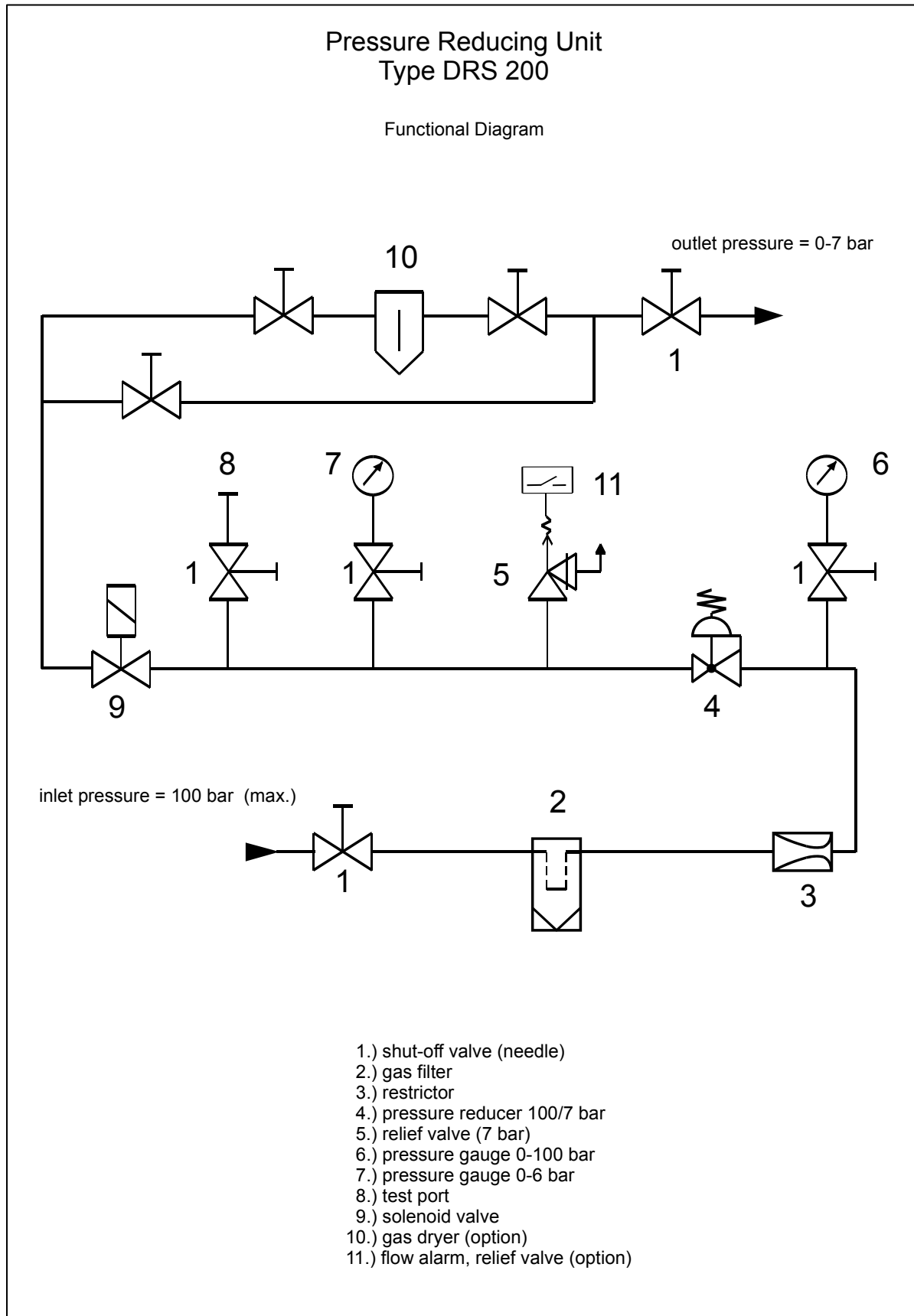


- 1.) rack (steel galvanized)
- 2.) isolation cabinet with window
- 3.) pressure reducer 100/7 bar
- 4.) pressure gauge 0-100 bar
- 5.) pressure gauge 0-6 bar
- 6.) relief valve (7 bar)
- 7.) coalescence filter / liquid separator (option)
- 8.) condensate collector (pipe section Ø6mm)
- 9.) test port
- 10.) regulating / shut-off valve
- 11.) heating (ex), 100W
- 12.) thermostat (ex)
- 13.) Ex(e) connecting box for pos.-no. 11, 12
- 14.) restrictor

