GAS ANALYSER

GA-60

Manual

Version: 3.1
9/2013

madur
ELECTRONICS

1. INTRODUCTION

Congratulations on your purchase of the microprocessor-controlled flue gas analyser

madur   GA-60

It is a high quality instrument produced using the latest technical discoveries. The **GA-60** is easy to use. You also have the possibility of using the extra capabilities of this analyser, of examining measurement results, checking service intervals and many others. Please read the operating manual carefully. It contains valuable tips and information for problem-free operation. Regular maintenance will help to keep your analyser ready for use at all times.

2. PACKAGE CONTENTS

1. **GA-60 gas analyser**
2. RS-232 (PC-analyser) communication cable
3. Software CD
4. MMC / SD memory card + USB card reader
5. Gas probe pipe (optionally)
6. Gas probe holder (optionally)
7. Mains cable

2.

3.

4.

6.

5.
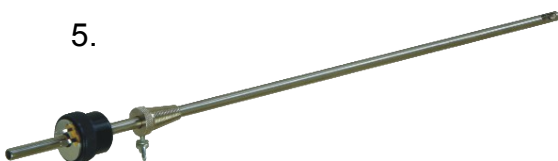
3. GENERAL INFORMATION

GA-60 gas analyser can be equipped with up to 6 electrochemical sensors and 2 NDIR gas sensors. Depended on the configuration, the analyser can measure the concentration of the following gases: O_2, CO_2, CH_4, CO, NO, NO_2, NOx, SO_2, H_2S, H_2, NH_3, Cl_2, HCl. CO_2, CH_4 gases are measured using optical sensors (NDIR – non-dispersive infra-red). All other gases are measured using electrochemical cells. Gas concentrations can be presented as:

- volume concentration (% or ppm)

- mass concentration (mg/m^3)

- mass concentration referred to oxygen (mg/m^3)

Additionally, the analyser measures fumes temperature, ambient temperature (with use of thermocouple and PT500 sensor), atmospheric pressure and differential pressure. Based on the measurement data and on the fuel parameters, the analyser can calculate the following values:

- stack loss

- loss by incomplete combustion

- efficiency

- excess air (lambda)

All the measured and calculated values can be presented on the analyser's display, stored in reports on MMC/SD memory card or in the analyser's internal memory. They can also be represented by electrical signals through analogue outputs (current or voltage).

4. CONSTRUCTION

4.1. Front panel

Drawing 1. **Front panel of the GA-60 gas analyser**

The drawing above shows the front panel of the analyser with its essential parts:

1. Gaseous connection of gas filter that is installed in case's lid.

2. MMC / SD card's slot – this memory card is used for saving measurements in a form of reports, that can be later viewed and processed on PC computer.

3. Display – ¼ VGA monochromatic LCD display to present results of measurements. For better viewing it is equipped with a back-light and a contrast control. At the bottom of the screen there is a function keys' description bar (10). Function keys may change depending on the screen the user is viewing.

4. Numeric keyboard, allows to enter values while operating.

5. Printer – allows immediate access to paper measurements results. 57 mm standard paper comes out of the analyser with speed of 2.5 lines per second.

6. Analysers ON/OFF switch – mechanical power switch.

7. Probes connector – allows analyser to work with a gas probe.

8. Gas inlet – connection for probes gas hose.

9. 4 directional buttons (arrow keys) – allow easy movement through analysers menu screens.

10. 4 function keys – fast access to programs functions. Each of the keys has its function's name visible on the screen, above the key.

11. Pressure connectors – for measurement of gas pressure and chimney draft.

12. Ambient temperature probes connector – allows to work with the PT500 probe.

13. Communication cable's connector – analyser can be set and checked from a computer. A special RS-232C cable and software are included. Software makes working with the analyser and setting up clients and fuels data bases easier.

4.2. Gas channel

4.2.1. Gas probe

Gas sample is collected with a gas probe (usually equipped with a temperature sensor). Typical probe lengths are: 150mm, 300mm, 750mm, 1500mm.

4.2.2. Gas pump

GA-60 is equipped with a gas pump (efficiency – 90l/h) that provides gas sample to the sensors. It is possible to manually switch the pump off (for example when analyser is to work with external gas dryer equipped with its own pump, like **PGD-100**).

4.2.3. Electrochemical sensors

Electrochemical sensors are used for all oxygen measurements and sometimes for some other gases. Oxygen sensor is calibrated with air within initial calibration.

Other sensors are only zeroed during that time.

4.2.4. NDIR sensors

Analyser can be equipped maximally with 2 NDIRs. These sensors are used for CO_2 and CH_4 measurements.

4.3.   Analogue outputs

GA-60 can be equipped with 16 analogue outputs (8 current and 8 voltage ones). Analogue outputs module is mounted on the right side in the analysers lid (shown in Drawing 2.). Connectors are numbered 1÷8 starting from the left. Each connection has a pair of outputs – one current and one voltage.

Drawing 2.   **Localisation of the analogue outputs module in the analysers lid.**

With a use of included software each output can be assigned to one of measured or calculated value. Then current or voltage in the appointed output will be proportional to the measured gas parameter. Program also allows to specify range within which the value of current will change.

