

CASPER Combustion Analyzer



TÜV SÜD approved:
EN 50379-1
EN 50379-2
1.BimSchV (RgG 292)

Compliant with:
UNI 10845
UNI 10389-1

USE AND MAINTENANCE MANUAL



Respect your environment: think before printing the full manual on paper.

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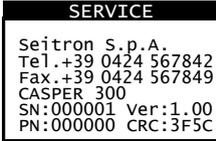
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Read these operation and maintenance manual carefully before use. The professional personnel must be familiar with this manual and follow the instructions contained herein.

This manual describes the operation, function and maintenance of the English version for **CASPER - Flue Gas Analyzer**.

Subject to change due to technical improvements - for mistakes or misprints no liability!

Danger levels and other symbols

Symbol	Meaning	Comments
	WARNING	Read information carefully and prepare safety appropriate action! To prevent any danger from personnel or other goods. Disobey of this manual may cause danger to personnel, the plant or the environment and may lead to liability loss.
	Information on LCD	
	Ensure correct disposal	Dispose of the battery pack at the end of its working life only at the dedicated collecting bin. The customer takes care, on his own costs, that at the end of its working life the product is collected separately and it gets correctly recycled.
 	Button with symbol for dialouge-operation with keypad	

 **The magnets in the back of the instrument can damage credit cards, hard driver, mechanical watches, pacemakers, defibrillators and other devices proven sensitive to magnetic fields. It is recommended to keep the instrument at a distance of at least 25cm away from these devices.**

This chapter describes the areas of application for which the CASPER is intended.

Using the CASPER in other application areas is on the risk of the operator and the manufacturer assumes no responsibility and liability for loss, damage or costs which could be a result. It is mandatory to read and pay attention to the operating/maintenance manual.

All products of the series CASPER are handheld measuring devices in professional flue gas analysis for:

- Small furnaces (see pages 24 and 25 for the available 11 fuels)
- Low-temperature and condensing boilers
- Gas heaters

Due to other configuration with electrochemical cells it is possible to use the measuring instrument in following application area:

- Service engineers/mechanics of burner/boiler manufacturers
- Service industrial combustion plants

The measuring instrument is approved for measurements under German regulations on immissions protection (1. BImSchV).

Additional functions of the measuring instrument:

- Flue gas analysis according 1. BImSchV or qA-mean value (selectable)
- Calculating of stack heat loss and efficiency
- CO environment measurement
- Gas pipes tightness test according to standards UNI 7129-1: 2015 and UNI 11137: 2012 (except models CASPER 201 and CASPER 201 S)
- Store Smoke value, calculating mean value
- Measuring differential pressure
- Draught measurement according UNI 10845

CASPER should not be used:

- For continuous measurements > 1h
- As safety alarm instrument

1.1 General Description of the Combustion Analyser

The design of the handheld combustion analyser "CASPER" is clean and ergonomic with an extremely clear and user-friendly keypad.

"CASPER" immediately suggests just how even the most sophisticated engineering can give life to an incredibly comfortable and easy to use work instrument.

Devised to analyse flue gases, monitor the pollutants emitted and measure environmental parameters, "CASPER" uses two electrochemical cells that provide the oxygen and carbon monoxide values while a third cell is used to measure the pollutants NO and NOx.

Two external sensors measure the environmental parameters; it is also possible to measure flue draught and carbon black (with external accessory) and, with the measuring range of up to 200mbar, system pressure and pressure in the combustion chamber can be measured and the pressure switches checked.

"CASPER" is designed for eleven main types of combustible substances, among which natural gas, LPG, Diesel fuel and fuel oil. Another 16 types of which the chemical composition is known can be entered in its memory. "CASPER" functions include storing and averaging the measurements acquired, printing the results (through IR communication interface) and connecting to the computer for filing the data, using a USB connection.

The memory can store 300 complete analyses and the data downloaded onto a PC by means of dedicated SW and a mini-USB serial communication cable. It is also interesting to note that "CASPER" has just one "Li-Ion" rechargeable battery pack used for powering the instrument; it also has a luminous and large (70 x 38 mm) LCD display boasting excellent readability thanks to its backlighting and also to the zoom function.

Another characteristic that distinguishes it from other similar products in the market is the fact the power supply that comes with the product can carry out the dual function of battery charger and power supply for the instrument which means the user can carry out analyses even if the batteries are completely flat.

As far as concerns maintenance, it is useful to know that the user can replace the sensors himself without having to send the instrument back to the technical assistance centre: in fact, the sensors are pre-calibrated and interchangeable.

Moreover:

- **Operator interface:** user-friendly - so much so that it can be used without the instruction manual.
- **Luminous and large LCD display:** easy readability thanks to the Zoom function and effective backlighting.
- **Infrared interface:** optional external impact printer is available.
- **One battery pack:** rechargeable for powering the instrument, indicating the charge level and is accessible from outside.
- **Pneumatic input connectors (gas and pressure/draught) staying inside the profile of the instrument:** for greater resistance to knocks.
- **Precalibrated sensors, directly replaceable by the user.**

1.2 General features of the Flue Gas Analyser

CASPER is a portable flue gas analyser that was meticulously designed to meet statutory requirements and specific customer demands. It may be provided in a rugged ABS carry case or waterproof shoulder bag.

The instrument contains one single board with all the basic circuitry, pre-calibrated measuring cells, sampling pump, silicone keypad, backlit graphic LCD display, high-capacity rechargeable Li-Ion battery pack. The two halves of the case are firmly secured by six screws on the rear of the instrument.

The pneumatic path and measuring cells inclusive of electronic micromodule are located on the back side of the plastic case and are easily accessed for maintenance and replacement by removing the back lid.

On the instrument lower side are located the pneumatic connectors for the gas probe and for the pressure/draft measurement, the connector for the gas probe thermocouple plug and the 8 poles mini-DIN connector for the combustion air probe.

On the instrument left side are located the connector for the external power supply and the mini USB one.

The user interface consists of a constantly active backlit graphic LCD display and silicone keypad. Menu screens and all user messages can be set in the language of the country where it is used; this can be selected through the menu in one of the available ones. Use of the analyser is simplified by symbol keys that give direct access to main instrument functions. Shifting between the various menu screens is easy and user-friendly thanks to four cursor keys, an 'ok' key and 'esc' key.

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1.3 CASPER Main configurations

	CASPER 201 S	CASPER 201	CASPER 202 S	CASPER 202	CASPER 301 S	CASPER 301
O2 SENSOR	✓	✓	✓	✓	✓	✓
CO SENSOR	✓	✓	✓	✓	✓	✓
NO SENSOR					✓	✓
NOT EXPANDABLE	✓	✓				
EXPANDABLE TO 3 SENSORS			✓	✓		
BLUETOOTH	✓	✓	✓	✓	✓	✓
TIGHTNESS TEST			✓	✓	✓	✓
DRAUGHT MEASUREMENT ACCORDING UNI 10845	✓	✓	✓	✓	✓	✓
CALIBRATION CERTIFICATE	✓	✓	✓	✓	✓	✓
QUICK GUIDE	✓	✓	✓	✓	✓	✓
FUMES PICKING PROBE 180mm	✓	✓	✓	✓	✓	✓
COMBUSTION AIR TEMPERATURE PROBE	✓	✓	✓	✓	✓	✓
CONDENSATE TRAP	✓	✓	✓	✓	✓	✓
DIFFERENTIAL PRESSURE MEASURING KIT			✓	✓	✓	✓
BATTERY CHARGER	✓	✓	✓	✓	✓	✓
BATTERY CHARGER CABLE	✓	✓	✓	✓	✓	✓
PC SOFTWARE	✓	✓	✓	✓	✓	✓
HARD CASE	✓	✓	✓	✓	✓	✓
EXTERNAL BLUETOOTH PRINTER	✓	✓	✓	✓	✓	✓
NON-FADING PAPER ROLL	✓	✓	✓	✓	✓	✓

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2.1 Technical Specifications

Autozero:	Manual autozero cycle (without probe inserted in the stack).
Self-diagnosis:	All the functions and internal functions are checked and anomalies signalled.
Type of combustible:	11 predefined by the factory and 16 that can be programmed by the user.
Power:	Li-Ion battery pack with internal protection circuit.
Battery charger:	External battery charger.
Charging time:	4 hours for charging from 0% to 90% (5 hours for 100% charge).
Instrument working time:	12 hours of non-stop operation.
Internal data memory:	300 complete data analyses, time and name of the customer can be stored.
User data:	3 programmable user names.
Print-out heading:	4 lines x 24 characters, customisable by the user.
Display:	Graphic backlit LCD, measuring 70 x 38 mm.
Communication port:	USB with mini-USB connector. IR interface for external printer using HP-IR protocol (optional).
Bluetooth:	Class 1 / Communication range: <100 meters (free field)
Line filter:	With replaceable cartridge, 99% efficient with 20um particles.
Suction pump:	1.2 l/min heads at the flue up to 80hPa.
Condensate trap:	Outside the instrument.
Carbon black:	Using an external hand pump; it is possible to enter and print the smoke index.
Condensing boiler efficiency:	Automatic recognition of the condensing boiler, with calculation and printout of efficiency (>100%) on the LHV (Lower Heating Value) in accordance with UNI10389-1.
Environmental gases:	Measurement and separate printout of the ambient CO values.
Draught test:	Draught tested as per the UNI 10845 standard.
Operating temperature range:	-5°C to +45°C
Storage temperature range:	-20°C to +50°C
Operating humidity range:	20% to 80% RH
Protection grade:	IP42
Air pressure:	Atmospheric
Outer dimensions: Analyser:	10 x 22 x 5,4 cm (W x H x D)
Case:	42,5 x 34 x 16 cm (W x H x D)
Weight: Analyser:	~ 550 gr.

Compliant with the European Standards EN 50379-1 and EN 50379-2 as well as the Italian standards UNI 10845, for draught measurement, and UNI 10389-1, for the measurement of the combustion efficiency.

External IR printer (optional):

- With thermal paper, 24 characters, data transmission through IR interface and HPir standard protocol.
- Paper roll size: 58mm x 40mm (paper length 25 meters, about 120 report tickets).
- Power supply: with internal rechargeable Li-Ion batteries.
- External battery charger provided with printer.

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2.2 Overview of Flue Gas Analyser Components



Fig. 2.2

LEGEND

- A** Keypad
- B** Display
- C** Fumes exhaust probe
- D** Condensate separator and fine dust filter unit
- E** Compensated male connector of the fumes exhaust temperature probe
- F** Combustion air temperature probe (Optional)
- G** P- connector (negative input for measuring differential pressure)
- H** A connector (fumes exhaust probe input by means of a complete condensate separator unit)
- I** P+ connector (positive input for measuring draught)
- L** Temperature Tc-K female connector
- M** Battery charger socket
- N** Serial cable socket for connecting to the combustion air temperature probe
- O** Mini-USB socket for connecting to a PC
- P** IR communication port

Keypad

Silicone rubber keypad featuring main control functions (pos. **A** in Fig. 2.2).

Display

Backlit 128 x 64 pixel LCD display (pos. **B** in Fig. 2.2), with 8 lines x 20 characters available. Allows the user to view the measured parameters in the most comfortable format; a Zoom function displays the measured values in magnified form.

CAUTION: If the instrument is exposed to extremely high or extremely low temperatures, the quality of the display may be temporarily impaired. Display appearance may be improved by acting on the contrast key.

Battery charger socket

The instrument is provided with a 12VDC, 2A power supply pack to charge the internal batteries.

The socket for connecting the battery charger to the instrument is shown as item **M** in Fig. 2.2. Once the charge is started the display turns on and shows the charge status.

Serial connector (Mini Din 8-pole)

In **N** of Fig.2.2 we find the socket of the serial cable for connecting the instrument to the combustion air probe.

Mini/USB connector

In **O** of Fig.2.2 we find the socket of the serial cable for connecting the instrument to a personal computer.

Sample pump

The sample pump located inside the instrument is a DC-motor-driven diaphragm pump, powered by the instrument, and is such as to obtain optimal flow of the sampled gas being analysed.

External suction unit

Stainless steel probe with plastic handgrip (see **C** of Fig.2.2). Length of the steel probe is 180 mm, 300 mm, 750 mm and 1000 mm with adapter cone for the flue hole, diameter 8-22 mm. A flexible probe is also available with a 300 mm long tip, for measuring inside flues where the fumes picking point is difficult to reach. All probes have a nominal outside diameter of 8 mm.

Connection to an analyser via a 3-metre rubber hose and replaceable condensate separator and fine dust filter unit (see **D** of Fig.2.2).

Measurement cells

The instrument uses precalibrated gas sensors of the long-lasting FLEX-Sensor series for measuring oxygen (O₂), carbon monoxide CO (high immunity to Hydrogen - H₂) and nitrogen oxide (NO). Up to 4 alarms can be programmed with visual and acoustic warning for the same number of measuring parameters.

The measuring cells are the electrochemical type.

The UNI 10389-1 standard prescribes that the instrument must be calibrated once a year by an authorised laboratory to issue calibration certificates. When the cells are flat they can be replaced easily by the user without having to send the instrument away and without complicated calibration procedures requiring sample mixtures as they are supplied already calibrated.

Seitron does, however, certify measurement accuracy only when a calibration certificate has been issued by its own laboratory or by an authorised laboratory.

Temperature sensors

Flue gas temperature is measured by means of a thermocouple inserted in the tip of the probe.

The thermocouple is connected to the instrument means a compensated cable (pos. **E** in Fig. 2.2.) housed in a special seating in the rubber hose of the sample probe.

Connection to the instrument is achieved means a temperature-compensated male connector.

The cold junction is compensated by a Pt100 resistance thermometer which measures the temperature at the thermocouple connector (pos. **L** in Fig. 2.2).

The type K thermocouple (nickel/nickel chromium) permits continuous measurements up to 800°C. If special-purpose probes are used, the instrument is able to measure temperatures as high as 999.9°C.

A Pt100 resistance thermometer located inside the instrument measures the internal temperature; this sensor is also used to measure the ambient temperature.

Should the user want to measure the combustion air temperature directly in the intake duct, the optional remote Pt100 sensor must be used - this measurement is recommended for more precise calculation of plant efficiency.

Remote temperature probe

The temperature probe consists of a Pt 100 probe, complete with 2 m cable and 7.5/17 mm pit adapter (pos. **F** in Fig. 2.2). This probe is used to measure the combustion air temperature, within a range of -10°C to +100°C, when boiler efficiency is to be calculated precisely.

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Pressure sensor

The instrument features an internal piezoresistive sensor to measure the stack draught (negative pressure) and other parameters if required (gas network pressure, pressure drop across filters etc.). The user can switch from flue gas analysis to this reading by simply pressing a key.

Sample and + / - pressure inputs

Pos. **H** in Fig. 2.2 is the input of the sample probe complete with water separator and particulate filter. Pos. **I** and **G** in Fig. 2.2 are respectively the positive and negative internal differential pressure sensor inputs.

The positive input P+ **I** is used to measure pressure in general. The negative input P- **G** is used to measure draught in accordance with standard UNI10845; the branch of the fume exhaust probe without the anti-condensation filter should be connected to it for simultaneous draught measurement and combustion analysis.

The positive input P+ and negative input P- are used simultaneously to measure differential pressure.

Fuel types

The instrument has been programmed with the technical characteristics that are typical of 11 common fuels. By means of the optional PC configuration program, this list and the relative coefficients may be updated with 16 more fuels, other than the ones already pre-programmed in the instrument.

[For more details see Annex B.](#)

Smoke measurements

It is possible to enter the smoke values measured according to the Bacharach scale. The instrument will calculate the average and print the results in the analysis report.

An external pump, available as an optional, must be used to effect this measurement.

Measuring ambient CO

Probe for monitoring the concentration of CO and checking safe conditions in the boiler room.

Burner pressure verification probe

It must be used to measure burner pressure of the gas-powered boiler so it can be regulated in real time. It is made of a silicone tube, 8x4mm and 1 metre long, complete with connector for connecting to the analyser.

Probe for measuring the ionisation current

With this special probe it is possible to measure the ionisation current of a boiler and check its value depending on the boiler's technical features.

Calibration certificate

The instrument is calibrated by comparing to specimen samples provided by a Metrology Lab., certified periodically by internationally recognised laboratories.

A calibration certificate is provided with each and every instrument where every parameter is accompanied by the relevant nominal value, measured value, permissible error tolerances and measured error.

Electromagnetic compatibility

The instrument was designed to comply with Council Directive 2004/108/EC governing electromagnetic compatibility. Seitron's declaration of conformity may be found in Annex B.

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2.3 Measurement and Accuracy Ranges

MEASUREMENT	SENSOR	RANGE	RESOLUTION	ACCURACY	
O ₂	Electrochemical sensor	0 .. 25.0% vol	0.1% vol	±0.2% vol	
CO high immunity H ₂	Electrochemical sensor	0 .. 8000 ppm	1 ppm	±20 ppm ±5% measured value ±10% measured value	0 .. 400 ppm 401 .. 4000 ppm 4001 .. 8000 ppm
NO	Electrochemical sensor	0 .. 5000 ppm	1 ppm	±5% ±5% measured value	0 .. 100 ppm 101 .. 5000 ppm
NO _x	Calculated				
CO ₂	Calculated	0 .. 99.9% vol ⁽¹⁾	0.1% vol		
Air temperature	Pt100 sensor	-20.0 .. 120.0 °C	0.1 °C	±0.5 °C ⁽²⁾	
Flue gas temperature	TcK sensor	-100.0 .. 1250.0 °C	0.1 °C	±0.5 °C ±0.5% measured value	0 .. 100 °C 101 .. 1250 °C ⁽³⁾
Pressure UNI 10845	Piezoelectric sensor	-250.0 .. 250.0 Pa ⁽⁴⁾	0.1 Pa	±0,5 Pa ±2 Pa ±2 Pa	-10.0 .. +10.0 Pa +10.1 .. +250.0 Pa -10.1 .. -250.0 Pa
Pressure (draught & differential)	Piezoelectric sensor	-10.00 .. 200.00 hPa	0.01hPa	±1% measured value ±0.02 hPa ±1% measured value	-2.01 .. -10.00 hPa - 2.00 .. +2.00 hPa +2.01 .. +200.00 hPa
Differential temperature	Calculated	0 .. 1250.0 °C	0.1 °C		
Air index	Calculated	0.00 .. 9.50	0.01		
Excess air	Calculated	0 .. 850 %	1 %		
Stack loss	Calculated	0.0 .. 100.0 %	0.1 %		
Efficiency (condensing)	Calculated	0.0 .. 120.0 %	0.1 %		
Smoke index	External instrument	0 .. 9			

All data relative to concentration accuracies are referred to an instrument operating at a constant temperature within the correct operating range (-5°C .. +45°C), being in operation for at least 15 minutes, powered by its internal battery and after completion of auto-zero procedure.

- Notes:** (1) The maximum CO₂ value displayed depends on the type of fuel.
(2) Stated precision includes error of the external sensor RTD Pt100 class A DIN 43760 (1980).
(3) Stated precision includes error of the external sensor type K thermocouple class 1 IEC584.
(4) Pressures greater than 750 hPa may permanently damage sensors or impair their characteristics.

3.1 Preliminary operations

Remove the instrument from its packing and check it for damage. Make sure that the content corresponds to the items ordered. If signs of tampering or damage are noticed, notify the SEITRON service centre or agent immediately and keep the original packing. A label at the rear of the analyser bears the serial number. This serial number should always be stated when requesting technical assistance, spare parts or clarification on the product or its use.

Seitron maintains an updated database for each and every instrument.

Before the first use it is recommended to perform a full battery charge cycle.

3.2 Warnings

- Use the instrument with an ambient temperature between -5 and +45°C.
- When it has finished being used, before turning the instrument off remove the probe and let it aspirate ambient clean air for at least 30 seconds to purge the pneumatic path from all traces of fumes.
- Do not use the instrument if the filters are clogged or damp.
- Before putting the measuring probe back in its case after use, make sure it has cooled down enough and there is no condensate in the tube. It might be necessary to periodically disconnect the filter and the condensate separator and blow compressed air inside the tube to eliminate all residues.
- Remember to have the instrument checked and calibrated once a year in order to comply with the existing standards.



IF THE INSTRUMENT HAS BEEN KEPT AT VERY LOW TEMPERATURES (BELOW OPERATING TEMPERATURES) WE SUGGEST WAITING A WHILE (1 HOUR) BEFORE SWITCHING IT ON TO HELP THE SYSTEM'S THERMAL BALANCE AND TO PREVENT CONDENSATE FORMING IN THE PNEUMATIC CIRCUIT.

3.3 Analyser power supply

The instrument contains a high-capacity Li-Ion rechargeable battery.

The battery feeds the instrument, built-in printer and any other probes or remote devices that may be connected. The instrument runs for approximately 18 hours. Should the battery be too low to effect the necessary measurements, the instrument can be hooked up to the mains via the power pack provided, allowing operations (and analysis) to proceed. The battery will be recharged whilst the instrument is being used.

The battery charging cycle takes up to 3 hours for a complete charge and finishes automatically.

ATTENTION: If the instrument is not going to be used for a long time we suggest recharging it at least once every 2 months.

3.3.1 Checking and replacing the batteries

The status of the internal battery can be checked during instrument auto-calibration or even after, if necessary, by accessing the information menu, then pressing the  key, and selecting the 'battery status' sub menu.

The menu displays the battery's residual capacity and voltage. If battery charge appears to be low, let it discharge completely and then carry out a full 100% charge cycle by connecting the instrument to the power pack for 3 hours.

If the problem persists, replace the battery pack with a SEITRON original or contact the SERVICE CENTRE to carry out the necessary repairs.

The average life of the battery pack is 500 charging/discharging cycles. To exploit this characteristic to the full it is advisable to always use the instrument powered by the internal batteries and to charge it only when it gives the battery flat message.



THE INSTRUMENT IS SHIPPED WITH THE BATTERY HALF CHARGED SO IT IS ADVISABLE TO CHARGE IT COMPLETELY BEFORE USE, TAKING 3 HOURS.

IT IS ADVISABLE TO CHARGE THE BATTERY AT AN AMBIENT TEMPERATURE RANGING BETWEEN 10°C AND 30°C.

3.3.2 Use with external power pack

The instrument can work with the batteries fully discharged by connecting the external power pack provided.

Kindly note that while the battery is charging, some heat is generated which increases the instrument's internal temperature. This may lower the accuracy of some readings.

The air temperature must be measured using the air temperature probe since the internal sensor might lie at a different temperature with respect to ambient.



THE POWER SUPPLY/BATTERY CHARGER IS A SWITCHING TYPE ONE.
THE APPLICABLE INPUT VOLTAGE RANGES BETWEEN 90Vac AND 264Vac.
INPUT FREQUENCY: 50-60Hz.
THE LOW VOLTAGE OUTPUT IS 12 VOLT WITH AN OUTPUT CURRENT GREATER THAN 1.5A.

LOW VOLTAGE SUPPLY CONNECTOR: DC PLUG 2.1x5.5x9 mm. WITH CENTRAL POSITIVE AND EXTERNAL GND.

IF AN UNSUITABLE POWER SUPPLY IS CONNECTED IT CAN DAMAGE THE INSTRUMENT; USE ONLY THE ONE SUPPLIED WITH IT.

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4.1 Working principle

The gas sample is taken in through the fumes probe, by a diaphragm suction pump inside the instrument.

The measuring probe has a sliding cone that allows the probe to be inserted in holes with a diameter of 11 mm to 16 mm and to adjust the immersion depth: **the fumes picking point must be roughly in the centre of the flue section.**

The gas sample is cleaned of humidity and impurities by a condensate trap and filter positioned along the rubber hose that connects the probe to the analyser.

The gas components are then analysed by the electrochemical sensors.

Oxygen (%O₂) is measured with an electrochemical cell that acts like a battery which, over time, is apt to lose sensitivity.

The toxic gases (CO, NO) are measured with electrochemical sensors that are not subject to natural deterioration being intrinsically lacking of oxidation processes.

The electrochemical cell guarantees high precision results in a time interval of up to about 60 minutes during which the instrument can be considered very stable. When measurement is going to take a long time, we suggest auto-zeroing the instrument again and flushing the inside of the pneumatic circuit for three minutes with clean air.

During the zero calibrating phase, the instrument aspirates clean air from the environment and detects the cells' drifts from zero (20.95% for the O₂ cell), then compares them with the programmed values and compensates them. The pressure sensor autozero must, in all cases, be done manually prior to measuring pressure.

The values measured and calculated by the microprocessor are viewed on the LCD display which is backlit to ensure easy reading even when lighting is poor.

4.2 Measurement cells

The measurement cells are electrochemical cells made up of an anode, a cathode, and an electrolytic solution, which depends on the type of gas to be analysed. The gas penetrates the cell through a selective diffusion membrane and generates an electric current proportional to the absorbed gas. Such current is measured, digitalized, temperature-compensated, processed by the microprocessor, and displayed.

The gas shall not be at a pressure such to damage or destroy sensors. The maximum estimated allowed pressure is ± 100 mbar.

The response times of the measurement cells used in the analyser are:

O₂ = 50 sec. at 90% of the measured value

CO = 60 sec. at 90% of the measured value

NO = 40 sec. at 90% of the measured value

It is therefore suggested to wait 5 minutes (anyway not less than 3 minutes) in order to get reliable analysis data.

If sensors of poison gases are submitted to concentrations higher than 50% of their measurement range for more than 10 minutes continuously, they can show up to $\pm 2\%$ drift as well as a longer time to return to zero. In this case, before turning off the analyser, it is advisable to wait for the measured value be lower than 20ppm by intaking clean air.

4.3 Connecting the fumes probe

The fumes picking probe is made up of an INOX steel tube with a plastic hand grip and an internal K-type thermocouple (Ni-NiCr) for measuring the fumes temperature up to 800°C. The probe is connected to the analyser through a double flexible hose, a filter group and a compensated cable for the thermocouple. The polarized connector of the thermocouple is to be connected to the special outlet on the lower side of the instrument. It is not possible to perform a wrong connection thanks to the different width of contacts. Connect the shorter tube of the probe to the filter group (fine dust/condensate trap) which, in turn, shall be connected to the central connector of the instrument marked with letter "A". Connect the longer tube, ending with a male connector, to the negative pressure input of the instrument marked with letter "P-". The different diameter of connectors does not permit any wrong connections; this permits to avoid any damages to the instrument.

4.4 Condensate trap and fine dust filter

The sample gas to be analysed shall reach the measurement cells after being properly dehumidified and purified from the residual combustion products. To this purpose, a condensate trap is used, which consists of a transparent polycarbonate cylinder placed along the rubber hose of the sampling probe. Its purpose is to decrease the air speed so that the heavier fine dust particles can precipitate and the vapour in the combustion gases can condensate.

The condensate trap must be always kept in the vertical position in order to prevent condensate from touching the measurement cells. This is also the reason why it is important to periodically drain the trap, anyhow at the end of each test (see chapter 'MAINTENANCE').

A replaceable low-porosity line filter is placed after the condensate trap aimed at keeping the solid particles suspended in the gases. It is recommended to replace the filter whenever visibly dirty (see chapter 'MAINTENANCE').



KEEP THE CONDENSATE TRAP IN THE VERTICAL POSITION DURING THE ANALYSIS; A WRONG POSITIONING MAY CAUSE CONDENSATE SEEPAGES IN THE INSTRUMENT AND DAMAGE SENSORS.

AFTER EACH ANALYSIS, CHECK FOR ANY PRESENCE OF WATER IN THE CONDENSATE COLLECTION BOWL AND ELIMINATE IT, IF ANY. PUT THE PROBE BACK IN THE CASE ONLY AFTER YOU HAVE ELIMINATED CONDENSATE FROM THE TUBE AND THE EXPANSION TANK (SEE CHAPTER 'MAINTENANCE').

REPLACE THE FINE DUST FILTER IF IT IS VISIBLY DIRTY OR WET (SEE CHAPTER 'MAINTENANCE').

DO NOT PERFORM ANY MEASUREMENT WHEN THE FILTER IS REMOVED OR DIRTY IN ORDER TO AVOID ANY RISK OF IRREVERSIBLE DAMAGES ON SENSORS.

4.5 Connecting the combustion air temperature probe

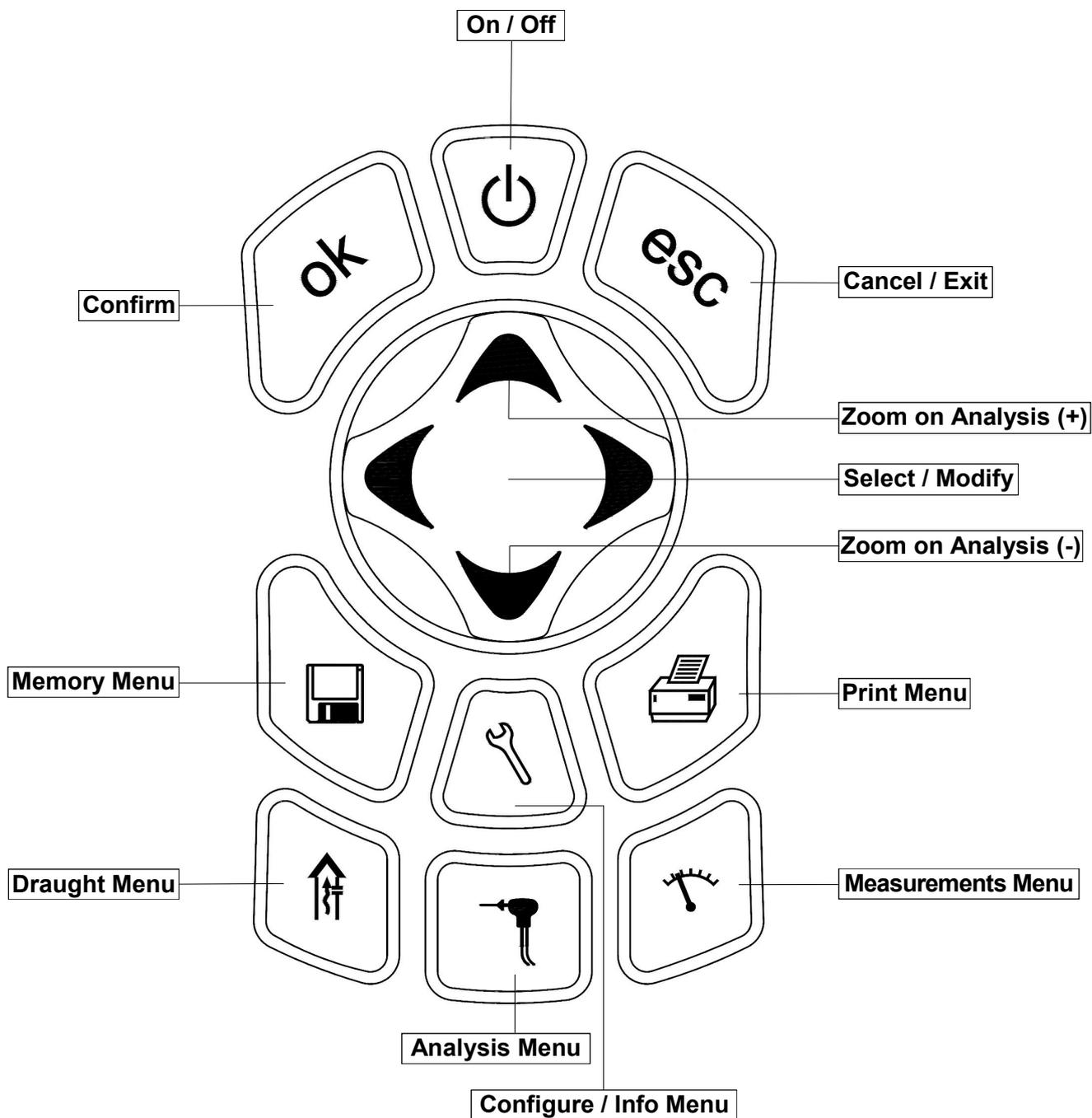
Should you need to measure the actual **combustion air temperature** and the analyser is not in the place where the combustion air is to be taken (important for a correct calculation of the burner efficiency), you shall use the remote probe.