- 15.) Ex(e) connection box for sample gas-line heating
- 16.) insect safety-sieve
- 17.) filter
- 18.) solenoid valve (ex), 24 V/DC (option)

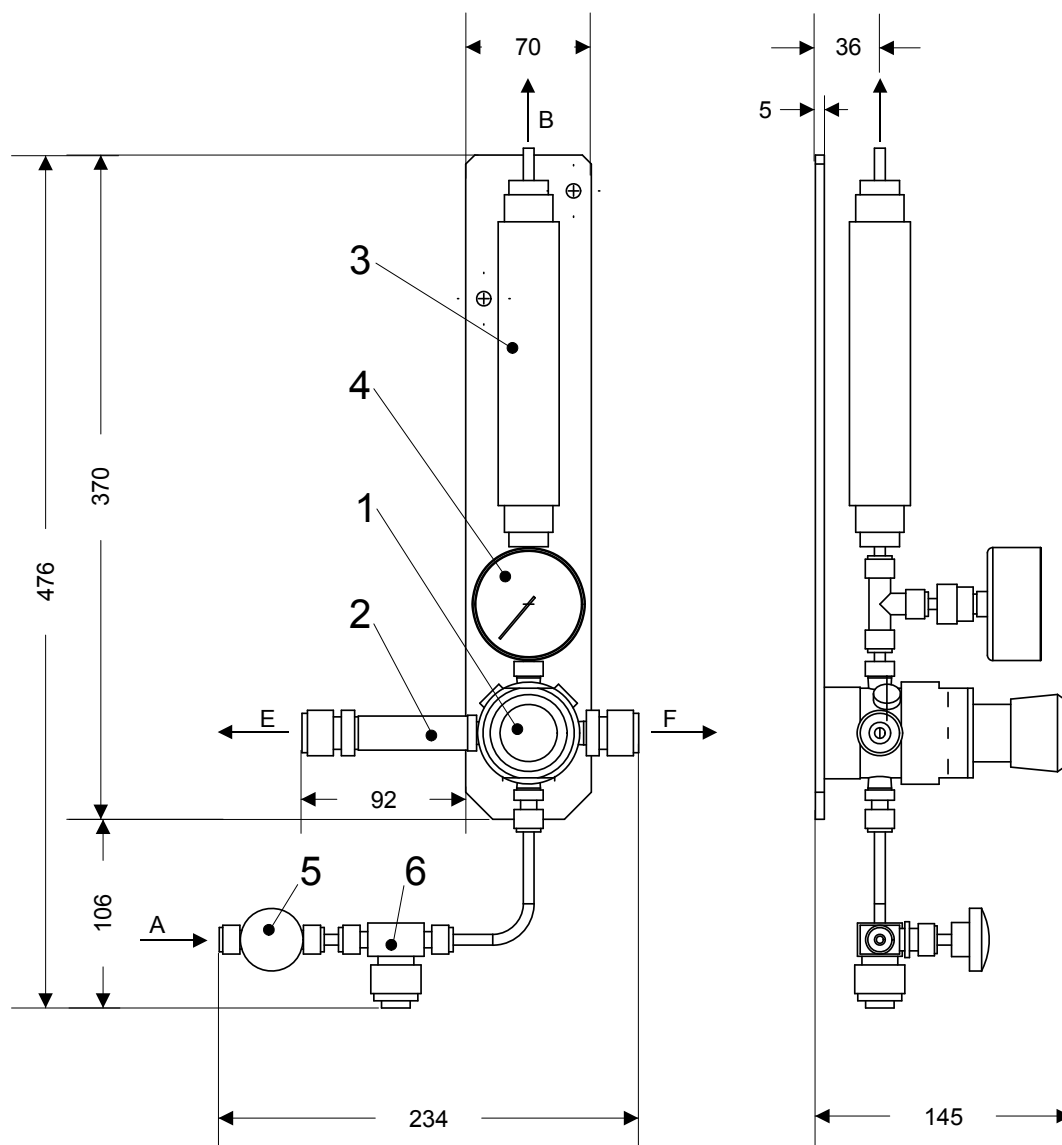
- A. measuring gas inlet (max. pressure 100 bar)
 B. measuring gas outlet (min./max. pressure 2-7 bar)
 C. vent line of relief valve (12mm pipe)
 D. vent line of pressure reducer (12 mm pipe)
 E. outlet for condensate

6mm pipe for connections A, B:
 all tube fittings and connections in Swagelok system.
 tube and connection material: stainless steel.