Voltage ranges in the voltage outputs (U1÷U8) can be set in the program to 0÷5V or 0÷10V. In a similar way current range can be set to 0÷20mA or 4÷20mA.

External devices can be connected to these analogue outputs with a use of an electrical wire (with a maximal diameter of $1mm^2$) that has to be screwed to the connector. In each connector wiring looks like on the pictures below.
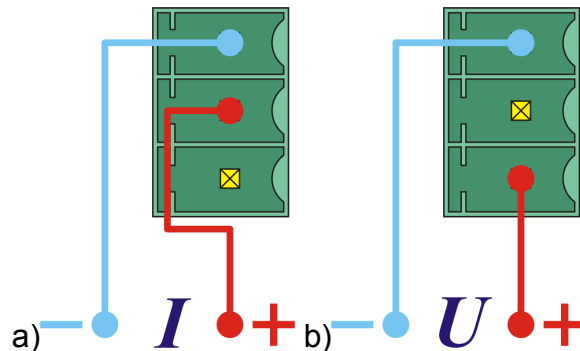
Drawing 3.   **Wiring in analogue outputs: a) current outputs, b) voltage outputs.**

4.4. Power

Analyser **GA-60** is to be powered from the mains power supply (110VAC or 230VAC). It can also be powered from its own built-in rechargeable battery for up to 12 hours. This battery charges whenever the analyser is connected to the mains power supply.

5. WORKING WITH THE ANALYSER

5.1. Starting up the analyser

To start up the analyser you have to use the switch placed on the right side of the front panel. If you did not use the mains power cord, the analyser will start, using its built-in rechargeable battery. When the power cord is used, the analyser will charge the battery regardless from the power switch being in ON or OFF position.

At first, a welcome screen will be displayed (like the one below) and afterwards an information about a process of gas sensors zeroing should be visible.
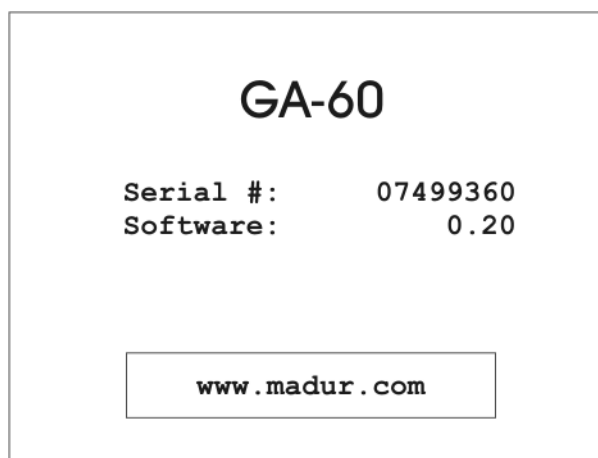
Drawing 4.   **Welcome screen visible straight after the analyser is starts.**

Zeroing procedure takes 120 seconds and is necessary for measurements precision. A countdown timer visible on the screen shows the time remaining to the end of this process. Afterwards the analyser is ready to work, with a screen of measurement's parameters displayed.
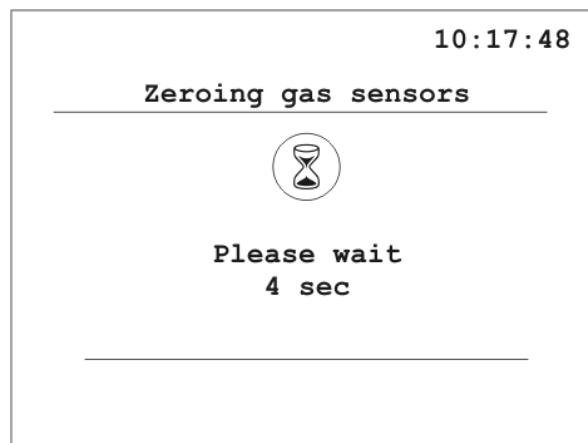
Drawing 5.   **Resetting screen with countdown timer.**

Attention!

Fresh air must be provided to the analyser through the analyser's probe throughout the whole process of zeroing.

If an *auto-start* option is chosen in the saving options, and an SD/MMC card is in the card port, the third screen visible will include request for clients number for which all following measurements will be carried (you can find more information about auto-start in chapter 5.3.3.3)

5.2.   Preparation for measurements

Before you start the analyser you should set up a complete measuring module:

- Connect a probe pipe with a probe holder

- Connect a gas hose to the analyser (both connectors, gas and electric)

- Connect the analyser to the mains power supply (if analyser is to work from the battery this step can be skipped)

- Start the analyser with the switch on the front panel (right side of the panel, close to the handle)

Then a process of zeroing the sensors will start and after about 2 minutes the analyser is ready to work.

Attention!

Fresh air must be provided to the analyser through the analyser's probe throughout the whole process of zeroing.