The remote probe is made up of a Pt100 thermal resistance equipped with cable (available 2 meters long) and connector for its connection to the analyser.

4.6 Connecting the TcK probe

Using the same input as for the K thermocouple (the same used for fumes temperature), it is possible to measure the water delivery and return temperature by connecting some **special probes**. If temperature is taken on the pipe, it is suggested to use arc probes with a suitable diameter.

4.7 Keypad overview



WARNING: to turn-on / off the instrument it is necessary to press and hold the On/Off button for at least 2 seconds.



4.8 Info Menu

This menu provides information regarding instrument status:

Battery status:

Shows the status of the internal battery.

The battery charge status is shown graphically and in text as a percentage between 0 and 100%, together with the battery voltage.

Sensors Configuration:

It allows to check which sensors are installed on the instrument, and in which position they are installed. The instrument automatically detects whether a sensor has been either added or removed. The screen page allows whether to accept the new configuration or ignore the change performed.

Sensor diagnostics:

This feature displays useful information about the status as well as about the calibration of the internal electrochemical sensors. Through this screen the user can access the data that fully identify the sensor, such as: sensor type, serial number, manufacturing and calibration dates. In addition to this are also shown the current values generated by the sensors thus allowing for a quick troubleshooting in case of issues referable to the sensors.

Gas path check:

Tests the tightness of the gas probe pneumatic path.

Memories diagnostics:

At instrument turn on the firmware performs a full check on the physical efficiency of all types of HW memories installed on the instrument, as well as on the integrity of the data stored into them. Any issue is evidenced in the screen 'Memories Diagnostics'. Should this happen it is advisable to turn the instrument off and then on again. In case the problem is permanent or frequently recurring, the user should contact the Service Center reporting the error code shown by the instrument.

Info service:

This submenu contains details regarding the nearest Service Center to be contacted in the event of instrument fault or ordinary maintenance. The instrument model, serial number and firmware version are also displayed, thus allowing for a quick product identification.

External probe:

Shows usefull information about the probe connected to connector **N** Fig. 2.2 on page 8.

The Flow Chart in the following page shows how to browse through the Info Menu screens.

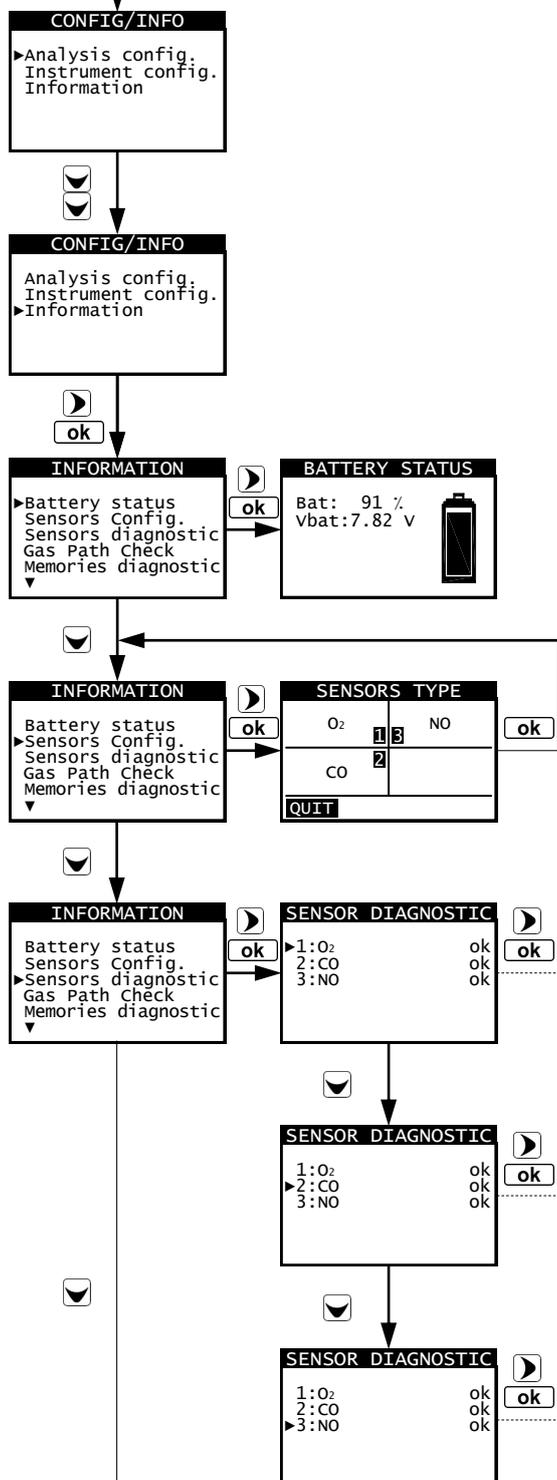


4.8.1 Flow Chart - Info Menu



Activates the Info Menu.

To return to the previous screen, press **esc**.



The battery symbol filling up means that battery charging is ongoing.

This screen page shows, for each position, the following messages (example referred to the sensor in position 3):

- NO** Sensor configured OK
- NO** Sensor missing or non communicating
- NO**→ New sensor detected
- GO** Sensor detected in a wrong position

Use arrows to scroll the parameters of each selected cell. Here below are the data which can be displayed through the sensors troubleshooting menu:

- Type:** Type of sensor
- Revision:** Sensor revision index
- Date code:** Production batch
- Gas:** Gas measured
- Serial:** Sensor serial number
- Manufacturing date:** Production date
- Calibration date:** Calibration date
- Is:** Sensor Is current
- Ia:** Sensor Ia current (CO sensor only)

Furthermore, under sensor troubleshooting mode, the instrument can display the status of each single cell (here is an example) visualized after the visualization of the measured gas:

- Ok:** No problem detected
- missing** The sensor has not been detected
- data err** Sensor memory data error
- Unknown** The instrument FW needs to be updated
- pos err** Sensor installed in the wrong position
- cal err** Calibration error
- curr err** Currents out of range
- non config** This sensor is not to be used because it has not been accepted in the page 'type of sensor'.



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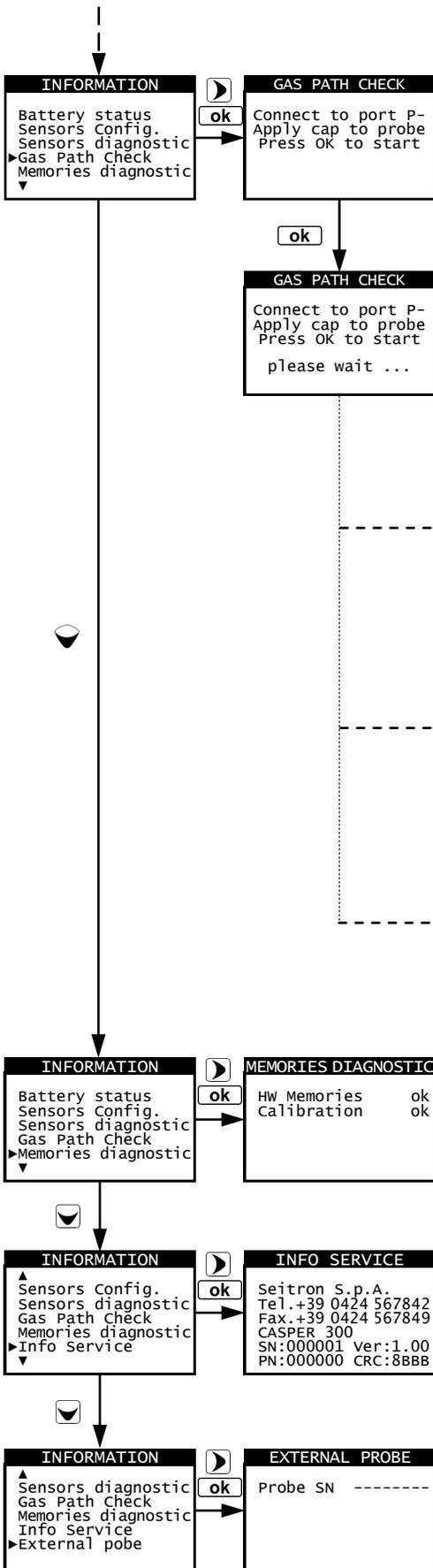
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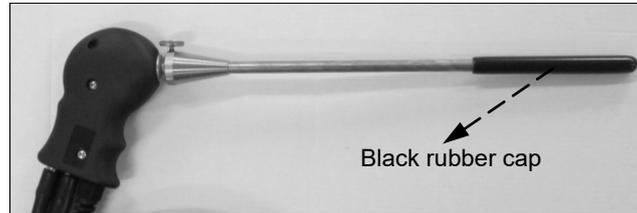
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Connect the flue gas sampling probe and filter unit assembly to the instrument;
Fully insert the black rubber cap on the gas probe tip, as shown in the following picture:



GAS PATH CHECK
Connect to port P-
Apply cap to probe
Press OK to start
Result: leak

GAS PATH CHECK
Connect to port P-
Apply cap to probe
Press OK to start
Result: tight

GAS PATH CHECK
Connect to port P-
Apply cap to probe
Press OK to start
Result: error

Result: error
Check that the probe is connected to P- input port.



4.9 Analysis configuration menu

Through this menu the user can configure the available parameters for a proper combustion analysis.

Fuel:

Lets the user select the type of fuel to be used during analysis. This datum can be varied either from this menu or during the analysis itself.

Measurement units:

Through this submenu the user can modify the units of measurement for all the analysis parameters, depending on how they are used.

O₂ Reference:

In this mode the user can set the oxygen percentage level to which pollutant emission values detected during analysis will be referenced.

Automatic analysis:

The user can set analysis mode to either manual or automatic.

In manual mode the user performs the three necessary analysis operations manually. In automatic mode the cycle duration for each reading must also be set - in this case the instrument will conduct each analysis in the specified time.

Printing may also be manual or automatic. If "auto" printing is selected, the instrument will automatically print the analysis report in a predetermined format at the end of the automatic analysis (in case an IR printer is used, this must be properly placed with respect to the instrument).

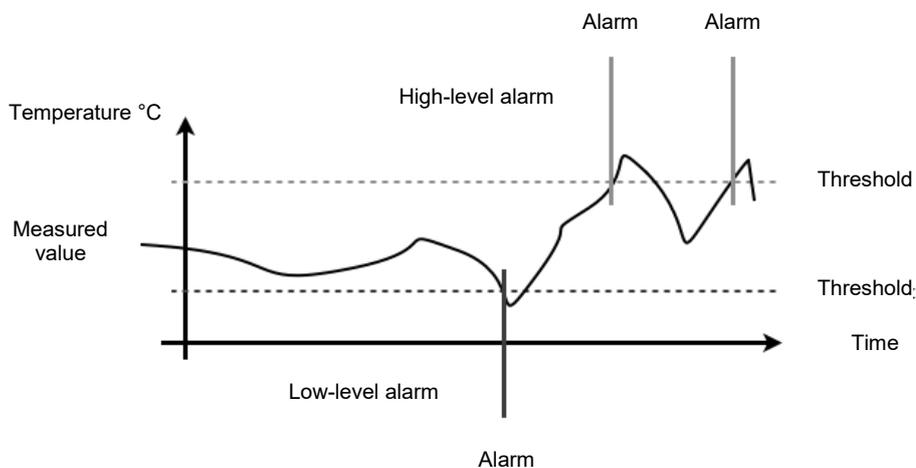
Condensation

The burner efficiency figure when condensation takes place is influenced by atmospheric pressure and humidity of the combustion air. As the atmospheric pressure is hardly precisely known, the operator is asked to enter a related parameter, i.e. the altitude of the place above the sea level, from which the pressure is then derived once the dependency from atmospheric conditions is neglected. In calculations the value of 101325 Pa is assumed as atmospheric pressure at sea level. Further the air relative humidity input is allowed, being this calculated at the combustion air temperature as measured from the instrument; in case this value is unknown the operator is recommended to enter 50% for this value.

Alarms:

This submenu allows the user to set and memorise 5 alarms, defining the monitored parameter for each (gas, pressure, T_a, T_f), the alarm threshold and relative unit of measurement and whether it is a low or high-level alarm.

Low-level alarms are triggered when the reading drops below the defined threshold, whereas high-level alarms are triggered when the reading rises above the defined threshold.



When an alarm threshold is crossed, the instrument emits an intermittent audible alarm besides activating a visible alarm wherein the background of the name of the relative reading will start flashing in the analysis screen.



NOx/NO Factor

NOx/NO: all the nitrogen oxides which are present in the flue emissions (Nitrogen oxide = NO). In the combustion processes, it is found out that the NO₂ percentage contained in the fumes is not far from very low values (3%); hence it is possible to obtain the NO_x value by a simple calculation without using a direct measurement with a further NO₂ sensor. The NO₂ percentage value contained in the fumes can be however set at a value other than 3% (default value).

Autozero/Pump:

This submenu is used to set the duration of the analyser auto-calibration cycle. It may also be used to switch off or switch on the sample pump temporarily. The sample pump cannot be switched off if the auto-calibration cycle is under way.

Operator:

The name of the operator conducting the analysis may be set or modified through this submenu. A maximum of three names may be stored. The name of the selected operator will be printed on the analysis report.

Report header setup:

This allows the Company or Owner's name to be entered in four lines with 24 characters each, together with other details (e.g. address, tel. no.). This data will be printed on the heading of the analysis report.

Air T:

In this submenu there is a possibility to acquire or manually enter the combustion air temperature.



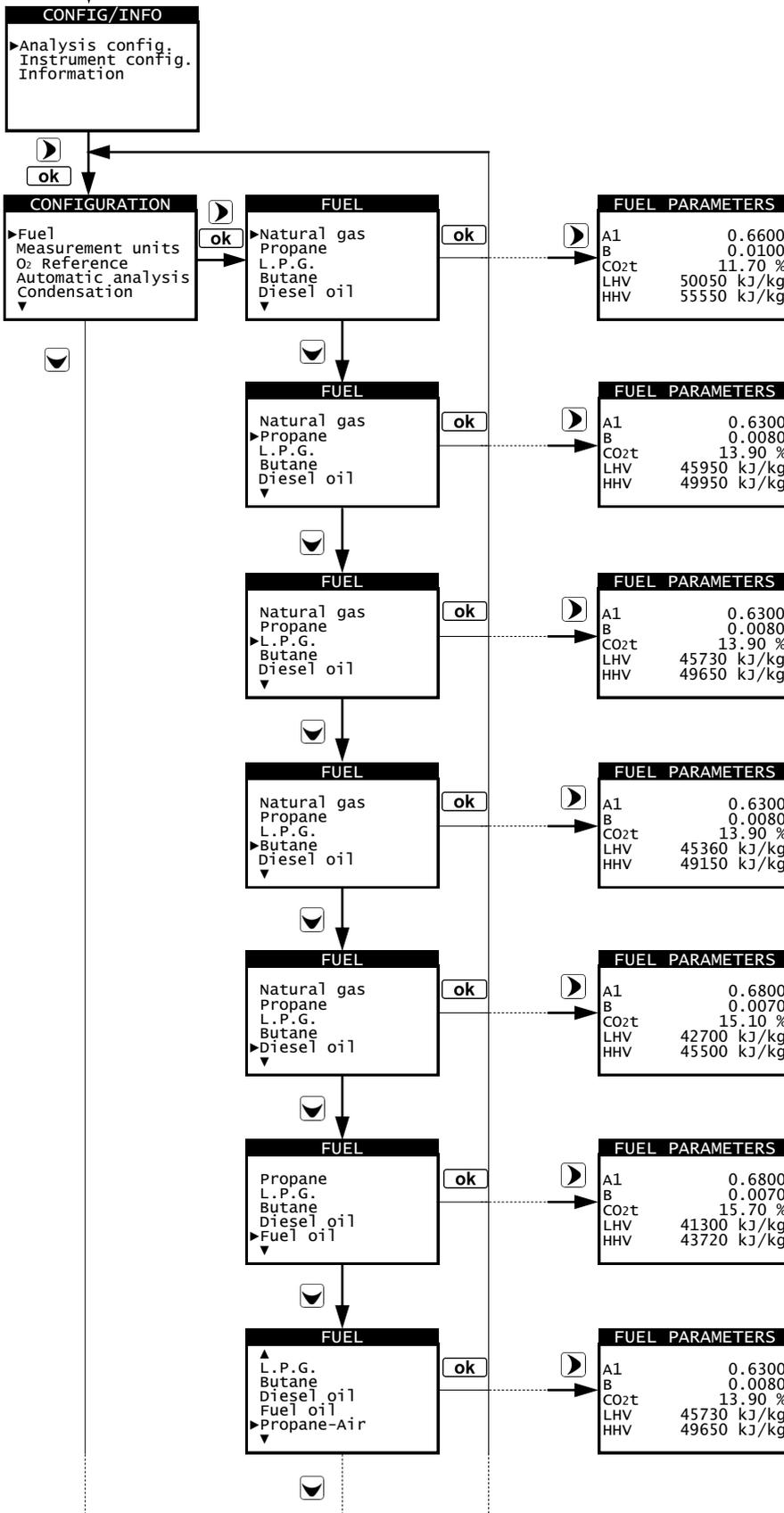
4.9.1 Flow Chart - Analysis configuration menu



Activates the Configuration/Information Menu

All selected data can be modified by pressing cursor keys \downarrow \uparrow .

To cancel changes and return to the previous menu press **ESC** .





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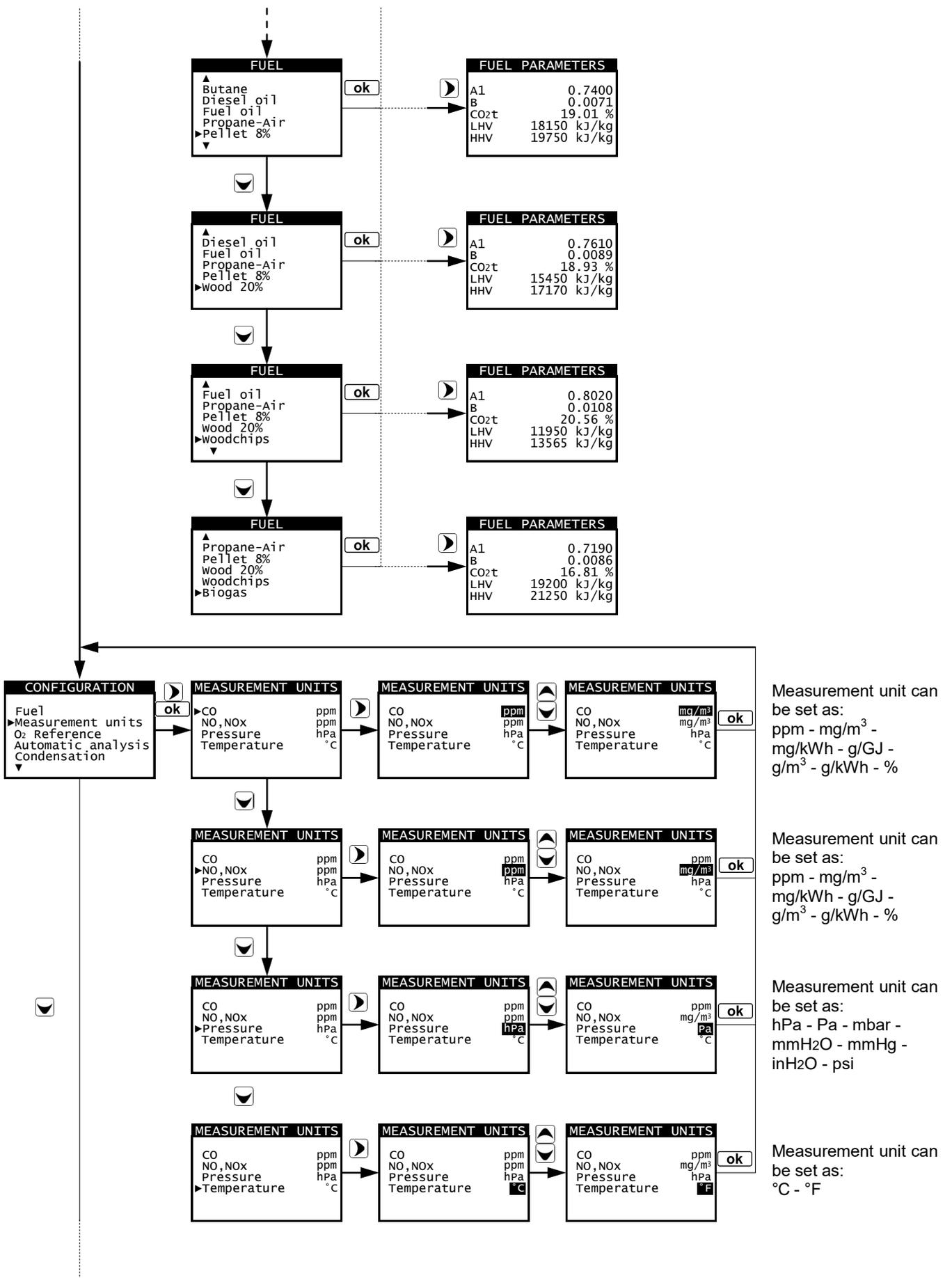
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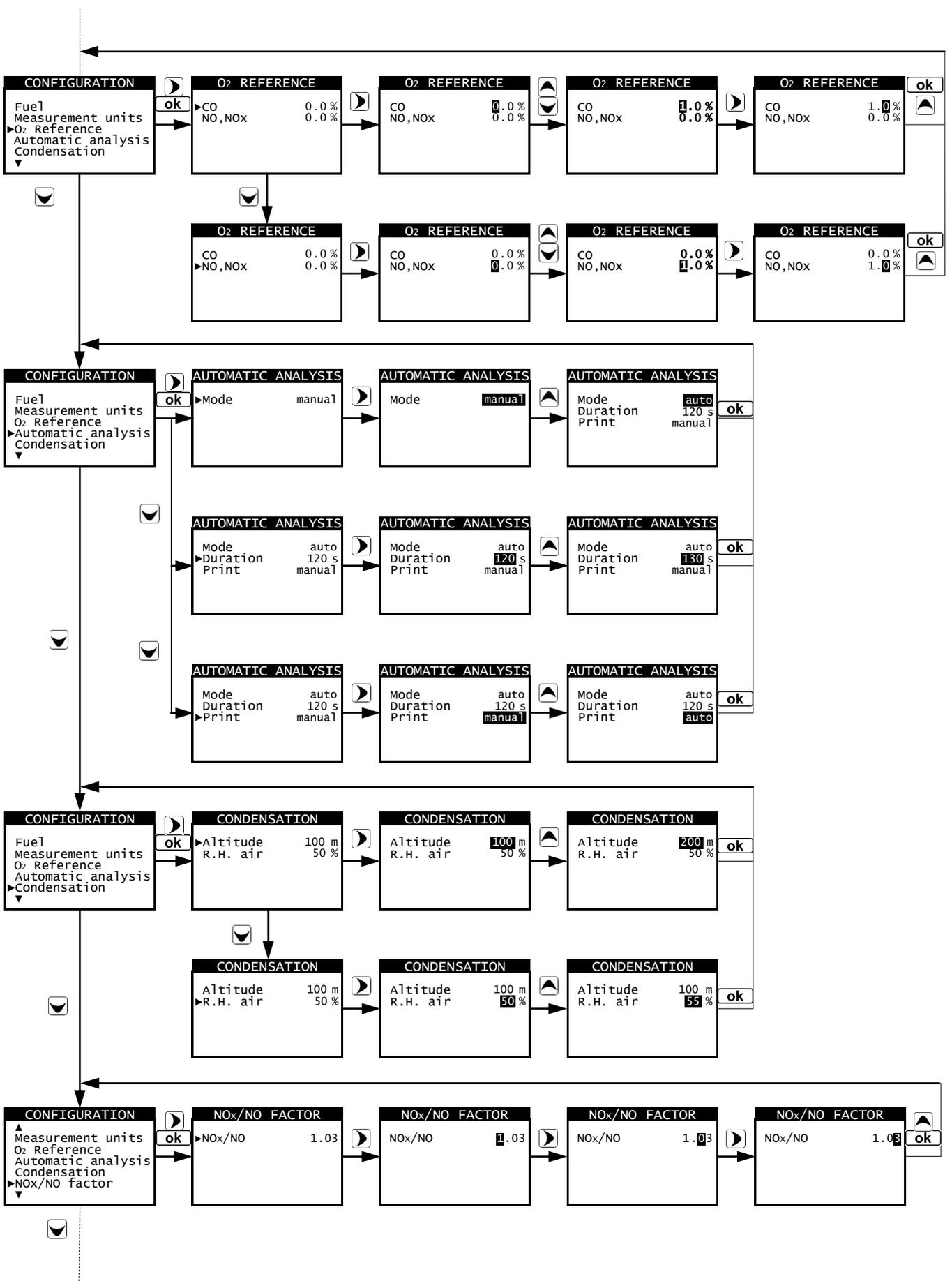
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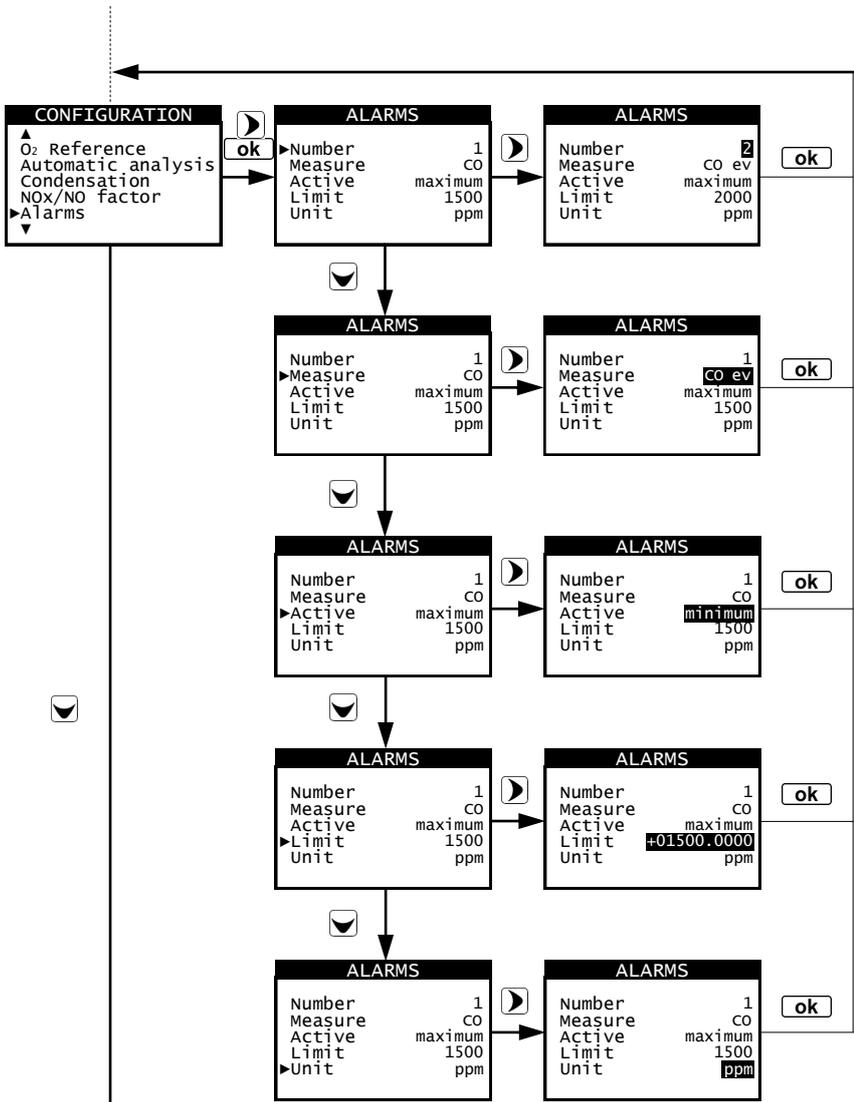


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Select the figure to be modified with the keys \downarrow \uparrow .
Modify the value of the highlighted figure with keys \leftarrow \rightarrow .