13 TECHNICAL DATA OF THE MEASURING ELEMENT

Pressure Reducing Unit Type DRS100



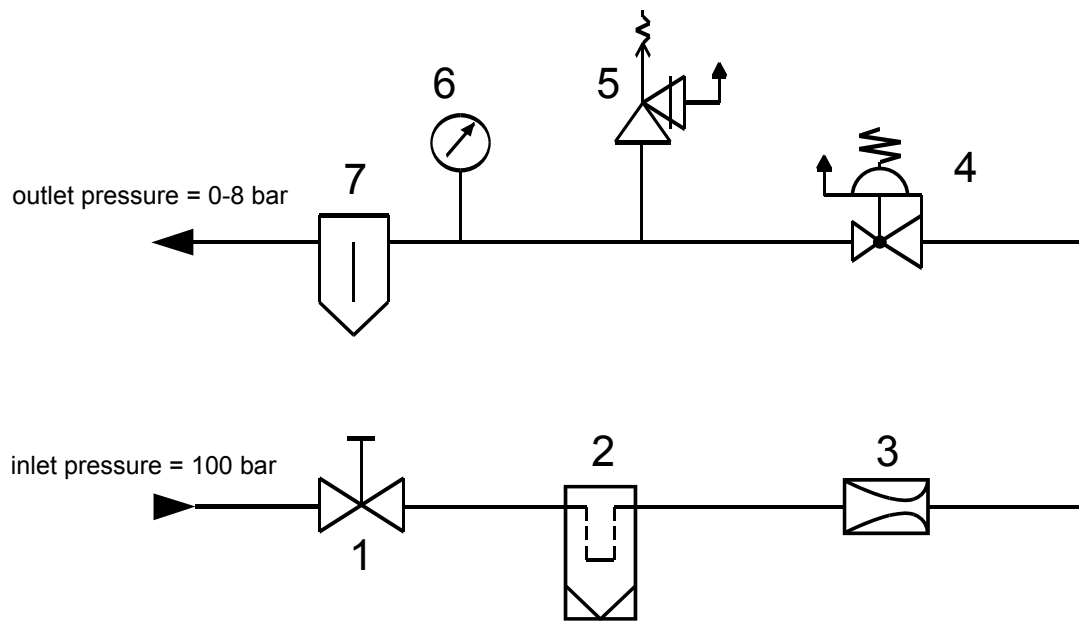
- 1.) pressure reducer 100/8 bar
- 2.) relief valve (8 bar)
- 3.) gas dryer
- 4.) pressure gauge 0-16 bar
- 5.) shut-off valve (needle)
- 6.) gas filter

- A. measuring gas inlet (max. pressure 100 bar)
- B. measuring gas outlet (max. pressure 0-8 bar)
- E. vent line of relief valve
- F. vent line of pressure reducer

6mm pipes for connections A,B
 6mm tube / Swagelok connector
 12mm pipes for connections E,F
 12mm tube / Swagelok connector