5.3.   Measurements screens

5.3.1.   Measurements parameters screens

Measurements parameters screen is the first that you can see when the analyser is ready to work. You can also get to this view from Results screens or *Menu screens.*

```
 Measurement parameters  10:45:22

➡ Averaging t:               2 s
  Time of XL test:          10 min
  NO in NOx:              96.0 %
  Reference O2:              3 %
  Fuel:                     0

        Light oil



  Esc    Change            Data
```
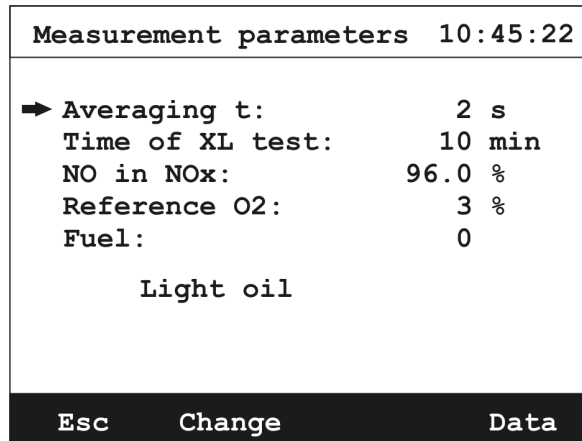
Drawing 6.   **Measurements parameters screen.**

From this place you can change analysers measurements parameters. Use arrow keys up/down to move between different settings. Keys left/right will allow changing chosen parameters value (that is highlighted with a small arrow on the left side of the screen). You can also use function key *change* to increase selected value.

You can change below mentioned parameters:

- *Averaging time* – time interval for which all measurement results will be recalculated averaged and displayed. **GA-60** reads measurements results every 2 seconds and stores the last 90 measurements in its inner memory. Analyser can display value averaged for chosen time from these stored results. You can set the averaging time to one of these values: 2s, 6s, 10s, 20s, 30s, 60s, 120s, 180s.

Attention!

This operation will change the averaging time globally. If the averaged results are being saved, all of them will be stored with the new time set.

- *Measurement time XL* – it is a time of single XL measurement. **GA-60** measures for the set time, averages the result and stores it as a report in its inner memory or on a SD/MMC card. XL time can be set to: 10s, 20s, 30s, 1min, 2min, 5min, 10min, 15min, 20min, 30min.

- *NO in NOx* – allows setting value of percentage content of NO in NOx (nitric oxide, on a separate screen *NO in NOx)*. If the analyser is equipped with NO_2 sensor, *NO in NOx setting will not be visible.*

- *Reference O2* – reference value of oxygen used for calculations of relative mass concentrations.

- *Fuel* – currently used fuel. Name of the fuel is displayed in the line below the setting name. **GA-60** stores 14 different fuel settings, of which 10 are factory defaults and 4 can be set by the user.

The last 3 settings are used for calculations, consequently should stay set to actual values to allow correct and precise measurements results.

One can leave the measurements parameters screen with the ESC key, this will transfer Results screens screen.

5.3.1.1. NO in NOx

Pressing the *change* function key in setting NO in NOx on the *Measurement parameters* will make the screen below appear:

```
NO in NOx:                  10:16:22


      Enter NO in NOx value:
        ┌─────────────────┐
        │   069.5 %       │
        │      ↕          │
        └─────────────────┘




     Esc        OK        C
```

Drawing 7.   **NO in NOx value setting screen.**

This value can be changed with the numeric keypad or with the arrow keys – left/right key will change the indicator position, up/down key will change the highlighted value.

NO in NOx value is displayed in % and should be set within the range of 50% - 100%. In case it is set above or lower, the analyser will automatically change the value to 50% or 100%. In situation when the analyser is equipped with NO2 sensor, NO in NOx setting will not be displayed.

5.3.2. Results screens

GA-60 analyser displays measurements results on 4 screens. You can switch between them by pressing up and down arrow keys. The computer software can be used for setting order in which the results will appear on the 4 results screens.

```
 1  M003  F1   T=2s 0:04 XL1  10:13

 CO        22 ppm  NO        10 mg/m³
 NO2       13 ppm  H2S       12 mg/m³
 SO2      220 ppm  NH3      160 mg/m³
 H2        45 ppm  HCl      286 mg/m³
 Cl2       15 ppm  NO         0 mg/m³
 ---      --- ppm  ---      --- mg/m³

 M+      Operation  Print    Param.
```

Drawing 8.   **Example of the results screen**

A status bar is visible in the top of the results screen. Information available:

- *1* – number of the results screen; 4 screens are available. You can change the screen by pressing up/down arrow key. Types of displayed parameters differ depending on the analysers configuration.

- *M003* – multiple saving measurement enrolling; Number represents value of remaining savings to be done.

- *F1* – ID number of fuel set; change can be done from Measurements parameters screens.

- *T=2s* – averaging time; change can be done from Measurements parameters screens. If working time of the analyser is shorter than averaging time, displayed value will equal the working time until it will reach the averaging value (then it will stop changing and set averaging time will be displayed permanently).

- *0:04 XL1* – XL measurement in process; This information means that a single XL measurement or the first of 3 XL measurements are being done. 0:04 represents time till the end of measurement.

- *10:13* – current time.

14

Description of function keys available on the Results screens:

- *M+* – go to the Saving options screen *screen*

- *Operation* – go to Operation screen screen.