The values that can be selected with the \downarrow \uparrow keys for this parameter are:

CO, NO, O₂, P, Tf, Ta

The values that can be selected with the \downarrow \uparrow keys for this parameter are:

maximum, minimum, no

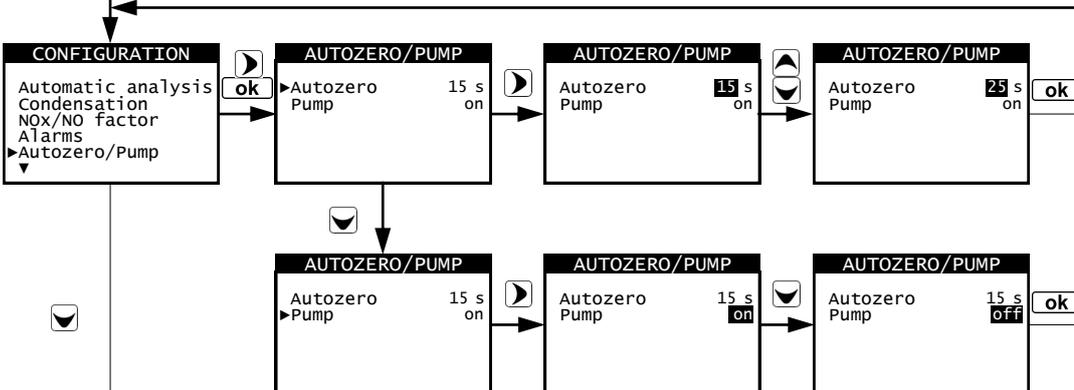
The alarm threshold values can be set via the \downarrow \uparrow keys within the following range:

- 99999.999 to + 99999.99

(the value is referred to the unit of measurement set) maximum, minimum, no.

The values that can be selected with the \downarrow \uparrow keys for this parameter are:

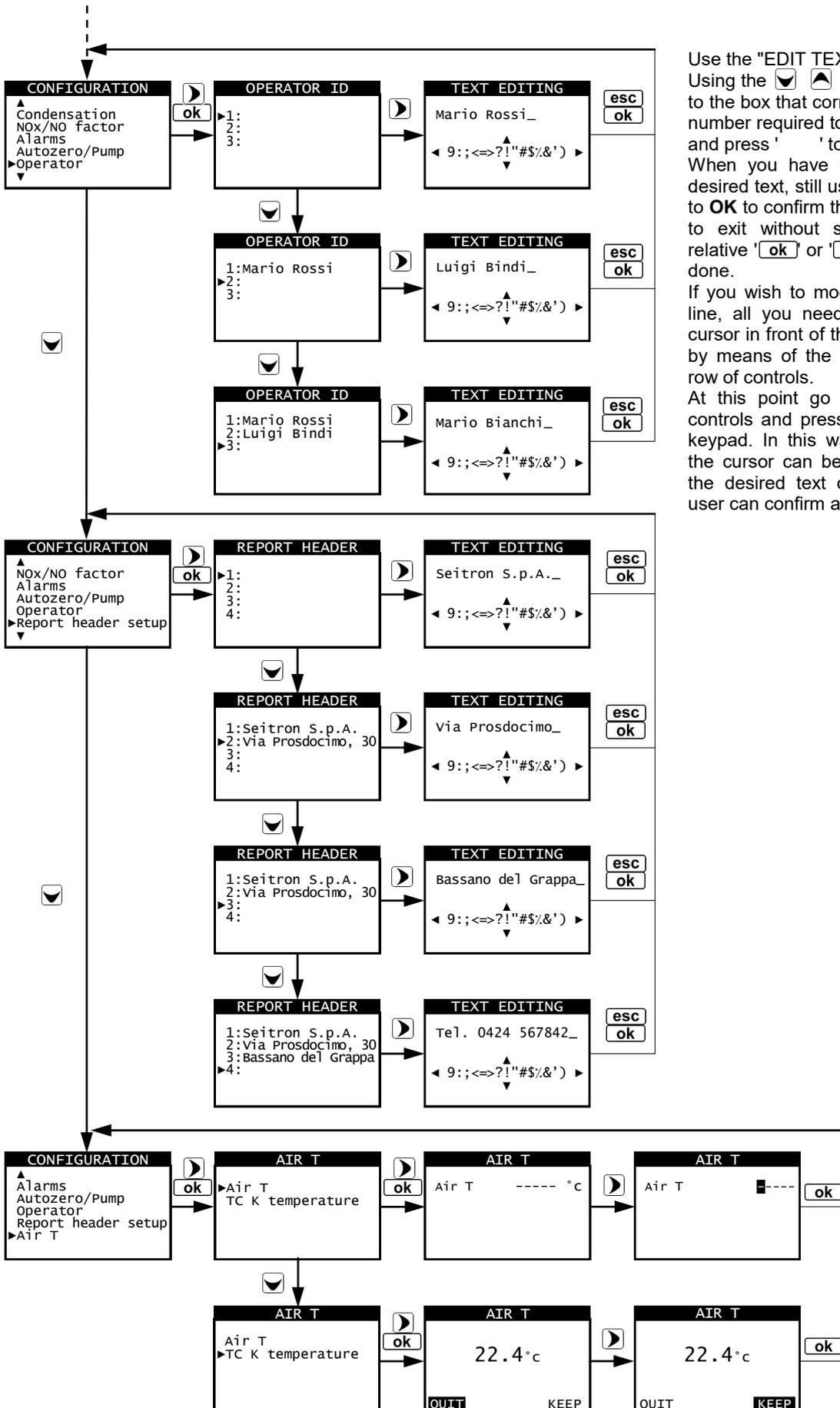
ppm, mg/m³, mg/kWh, g/GJ, g/m³, g/kWh, %



Note:
The pump cannot be switched off during auto-calibration.
If auto-calibration has not been performed the pump cannot be switched on.



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Use the "EDIT TEXT" function as follows:
Using the cursor keys, go to the box that corresponds to the letter or number required to form the desired word, and press ' ' to confirm.

When you have finished striking in the desired text, still using the cursor keys, go to **OK** to confirm the entered data or to **es** to exit without saving, and press the relative '**ok**' or '**esc**' button. The task is done.

If you wish to modify a letter or a whole line, all you need to do is position the cursor in front of the letter to be cancelled by means of the cursor keys in the first row of controls.

At this point go to the second row of controls and press the '**esc**' key on the keypad. In this way the letter preceding the cursor can be cancelled, after which the desired text can be entered or the user can confirm and exit.

Select the figure to be modified with the keys . Modify the value of the highlighted figure with keys .

4.10 Instrument configuration menu



This menu is used to configure the instrument's reference parameters described below:

Bluetooth

Through this sub menu the user can turn on and off the instrument Bluetooth wireless communication with a PC or PDA.



Calibration

It is possible to make a recalibration of the instrument's gas sensors with suitable known concentration gas cylinders. Recalibration of Oxygen (O₂) sensor is not available since it is already recalibrated during every autozero sequence. See 'MAINTENANCE' section.

Display contrast

The display contrast may be increased or decreased by acting on cursor keys     . This operation may be performed even when the introductory screen is active.

Time/Date

This allows the current time and date to be set. The user can select the date and hour format either in EU (European) or USA (American) mode.

Micromanometer

This submenu is irrelevant because this type of firmware configuration does not use the external micromanometer.

Buzzer

This sub-menu permits to activate or deactivate the instrument buzzer.

Language

This sub-menu permits to select the desired language for the visualization of the various menus and the report printing.



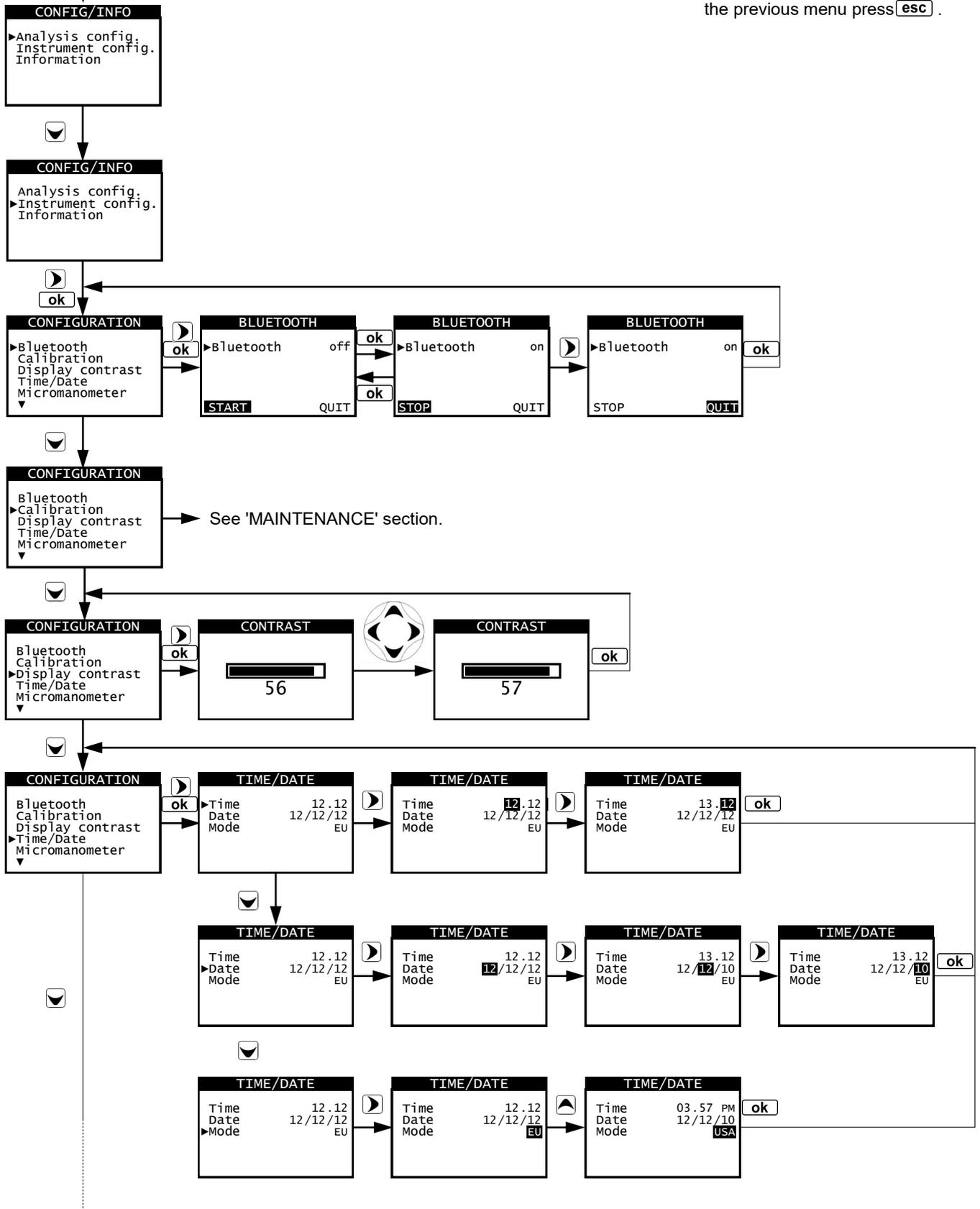
4.10.1 Flow Chart - Instrument configuration menu



Activates the Configuration/Information Menu

All selected data can be modified by pressing cursor keys \blacktriangle \blacktriangledown .

To cancel changes and return to the previous menu press **[ESC]** .





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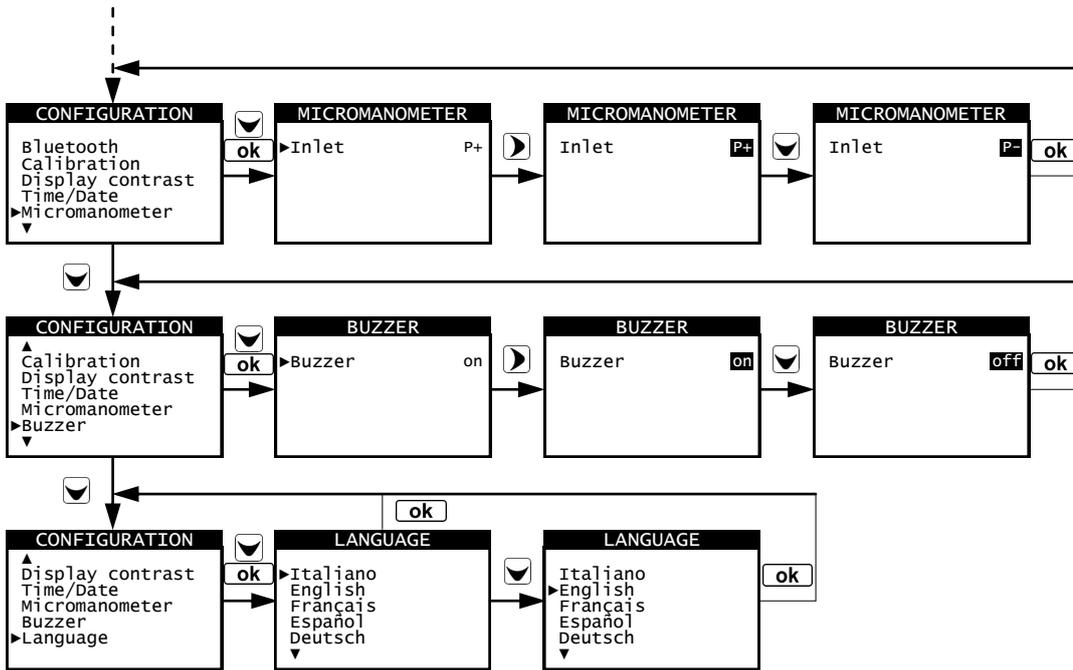
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4.11 Memory Menu

This menu is used to display and print individual and average values of the analysis data stored in memory. Analysis data can be ordered either by memory position or by storage date; draught, smoke and ambient CO, NO values can also be recalled. Inside the "Recall Memory" menu, the Print Menu is only enabled in the analysis screen or in the draught, smoke and ambient CO values screen.

2

Save analysis:

This submenu displays the current active MEMORY and the data stored within, and allows the user to record new values or to overwrite them if these are already present and complete.

Display average:

Displays the average of the analysis data stored in the active memory.

3

Select memory:

Allows the user to select the memory within which to record any effected analyses or other data such as draught, smoke and ambient CO values. When the menu is accessed a preview of all saved data will appear.

Recall memory:

This menu, just like the previous one, lets the memory be selected on the basis of the stored position or storage date, thereby letting all stored data be displayed (individual and average readings, draught, smoke and ambient CO values).

4

Delete single:

Allows the user to erase the data stored for a single memory. A confirmation is required in order to avoid an accidental loss of the formerly stored data.

Delete all:

This is used to cancel the entire contents of the 99 memory positions; even for this option a confirmation is required in order to avoid an accidental loss of the formerly stored data.

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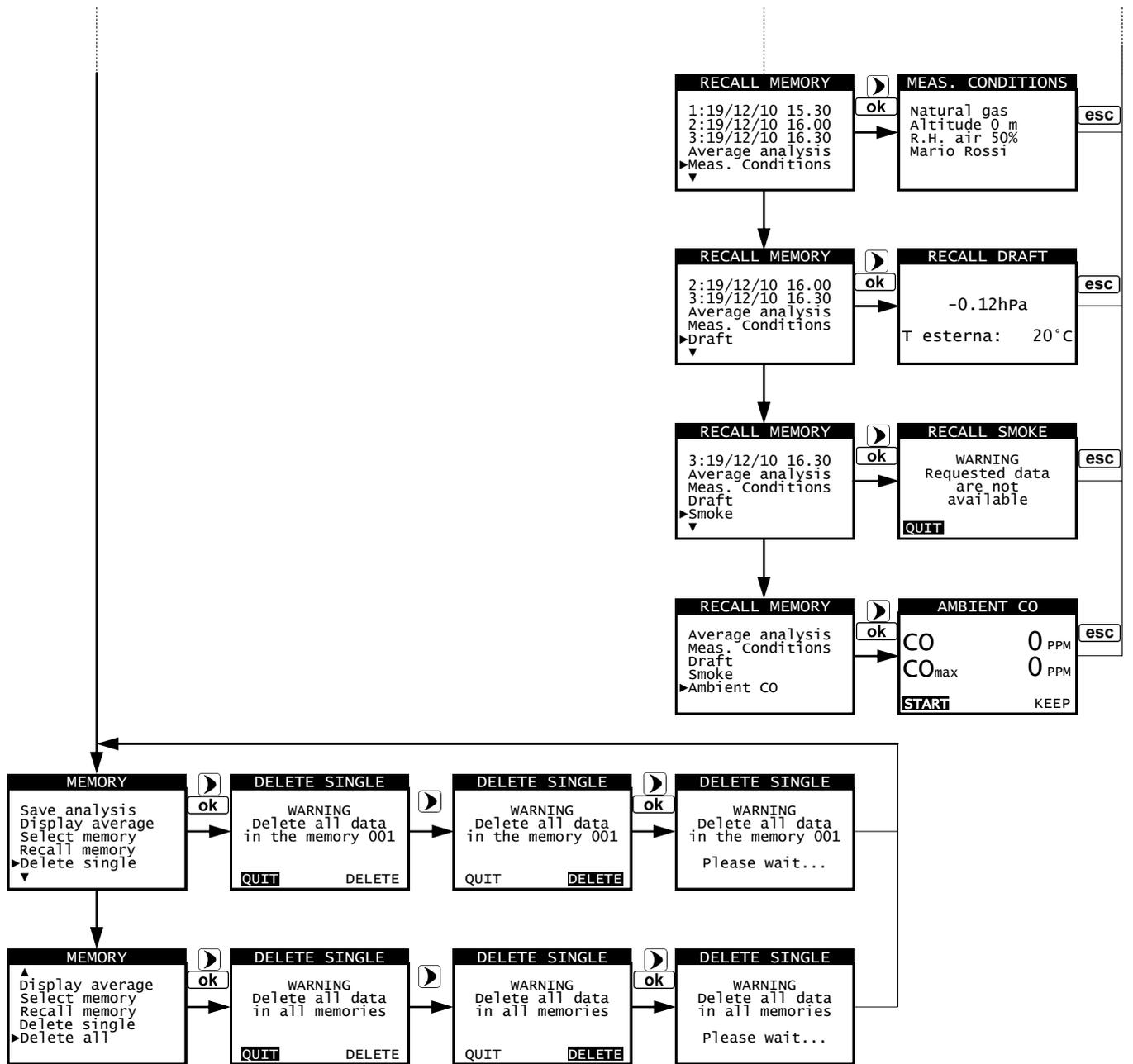
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4.11 Print Menu

This menu is used to access the following print and check configurations:

Print report:

Shows the details of the selected ticket type and allows to start printing.

Print setup:

Copies: Allows to set the number of desired copies.

Model: The ticket layout selection is only valid for combustion analysis. Tickets for draught, smoke and ambient gas concentration only allow a specific layout. Layouts for combustion analysis are specified as described in the following:

Full: includes a header with company data as well operator data previously programmed in the configuration menu, measurements sampled in the combustion analysis and, when sampled, the draught, smoke and CO ambient gas values.

Partial: only reports the combustion analysis measurement values and informations, without any header, comments or blank lines for operator comments.

Total: is arranged with the complete layout of the average analysis followed by the single analysis measurements report.

Print test:

Prints a graphical/alphanumeric test ticket for a complete check of the printer operation.

Printer type:

Selects the printer type: infrared or Bluetooth.

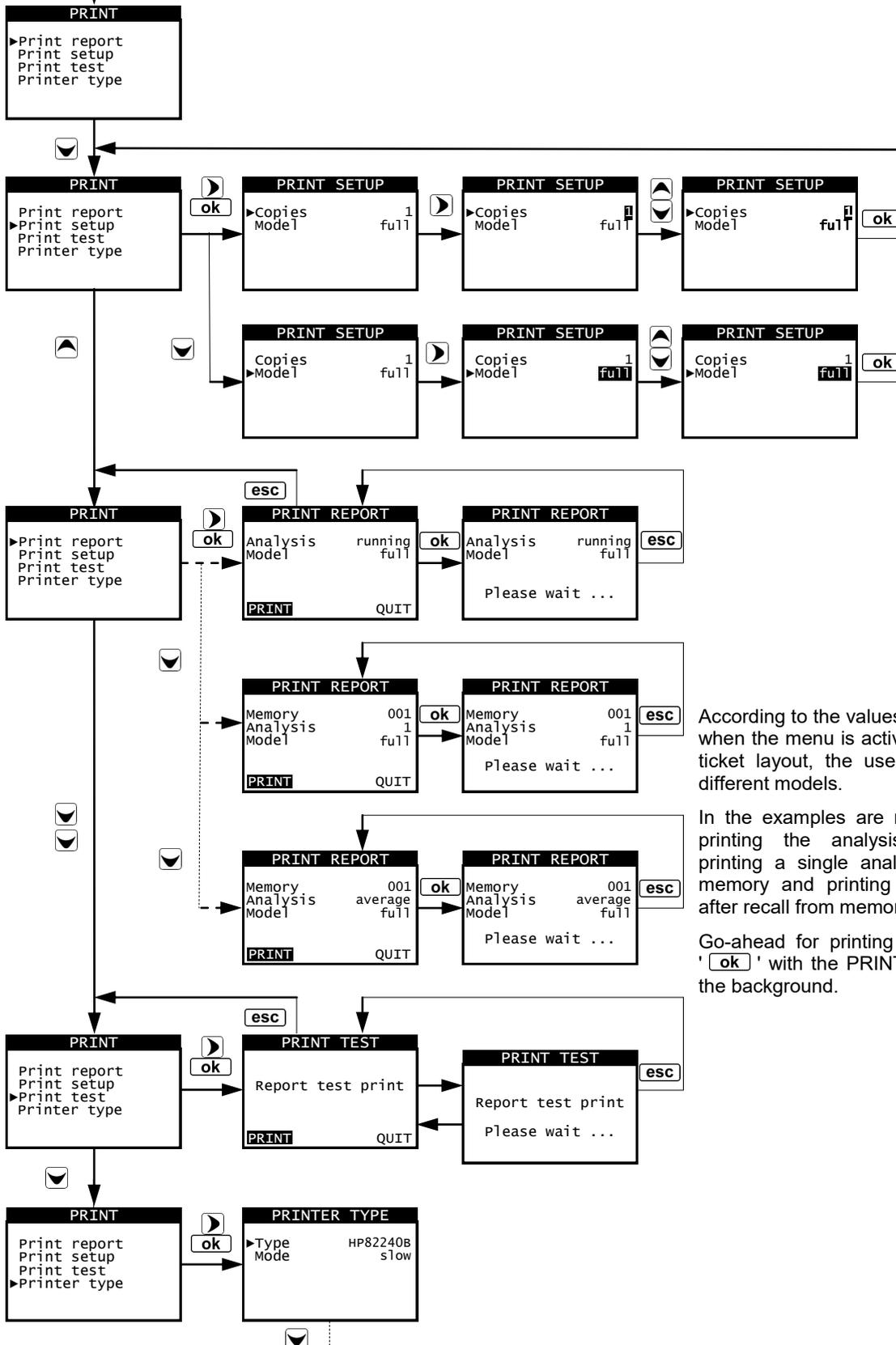
- When infrared printer is selected a further choice for the printing mode is allowed: fast or slow (Select 'slow' in order to make the printing process compatible when an HP IR printer is used).
- When Bluetooth printer is selected a pairing procedure will be needed in order to match the printer to the instrument. The pairing procedure has to be performed only once.



4.12.1 Flow Chart - Print Menu



Enables the Print Menu. Allows to print the combustion analysis data on a paper ticket which reports the measurement values. The printed values are those shown on the display when the menu is enabled. This menu can be used for combustion analysis, even when recalled from the memory, for draft, smoke and ambient gas results.



Several copies of the test ticket can be printed, choosing among different layouts according to the informations included.

According to the values shown on the display when the menu is activated and the selected ticket layout, the user can choose among different models.

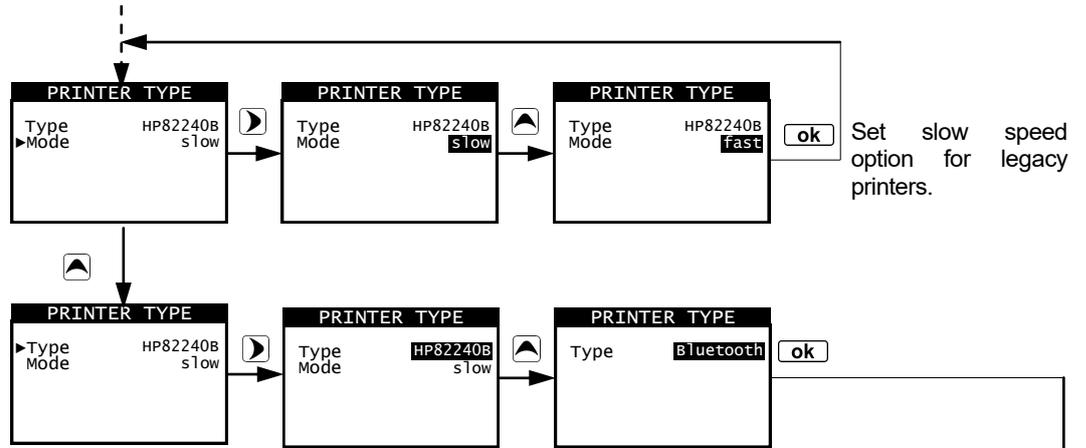
In the examples are reported the cases of printing the analysis under acquisition, printing a single analysis after recall from memory and printing an average analysis after recall from memory.

Go-ahead for printing is given by pressing 'ok' with the PRINT option highlighted in the background.

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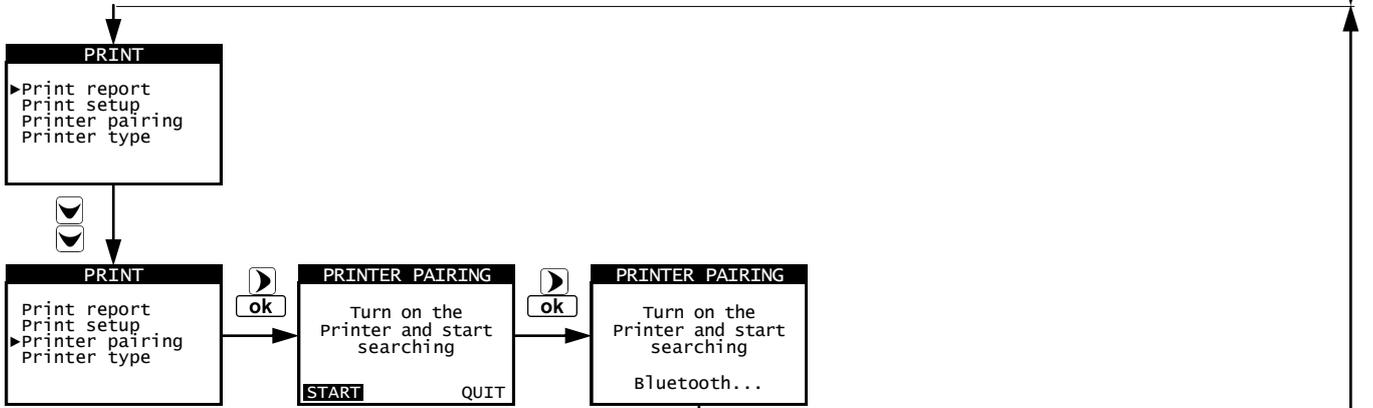


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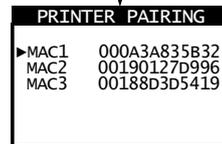
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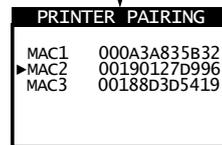


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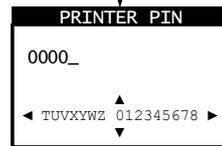
The instrument detects and shows all the Bluetooth devices found.



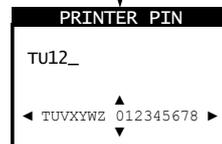
Select the MAC code of the printer that must be connected.



Enter the PIN code of the selected printer to complete the pairing procedure.



Use 'EDIT TEXT' as follows:
 With arrow the proposed code is erased.
 With arrows move the cursor to the position corresponding to the destre letter or digit in order to compose the required PIN number.
 With arrow the selected letter or digit is inserted.
 Press the key to confirm the PIN code just entered.



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4.13 Analysis Menu

Through this key the analysis results are displayed. Moreover the operator is allowed, once this key is further depressed, to display and possibly modify the analysis parameters before proceeding with the measurements.

Measured values are:

O₂:	Oxygen percentage in the fumes.
CO:	CO concentration in the fumes.
NO:	NO concentration in the fumes.
CO₂:	CO ₂ concentration in the fumes.
T_f :	Fumes temperature.
T_a :	Combustion air temperature.

Calculated values are:

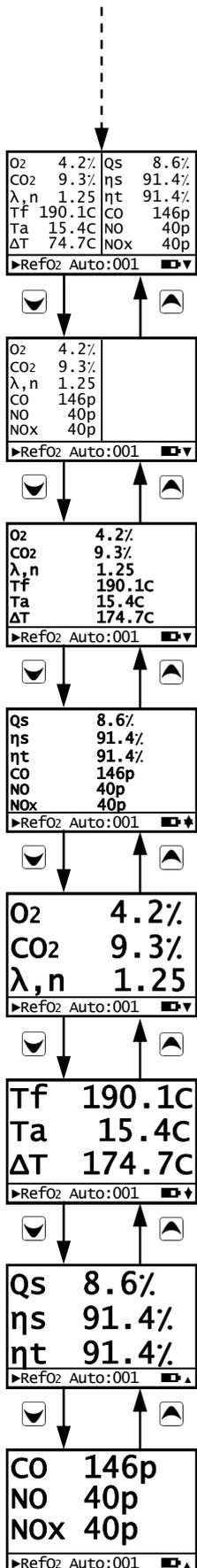
λ, n :	Excess of air, ratio between the combustion air volume and the volume demanded by combustion under stoichiometric conditions.
CO₂:	Carbon dioxide percentage in the fumes.
ΔT :	Difference between flue gases temperature and combustion supply air temperature.
NO_x:	Nitrogen oxides concentration in flue gases.
Q_s:	Percentage of heat lost through the stack.
η_s:	Sensible efficiency. This is the burner efficiency calculated according to the UNI 10389-1 standard, as ratio between the conventional heating power and the burner heating power. Among the combustion losses, only the sensible heat lost with the flue gases is taken into account, thus neglecting the radiation losses and incomplete combustion losses; this value is referred to LHV (Lower Heating Value) and cannot be higher than 100%. The sensible efficiency value is to be compared against the minimum efficiency stated for the heating systems performances.
η_t:	Total efficiency. It is the sum of sensible efficiency and the additional efficiency deriving from the recovery of water vapour condensation contained in the flue gasses, calculated according to the UNI 10389-1 standard. When it is greater than sensible efficiency, then condensation is taking place. It is referred to LHV (Lower Heating Value) and can exceed 100%.