Pressure Reducing Unit Type DRS100

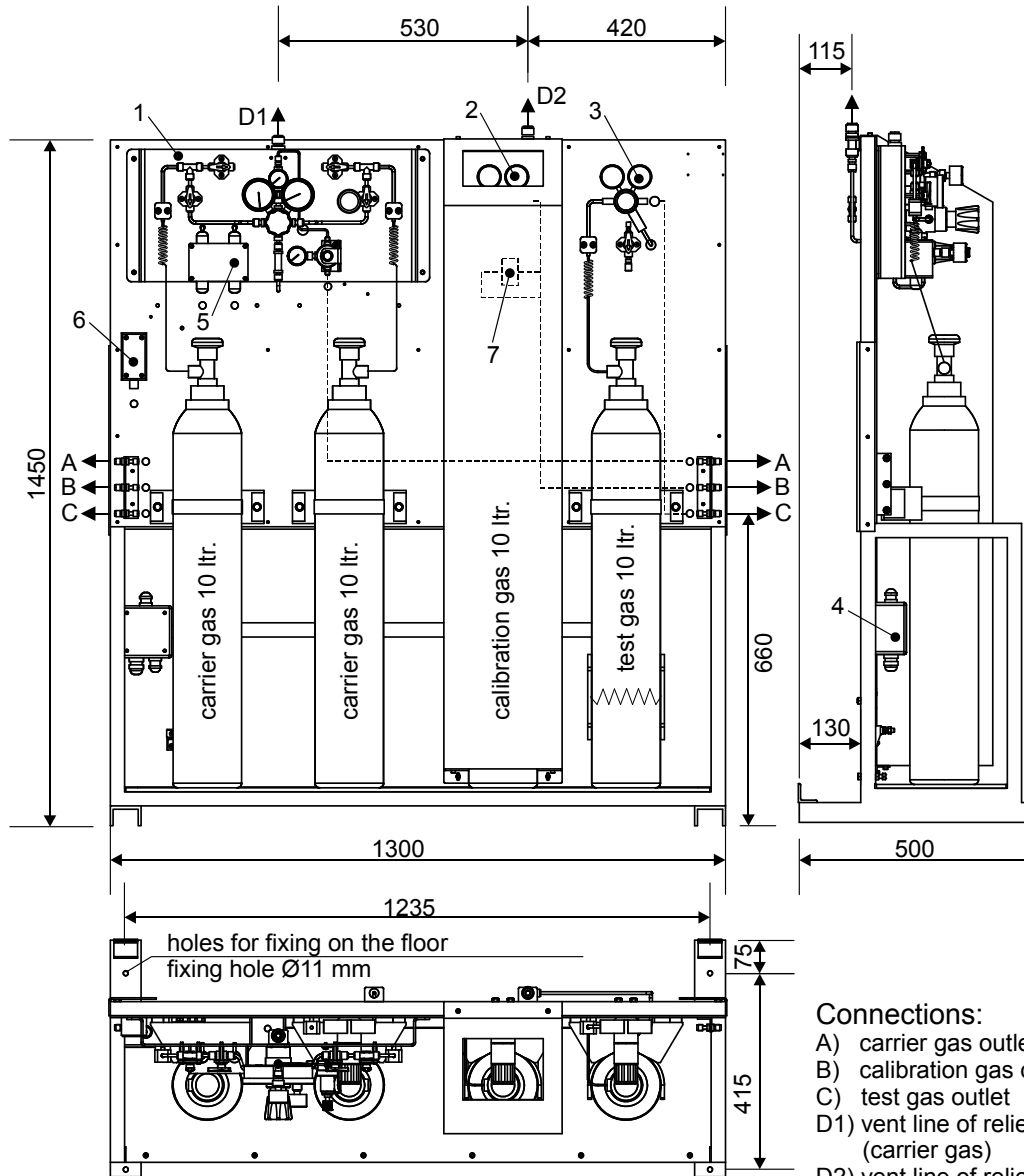
Functional Diagram



- 1.) shut-off valve (needle)
- 2.) gas filter
- 3.) restrictor
- 4.) pressure reducer 100/8 bar
- 5.) relief valve (8 bar)
- 6.) pressure gauge 0-16 bar
- 7.) gas dryer

Gas Supply Unit

for PGC 9000 VC



- 1.) switching unit (autom. or manually) for two carrier gas cylinders.
- 2.) pressure reducer with relief valve for calibration gas.
- 3.) pressure reducer with relief valve for test gas.
- 4.) EEx(e) terminal box for cylinder heating.
- 5.) EEx(i) terminal box for contact gauges (carrier gas)

option:

- 6.) temperature monitor
- 7.) solenoid valve for calibration gas shut-off

Connections:

- A) carrier gas outlet
- B) calibration gas outlet
- C) test gas outlet
- D1) vent line of relief (carrier gas)
- D2) vent line of relief (calibration gas)

Die Ausgänge A,B,C können wahlweise auf rechter oder linker Seite montiert werden.

1/8" pipes for connections A, B, C
12mm pipes for connections D1, D2
all tube fittings and connections in Swagelok system, tube and connector material stainless steel