- Print– go to Print options *screen*.

- *Param.* – go to Measurement parameters screen.

Measured gas concentrations are displayed like below:

- *CO* – volume concentration of a gas (% or ppm)

- *COm* – mass concentration (mg/m3)

- *CO** - mass concentration in relation to oxygen (mg/m3)

The same symbols are used on the printouts.

Results on the screen are updated every 2 seconds. At any time the result is averaged for chosen time.

5.3.2.1. *Results screen number 4*

The number 4 results screen is specific because some measurement results can be presented graphically. Functions available for function keys are also different on this screen.

```
4   M003   F1    T=2s 0:04 XL1   10:13
CO          0.00 %   CO  IR       0 ppm
CO2         0.00 %   NO  IR       0 ppm
Tgas         --- °C  SO2 IR       0 ppm
Tamb         --- °C  NOx          0 ppm
qA           --- %
   4                              39
                                 Pdif
                                 [Pa]

   -6
     -180      -120      -60       0
     M+        (+)       (-)    Options
```
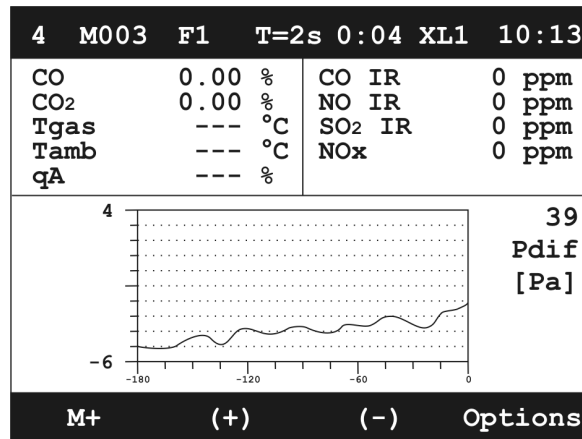
Drawing 9. **Example of a graph on results screen 4.**

Y (vertical) axis displays value of the variable. X (horizontal) axis displays time, last 180 seconds of the measurement. Results are presented by the curve on the graph.

Name of the variable, its number and unit are displayed on the right side of the graph.

Description of function keys available on the Results screen number 4:

- *M+* – go to the *Saving options screen*

- *(+)* – change presented gas channel to the next one.

- *(-)* – change presented gas channel to the previous one.

- *Options* – go to charts setting screen (like the one below):

```
┌─────────────────────────────────────┐
│ Chart                    10:45:22    │
│ ➡ Grid:                      Yes     │
│   Y axis:                    Auto    │
│   Hide variable                      │
│   Show all variables                 │
│   Set to default                     │
│                                      │
│                                      │
│    Esc        OK                     │
└─────────────────────────────────────┘
```
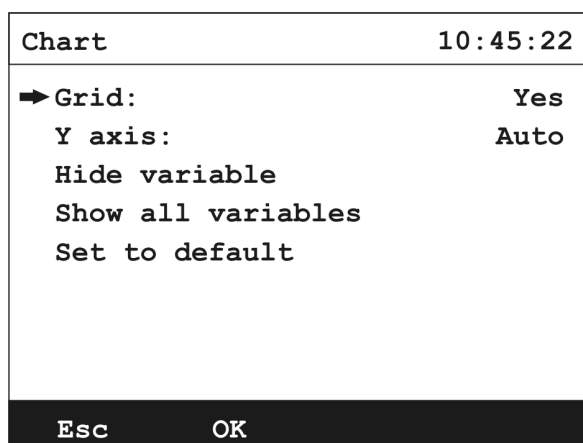
Drawing 10.   **Example of a charts settings screen**

These graph parameters can be changed by the user:

- *Grid* – turn the graph grip on or off

- *Y axis* – this variable can be set to the following values:

    - *AUTO* – fits the range of the Y axis to the minimum and maximum values measured in the currently set gas channel.

    - *Full* – sets the range of the Y axis to the widest range possible for current gas channel.

    - *Default* – sets the range of the Y axis to the typical values for current gas channel.

- *Hide variable* – removes currently chosen variable on the graph from the list of available values for the graph.

- *Show all variables* – adds all variables to the available for the graph list

- *Set to default* – sets graph into factory default settings, the list of available variables will be changed to over a dozen of most important ones.

5.3.3.   Saving options screen

GA-60 stores the measurements results as reports, with information about actual measurements parameters and values of all measured and calculated variables

Results can be saved on a SD/MMC memory card or on an internal memory. Internal memory can store up to 4 reports and is used in the absence of external memory (SD/MMC) or when external memory is full.

```
Saving options              10:16:22
➡ Current results:            6 sec
  Single XL test:            10 sec
  Triple XL test:       3 x 10 sec
  Multiple storage:            Off

  Memory card:              64 MB
  Available memory:       37.2 MB
  Storage interval:         10 sec
  Storage quantity:            5
  No. of reports to save:      3

  Esc     Start    Options   MMC/SD
```

Drawing 11.   **Example of saving options screen**

Information about the memory card, remaining memory available and space for reports is displayed on the bottom part of the screen Saving options. Multiple saving settings are also available here.