4.13.1 Zoom Menu

This menu can only be accessed when the analysis screen is displayed. This key is used to view the test data on a complete list or multi-page list or to zoom in on displayed text for better reading.



4.13.2 Flow Chart - Analysis Menu (zoom)



O2	4.2%	Qs	8.6%
CO2	9.3%	η_s	91.4%
λ, n	1.25	η_t	91.4%
Tf	190.1C	CO	146p
Ta	15.4C	NO	40p
ΔT	74.7C	NOx	40p
▶RefO ₂ : Auto:001 ◀			

For each of the screens until now shown the display in 'O₂ reference mode' (RefO₂ is highlighted) can be activated or deactivated by pressing the keys.



By pressing the Analysis key once more, and starting from any of the above screens, the user may proceed as follows:



Activates the Analysis Menu.

ANALYSIS SETUP

Mem.: 01
 Fuel.: Natural gas
 Oper.: Mario Rossi
 Rep.: full
 Mode: manual

SELECT MEMORY

Mem.: 001 1□□□
 Date: --/--/-- 2□□□
 Time: --:--:-- 3□□□
 Name: -----

Select the memory wherein to store the acquired data.

FUEL

► Natural gas
 Propane
 L.P.G.
 Butane
 Diesel oil

Select the fuel of the plant being tested.

OPERATOR ID

► 1: Mario Rossi
 2: Luigi Bindi
 3:

Select the test operator.

PRINT SETUP

Copies 1
 Model full
 ► Printer fast

Setup the report printing, selecting the number of copies and the type of report to print.

AUTOMATIC ANALYSIS

► Mode auto
 Duration 120 s
 Print manual

Select the analysis mode - automatic or manual. If automatic mode is selected, define the test time and print mode - automatic or manual.

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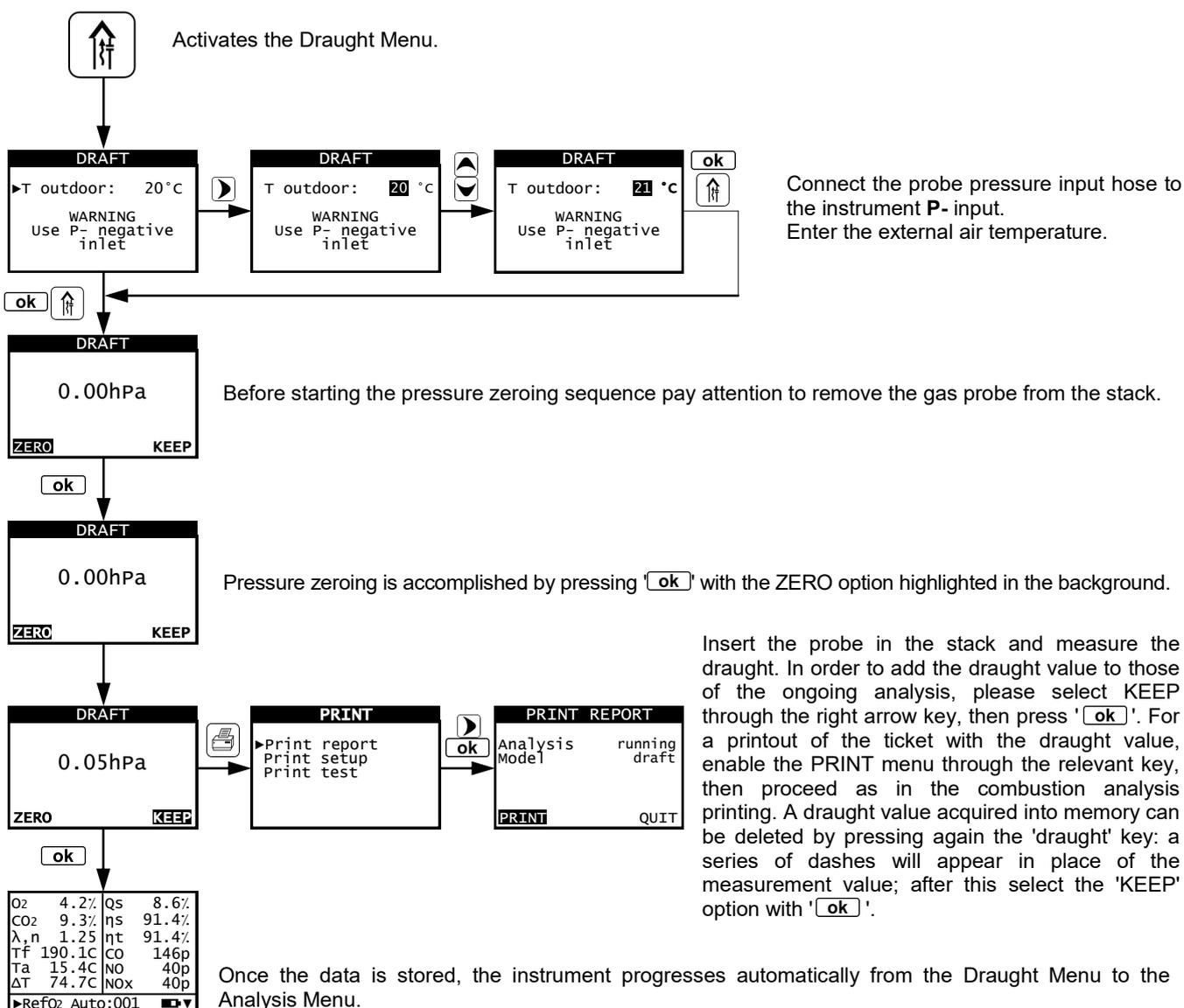
4.14 Draught Menu

The DRAUGHT menu gives access to the stack draught measurement. Being a negative pressure, in accordance with standard UNI10845, draught must be measured using the negative pressure input P-. The correct values for a natural draught boiler are therefore positive by definition. Before performing the measurement the instrument allows the user to input the external air temperature as required by the standard. Afterwards the measurement screen is reached: here the user can acquire the value displayed in order to add it to the running analysis measurements or, alternatively, print the relevant ticket through the 'PRINT' menu.

NOTE: The measurement may not be accurate due to condensation inside the fumes probe. Should you notice an inaccurate or unstable reading on the instrument, it is advisable to disconnect the fumes probe from the instrument itself, and purge pipes by blowing with a compressor. In order to be sure there is no humidity, it is suggested to perform the measurement by means of the transparent rubber pipe supplied on issue.



4.14.1 Flow Chart - Draught Menu



NOTE: The draught values to be stored in the memory must be acquired before performing the flue gas analysis.



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4.15 Readings Menu

This menu is used to access the following readings:

Carbon black:

It is possible to enter the data concerning one to three CARBON BLACK measurements taken by means of an optional device (black-carbon measurement kit); see the relevant instructions.

The method consists in taking a certain quantity of combustion gas from the middle of the flue behind the surfaces of the exchangers at the end of the boiler, and make it pass through a special filter paper. The soot stain obtained is compared with the surfaces blackened in a different way according to a comparison scale; it is thus determined the "soot number", which will be entered in the instrument by hand.

These measurements can be either stored in memory together with the combustion analysis data or printed on a ticket.

Ambient CO:

This type of analysis lets the user measure the CO value present in the environment, with the scope of checking the personal safety conditions of a specific working environment. The instrument leaves our factory with the following preset threshold values:

CO_{max}: 35 ppm Recommended exposure limit (REL) stipulated by the National Institute for Occupational Safety and Health (NIOSH), equivalent to 40 mg/m³ and calculated as an 8-hour Time-Weighted Average (TWA).



It is compulsory to perform the autozero in the clean air, so that the ambient CO measurement is correct. It is advisable to turn on the instrument and wait for the autozero completion outside the area where the test is being performed.

The result of the test can be either associated to the combustion analysis and consequently stored in memory or immediately printed through the 'Print' menu.

Pressure:

It is possible, through the use of the external flexible pipe made in RAUCLAIR (supplied), to measure a pressure value within the range stated in the technical features (connect the pipe to P+ input). During the pressure measurement the 'HOLD' function is made available, which allows to 'freeze' the value shown on the display, by pressing 'HOLD' key.

Tightness test:

According to the version, CASPER can perform the tightness test on heating plants which use combustible gases according to the standards UNI 7129-1: 2015 and UNI 11137: 2012, respectively applicable to new or renewed pipings and to existing pipings, or according to the German standard DVGW TRGI 2008. The result of this tightness test, whose steps are described in the following, can be printed, once acquired, by starting the 'print menu' in any of the screens of the 'Tightness Test' menu.

New piping: UNI 7129-1: 2015 STANDARD (when the instrument version so provides)

The standard UNI 7129-1: 2015 can be adopted for testing new piping systems or reconditioned ones. This test requires to charge the piping up to a pressure between 100 hPa and 150 hPa, then wait for a stabilization which must last at least 15 minutes and required in order for the thermal effects caused by the test gas compression to fade out, and finally to test the piping tightness by analysing the decay of pressure over time.

The maximum pressure decay measured, espressa as a function of the piping volume, must be smaller than the values shown in the following table:

Internal piping volume (liters)	Wait time (minutes)	Maximum pressure decay allowed (hPa)
$V \leq 100$	5	0,5
$100 < V \leq 250$	5	0,2
$250 < V \leq 500$	5	0,1

Table 1.

CASPER allows the user to customize the stabilization phase through the following parameter:

WAIT TIME: it is the stabilization time and can be set by the user from 15 to 99 minutes. Please note that



UNI 7129-1: 2015 standard requires a stabilization time of at least 15 minutes, anyway there is the possibility to skip stabilization by pressing '**ok**' button.

PIPING VOLUME: An accurate tightness test performed according to the UNI 7129-1: 2015 standard requires to know the piping volume. Because this data is often unavailable, CASPER splits the test from the beginning into two different paths: the first is adequate for pipings having volume smaller than 100 dm³ (liters); this is the most usual situation: in this case the volume value is not required because, through an 'overestimation' the piping is assumed as having a volume of 100 dm³. The second path requires to input the piping value either directly through the keyboard when known, or by a calculation which takes into account the sum of the contributions due to each single pipe section or, finally, by measuring it through a simple procedure which requires the injection into the piping of a known gas quantity through a graduated syringe.

In case the volume calculation is used, for each single piping section the 'Add tube' option must be selected and then input the relevant material, nominal diameter and length. CASPER calculates the single section volume and adds it, when confirmed, to the total piping value. For error correction or for modifying the ongoing calculation the subtraction operation is also available.

When the 'Volume measurement' option is selected instead, the procedure, described also in the flow charts of the tightness test according to UNI 7129-1: 2015, is described in the following steps:

- Close both faucets in the kit assembly supplied for the test execution.
- Connect the graduated syringe to the hose which in the assembly is opposed to the pump.
- Open the faucet on the side where the syringe is applied and withdraw exactly 100 ml (100 cc) of the gas present in the piping. Press the '**ok**' button.
- Inject the gas present in the syringe back into the piping and then close the faucet again.
- Wait for the pressure in the piping to stabilize. After a few seconds the instrument returns to the volume input screen in which the measured volume is shown. The proposed value can be accepted by pressing the '**ok**' button, modified through the arrow keys or rejected through the '**ESC**' key.

Once the stabilization parameter has been set the user can proceed with the tightness test. Selecting the item 'Start Test', the test pressure required by the standard is shown, then a screen with actual pressure applied to the instrument inputs is displayed. After having zeroed the instrument and, subsequently, having charged the piping with at least 100 mbar, the tightness test can be started through the option 'TEST', which actually starts the stabilization phase. In the stabilization screen the following values are displayed:

P: Actual pressure measured by the instrument, in the selected measurement unit.

ΔP1': Pressure variation in the last minute, updated every 10 seconds. This value gives a rough indication about the stabilization level reached in the piping system.

Wait time: Remaining time before the stabilization phase ends.

Once the stabilization phase is terminated the tightness test is started. This test is performed by observing how the pressure decays over a fixed time interval of 5 minutes, as required by the standard.

During the tightness test phase the following values are displayed:

P1: Pressure measured at the beginning of the test.

P2: Pressure actually measured by the instrument.

ΔP: Pressure variation with respect to the initial value. In case the actual pressure is lower than the initial value (pressure is decreasing) this value has a negative sign.

Result: Reports the test result:

tight when the pressure is within the limit of table 1.

leak when the pressure is outside the limit of table 1.

Positive pressure changes are symptom of a temperature change meanwhile the test is performed. Should this happen it is advisable to repeat the entire test.

Existing piping: UNI 11137: 2012 STANDARD (when the instrument version so provides)

The standard UNI 11137: 2012 can be adopted for testing already existing internal piping systems. This test requires to charge the piping up to the test pressure, then wait for an unspecified stabilization time until the thermal effects caused by the test gas compression are ZEROed, and then calculate the amount of the possible leakage from the measure of the pressure decays in 1 minute time for Methane and LPG in air and 2.5 minutes for the LPG fuel. The test pressure should be as close as possible as the reference conditions following explained.

REFERENCE CONDITIONS: According to the combustible gas to be used in the piping, the tightness test must be performed in one of the following reference conditions:

Natural gas: Reference pressure for test with supply gas 2200 Pa



	Test pressure with air	5000 Pa
L.P.G.:	Reference pressure for test with supply gas	3000 Pa.
	Test pressure with air	5000 Pa.

Note: CASPER allows the user to perform the tightness test even with a combustible gas different from the supply gas. Anyway the reference standard does not provide a reference pressure in this situation, so the reference pressure is taken like test gas is the same. Test result should be considered only indicative.

CASPER allows the operator to customize the stabilization phase through the following parameter in the stabilization menu:

WAIT TIME: the stabilization phase duration can be set in the 1 .. 99 minutes range. As the UNI 11137: 2012 standard does not prescribe any stabilization duration, the factory setting for this value is borrowed from the UNI 7129-1: 2015 standard, which requires a minimum stabilization time of 15 minutes. The waiting can be interrupted any time by pressing the 'ok' key, even in case the interval has not fully elapsed.

The tightness test performed according to the UNI 11137: 2012 standard requires the input of some data regarding the piping system and the test conditions, as described in the following.

PIPING VOLUME: An accurate tightness test performed according to the UNI 11137: 2012 standard requires to know the piping volume. Because this data is often unavailable, CASPER splits the test from the beginning into two different paths: the first is adequate for pipings having volume smaller than 18 dm³ (liters); this is the most usual situation: in this case the volume value is not required because, through an 'overestimation' the piping is assumed as having a volume of 18 dm³. The second path requires to input the piping value either directly through the keyboard when known, or by a calculation which takes into account the sum of the contributions due to each single pipe section or, finally, by measuring it through a simple procedure which requires the injection into the piping of a known gas quantity through a graduated syringe.

In case the volume calculation is used, for each single piping section the 'Add tube' option must be selected and then input the relevant material, nominal diameter and length. CASPER calculates the single section volume and adds it, when confirmed, to the total piping value. For error correction or for modifying the ongoing calculation the subtraction operation is also available.

When the 'Volume measurement' option is selected instead, the procedure, described also in the flow charts of the tightness test according to UNI 11137: 2012, is described in the following steps:

- Close both faucets in the kit assembly supplied for the test execution.
- Connect the graduated syringe to the hose which in the assembly is opposed to the pump.
- Open the faucet on the side where the syringe is applied and withdraw exactly 100 ml (100 cc) of the gas present in the piping. Press the 'ok' button.
- Inject the gas present in the syringe back into the piping and then close the faucet again.
- Wait for the pressure in the piping to stabilize. After a few seconds the instrument returns to the volume input screen in which the measured volume is shown. The proposed value can be accepted by pressing the 'ok' button, modified through the arrow keys or rejected through the 'esc' key.

Table volumes: Examples relating to the various lengths of indoor systems, capacity approximately corresponding to 18dm³, depending on the material and the diameter of the fuel gas adduction pipe.

Steel		Copper / Multilayer/ Polyethylene	
Diameter	length (m)	Internal diameter (mm)	length (m)
1/2"	82 (68)	10	228 (190)
3/4"	49 (40)	12	160 (133)
1"	28 (23)	14	116 (97)
1 1/4"	17 (14)	16	90 (75)
		19	64 (53)
		25	37 (31)
		26	34 (28)
		34	20 (17)

Note: When the measurement group can not be excluded from the test, the indicative length of the plant is given in brackets.



COMBUSTIBLE GAS: consider that the amount of the leakage is strictly related to the nature of the gas under pressure. When the tightness of a piping has to be evaluated it is mandatory to specify the family to which the gas belongs: Natural Gas or L.P.G..

TEST GAS: again the amount of the leakage is related to the nature of the gas under pressure, therefore it is mandatory to specify the type of the gas used: Natural Gas, L.P.G. or air. Please note that the gas used for the test could also be different from the gas to be used in the plant and could even be a not flammable gas.

Once the stabilization parameter has been set the user can proceed with the tightness test. Selecting the item 'Start Test', the test pressure required by the standard is shown, then a screen with actual pressure applied to the instrument inputs is displayed. After having zeroed the instrument and, subsequently, having charged the piping to a pressure close to the reference values indicated, tightness test can be started through the option 'TEST', which actually starts the stabilization phase. In the stabilization screen the following values are displayed:

- P:** Actual pressure measured by the instrument, in the selected measurement unit.
- ΔP1':** Pressure variation in the last minute, updated every 10 seconds. This value gives a rough indication about the stabilization level reached in the piping system.
- Wait time:** Remaining time before the stabilization phase ends.

Once the stabilization phase is terminated the tightness test is started. This test is performed by observing how the pressure decays in time during a fixed 1 minute interval for Methane and LPG in air and 2.5 minutes for the LPG fuel, as stated in the applied standard.

During the tightness test phase the following values are displayed:

- P1:** Pressure measured at the beginning of the test
- P2:** Pressure actually measured by the instrument
- ΔP:** Pressure variation with respect to the initial value. In case the actual pressure is lower than the initial value (pressure is decreasing) this value has a negative sign.
- Qtest:** Is the calculated leakage measured in dm^3/h according to the conditions under which the test has been performed, i.e. the gas used for the test as well as the final pressure measured during the test.
- Qref:** is the calculated leakage measured in dm^3/h according to the reference conditions described in the standard, it is related to the gas to be used in the piping as well as to the reference pressure.
- Result:** is the result of the tightness test.

Compliant (piping suitable for operation): when the leakage flow calculated in the reference conditions is not greater than $1 \text{ dm}^3/\text{h}$ for methane and not greater than $0,4 \text{ dm}^3/\text{h}$ for LPG the system is authorized to operate without restrictions or intervention.

Compl. 30 DD (piping temporarily suitable for operation): when the leakage flow calculated in the reference conditions is included in the range $1 \text{ dm}^3/\text{h} < Q_{\text{ref}} \leq 5 \text{ dm}^3/\text{h}$ for methane and in the range $0,4 \text{ dm}^3/\text{h} < Q_{\text{ref}} \leq 2 \text{ dm}^3/\text{h}$ for LPG. The system is authorized to operate only for the time needed for the maintenance of the pipe in order to fix the leakage problem, and in any case for no more than 30 days after the testing day. Once the fixing has been completed the piping must be tested again for its tightness according to the UNI 7129-1: 2015 standard.

Non compliant (not suitable for operation): when the leakage flow is greater than $5 \text{ dm}^3/\text{h}$ for methane and greater than $2 \text{ dm}^3/\text{h}$ for LPG. In this situation the measured leakage is such that the piping is not suitable for operation and must immediately be placed out of order. Once the leakage problem has been fixed the piping must be tested again for its tightness according to the UNI 7129-1: 2015 standard.

Tightness test according DVGW TRGI (when the instrument version so provides):

With the flue gas analyzer CASPER (according to the model) it is possible to test gas lines (DVGW TRGI 2008).

This test procedure is valid for gas lines with maximum operating pressure of 100 mbar:

The Standard DVGW TRGI 2008 is valid for new or after servicing existing gas lines. The tightness test uses a test pressure of 150mbar (test gas: air) all other parameters have to be selected according to the gas line volume: waiting time and time duration for the test (time duration when the gas line is under pressure with 150 mbar).

Tightness test - DVGW TRGI 2008		
Volume of the gas line *	Waiting time before test starts	min. duration for the test
< 100 l	10 min	10 min
≥ 100 l bis 200 l	30 min	20 min
≥ 200 l	60 min	30 min

* Benchmark



waiting time (Stabilization phase): You can edit manually the waiting time according to the volume of the gas line before you start the test procedure. The range is variable from 10 ... 99 minutes.

P: Current pressure measured when waiting time started.

ΔP_1 : Current pressure difference.

wait time: Time to stabilize the pressure in the gas line, the pressure must be higher than 150 mbar. On the display is the timer shown (count backwards).

Minimum duration time of tightness test according to the volume of the gas line: **duration time**

Waiting time according to the volume of the gas line: **wait time**

After the waiting time is finished the tightness test can start.

During the tightness test the following values measured for the duration time of the test will be shown at the display:

P1: Pressure measured at the moment the tightness test begins (minimum 150 mbar).

P2: Current measured pressure.

ΔP : Pressure difference between start and finished test; negative value means pressure drop.

Result: **tight or leak.**

According to DVGW TRGI 2008 - no pressure drop is allowed!

It is possible to enter the data of the gas line (e.g. location, ...). They are shown later on the print out (report).

If duration time or waiting time varies (according to the DVGW Standard) you can change the used time by yourself.

The loading and the serviceability test can not be tested with the flue gas analyzer CASPER, you have to use other measuring devices.

TcK Temperature:

The user can measure the temperatures within the range specified in the technical specifications (e.g. plant delivery temperature) by using an OPTIONAL Type K thermocouple contact probe connected to the TcK input.

Pt100 Temperature:

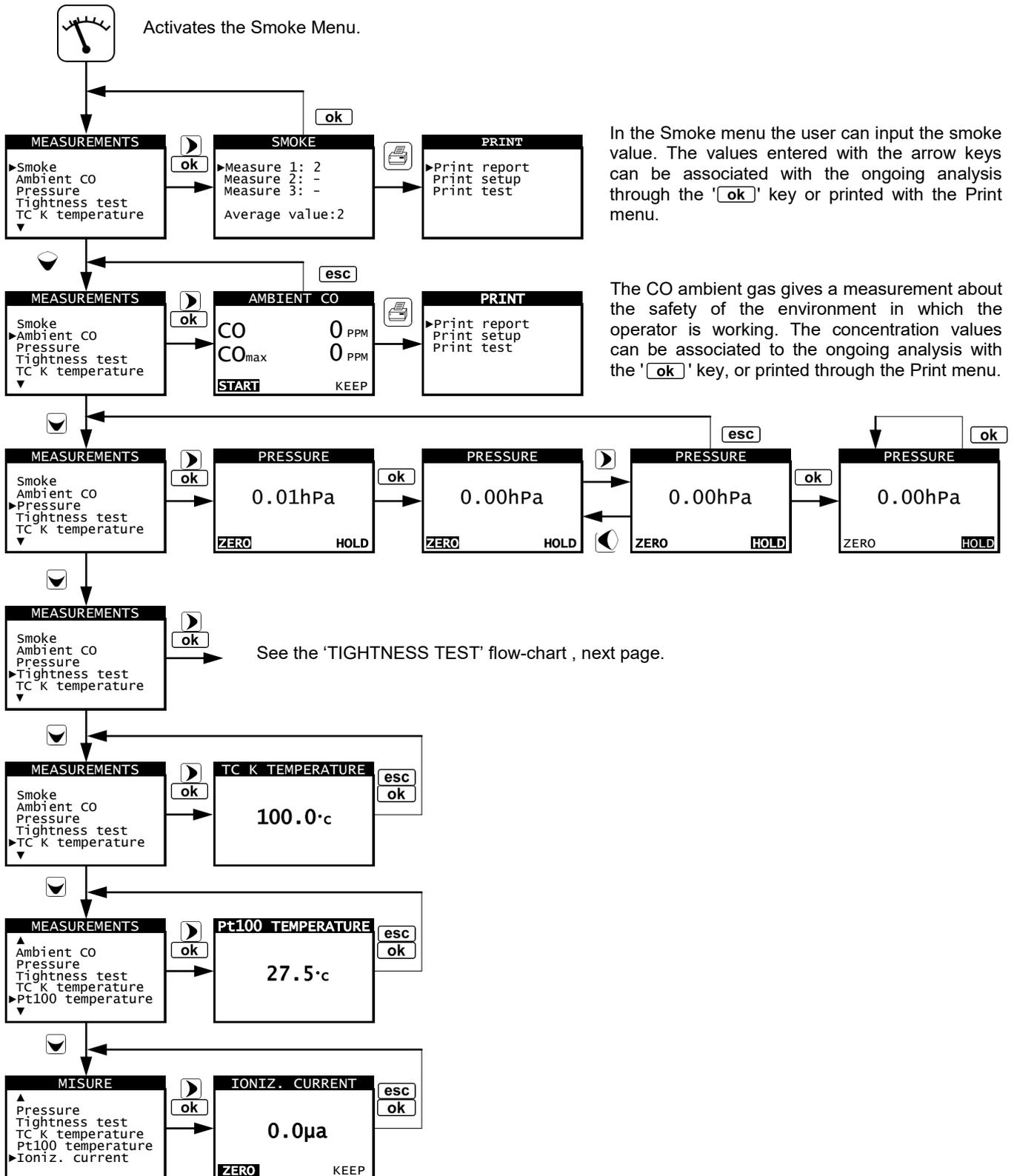
The ambient temperature can be measured within the range specified in the technical specifications by connecting the remote air temperature probe provided with the instrument to the Pt100 input.

Ioniz. current:

It is possible to measure the ionization current of a boiler and check its value depending on the boiler's technical features by connecting the ionization probe (optional) to the serial cable socket (visible in **N** on page 10).



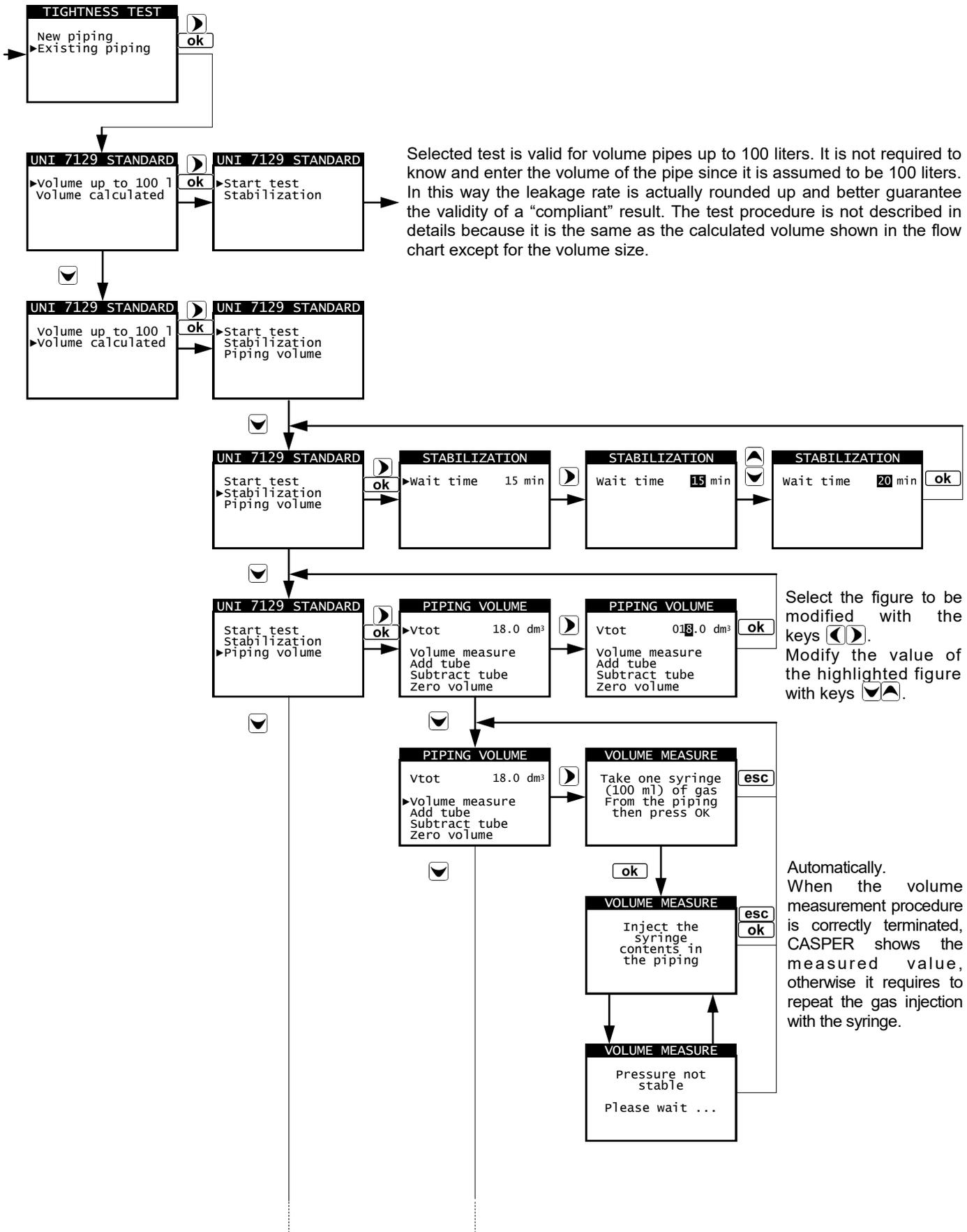
4.15.1 Flow Chart - Readings Menu





Tightness test according to UNI 7129-1: 2015 standard (where instrument so provides)

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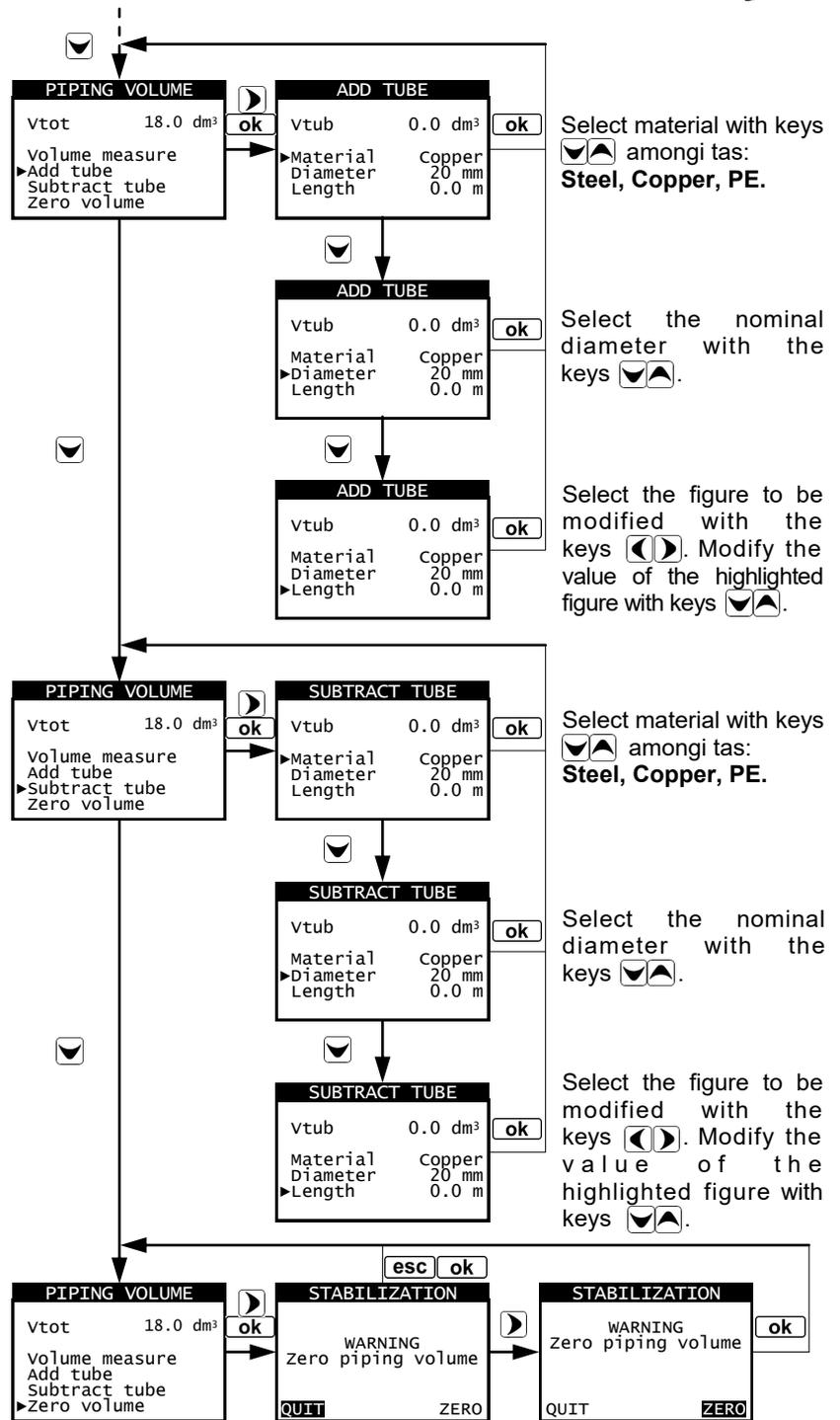
Selected test is valid for volume pipes up to 100 liters. It is not required to know and enter the volume of the pipe since it is assumed to be 100 liters. In this way the leakage rate is actually rounded up and better guarantee the validity of a “compliant” result. The test procedure is not described in details because it is the same as the calculated volume shown in the flow chart except for the volume size.