Top half of the screen displays settings for the type of saving. Selected setting is highlighted by a small arrow on the left side of the screen.

- *Current results* – values of all actually measured and calculated parameters will be saved for averaging time set.

- *Single XL test* – One long measurement processes will be carried, for time set in measurement parameters. Saving time can be changed with left/right arrow keys or through the options screen available from savings option screen. Measurement results will be averaged for the time of the whole time of the XL test.

- *Triple XL test* – 3 long measurement processes will be carried, each one lasting the time of a single XL test. Measurements results will be averaged for the time of the whole single XL test. Results for the triple test are stored as a single file.

- *Multiple storage* – multiple measurement processes will be carried. The amount of tests and the time interval between them are visible on the bottom part of the screen. Parameters can be changed through the Options screen available under Option key. Results will be stored as a single file with series of measurements. Wile the multiple storage process is lasting, other measurements can be carried normally.
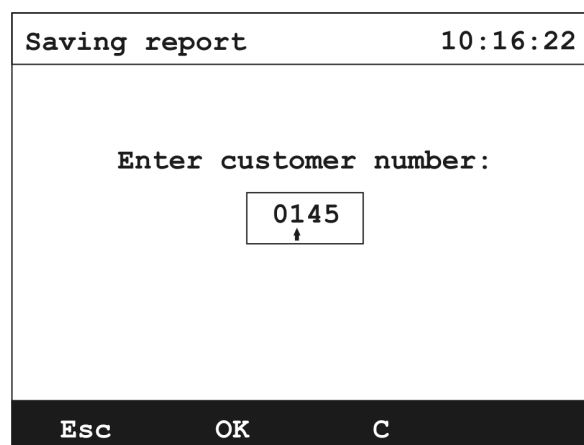
Description of function keys available on the Saving options screen:

- *Esc* – go back to Results screens.

- *Start* – starts the process of saving for chosen savings options (chapter 5.3.3.1).

- *Options* – go to Storage options screen (chapter 5.3.3.2).

- *MMC/SD* – go to MMC/SD*, that shows a list of all reports available on the card.*

5.3.3.1.   Start function key

This key starts savings for chosen (highlighted with an arrow) savings option. When Start key is pressed the screen below will be visible:

```
Saving report              10:16:22


      Enter customer number:
            ┌──────────┐
            │   0145   │
            └──────────┘
                 ↕




     Esc        OK        C
```

Drawing 12.   **Example of the screen for imputing customer number.**

User will be asked for customer number, arrow keys can be used for setting its value (left/right for changing highlighted digit, up/down for changing the digit) or numeric keypad optionally.

In case when MMC/SD card is not present in the card slot or when there is no more free space available, the screen below will be displayed:

```
Saving report              10:16:22



        ┌─────────────────────────────┐
        │  ⚫   No free mem for report! │
        │  ❗   Overwrite the oldest?   │
        └─────────────────────────────┘




     Esc      Yes
```
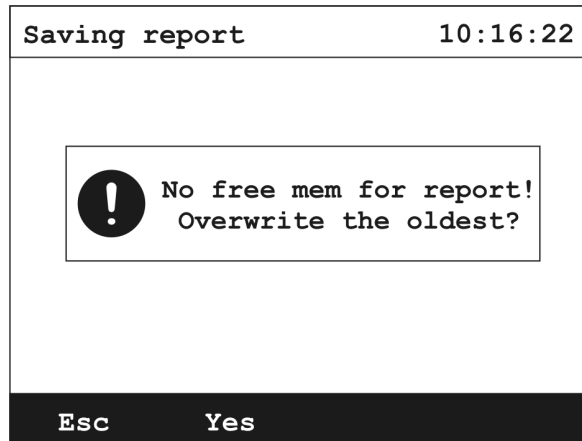
Drawing 13.   **Screen with information about lack of free space in memory for saving measurements results.**

Choosing Esc will take you back to the saving options.

Choosing Yes will allow overriding the oldest result with the current one.

When XL test was chosen, screen measurements results will appear. Instead of function key *M+* a new key Stop will be displayed. This key leads to the stopping confirmation screen:

```
Saving report              10:16:22



        ┌─────────────────────────────┐
        │  ⚫   XL test in progress!    │
        │  ❓      Cancel test?         │
        └─────────────────────────────┘




     Esc      Yes
```
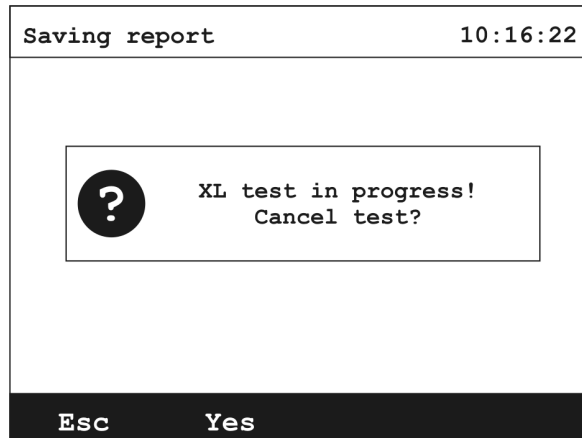
Drawing 14.   **Example screen with confirmation for XL test.**

Esc key will lead back to results screen without stopping the XL test.

The Yes key will stop the test and lead back to the results screen.

If Multiple storage was chosen, Stop key will be visible instead of the Start key on the saving options. If pressed it shows this screen:

```
Multiple storage:              10:16:22


            ┌─────────────────────────────┐
      ●     │                             │
     ?      │      Cancel saving?         │
            │                             │
            └─────────────────────────────┘




        Esc       Yes
```
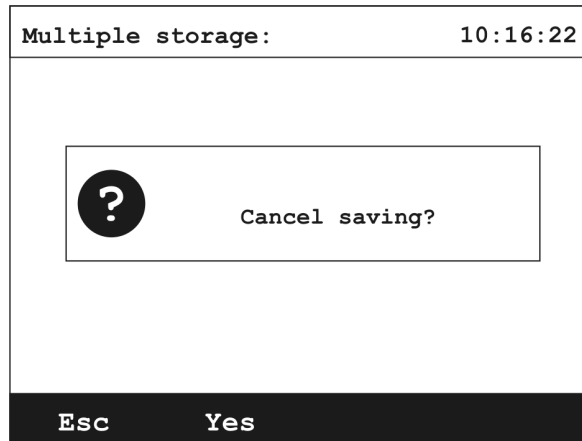
Drawing 15.   **Screen for stopping the multiple storage process.**

Yes will stop the process.

Esc will cancel the question and lead back to results screen.

5.3.3.2.   Function key Options

Pressing the Options key on the saving options screen will open the screen with storage options:

```
Storage - options         10:16:22
➡ Storage interval:         10 s
  Storage quantity:         60
  Time of XL test:          10 min
  Autostart:                Yes




    Esc    Change
```
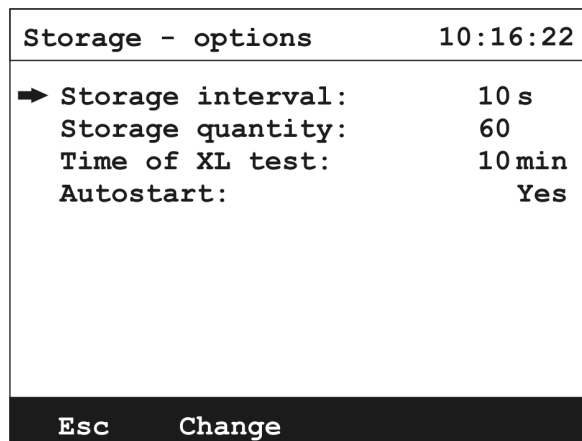
Drawing 16.   **Storage options screen.**

Changing parameters can be achieved by using the arrow keys (left/right) or by pressing the *Change* function key.

These are the available settings:

● *Storage interval* – this parameter concerns only the multiple storage option. It describes time interval between each results savings (for measurements averaged to the specified in the Parameters screen time. It can be changed

21

by left/right arrow key or *Change* function key between these values: 10sec, 20sec, 30sec, 1min, 2min, 5min, 10min, 15min, 20min, 30min.

In the mean time XL single and triple test can be carried out.

- *Storage quantity* – this parameter concerns only the multiple storage option. It displays the amount of savings of the results carried through the whole multiple storage saving process. 0 value sets infinite amount of savings carried until the memory is full. Changing this value is done through the screen visible below:

```
Storage - options            10:16:22


 Set no. of records (0 = const.):

           0000

     Esc        OK         C
```

Drawing 17. **Storage quantity changing screen for multiple storage process.**

- *Time of XL test* – time of single XL test, this option is identical with Measurement time XL *from Measurement parameters.*

- *Autostart* – this function (if set to YES) will start savings automatically, immediately after the MMC/SD card is put into the card slot(see chapter 5.3.3.3).

5.3.3.3.   *MMC/SD*

MMC/SD card will be detected automatically after it is put into the card slot (on the left side of the front panel behind the ambient temperature connector). When you insert a card into the slot, you should see a screen with information about a card being found, for a few seconds:

Drawing 18. **Screen with information about card detection.**

When autostart option is set to Yes, card detection screen will be followed by the screen with request for customer number.

Attention!

In case when:

- *analyser is starting*

- *Autostart* **option was previously set to Yes**

- **MMC/SD card is in the card slot**

The analyser will try to initialize the multiple storage saving process. Then user will be asked for customer number.

Card in the card slot blocks savings to the analysers internal memory. However it is possible to move previous results from the internal memory to the memory card. To do that you must get to the Internal memory *screen and press →MMC/SD function key.*
Please note that it will move (not copy) the results, so they will be erased from the internal memory:

```
On-board memory              10:26:27

    No.     Date    Hour  Cust.  Time

 ➡ #00012¹ 12/08/06 11:10 K0010   3min
   #00012² 12/08/06 11:13 K0010   3min
   #00012³ 12/08/06 11:16 K0010   3min
   #00013  12/08/06 12:36 K0013   2sec



   Esc    Print    Erase  →MMC/SD
```

Drawing 19.   **Internal memory results preview screen.**

Information about the size and available space on the memory card is collected from the card only once, immediately after the card is insert into the card slot. Possible is a situation when, during long savings, analyser will display information about ending of space on the card even when the information displayed in the savings option screen says something different.