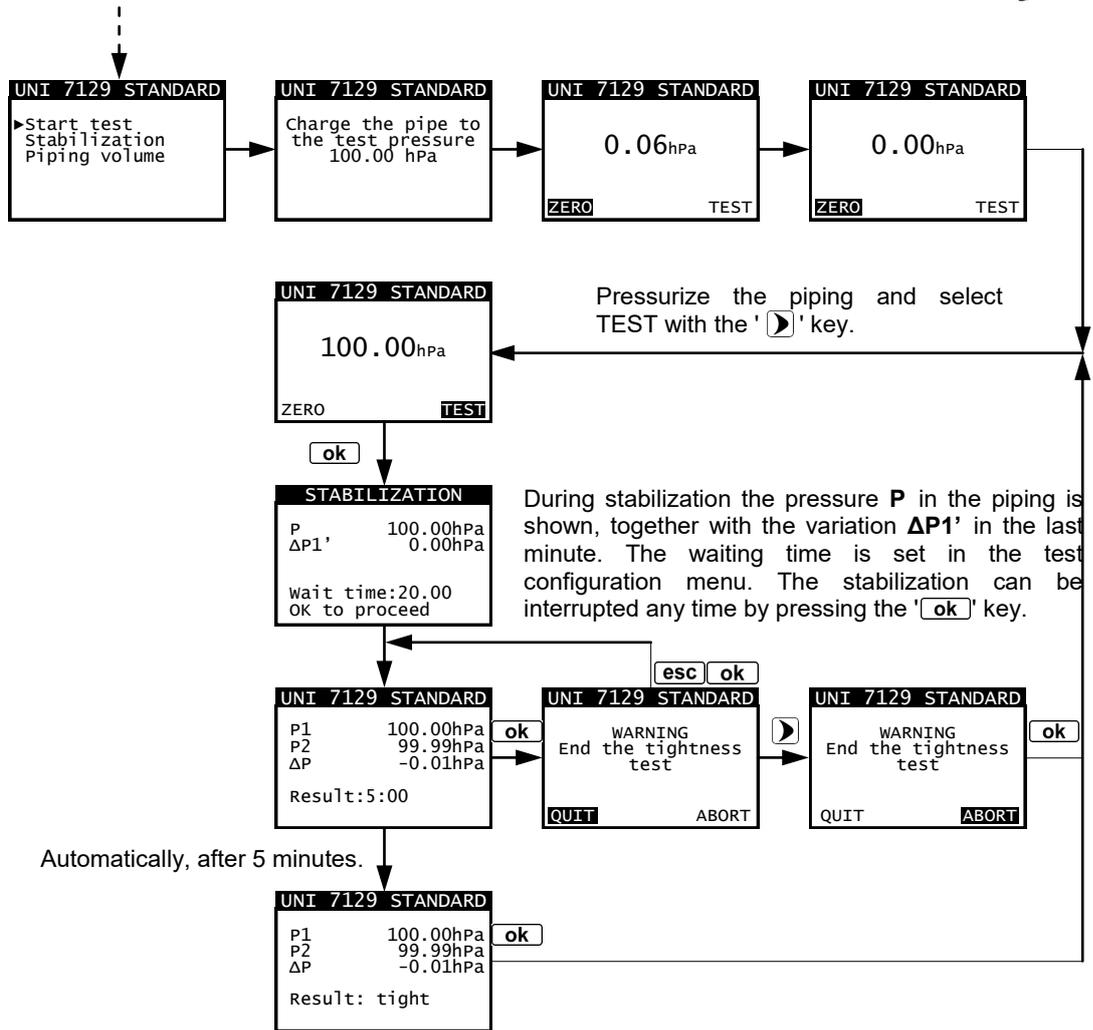
Select the figure to be modified with the keys **←** **→**. Modify the value of the highlighted figure with keys **↑** **↓**.

Automatically. When the volume measurement procedure is correctly terminated, CASPER shows the measured value, otherwise it requires to repeat the gas injection with the syringe.



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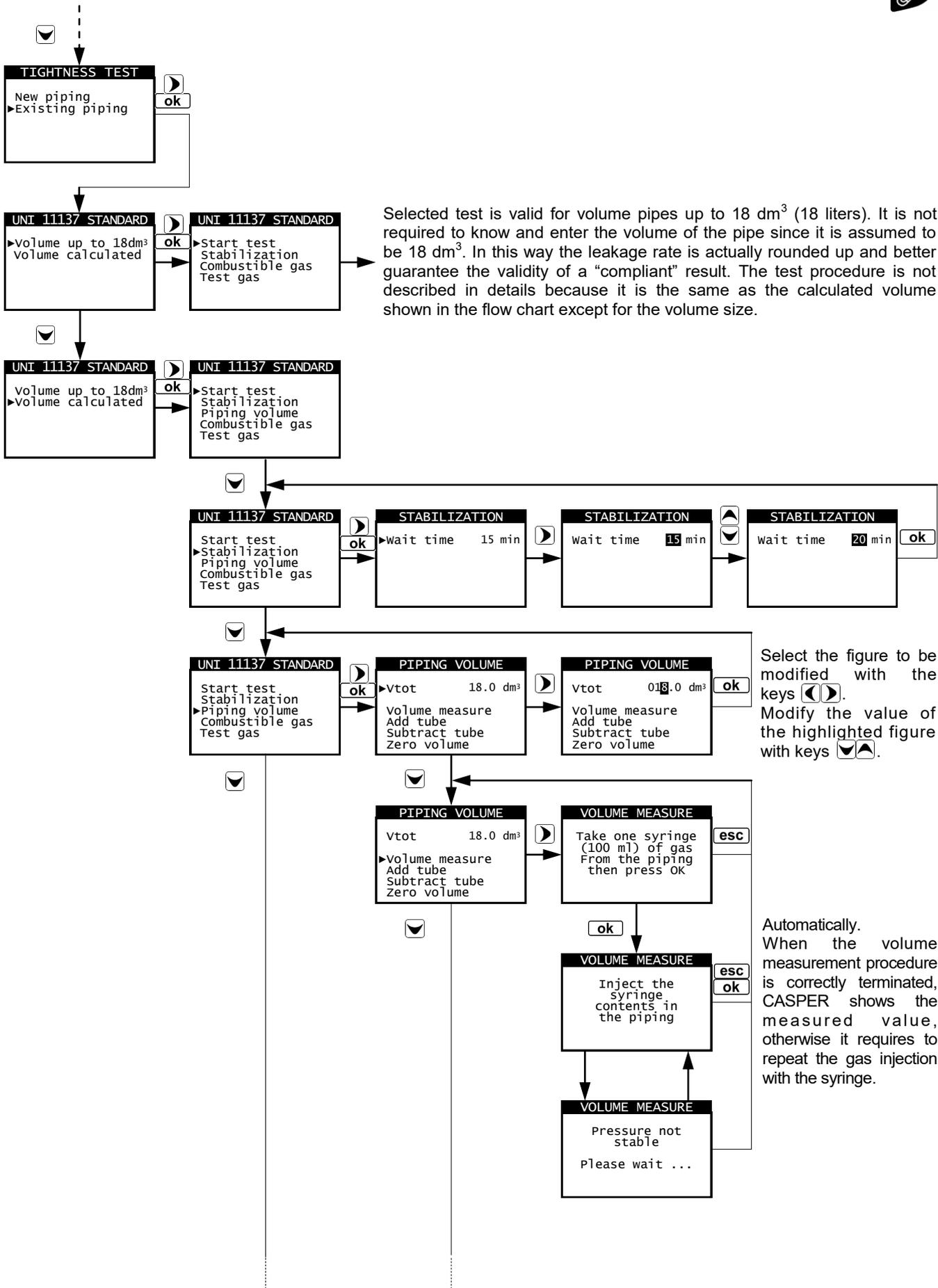


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Tightness test according to UNI 11137: 2012 standard (where instrument so provides)



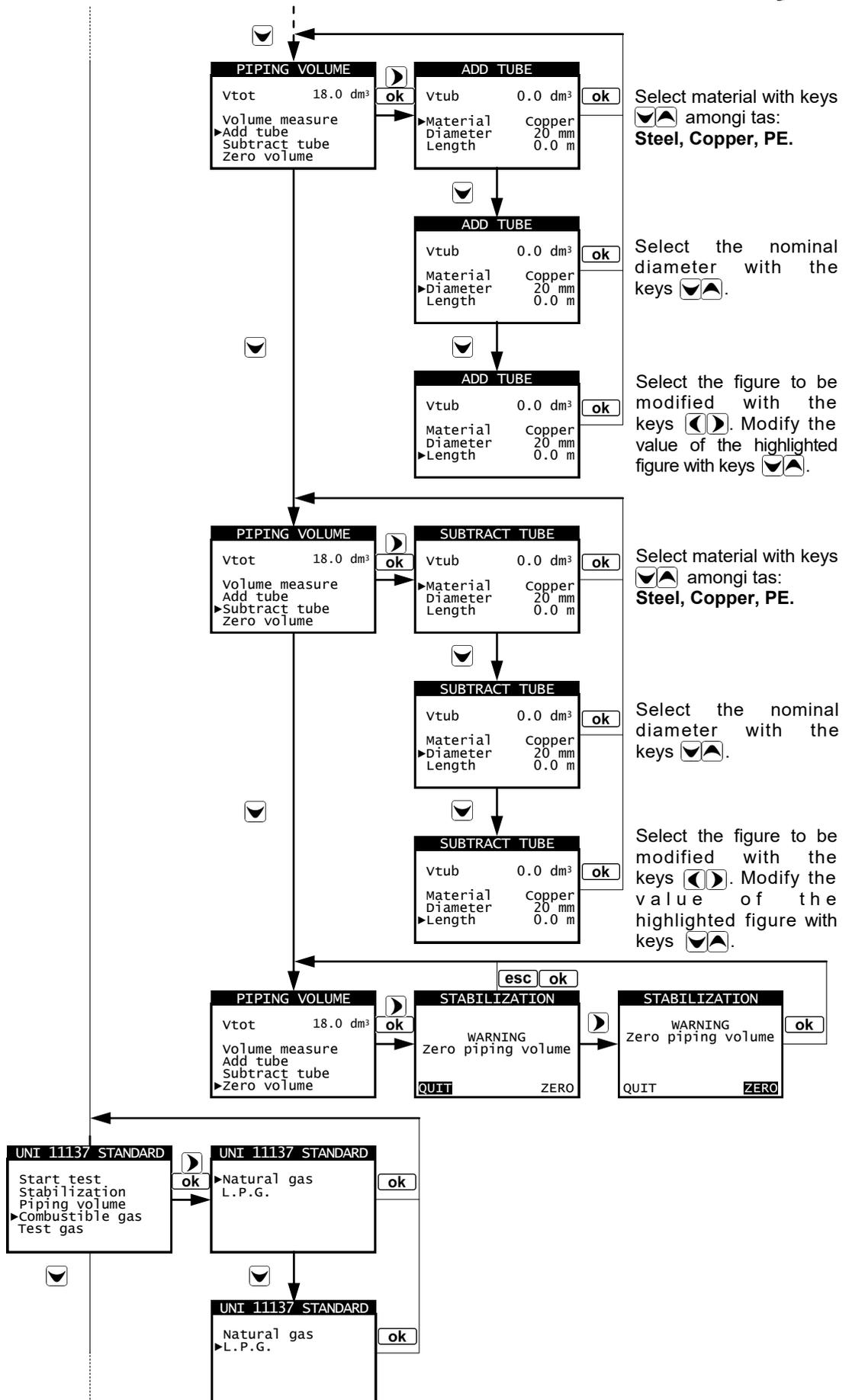
Selected test is valid for volume pipes up to 18 dm³ (18 liters). It is not required to know and enter the volume of the pipe since it is assumed to be 18 dm³. In this way the leakage rate is actually rounded up and better guarantee the validity of a “compliant” result. The test procedure is not described in details because it is the same as the calculated volume shown in the flow chart except for the volume size.

Select the figure to be modified with the keys **←** **→**. Modify the value of the highlighted figure with keys **↑** **↓**.

Automatically. When the volume measurement procedure is correctly terminated, CASPER shows the measured value, otherwise it requires to repeat the gas injection with the syringe.



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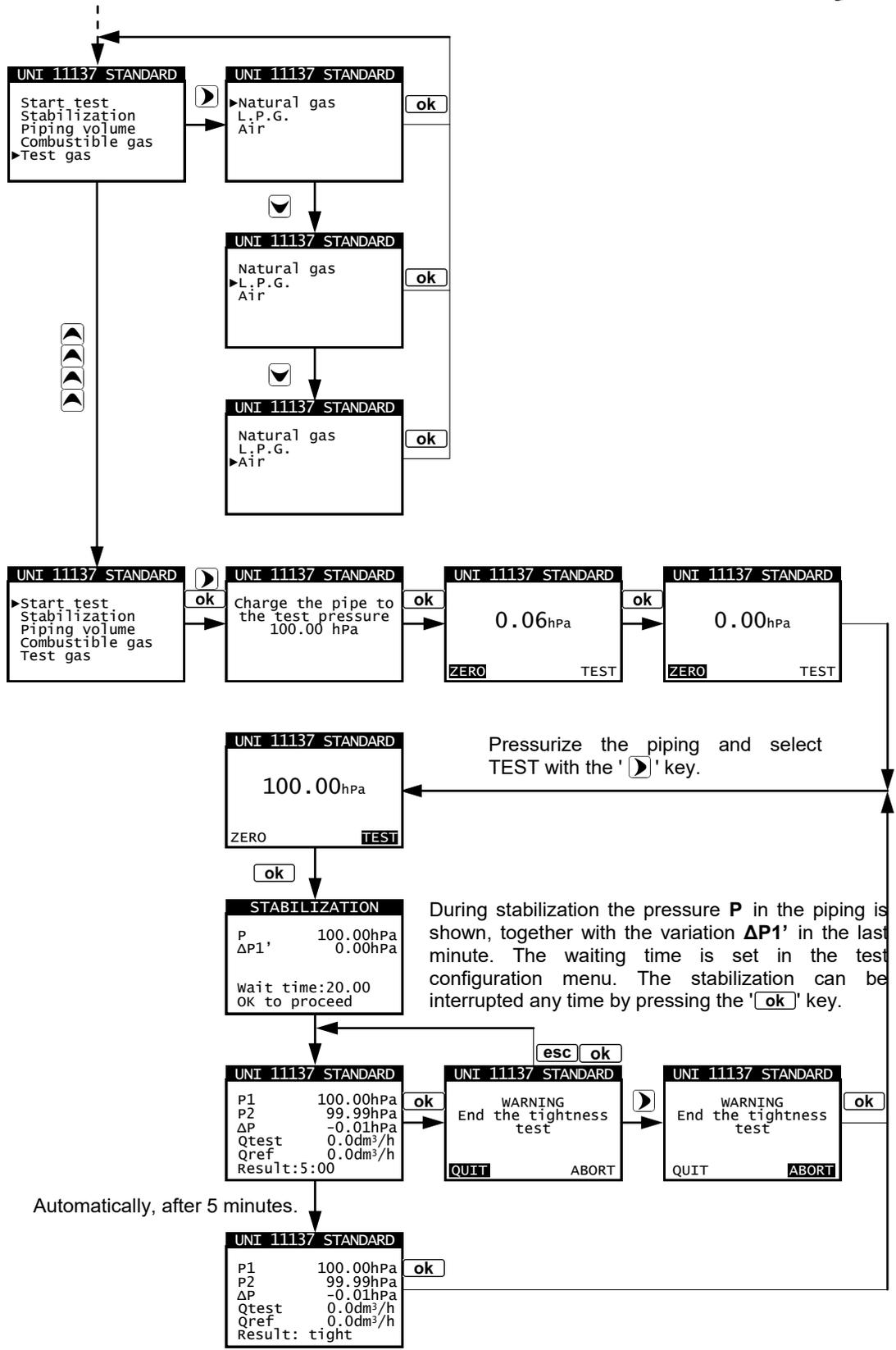
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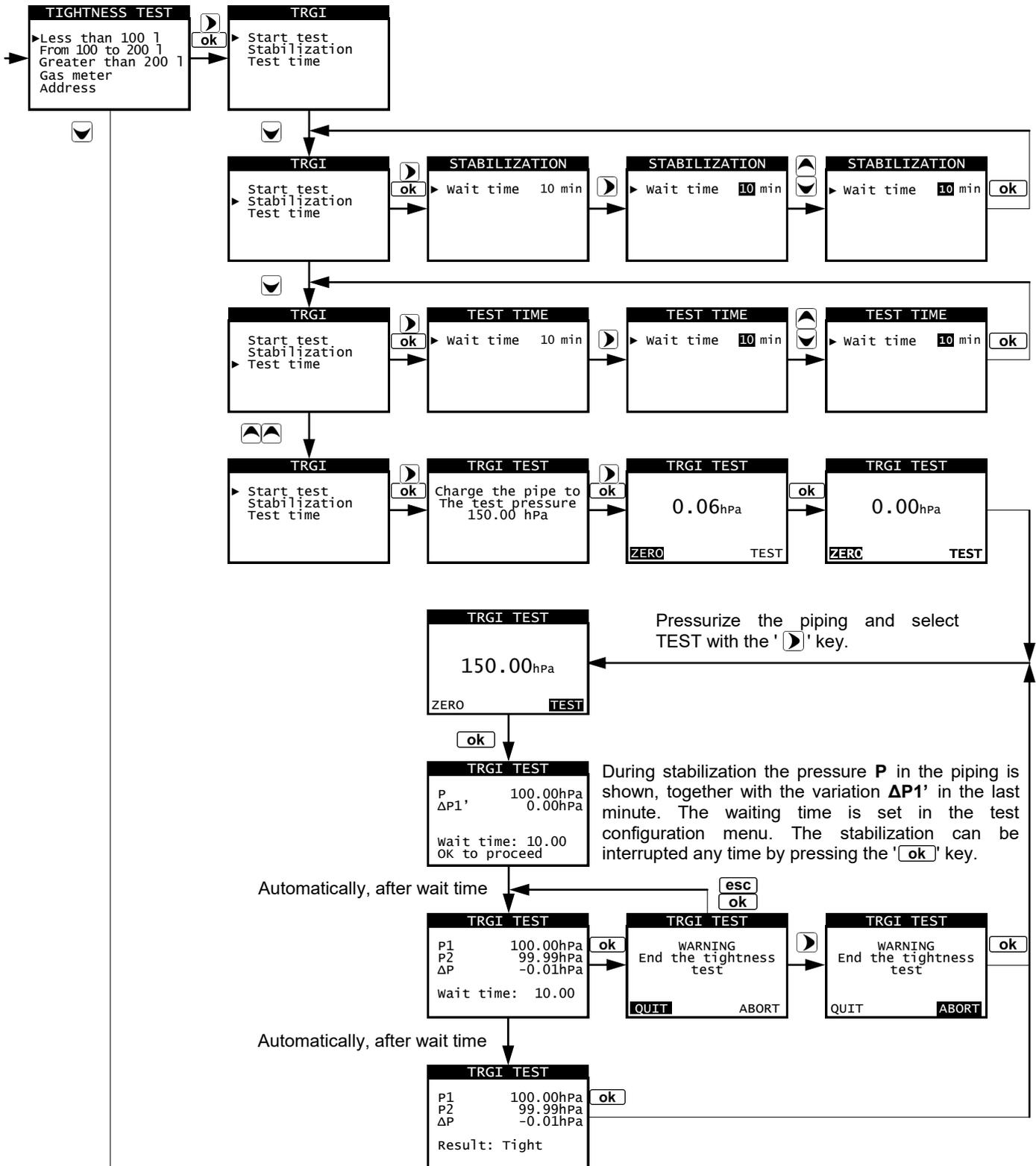
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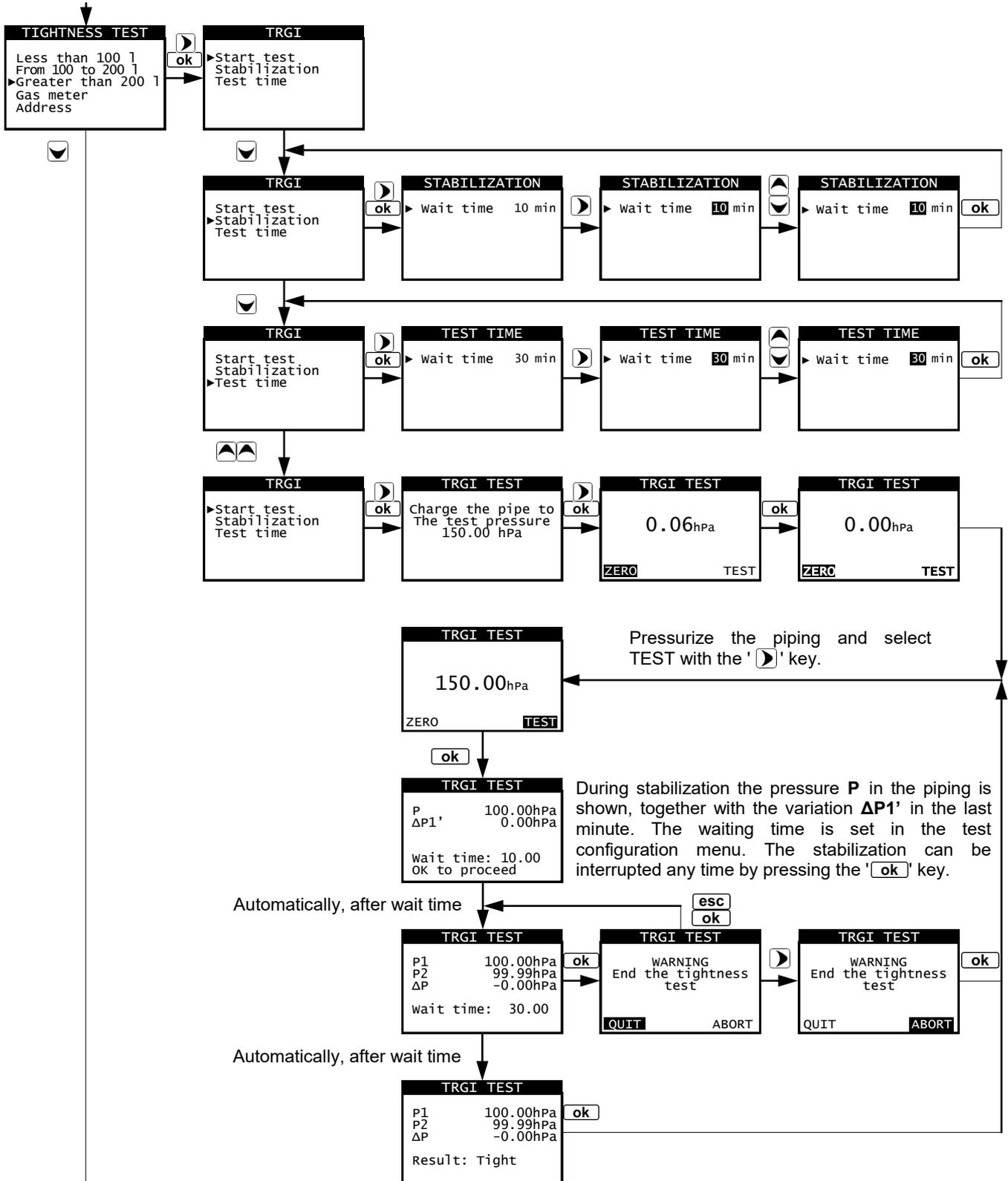
Tightness test according to DVGW TRGI 2008 standard (where instrument so provides)

Perform a tightness test for a gas line up to 100 liter.





Perform a tightness test for a gas line with volume greater 200 liter.



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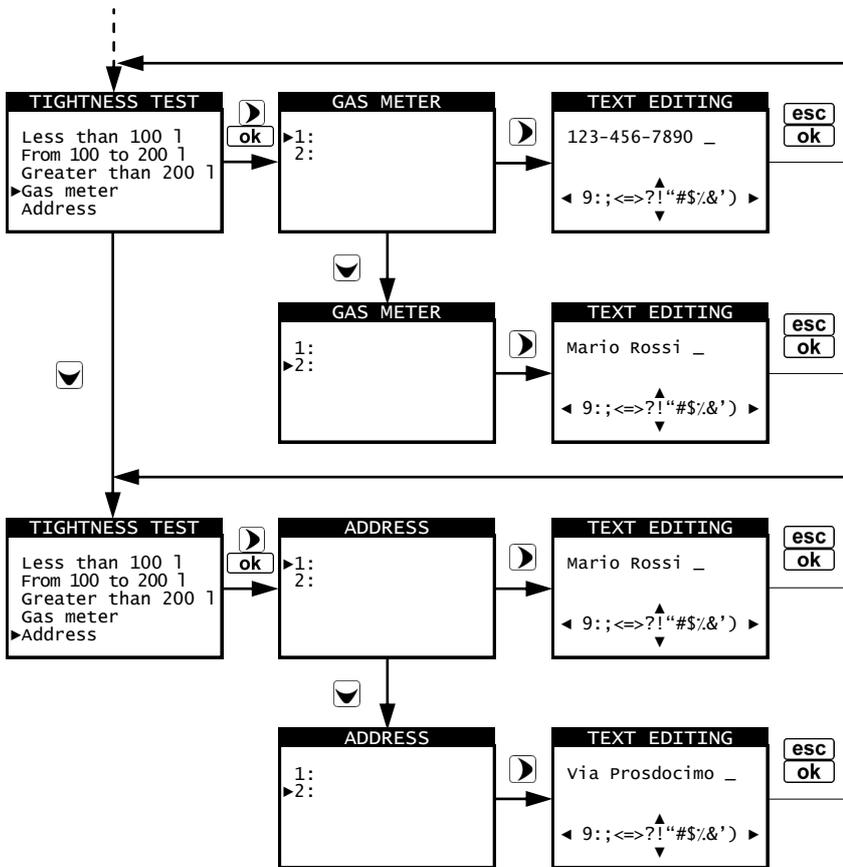
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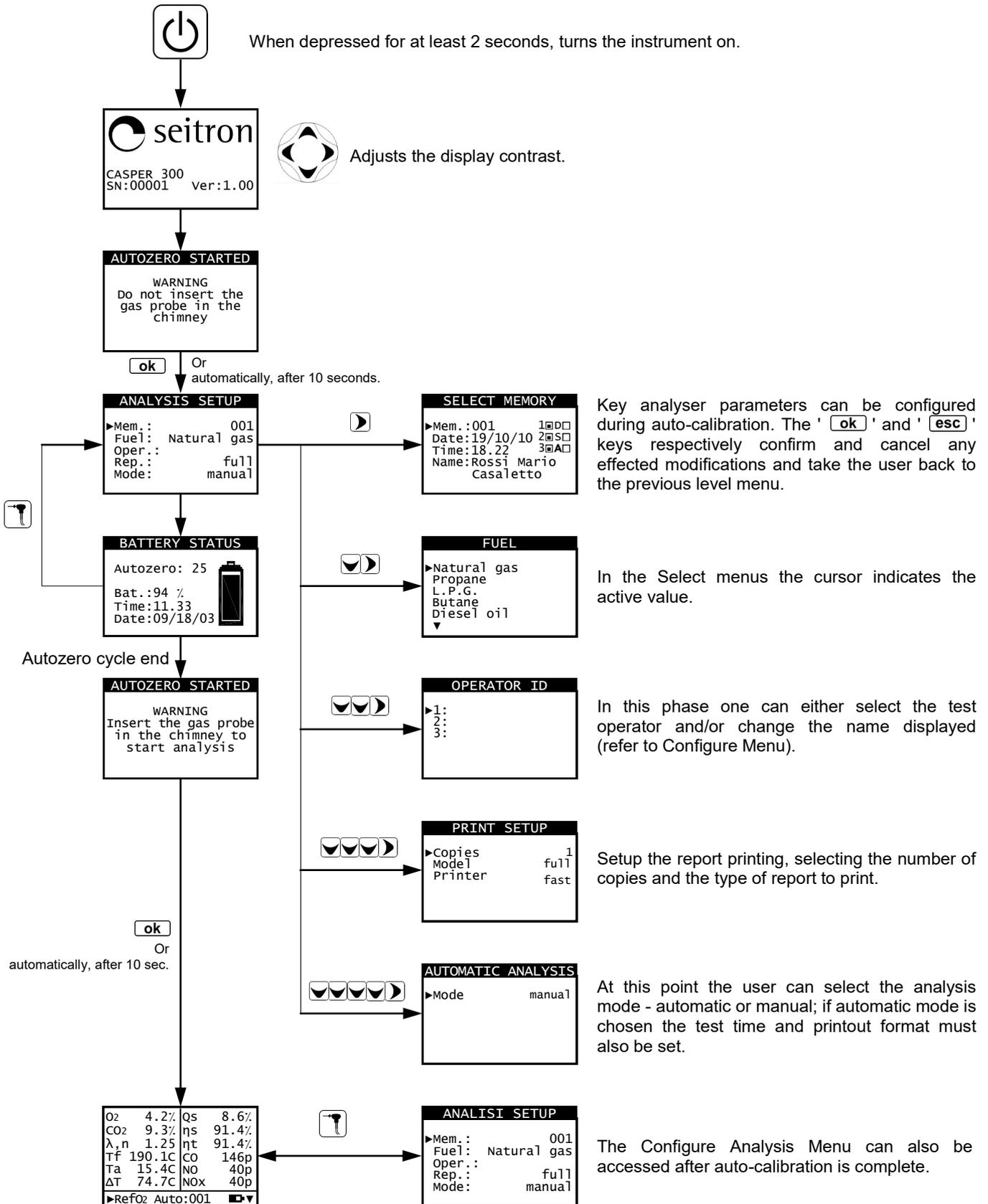
Use the "EDIT TEXT" function as follows: Using the cursor keys, go to the box that corresponds to the letter or number required to form the desired word, and press to confirm.