Each report is stored in a separate file (apart from multiple storage process and triple XL test where one file holds series of data). File is saved under a name of XX_XXXXX.rp (where X represent a digit). Multiple storage reports are described by a name of XXXXXXXX.mrp (mrp - Multiple RePort).

→*MMC/SD* key (in the saving options) allows to have a look at the results reports already saved on the card:


```
MMC/SD card          10:16:22  | MMC/SD card          10:16:22
       Name   Size   Date Time |        Name   Size   Date Time
➡00000017.RP    10 12.08.06 11:30|➡00000017.RP    10 12.08.06 11:30
 00000216.RP 65530 15.08.06 23:31| 00000216.RP 65530 15.08.06 23:31
 00001447.RP   123 15.08.06 06:54| 00001447.RP   123 15.08.06 06:54




   Esc   Next...  Print  Format |   Esc   Home   Print  Format
```

Drawing 20.   **Example screen of the content of the memory card.**

If the card contains more result reports than can be displayed on one screen simultaneously, a function key *Next* will appear to allow viewing next reports pages.

When the last page of all available will be opened key *Next* will be replaced with *Home* that will lead to the first page of the results reports. Desired report can be chosen with the use of up/down arrow keys.

In case of multiple storage saving process, information about currently used file is updated every time the screen with the file is displayed again.

Description of a single line of the screen of MMC/SD card:

- *00000216.RP* – name of the file

- *15/08/04 23:31* – date and time of the measurement

- *65530*– size of the file (amounts of records in the file)

If the card is not recognised correctly by the analyser, instead of Drawing 20. a screen with request for a format will be visible:

```
Formatting MMC/SD card!  10:16:22


          ┌──────────────────────────────┐
    ┌─┐   │    Unknown card format!      │
    │?│   │    Format the SD card?       │
    └─┘   │                              │
          └──────────────────────────────┘



    Esc      Yes
```
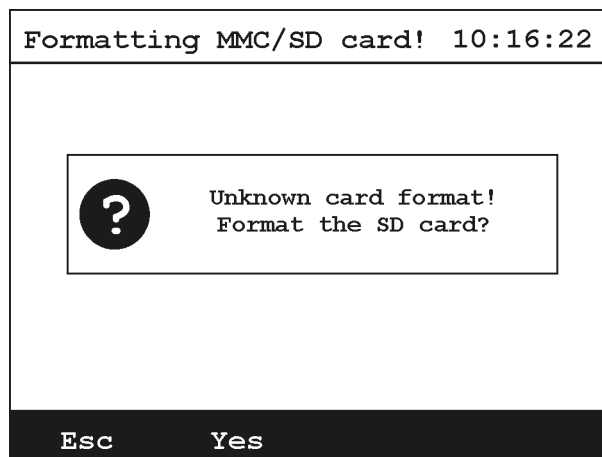
Drawing 21.   **Example screen of the format request when card was not recognised by the device.**

Function Key *Format* allows deleting the whole content of the memory card and quick format of the card (in FAT format). A warning screen will appear while the card is being formatted (this operation can take up to 15 seconds):

```
Formatting MMC/SD card! 10:16:22



          ?        Format the SD card?




        Esc      Yes
```
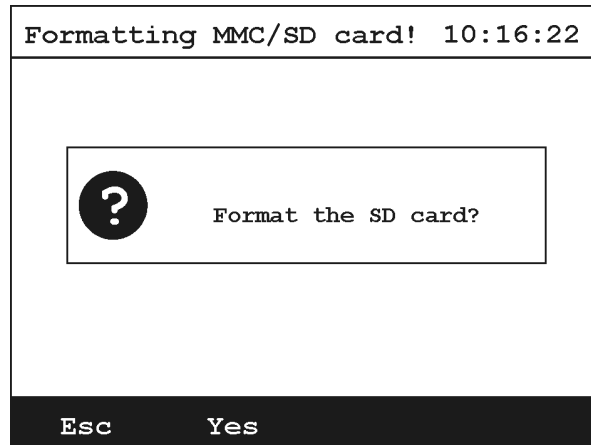
Drawing 22.   **MMC/SD card formatting process information screen.**

5.3.4.   *Operation screen*

From the Results screen you can directly jump to the Operation screen (pressing the function key *Operation*)

```
Operation                    10:26:27
➡ HOLD - ✳
  Pressure sensor zeroing
  Get pressure value
  Restart averaging
  Gas sensors zeroing
  Gas sensors zeroing (FAST!)
  Soot test



     Esc        OK      Data
```
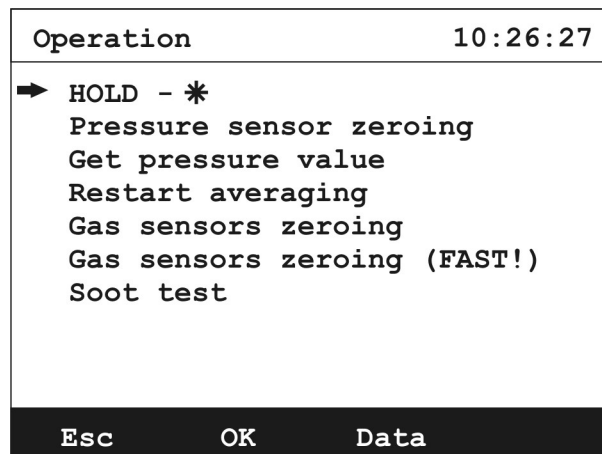
Drawing 23.   **Operation Screen**