When you have finished striking in the desired text, still using the cursor keys, go to **OK** to confirm the entered data or to **es** to exit without saving, and press the relative or button. The task is done.

If you wish to modify a letter or a whole line, all you need to do is position the cursor in front of the letter to be cancelled by means of the cursor keys in the first row of controls.

At this point go to the second row of controls and press the key on the keypad. In this way the letter preceding the cursor can be cancelled, after which the desired text can be entered or the user can confirm and exit.

4.16 Flow Chart - Configure Analysis Menu



4.17 FLUE GAS ANALYSIS

To perform complete flue gas analysis, follow the instructions below.



SOME IMPORTANT WARNINGS TO CONSIDER DURING THE COMBUSTION ANALYSIS ARE LISTED BELOW:

FOR A CORRECT ANALYSIS NO AIR MUST FLOW INTO THE PIPE FROM OUTSIDE DUE TO A BAD TIGHTENING OF THE CONE OR A LEAK IN THE PIPELINE.

THE FUMES PIPE MUST BE CHECKED IN ORDER TO AVOID ANY LEAKAGES OR OBSTRUCTIONS ALONG THE PATH.

THE CONNECTORS OF THE FUMES PROBE AND OF THE CONDENSATE FILTER MUST BE WELL CONNECTED TO THE INSTRUMENT.

KEEP THE CONDENSATE TRAP IN THE VERTICAL POSITION DURING THE ANALYSIS; A WRONG POSITIONING MAY CAUSE CONDENSATE INFILTRATIONS IN THE INSTRUMENT AND THUS DAMAGE THE SENSORS.

DO NOT PERFORM ANY MEASUREMENT WHEN THE FILTER IS REMOVED OR DIRTY IN ORDER TO AVOID ANY RISK OF IRREVERSIBLE DAMAGES ON SENSORS.



4.17.1 Switching on the instrument and auto-calibration

Press the On/Off key to switch on the instrument - an introductory screen will appear. After a couple of moments the instrument will zero itself and will state that the sample probe should not be inserted in the stack.

It is important that the sample probe is not inside the stack since, during auto-calibration, the instrument draws fresh air from the environment and detects the zero value of the O₂, CO and NO sensors, the details of which are then memorised and used for reference during the analysis. It is equally important that this phase is performed in a fresh-air environment.

The pressure sensor is also zeroed during auto-calibration.

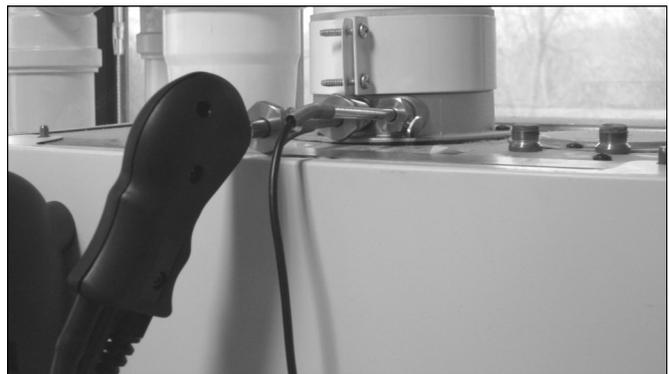
4.17.2 Inserting the probe inside the stack

When auto-calibration is complete the instrument will instruct the user to insert the sample probe that has been previously connected to the relative input on the instrument, and the analysis screen will appear automatically.

In order for the probe to be inserted at the right point within the stack, its distance from the boiler has to be twice the diameter of the stack pipe itself or, if this is not possible, must comply with the boiler manufacturer's instructions.

In order to position the probe correctly, a reliable support must be provided by drilling a 13/16 mm hole in the manifold (unless already present) and screwing in the positioning cone provided with the probe - in this way no air is drawn from the outside during sampling.

The screw on the cone allows the probe to be stopped at the right measuring depth - this usually corresponds to the centre of the exhaust pipe. For greater positioning accuracy, the user may insert the probe gradually into the pipe until the highest temperature is read. The exhaust pipe must be inspected before carrying out the test, so as to ensure that no constrictions or losses are present in the piping or stack.



4.17.3 Flue Gas Analysis

After the sample probe has been inserted in the stack and the combustion air temperature probe (if used) has been inserted in the relative sample manifold, if the instrument has not been configured during auto-calibration, the following data must be configured:

Memory: use this submenu to define the memory in which the test data and client details are to be stored.

Fuel: the user will be asked to define the type of fuel used by the plant.

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Operator: this is where the name of the test operator can be entered.
Mode: by entering this submenu, the user can determine the analysis mode - manual or automatic.
 If automatic mode is chosen, the reading duration of each and every test must be set, besides the printing mode - manual or automatic. When flue gas analysis begins, the instrument will perform and memorise the three tests automatically, at the respective intervals set (at least 120 sec. according to UNI 10389-1).
 At the end of each test the instrument will emit an audible alarm (one "beep" after the first test, two "beeps" after the second test and three "beeps" after the third test).
 At this point, when all three tests are over, if "Manual Printing" has been chosen the instrument will display the average of the three tests with the possibility of recalling the individual values.
 If desired, the user can then print the relative data (total, complete, etc...). On the contrary, if "Automatic Printing" was selected, the instrument will print the test data automatically, based on the current print settings, without displaying the average test values.

Caution: when in automatic mode Draught, Smoke and ambient CO measurements must be taken before initiating the flue gas analysis.

If, on the other hand, manual analysis mode is chosen, flue gas analysis will proceed manually (please see relative Flow Chart). In this case the print settings and automatic test duration will not be considered.
 At this point manual analysis may commence, first waiting at least two minutes until the displayed values stabilise: The user can then proceed with data storage, if required, or print the analysis report directly. The latter will be printed in the format set beforehand.
 When all three tests are over, the user can recall the average analysis screen containing all the data necessary for compiling the maintenance log of the boiler or plant.

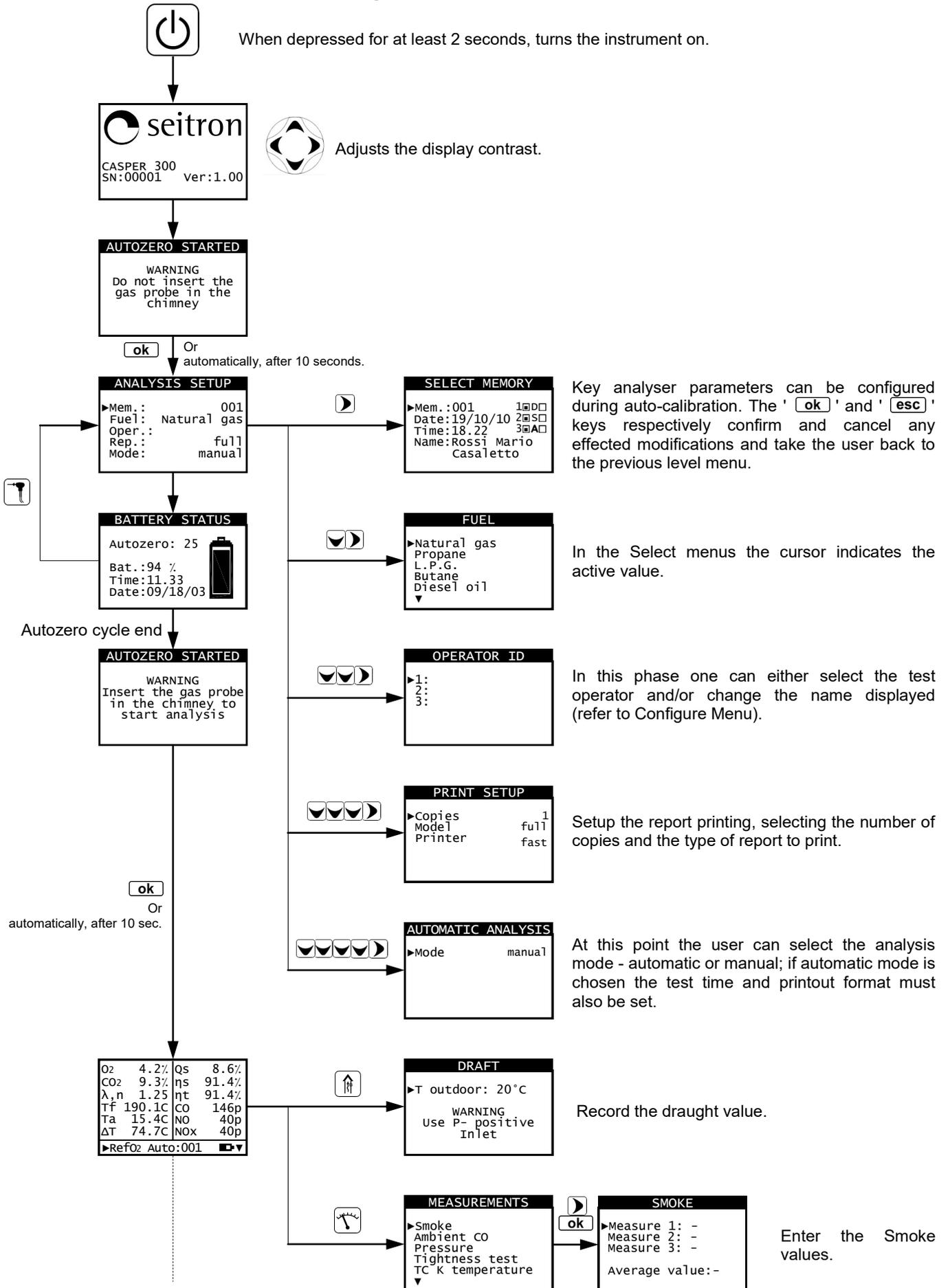
While in manual analysis, holding pressed both keys **[esc]** and **[▼]** makes the instrument switch off the suction fumes pump and blocks the refresh of any current measure.
 To switch on the suction fumes pump again and reactivate the refresh of the current measure, press again the keys **[esc]** and **[▼]**.

In both automatic and manual modes, all the pollutant values CO / NO / NO_x can be translated into normalised values (referenced to the previously defined O₂ level) by simply pressing the button **[▶]**.

4.17.4 End of Analysis

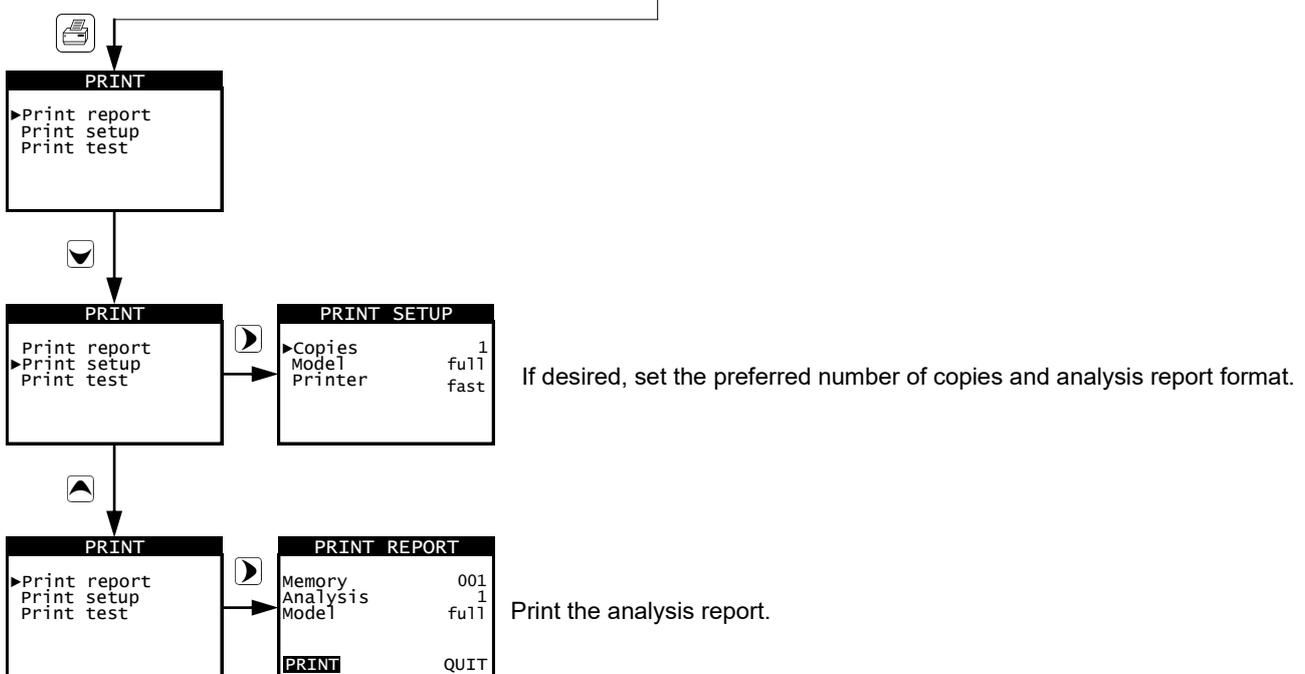
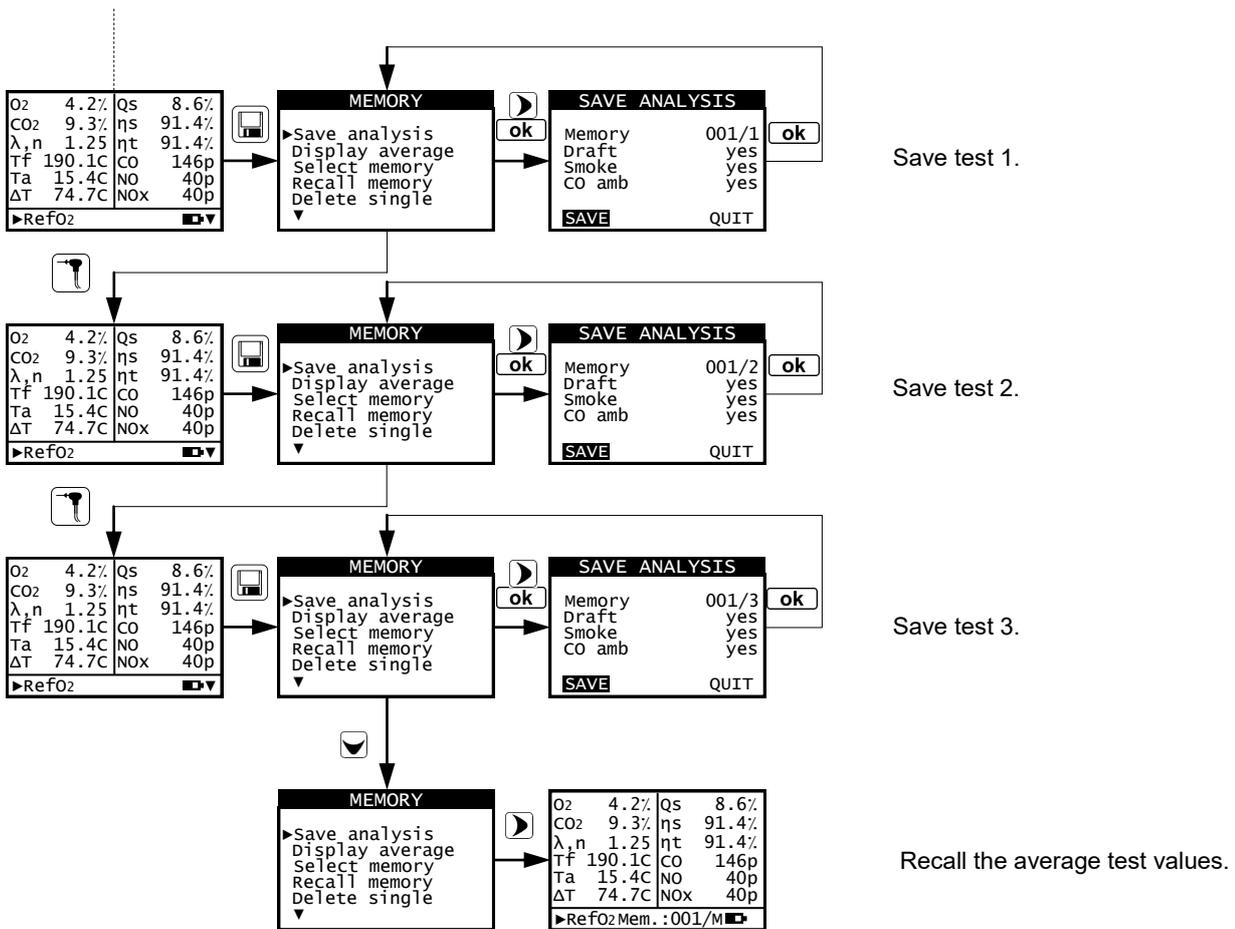
At the end of the combustion analysis, carefully remove the sample probe and remote air temperature probe, if used, from their relative ducts, taking care not to get burnt.
 Switch off the instrument by pressing the On/Off key.
 At this point, if the instrument has detected a high concentration of CO and/or NO, a self-cleaning cycle will be initiated during which the pump will draw fresh outside air until the gas levels drop below acceptable values.
 At the end of the cycle (lasting no longer than 3 min.) the instrument will switch itself off automatically.

4.17.5 Flow Chart - Flue Gas Analysis



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How to proceed in manual mode (standard sequence).

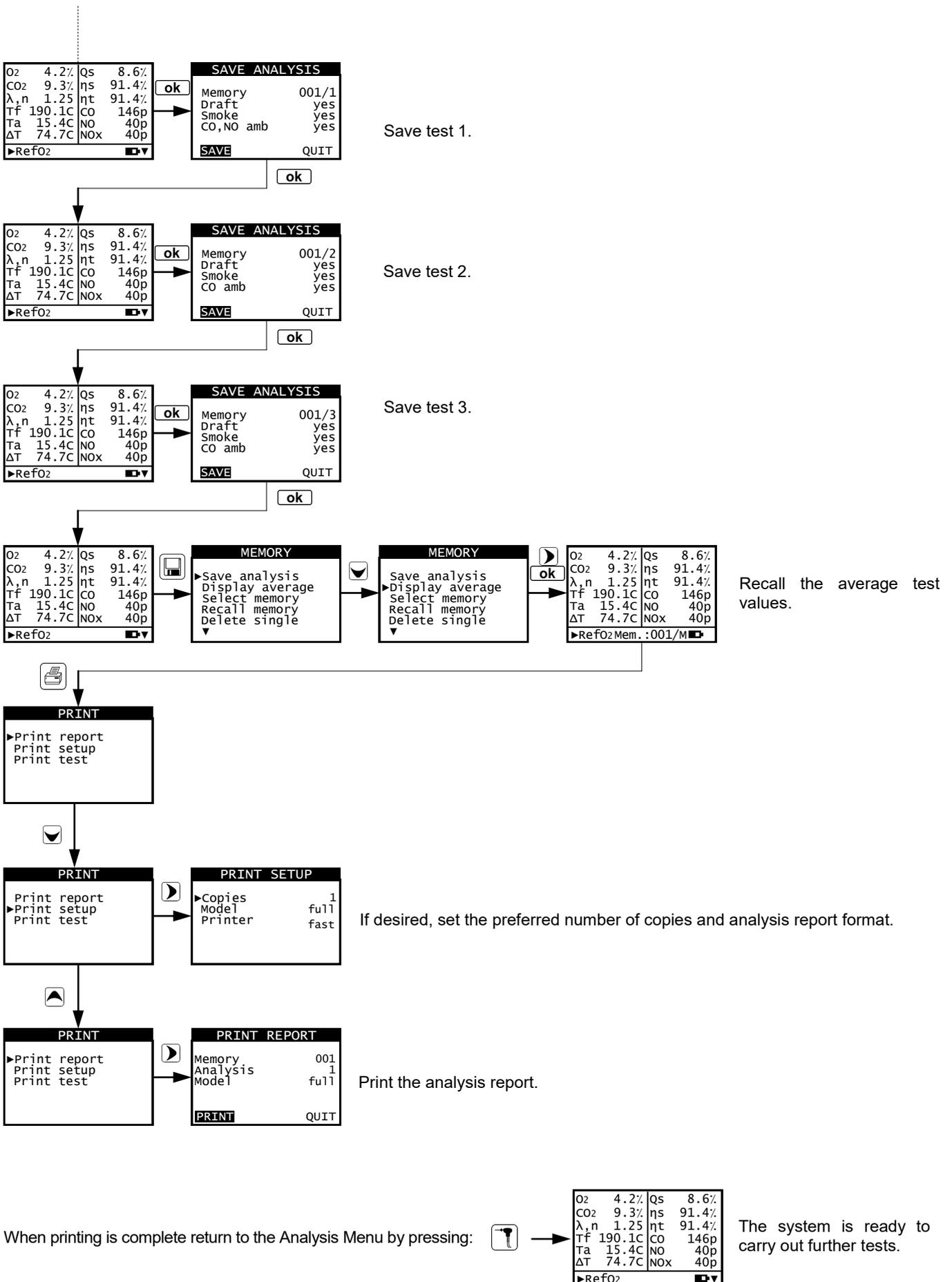


When printing is complete return to the Analysis Menu by pressing:

O ₂	4.2%	Qs	8.6%
CO ₂	9.3%	ηs	91.4%
λ, n	1.25	ηt	91.4%
Tf	190.1C	CO	146p
Ta	15.4C	NO	40p
ΔT	74.7C	NOx	40p

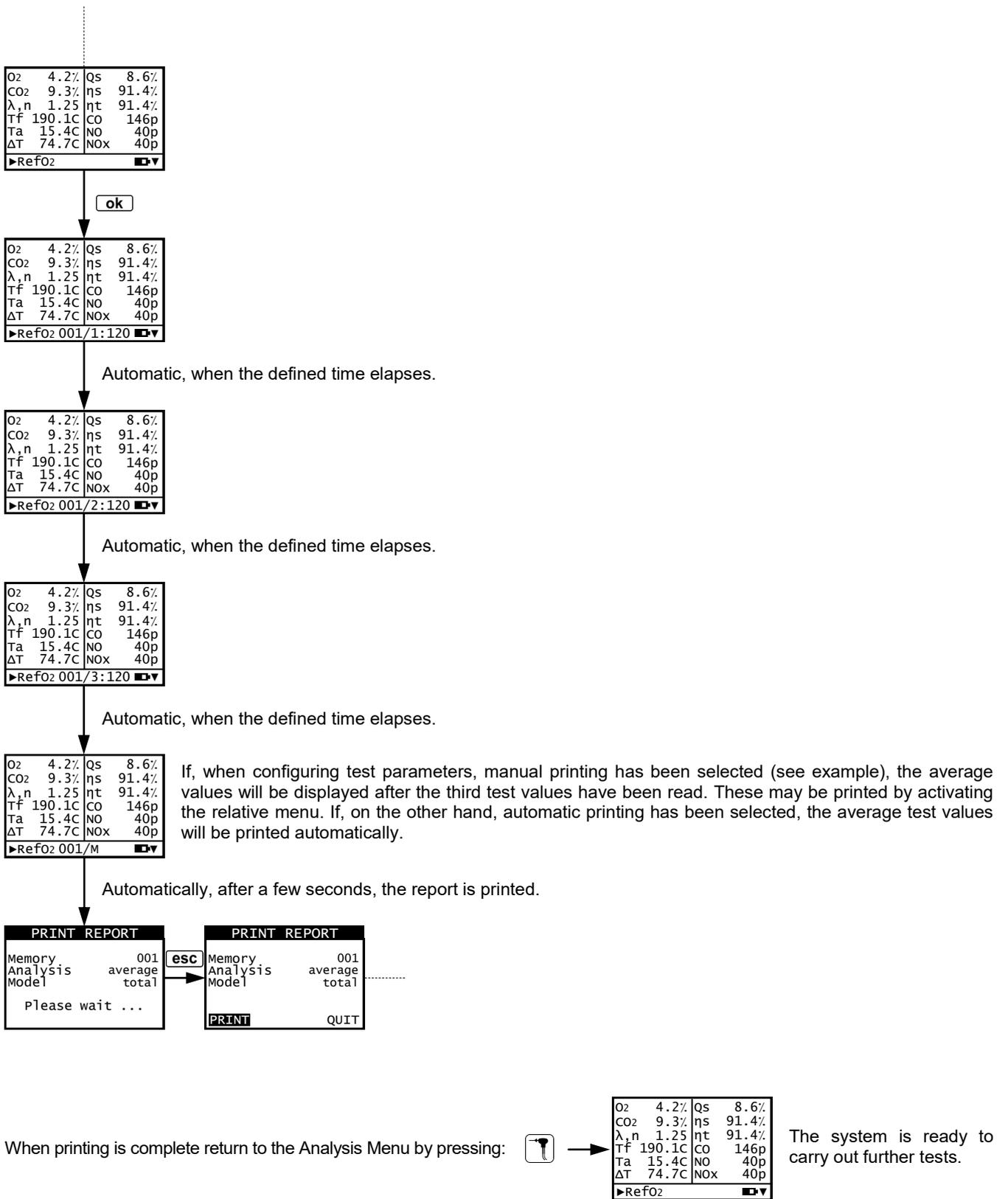
The system is ready to carry out further tests.

How to proceed in manual mode (quick sequence).



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How to proceed in automatic mode.



4.18 Measuring the Differential Pressure

The instrument is fitted with an internal temperature-compensated piezoresistive transducer to measure positive and negative pressures. This sensor, which is mounted on the instrument, is of the differential type.

With the special KIT, the sensor can be used to measure the differential pressure thanks to the positive and negative pressure connectors.

The measuring range varies between -1000 Pa and +20000 Pa.

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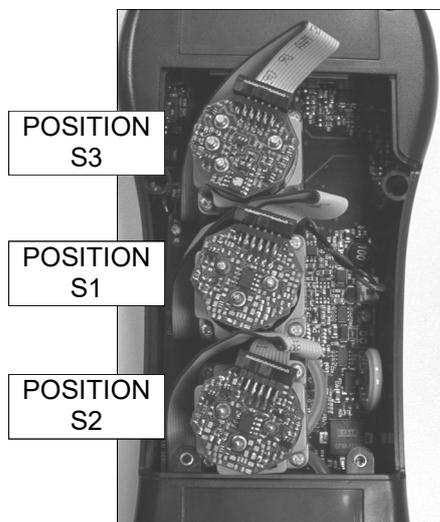
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5.1 Sensors arrangement

SENSORS ARRANGEMENT INSIDE THE SENSORS COMPARTMENT



GRAPHICAL DISPLAY OF ARRANGEMENT

SENSORS TYPE	
O ₂	NO
CO	
QUIT	

5.2 Sensor types and relevant positioning

CODE \ POSITION	S1	S2	S3
Flex-Sensor O₂ Cod. AACSE15	✓		
Flex-Sensor CO high immunity H₂ Cod. AACSE20		✓	
Flex-Sensor NO Cod. AACSE10			✓

5.3 Gas sensors life

The gas sensors used in this instrument are electrochemical: thus, when the relative gas is detected, a chemical reaction takes place inside them that generates an electrical current.

The electrical current acquired by the instrument is then converted into the corresponding gas concentration. Sensor life is strongly related to the consumption of the reagents within.

Sensor characteristics diminish as the reagents are consumed and when these have been used up completely the sensor must be replaced. The sensors must be recalibrated on a regular basis to assure measuring accuracy: recalibration can only be performed by a qualified SEITRON service centre. Chart 5.4 illustrates the characteristics inherent to each sensor.

5.4 Table gas sensors life

CODE	MEASURED GAS	IDENTIFYING ⁽¹⁾ COLOR	AVERAGE LIFE	RECALIBRATION
FLEX-Sensor O₂ Cod. AACSE15	O ₂ Oxygen		>24 months	not necessary
Flex-Sensor CO high immunity H₂ Cod. AACSE20	CO Carbon Monoxide		>36 months	Yearly ⁽²⁾
FLEX-Sensor NO Cod. AACSE10	NO Nitrogen Oxide	Orange	48 months	Yearly ⁽²⁾

Notes:

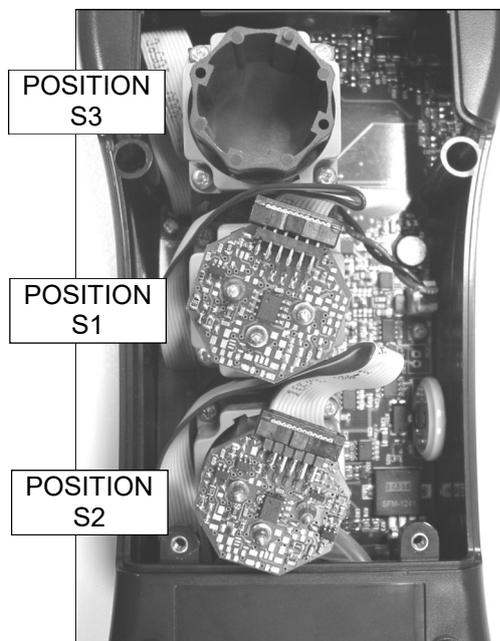
(1) Coloured dot on the sensor electronic board.

(2) UNI 10389-1 standard requires for the instrument calibration once per year to be performed in a laboratory authorised to issue calibration certificates.

5.5 Expandability to 3 sensors

In the CASPER instruments range, the only expandable model is CASPER 200:

CASPER 200: 2 sensors, expandable to 3 sensors.



The upgrading of the number of sensors can be easily done by the user by performing the following directions:

- The CASPER 200 is arranged in a way to accept one additional sensor in position S3.
- Identify, with the help of paragraph 5.2 'Sensor types and relevant positioning' the sensor which must be added to the existing configuration (Seitron delivers all FLEX-series sensors already pre-calibrated and ready to use).
- To install the new sensors follow all the steps described in the paragraph 'MAINTENANCE' under 'gas sensors replacement'.



THE INSTRUMENT AUTOMATICALLY DETECTS WHEN AN ADDITIONAL SENSOR IS INSTALLED OR HAS BEEN REMOVED. THE SCREEN 'SENSORS CONFIGURATION' ALLOWS TO ACCEPT THE NEW PROPOSED CONFIGURATION OR TO IGNORE THE CHANGE DETECTED.

IN THIS SCREEN IS SHOWN, THE FOLLOWING MESSAGE:

EXAMPLE OF A NEW SENSOR INSTALLED IN POSITION 3 (PREVIOUSLY NOT PRESENT):

NO → A NEW SENSOR HAS BEEN DETECTED.

6.1 Routine maintenance

This instrument was designed and manufactured using top-quality components. Proper and systematic maintenance will prevent the onset of malfunctions and will increase instrument life altogether.

The following basic requisites are to be respected:

- Do not expose the instrument to substantial thermal shocks before use. If this happens, wait for the temperature to return to normal working values.
- Do not extract flue gas samples directly without using a particulate/water trap.
- Do not exceed sensor overload thresholds.
- When the analysis is over disconnect the sample probe and let CASPER draw fresh air for a few minutes, or at least until the displayed parameters return to their original values.
- Clean the filter unit when necessary, replacing the particulate filter and applying a jet of air to the sample probe hose to eliminate any condensate that may have formed.

Do not clean the instrument with abrasive cleaners, thinners or other similar detergents.

6.2 Preventive maintenance

At least once a year send the instrument to a SERVICE CENTRE for a complete overhaul and thorough internal cleaning.

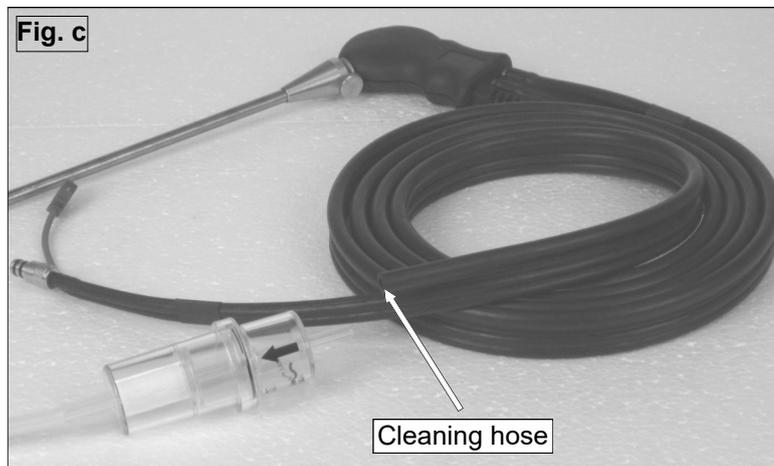
SEITRON's highly qualified staff is always at your disposal and will provide you with all the sales, technical, application and maintenance details required.

The service centre will always return the instrument to you as new and in the shortest time possible. Calibration is performed using gases and instruments comparable with National and International Specimens. Annual servicing is accompanied by a specific calibration certificate that is a guarantee of perfect instrument performance as required by UNI 10389-1, besides being indispensable for users wishing to maintain ISO 9000 status.

6.3 Cleaning the sample probe

When you finish using the sample probe clean it thoroughly as described below before returning it to its case:

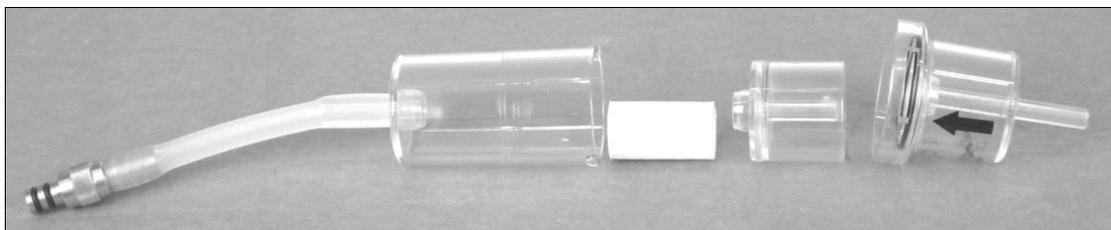
- Disconnect the sample probe from the instrument and from the water trap (Fig. a-b) then blow a jet of clean air into the hose of the probe (refer to Fig. c) to remove any residual condensate that may have formed within.



6.4 Maintaining the water trap / filter unit

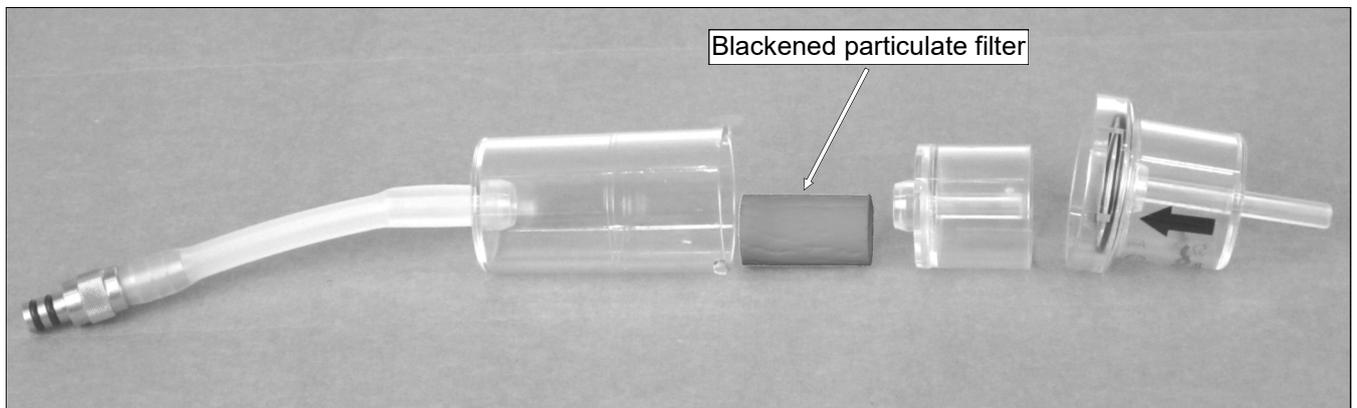
To remove the water trap, just rotate the cover and unhook the filter holder body; remove the internal cup and then replace the filter (see figure on the side).

Clean all the filter parts using water only, dry the components and reassemble the filter.



6.5 Replacing the particulate filter

If the particulate filter appears black, especially on the inner surface (see adjacent example), it has to be replaced immediately. In this way gas flow is not obstructed.

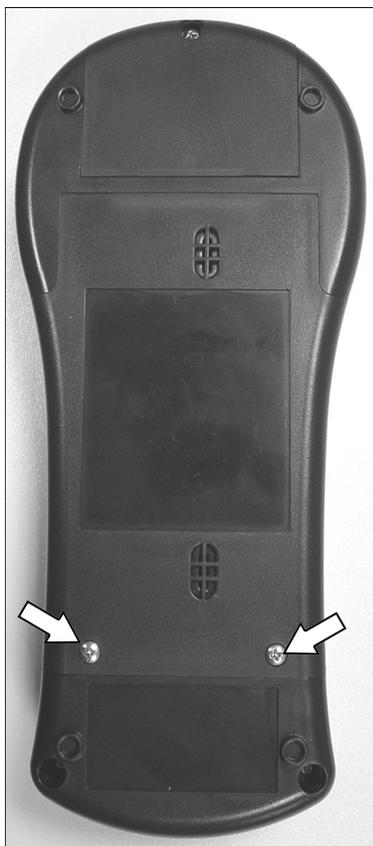


6.6 Replacing the gas sensors

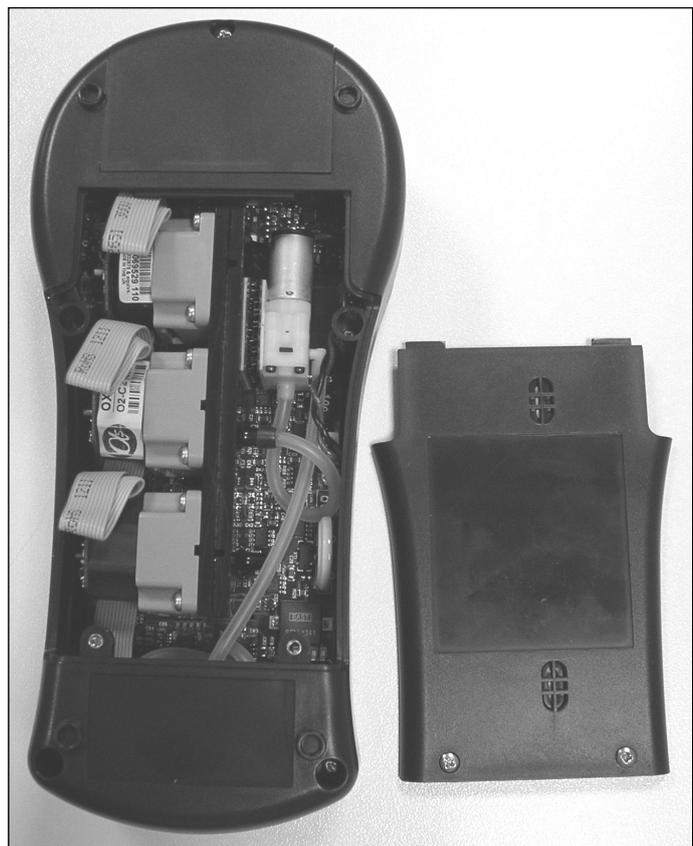
The gas sensors of the instrument shall be periodically replaced (see the following table) with new or recalibrated sensors.

The user can easily perform this replacement operation according to the following instructions:

- 1 Undo the two fixing screws on the sensor compartment cover.



- 2 Extract the cover to have access to the sensor compartment.

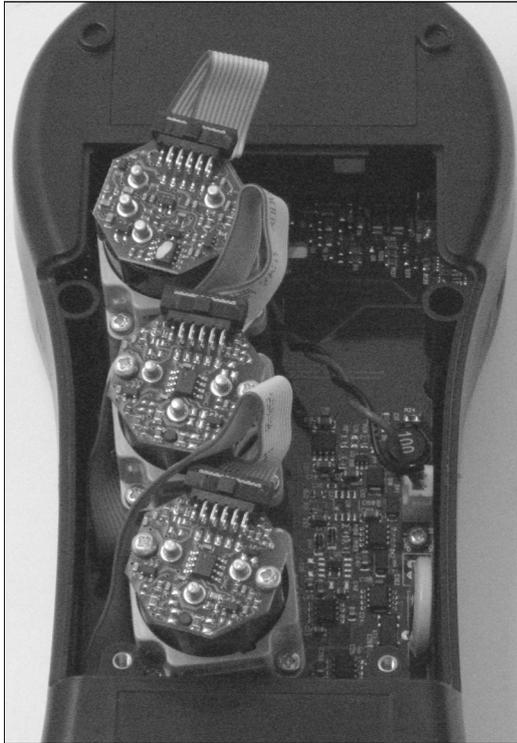


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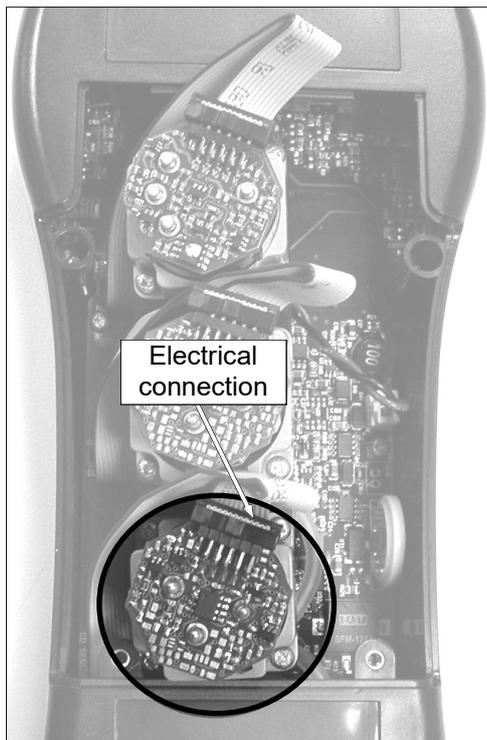
3 Raise the sensors assembly.



**While raising the sensors assembly pay attention not to damage the close circuits or components.
Do not use any tool.**



4 Locate the sensor to be replaced; here is an example of a connected sensor to be replaced.



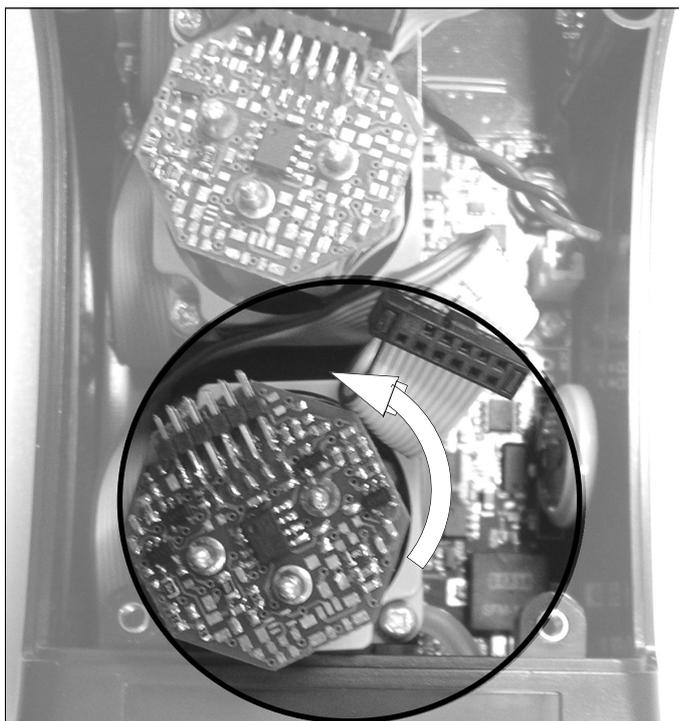
- 5 Disconnect the sensor to be replaced; here is an example of a disconnected sensor to be replaced.



- 6 The sensor is bayonet-connected to its socket; rotate it anticlockwise to remove it. Here is an example of a rotated sensor.

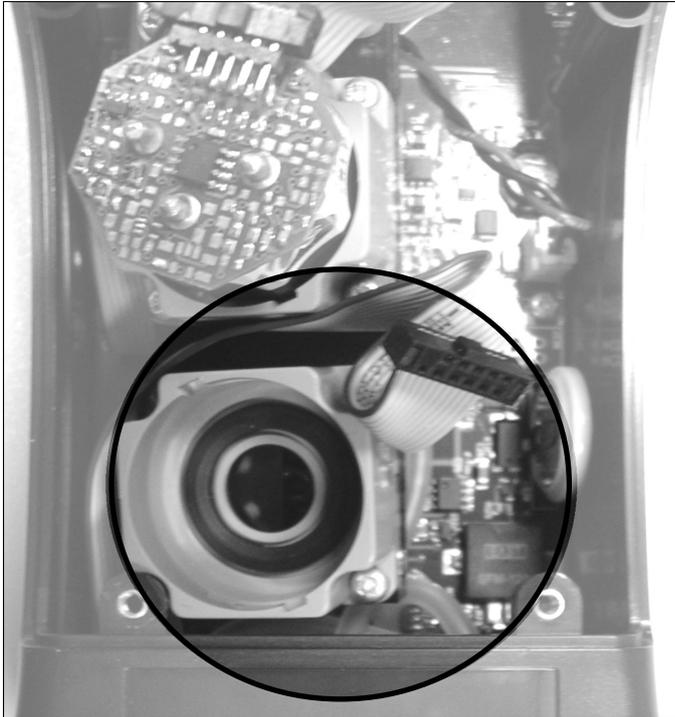


While rotating the sensor, take care not to exert any pressure onto the printed circuit above: exert pressure only onto the plastic body.



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- 7 After rotating the sensor, pull it upward; here is an example of the sensor compartment with a sensor removed.



- 8 Fit the sensor again taking care the electric connection is turned outside the instrument, not inside (See point 5).

- 9 Rotate the sensor clockwise until hearing a click (See point 4).



While rotating the sensor, take care not to exert any pressure onto the printed circuit above: exert pressure onto the plastic body only.

- 10 Reconnect the sensor (See point 3).

- 11 Reposition the sensors assembly inside the sensors compartment.



While repositioning the sensors assembly pay attention not to crush the hoses; the suction pump cable (red/black) must be laid down on one side of the pump itself.

The two pins on the left side of the sensor (see Figure 11/a) must be inserted in the two holes located on the printed circuit board (see Figure 11/b).

Do not use any tool.

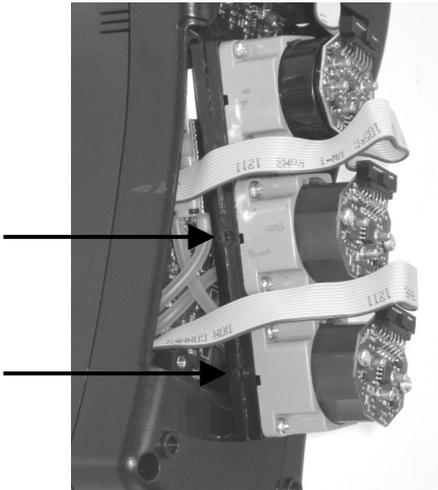


Fig. 11/a

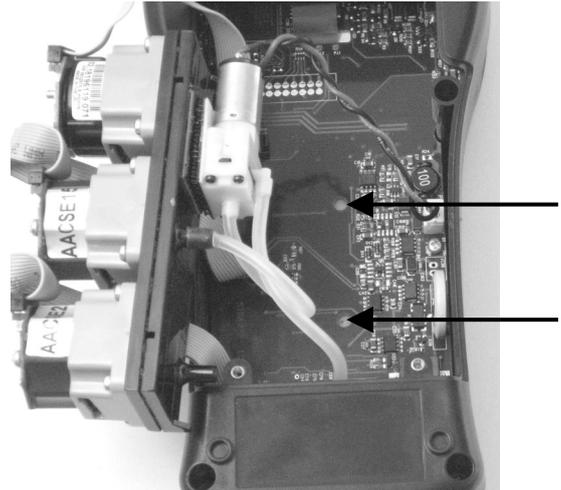


Fig. 11/b

12 Close the back door of the sensor compartment again, and tighten screws again (See point 1).

Turn on the instrument to check the new sensor works correctly through the menu "Sensor Troubleshooting".
It is normal if a newly installed sensor gives a 'current error': it is necessary to wait some time, so that the sensor polarization can settle. The table here below shows the minimum settling time for each sensor.

CODE	MEASURED GAS	POSITION	SETTLING TIME
Flex-Sensor O₂ Cod. AACSE15	O ₂ Ossigeno	S1	2 ore ⁽¹⁾
Flex-Sensor CO high immunity H₂ Cod. AACSE20	CO Monossido di Carbonio	S2	2 ore ⁽¹⁾
Flex-Sensor NO Cod. AACSE10	NO Ossido di Azoto	S3	48 ore ⁽²⁾

Note:

(1) 2 hours' settling time is required.

(2) 48 hours' settling time is required; should the sensor be equipped with an external polarisation battery, the settling time is reduced down to 2 hours.

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6.7 On-site recalibration

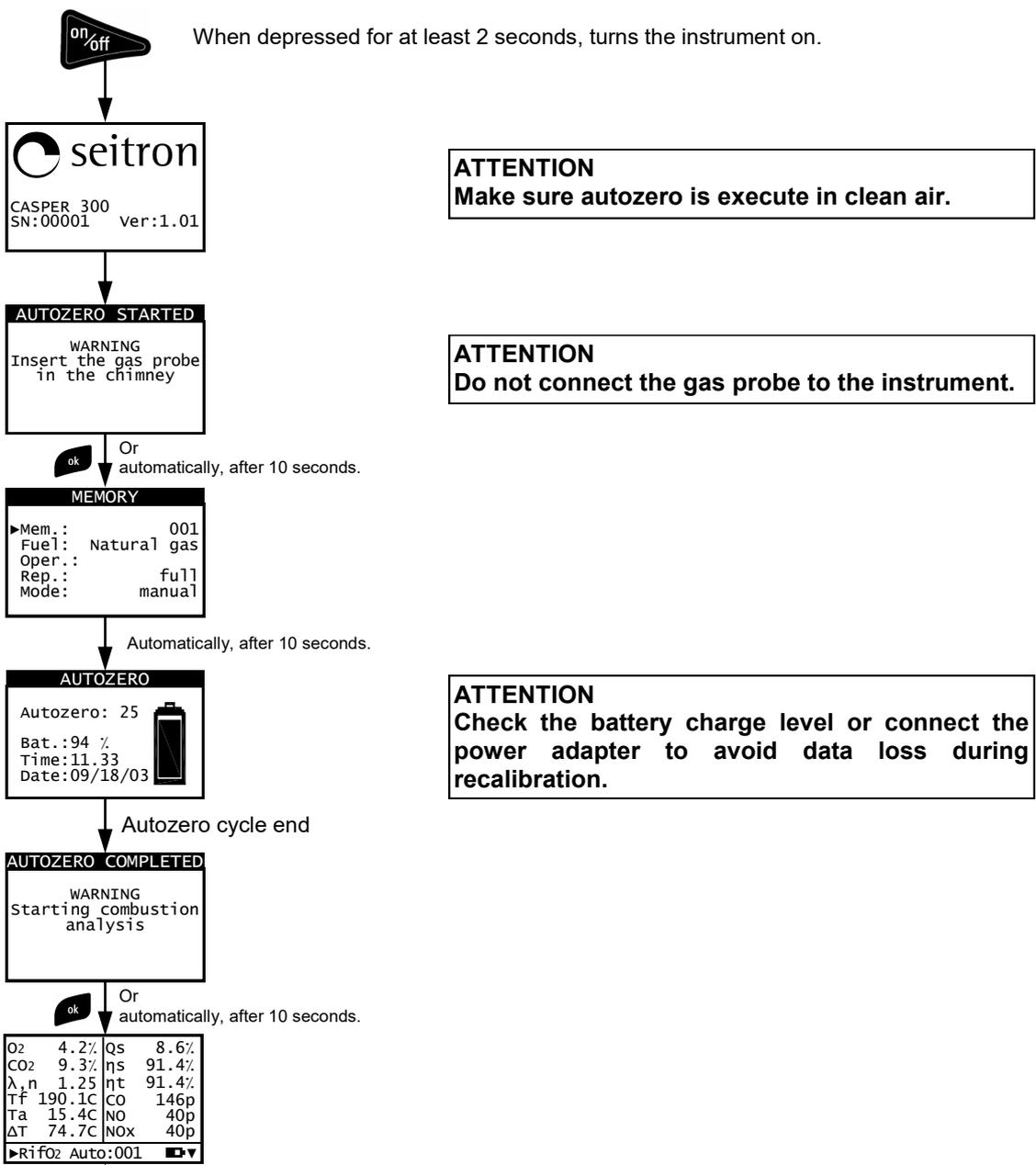
It is possible to make a recalibration of the instrument's gas sensors with suitable known concentration gas cylinders. Recalibration of Oxygen (O₂) sensor is not available since it is already recalibrated during every autozero sequence.

The access to the sensor recalibration is password protected, the password is '1111'.

To carry on the recalibration the following instruments are needed:

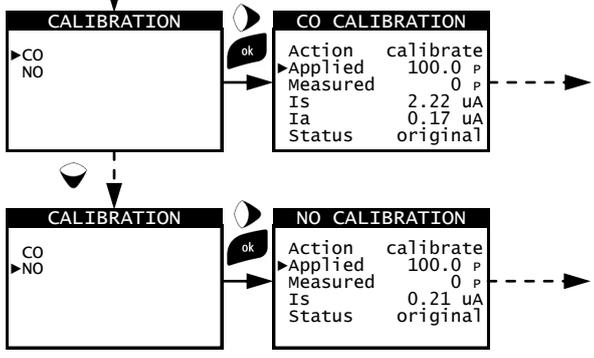
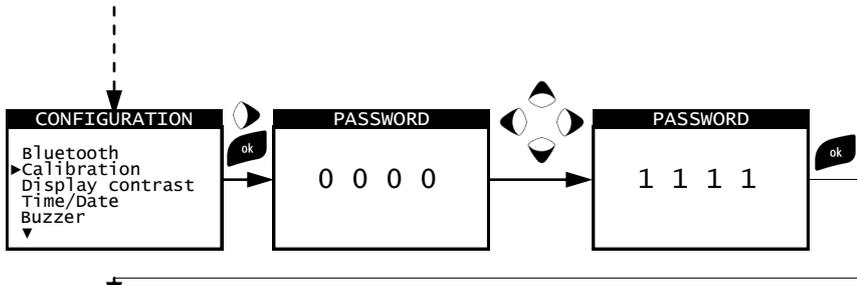
- Known concentration gas cylinder suitable for the sensor, complete with a pressure regulator
- Flow meter
- Hose with Tee fitting to connect the cylinder to the flowmeter and to the instrument

6.7.1 Flow Chart - On-site recalibration



Depress key and with move the cursor to 'Calibration'.

In the following a recalibration example, referred to the CO sensor, is explained.



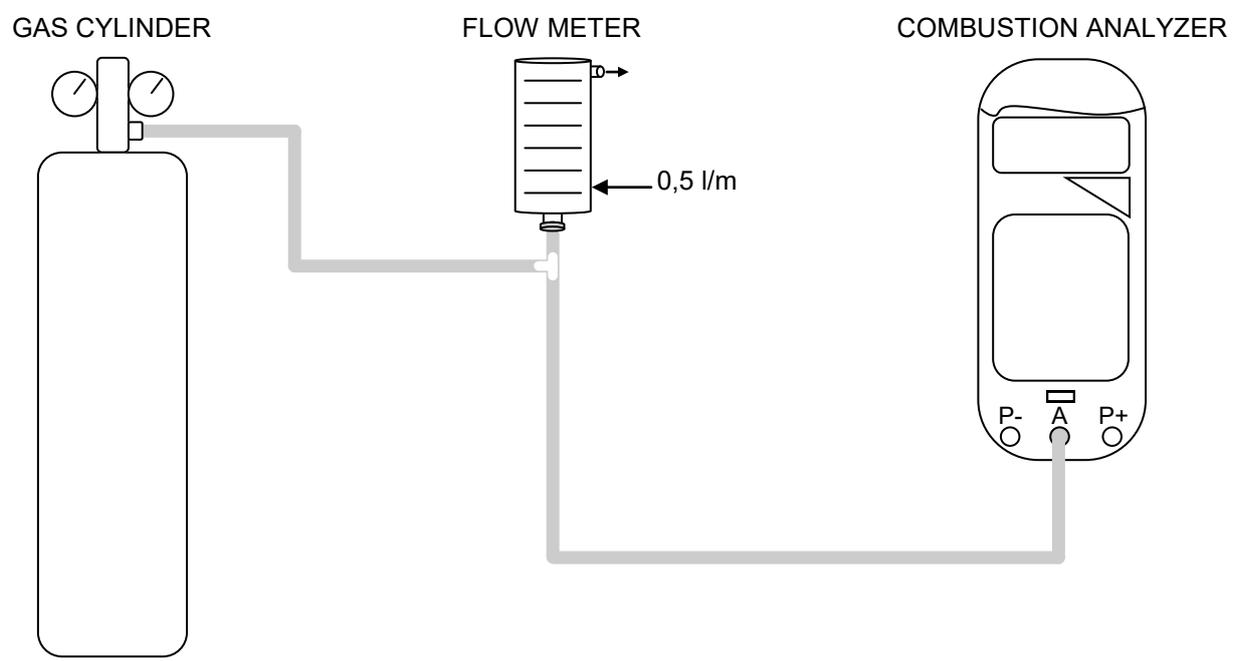
Installed sensors which can be recalibrated are shown, and can be chosen for recalibration. In recalibration screenshot, information about the calibration in use and sensor output are displayed.

- Action: selection of action to make
 - calibrate:** save new calibration
 - set original:** bring back factory original calibration
 - set user:** bring back last user calibration done
- Applied: selection of cylinder gas concentration
- Measured: Actual sensor reading
- Is: 'Is' current from the sensor
- Ia: 'Ia' current from the sensor
- Status: Shows calibration status:
 - original:** factory original calibration in use
 - user:** user calibration in use
 - saving:** busy saving calibration
 - user cal OK:** user calibration successful
 - cal error:** user calibration error
 - orig cal ok:** restore of original cal successful

CHOOSE THE SENSOR TO BE RECALIBRATED AND PROCEED AS DESCRIBED (CO SENSOR EXAMPLE):

- Connect the known concentration gas cylinder to the instrument as shown in the following scheme:

WARNING!
Adequate ventilation must be provided when working with toxic gases, particularly the flow meter and instrument outputs must be evacuated by a ventilation system.



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- Apply the gas to the instrument and regulate the cylinder output pressure so that the flow meter shows a minimum flow (0,5 l/m) this ensures that the instrument is getting exactly the gas needed by its internal pump.
- The instrument measures the concentration of the applied gas; **wait at least 3 minutes for the measure to stabilize**. The reading is shown in the 'Measured' row.

CO CALIBRATION	
Action	calibrate
▶Applied	1000.0 P
Measured	990.5 P
Is	82.22 uA
Ia	10.17 uA
Status	original

- Whenever the reading is not satisfactory, proceed with the recalibration; Select the concentration of the applied gas (cylinder concentration) in the 'Applied' row.

CO CALIBRATION	
Action	calibrate
▶Applied	1022.0 P
Measured	990.5 P
Is	82.22 uA
Ia	10.17 uA
Status	original

With  keys set the cylinder concentration in the 'Applied' row.

- Select 'Calibrate' in 'Action' row.

CO CALIBRATION	
▶Action	calibrate
Applied	1022.0 P
Measured	990.5 P
Is	82.22 uA
Ia	10.17 uA
Status	original

- Depress the '  ' key to save the new calibration.

CO CALIBRATION	
▶Action	calibrate
Applied	1022.0 P
Measured	990.5 P
Is	82.22 uA
Ia	10.17 uA
Status	cal ok

The recalibration result will be shown in the 'Status' row:

'CAL OK': sensor recalibrated successfully

'CAL ERROR': sensor not recalibrated due to:

- The gas was not correctly delivered to the instrument.
- The applied gas concentration was not correctly set in the 'Applied' row.
- The 3 minutes stabilization time was not observed.
- The sensor might be damaged or exhausted and need to be replaced.

It is always possible to bring back the original calibration with the action 'set original' and bring back the last on-site calibration with 'set-user'.

6.8 Replacing the battery pack

Follow these instructions to replace the battery pack:

- 1 Undo the fixing screw on the battery compartment cover, and
- 2 Extract the battery pack.



- 3 Remove the battery pack connector, and replace the pack with a new one following the reverse procedure described above.



Battery pack connector

7.1 Troubleshooting guide

SYMPTOM	PROBABLE CAUSES AND REMEDIES
The instrument does not work at all. When the On/Off pushbutton is pressed the instrument does not come on.	<ul style="list-style-type: none"> a. Keep the On/Off key depressed for at least 2 seconds. b. The battery is low; connect the battery charger to the instrument. c. The battery pack is not connected to the instrument; remove the cover from the battery compartment and connect the connector of the battery pack to the outlet on the printed circuit board. d. The instrument is faulty: send it to a service centre.
The battery symbol  is empty on the inside.	The batteries are low. The instrument will remain on for a couple of minutes after which it will switch off; connect the battery charger.
After auto-calibration is complete the sensor diagnostics screen appears and gives an error for one or more cells.	<ul style="list-style-type: none"> a. Auto-calibration took place while the flue gas was being sampled. b. The O₂ sensor is faulty, is not connected correctly or is not connected at all. Check the above points, also referring to sections 5.3, 5.4, 6.6. c. The sensor was not allowed the necessary adjustment time or the instrument was left with a low battery for too long.
A pressure sensor error is shown in the pressure/draught screen.	There is a calibration problem. Send the instrument to a service centre.
The analysis screen gives a flue gas temperature (Tf) error.	<ul style="list-style-type: none"> a. The thermocouple is not connected; connect the thermocouple to the analyser. b. The sensor has been exposed to temperatures greater or lower than its operating temperature range. c. The thermocouple is faulty. Send the complete probe to a service centre.
The following symbol "----" appears on the analysis screen.	The instrument is not able to calculate a numerical value based on the flue gas analysis conducted. The "----" are replaced by numbers when the analyser detects valid combustion data.
"Max. Lim." or "Min. Lim" appears on the analysis screen.	The relative sensor is detecting a value that is beyond the analyser's measuring range. "Max. Lim" or "Min. Lim." are replaced by numbers when the instrument reveals values that are within the measuring range.
The sample pump sounds as though it is running slowly, tends to stop or does not even start.	<ul style="list-style-type: none"> a. Sample flow is obstructed. Check that the water filter is clean and that it is not completely soaked. Also check that the hose connected to the probe is not crushed. b. Sample intake flow is obstructed. Check that the particulate filter is clean. c. The pump is not connected as it should be. Remove the rear flap and check that the pump's electrical connector is connected to the printed circuit board. d. Pump is faulty. Replace the pump unit. e. Pump is disabled. The key combination   has been pressed. To re-enable the pump, switch off the instrument and then switch it on again.

Troubleshooting guide

SYMPTOM	PROBABLE CAUSES AND REMEDIES
The rear lighting of the display is not on.	The backlighting LED's are faulty. Contact the nearest service centre to replace the display.
The batteries last less than 12 hours.	<p>a. Battery capacity is limited by low temperatures. To achieve a longer battery life it is recommended to store the instrument at higher temperatures.</p> <p>b. The battery pack is old. Battery capacity tends to diminish with age. If battery life has become unacceptable, replace the battery pack:</p>
The values shown in the analysis screen are not reliable.	<p>a. Sensor/s is/are faulty. Check that the sensors are installed correctly by accessing the sensor diagnostics menu.</p> <p>b. The sample probe connection presents a leak. Check all joints and the conditions of the hose.</p> <p>c. Pump is faulty. Replace the pump unit.</p> <p>d. The instrument is faulty: Send it to a service centre for repair.</p>

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8.1 Spare parts

- AAC BF01: Sensor junction block
- AAC FA01: Particulate filter
- AAC PB07: Li-Ion Battery pack - 7,4V 1,8Ah
- AA RC05: Paper roll for printer, h=58 mm, diam.= 44 mm
- AAC SE15: FLEX-Sensor O₂, pre-calibrated and interchangeable
- AAC SE20: FLEX-Sensor CO high immunity H₂, pre-calibrated and interchangeable
- AAC SE10: FLEX-Sensor NO/NO_x, pre-calibrated and interchangeable

8.2 Accessories

- AAC AL04: 100-240V~/12 VDC 2A power supply with 2 m. cable
- AAC CV02: Cable with Schuko plug
- AAC CV03: Cable with Italy plug
- AAC CV05: Cable with US/JAPAN plug
- AA CA02: Power supply with car adapter
- AA CR03: Rigid plastic case
- AAC CT01: Shoulder bag
- AAC KP01: Differential pressure kit
- AA PM02: Manual pump kit for smoke measurement
- AA SA05: 100 mm air temperature probe (cable length 3 m)
- AA SA07: 200 mm air temperature probe (cable length 3 m)
- AA SF61A: 180 mm. gas probe, 1100°C extended temperature range, with 3 mt cable
- AA SF51A: 180 mm. gas probe, 1100°C extended temperature range, with 2 mt cable
- AA SF62A: 300 mm. gas probe, 1100°C extended temperature range, with 3 mt cable
- AA SF52A: 300 mm. gas probe, 1100°C extended temperature range, with 2 mt cable
- AA SF65A: 750 mm. gas probe, 1100°C extended temperature range, with 3 mt cable
- AA SF66A: 1000 mm. gas probe, 1100°C extended temperature range, with 3 mt cable
- AA SL05A: 220 mm. flexible gas probe, 1100°C extended temperature range, with 2 mt cable
- AAC EX02S: 3 mt extension cable for flue gas probe
- AA SM05: Rubber protecting cover with magnets
- AAC SW04: Configuration software kit (USB flash drive + PC cable)
- AAC TA03: Particulate/water filter assembly
- AAC TA03A: Particulate/water filter assembly with steel pipe and connector
- AAC UA02: Adapter cable USB-A / mini USB-B.
- AC ST02: External IR printer with battery charger.
- AA ST01: Thermal printer Bluetooth connection
- AAC SO01: Probe for measuring the ionisation current
- AA KT04: Kit for tightness test with 4 ways manifold

8.3 Service Centres

Seitron S.p.A.
Via Prosdocimo, 30
I-36061 Bassano del Grappa (VI) ITALY
Tel.: +39.0424.567842
Fax.: +39.0424.567849
E-mail: info@seitron.it
<http://www.seitron.it>

Example of Total analysis report.

COMPANY Ltd. Park Road, 9 Tel.02/12345678	
Oper.: John Smith	
Sign.: _____	
Test according to UNI 10389-1 L. 10/1991 and s.m.i. D.Lgs. 192/2005 and s.m.i.	
Casper 300 Serial: 999989 Memory: 01 Analysis: average	
Date: 26/10/11	
Time: 10.15	
Fuel: Natural gas Altitude: 0 m R.H. air: 50 %	
MEASURED VALUES	
T flue	100.6 °C
T air	27.0 °C
O2	15.7 %
CO	23 ppm
NO	14 ppm
CO amb	0 ppm
Draft	4.5 Pa
T ext.	10.0 °C
CALCULATED VALUES	
CO2	15.7 %
l,n	4.01
QS	10.0 %
ES	90.0 %
EC	0.0 %
Et	90.0 %
dT	73.6 %
NOx/NO:	1.03
NOx	41 ppm
Ref. O2:	0.0 %
CO	182 ppm
Ref. O2:	0.0 %
NO	50 ppm
Ref. O2:	0.0 %
NOx	51 ppm
Note: -----	

Analysis: 1	
26/10/11 10.10	
O2	4.2 %
CO2	9.3 %
l,n	1.25
QS	8.6 %
ES	91.4 %
EC	4.9 %
Et	91.4 %
T flue	190.2 °C
T air	15.4 °C
T diff.	174.8 °C
CO	148 ppm
PI	0.16 %
Analysis: 2	
26/10/11 10.15	
O2	4.7 %
CO2	9.8 %
l,n	1.5
QS	8.8 %
ES	92.3 %
EC	5.2 %
Et	92.4 %
T flue	194.1 °C
T air	14.4 °C
T diff.	179.7 °C
CO	150 ppm
PI	0.18 %
Analysis: 3	
26/10/11 10.20	
O2	5.2 %
CO2	10.3 %
l,n	1.7
QS	9.6 %
ES	98.4 %
EC	2.9 %
Et	94.4 %
T flue	193.2 °C
T air	16.4 °C
T diff.	176.8 °C
CO	152 ppm
PI	0.19 %

Example of Full analysis report.

COMPANY Ltd.
 Park Road, 9
 Tel.02/12345678

Oper.: John Smith

Sign:_____

Test according to
 UNI 10389-1
 L. 10/1991 and s.m.i.
 D.Lgs. 192/2005 and s.m.i.

Casper 300
 Serial: 999989

Date: 26/10/11
 time: 10.15

Fuel: Natural gas
 Altitude: 0 m
 R.H. air: 50 %

MEASURED VALUES

T flue	190.1 °C
T air	15.4 °C
O2	4.2 %
CO	146 ppm
NO	40 ppm

CALCULATED VALUES

CO2	9.3 %
l,n	1.25
QS	8.6 %
Es	98.5 %
EC	4.9 %
Et	103.4 %
dT	174.7 %

NOx/NO:	1.03
NOx	41 ppm

Ref. O2:	0.0 %
CO	182 ppm

Ref. O2:	0.0 %
NO	50 ppm

Ref. O2:	0.0 %
NOx	51 ppm

Note:-----

Example of Partial Paper print-out.

Date: 04/04/14
 Time: 10.15

Fuel: Natural gas
 Altitude: 0 m
 R.H. air: 50 %

O2	15.7 %
CO2	2.9 ppm
l,n	4.01
T flue	95.4 °C
T air	26.9 °C
dT	68.5 %
QS	9.3 %
Es	90.7 %
EC	0.0 %
Et	90.7 %
CO	23 ppm
NO	13 ppm
NOx	14 ppm
Ref. O2:	0.0 %
CO ref	92 ppm
Ref. O2:	0.0 %
NO ref	52 ppm
Ref. O2:	0.0 %
NOx ref.:	56 ppm
Smoke	4.5 Pa
T ext.	10.0 °C

Smoke:	3	1	2
Aver n°:		2	

Example of Tightness test Ticket.

COMPANY Ltd.
Park Road, 9
Tel.02/12345678

Oper.: John Smith

Sign.: _____

Test according to
UNI 11137: 2012 standard
Indirect method

Casper 300
Serial: 999989
Memory: 01

Date: 26/10/11
Time: 10.15

Stab. duration: 1 min
Test duration: 1 min

Comb. gas: City gas
Test gas: City gas

Vimp	25.0 dm ³
P1	10.05 hPa
P2	10.03 hPa
ΔP	-0.02 hPa
Qtest	0.0 dm ³ /h
Qrif	0.0 dm ³ /h

Esito: idoneo

Note: -----

Example of ambient CO Ticket.

COMPANY Ltd.
Park Road, 9
Tel.02/12345678

Oper.: John Smith

Sign.: _____

Casper 300
Serial: 999989
Memory: 01

Date: 26/10/11
Time: 10.15

CO amb 0 ppm

Notes: -----

Example of Draught Ticket.

COMPANY Ltd.
Park Road, 9
Tel.02/12345678

Oper.: John Smith

Sign.: _____

Casper 300
Serial: 999989
Memory: 01

Date: 26/10/11
Time: 10.15

Draft: 0.05 hPa
T outdoor: 20 °C

Notes: -----

Example of Smoke Ticket.

COMPANY Ltd.
Park Road, 9
Tel.02/12345678

Oper.: John Smith

Sign.: _____

Casper 300
Serial: 999989
Memory: 01

Date: 26/10/11
Time: 10.15

Fuel: Diesel

Smoke:	3	4	2
Aver. n°:			3

Notes: -----

Coefficients of the fuels and Formulas

The following chart, derived from standard UNI 10389-1, lists the coefficients of the memorised fuels, used for calculating losses and efficiencies.

Coefficients for calculating combustion efficiency									
Fuel	A1	A2	B	CO ₂ t (%)	PCI (KJ/Kg)	PCS (KJ/Kg)	M air (Kg/Kg)	M H ₂ O (Kg/Kg)	V dry gas (m ³ /Kg)
Natural gas	0,660	0,380	0,0100	11,70	50050	55550	17,17	2,250	11,94
Propane	0,630	0,420	0,0080	13,90	45950	49950	15,61	1,638	11,11
L.P.G.	0,630	0,420	0,0080	13,90	45730	49650	15,52	1,602	11,03
Butane	0,630	0,420	0,0080	13,90	45360	49150	15,38	1,548	10,99
Diesel oil	0,680	0,500	0,0070	15,10	42700	45500	14,22	1,143	10,34
Fuel oil	0,680	0,520	0,0070	15,70	41300	43720	13,73	0,990	10,06
Propane air	0,682	0,447	0,0069	13,76	28250	30700	9,13	0,999	6,77
Biogas	0,719	0,576	0,0086	16,81	19200	21250	6,38	0,840	5,82
Pellets (8% RH)	0,740	0,670	0,0071	19,01	18150	19750	6,02	0,660	4,58
Wood (20% RH)	0,761	0,686	0,0089	18,93	15450	17170	5,27	0,700	4,01
Chipped wood	0,8020	0,785	0,0108	20,56	11950	13565	4,20	0,660	3,25
Coal	0,7620	0,691	0,0023	19,06	31400	32300	10,70	0,370	8,14

Details of the coefficients of the fuels:

- **CO₂ t:** The value of CO₂ generated by combustion in stoichiometric condition, i.e. without excess Oxygen and therefore maximum.
- **A1, A2, B:** Also please have a look at the Siegert formulas from the European standard EN50379-1 (in the following).
 A1 is the parameter in the Siegert Formula when the O₂ measurement is available.
 A2 is used when the CO₂ measurement is available.
 Note: - Please also consider that in the U.S. usually the A1 parameter is the same as the 'european' A1 BUT divided by 2.
 - For Germany coefficients A1 and A2 are swapped.

Flue gas heat losses are calculated from measured oxygen content according to the relationship:

$$q_A = (t_A - t_L) \times \left(\frac{A1}{21 - O_2} + B \right)$$

Flue gas heat losses are calculated from measured carbon dioxide content according to the relationship:

$$q_A = (t_A - t_L) \times \left(\frac{A2}{CO_2} + B \right)$$

- **CO conv:** Conversion coefficient from ppm to mg/KWh. It can be expressed as a function of the gas density (CO in this case) and the volume of the dry smoke.
- **NO conv:** Same as CO conv, but for NO.
- **NO_x conv:** Same as CO conv, but for NO_x.
- **SO₂ conv:** Same as CO conv, but for SO₂.
- **PCI:** Potere Calorifico Inferiore. Italian for LHV (Lower Heating Value).
- **PCS:** Potere Calorifico Superiore. Italian for HHV (Higher Heating Value).
- **m H₂O:** Mass of the air produced (per each Kg of fuel) in the combustion in stoichiometric condition.
- **m Air:** Mass of the air needed for combustion in stoichiometric condition.
- **V g.d.:** Volume of dry smokes produced in the combustion.

Flue gas analysis according to Italian Law No. 10/1991 and subsequent modifications and supplements, Legislative Decree 192/2005 and the UNI 10389-1 standard

Preamble

It is Seitron's intention, by means of this compact guide, to provide boiler installers/service technicians with a quick and easy way to understand whether a boiler conforms to the requirements of Italian Law no. 10 dated January 1991, and subsequent modifications and supplements, and Legislative Decree 192/2005. The contents of this guide have been extremely simplified whereby they are not to be deemed at all comprehensive of the complex phenomenon of combustion.

Flue Gas Analysis: theory

During the combustion process taking place in a boiler, part of the heat evolved by the burner is transferred to the water or air to be heated. The quantity of heat available at the burner is called the input rating (Pf) and is usually declared by the boiler manufacturer. Part of this energy, known as the useful output (Pu), is used by the boiler. The remainder is lost to the flue gas in the stack and is known as Stack loss (Qs).

Thus we can say that: $Pf = Pu + Qs$

THE THERMAL EFFICIENCY OF COMBUSTION is given by:

$$\eta = 100 - Qs$$

According to the Italian Legislative Decree 192/2005 the MINIMUM thermal efficiency η should respect the values below:

For hot water generators:

Period of installation	Minimum efficiency %	Minimum with Pn < 35 kW
Before 29/10/1993	$84 + 2 * \log Pn - 2$	around 85 %
From 29/10/1993 to 31/12/1997	$84 + 2 * \log Pn$	around 87 %
From 01/01/1998 to 07/10/2005	Standard boilers $84 + 2 * \log Pn$	around 87 %
	Low temperature boilers $87.5 + 1.5 * \log Pn$	around 90 %
	Condensing boilers $91 + 1 * \log Pn$	around 92.5 %
After 08/10/2005	Condensing boilers $90 + 2 * \log Pn - 1$	around 92 %
	Other boilers $88 + 2 * \log Pn - 1$	around 90 %

For hot air generators:

Period of installation	Minimum efficiency %	Minimum with Pn < 35 kW
Before 29/10/1993	$83 + 2 * \log Pn - 6$	around 80 %
After 29/10/1993	$84 + 2 * \log Pn - 3$	around 83 %

Stack loss is calculated by applying a simple formula which relates it to other easily measurable parameters:

$$Q_s = \left(\frac{A_2}{CO_2} + B \right) (T_f - T_a)$$

Where: A2, B = factor that depends on the fuel used
 Tf = flue gas temperature
 Ta = combustion air temperature
 CO₂ = % carbon dioxide in the flue gas

Thus in order to calculate the stack loss and hence the thermal efficiency of a plant, one must measure the two temperatures (flue gas and air) and the level of carbon dioxide contained in the flue gas (% CO₂). These operations are performed automatically by the flue gas analyser during testing.

Let's take a look at the gases produced by combustion that need to be kept under control:

➤ **CO₂: CARBON DIOXIDE**

The maximum CO₂ values that can be obtained from perfect combustion (theoretical) for the different types of fuels are:

Fuel	% max CO ₂
Methane	11,7
Propane	13,9
LPG	13,9
Butane	13,9
Diesel oil	15,1
Fuel oil	15,7

In truth, the percentage of CO₂ that can be detected during analysis will always be lower than these limit values.

➤ **CO: CARBON MONOXIDE**

Carbon monoxide (CO) is usually produced by bad combustion that is weak in oxygen: since CO is a highly dangerous gas (it is fatal for man even in very low concentrations: exposure to 400 ppm for 3 hours is already fatal), standard UNI 10389-1 has established a limit value beyond which the test results of the boiler plant are deemed unsatisfactory. The percentage of gas considered by the standards, however, is not the value measured directly in the flue gas, which is "diluted" with other combustion products, but is the value referred to the volume of flue gas generated by perfect combustion, that is, where the oxygen is zero.

This limit is:

CO (referenced to 0% O₂) = 1000 ppm = 0.1%

Flue Gas Analysis: in practice

Below is an example of the flue gas analysis of a methane-fired boiler (natural gas) that is working correctly:

COMPANY Ltd.
Park Road, 9
Tel.02/12345678

Oper.:
Sign:

Test according to
UNI 10389-1
L. 10/1991 and s.m.i.
D.Lgs. 192/2005 and s.m.i.

CASPER 301
Serial: 421023

Data: 29/07/13
Ora: 10.15

Fuel: Natural gas
Altitude: 0 m
R.H. air: 50 %

MEASURED VALUES

T flue	190.1 °C
T air	15.4 °C
O ₂	4.2 %
CO	146 ppm
NO	40 ppm

CALCULATED VALUES

CO ₂	9.3 %
l,n	1.25
Q _s	8.6 %
E _s	98.5 %
E _c	4.9 %
E _t	103.4 %
T diff	174.7 °C

NO _x /NO:	1.03
NO _x	41 ppm

Rif. O ₂ :	0.0 %
CO	182 ppm

Rif. O ₂ :	0.0 %
NO	50 ppm

Rif. O ₂ :	0.0 %
NO _x	51 ppm

Note:

Flue gas temperature T flue

This should be as low as possible: less heat leaving the stack will leave more heat available for heating purposes.

Combustion air temperature T air

This is not always the same as the ambient temperature. Combustion air may be heated by the flue gas in coaxial pipes, or may be drawn from outside: in these cases the remote air temperature probe is necessary.

Oxygen O₂

The percentage of oxygen in air is around 21%: an ideal combustion process will "burn" all the oxygen present; in truth, however, the residual percentage is never zero due to the presence of excess air.

Carbon Monoxide CO

This is expressed in parts per million and indicates the concentration of CO "diluted" in the flue gas.

Excess air l, n

This is the ratio between the volume of air that actually enters the combustion chamber and that which is theoretically required.

Carbon Dioxide CO₂

This results from good combustion and should approach the theoretical threshold value as much as possible.

Stack loss Q_s

This is the percentage of heat lost through the stack.

Sensible efficiency E_s

It is the burner efficiency calculated according to the UNI 10389-1 standard, as the ratio between conventional heating power and the burner heating power. Among the combustion losses, only the sensible heat lost with flue gasses is taken into account, thus neglecting the radiation losses and incomplete combustion losses. This value is referred to the Lower Heating Value (LHV) of the fuel and cannot exceed 100%. The sensible efficiency value is to be compared against minimum efficiency stated for the heating system performances.

Condensation efficiency E_c

Efficiency deriving from the condensation of water vapour contained in flue gasses, calculated according to the UNI 10389-1 standard.

Total efficiency E_t

Total efficiency. It is the sum of sensible efficiency and condensation efficiency. It is referred to LHV (Lower Heating Value) and can exceed 100%.

Differential temperature T diff

This is the difference between the temperature of the flue gas and that of the combustion air.

Carbon Monoxide CO (referenced to 0% O₂)

This is expressed in parts per million and indicates the concentration of CO that the law requires us to keep under control (it should be lower than 1000 ppm).

Instructions for accurate testing

In order to achieve a certain degree of accuracy when conducting flue gas analysis, the following should be respected:

the boiler being checked should be running in steady state conditions

the flue gas analyser should be switched on at least 3 minutes before testing (time to auto-calibrate) with the probe located in fresh air

the point in which the probe is inserted for analysis has to be at a distance of approximately twice the stack diameter or, alternatively, as directed by the boiler manufacturer.

the water trap should be completely empty and positioned vertically

before switching off the instrument, extract the probe and wait at least 3 minutes (the CO value has to drop below 10 ppm)

Before returning the instrument to its place, clean the water trap and relative hose; if water is present in the hose clean the latter by blowing inside.

 Tel. (+39).0424.567842 Fax. (+39).0424.567849	DICHIARAZIONE DI CONFORMITA' UE EU DECLARATION OF CONFORMITY	Nr. 027448 Pag. 01 di 01		
Nome del fabbricante: Seitron S.p.A. a socio unico. <i>Constructor name:</i>				
Indirizzo del fabbricante: Via Prosdocimo, 30 <i>Constructor address:</i> 36061 Bassano del Grappa (VI) Italia				
dichiara sotto la propria esclusiva responsabilità che il seguente prodotto: <i>declares under its sole responsibility that following product:</i>				
Nome del prodotto: AS0800 (incluso nel kit K8- --- --- / included in the K8- --- --- kit) <i>Product name:</i> Analizzatore di combustione <i>Combustion analyzer</i>				
Versioni del prodotto: Tutte <i>Product versions:</i> All Nomi commerciali: Casper 20- - / Casper 30- - <i>Sales models:</i>				
e' conforme alla pertinente normativa di armonizzazione dell'Unione: <i>is in conformity with the relevant Union harmonisation legislation:</i>				
EMC (2014/30/UE): EN-50270 (2006)				
LVD (2014/35/UE): EN 60335-1 (2012) (Per le parti citate nella norma di prodotto) <i>(For parts mentioned in the Product Standard)</i>				
Di prodotto: EN 50379-1* (2012) <i>(Product):</i> (Requisiti generali e metodi di prova) <i>(General requirements and test methods)</i>				
EN 50379-2 ^{1*} (2012) (Requisiti prestazionali per apparecchiature impiegate per ispezioni e valutazioni obbligatorie) <i>(Performances requirements for apparatus used in statutory inspections and assessment)</i>				
RoHS2 (2011/65/UE): EN-50581 (2012) Per i sensori di O ₂ elettrochimici vale l'esenzione di cui all'Allegato IV, punto 1b. <i>Electrochemical O₂ sensors are exempted according to Annex IV, point 1b.</i>				
Note aggiuntive: Lo strumento è conforme alle norme italiane UNI 10845, per la misura del tiraggio ed UNI 10389-1, per la misurazione del rendimento di combustione. Lo strumento e' inoltre conforme alla norma VDI4206-1* ed e' stato approvato dal comitato UBA per l'utilizzo come misuratore di emissioni secondo lo schema 1.BimSchV (RgG 292) ² . <i>Further notes:</i> This instrument is compliant with the requirements of the Italian standard UNI 10845, for draft measurement, and UNI 10389-1, for combustion efficiency measurement. Moreover the instrument is in conformity with the standard VDI4206-1* and has been approved by the UBA committee for the use as emissions measurement device, according to the 1.BimSchV scheme (RgG 292) ² .				
Bassano del Grappa, li 16/09/16 <div style="text-align: right;">  Amministratore Delegato Seitron S.p.A. a socio unico </div>				
<table border="0"> <tr> <td style="width: 50%;"> 1 Valido per le configurazioni che includono i seguenti sensori: Valid for configurations equipped with the following sensors: O₂: Cod. AAC SE15 - Cod. AAC SE11 CO+H₂: Cod. AAC SE20 - Cod. AAC SE12 NO (optional): Cod. AAC SE10 </td> <td style="width: 50%;"> 2 Valido per le configurazioni che includono i seguenti sensori: Valid for configurations equipped with the following sensors: O₂: Cod. AAC SE15 CO+H₂: Cod. AAC SE20 NO (optional): Cod. AAC SE10. </td> </tr> </table>			1 Valido per le configurazioni che includono i seguenti sensori: Valid for configurations equipped with the following sensors: O ₂ : Cod. AAC SE15 - Cod. AAC SE11 CO+H ₂ : Cod. AAC SE20 - Cod. AAC SE12 NO (optional): Cod. AAC SE10	2 Valido per le configurazioni che includono i seguenti sensori: Valid for configurations equipped with the following sensors: O ₂ : Cod. AAC SE15 CO+H ₂ : Cod. AAC SE20 NO (optional): Cod. AAC SE10.
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*: Tests performed by TÜV SÜD Industrie Service GmbH - Munich, Germany.				
Seitron S.p.A. a socio unico Via Prosdocimo, 30 36061 Bassano del Grappa (VI) Tel. (+39).0424.567842 Fax. (+39).0424.567849				

WARRANTY CERTIFICATE

WARRANTY

The CASPER flue gas analyzer is guaranteed for **24 months** from purchasing date including the internal electro-chemical sensors which are also guaranteed for **24 months** from purchasing date.

Seitron undertakes to repair or replace, free of charge, those parts that, in its opinion, are found to be faulty during the warranty period. The products which are found defective during the above mentioned periods of time have to be delivered to Seitron's Laboratories carriage paid. The following cases are not covered by this warranty: accidental breakage due to transport, inappropriate use or use that does not comply with the indications in the product's instruction leaflet.

Any mistreatment, repairs and modifications to the product not explicitly authorized by Seitron shall invalidate the present warranty.

IMPORTANT

For the product to be repaired under Warranty, please send a copy of this Certificate along with the instrument to be repaired, together with a brief explanation of the fault observed.

Space reserved for user

Name: _____

Company: _____

User's notes:

Date: _____

S.N.:



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