From the Operation screen one can perform the following operations:

- *Hold* – holds the current values presented in the Results screen. The measurements and averaging are still in process. To leave the Hold mode, press the asterisk " ✳ " function button

- *Pressure sensor zeroing* – actual pressure value across the differential pressure connectors is set to 0. It is recommended to use this function before the start of the pressure measurements

- *Get pressure value* – analyser will perform single pressure measurement. The result of the following measurement will be displayed on the screen presented below and saved in the next report

```
┌─────────────────────────────────────┐
│    Pressure set:                     │
│ i    19 Pa                           │
└─────────────────────────────────────┘
```
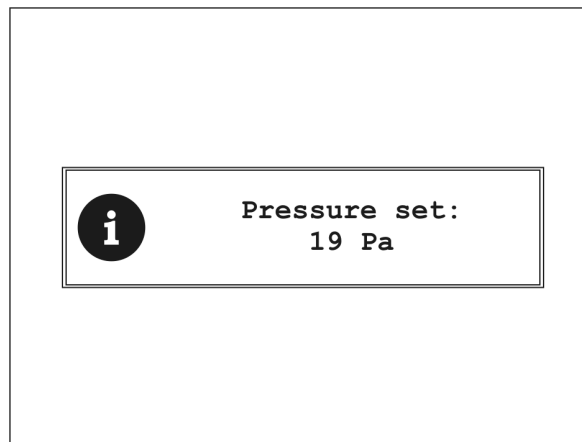
Drawing 24.   *Get pressure value screen*.

- *Reset averaging* – clears the buffer of the last measurements, new data for averaging will be calculated after performing this operation

- *Gas sensors zeroing* – starts ventilating the gas sensors for 3 minutes and after that time zeros the gas sensors in the same way like it is performed while starting up the device.

  Caution! Make sure that during ventilation analyser gather atmospheric air (inert gas) from the GAS connector.

- *Gas sensors zeroing (FAST!)* – performs fast zeroing that lasts 10 seconds.

  Caution! Before using this operation the sensors must be ventilated for at least for 3 minutes.

- *Soot test* – starts the soot test procedure (see chapter 5.3.4.1).

5.3.4.1.   Soot test

In order to perform the soot measurement, analyser should be equipped with heated probe handle with a slot for soot test filters.

To start the procedure select Soot test in the Operation screen and follow the steps presented below:

1. Put the soot test filter into the probe holder's slot.
2. Set the pointer on the Pump regulation and press *Start* function key

```
┌─────────────────────────────────────┐
│ Soot test              10:16:22      │
│                                      │
│ ➡ Pump regulation         150        │
│   Soot test                          │
│                                      │
│                                      │
│                                      │
│                                      │
│                                      │
│        Set the flow to 100l/h        │
│                                      │
│    Esc     Start      (+)      (-)   │
└─────────────────────────────────────┘
```
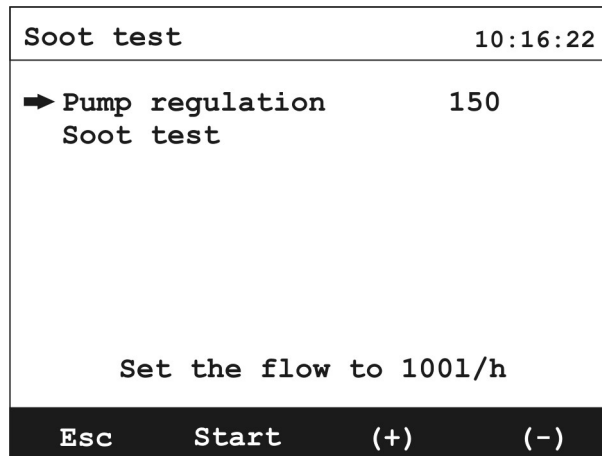
Drawing 25.   **Screen of flow setting for soot measurements**

3. Observe the flow meter, set the flow value to 100 l/h by regulating the pump efficiency using function keys *(+)*, *(-)*.
4. When the flow is set, press the *Stop* function key and set the pointer at the Soot test.
5. Put the clean paper filter into the hose's holder and start measurement by pressing Start function key.
6. To confirm the measurement choose *Yes*, to cancel choose *Esc*.

```
┌─────────────────────────────────────┐
│ Soot test              10:16:22      │
│                                      │
│                                      │
│      ┌─────────────────────────┐     │
│      │           Soot test     │     │
│      │  ❓                      │     │
│      │           Start test?   │     │
│      └─────────────────────────┘     │
│                                      │
│                                      │
│    Esc      Yes                      │
└─────────────────────────────────────┘
```
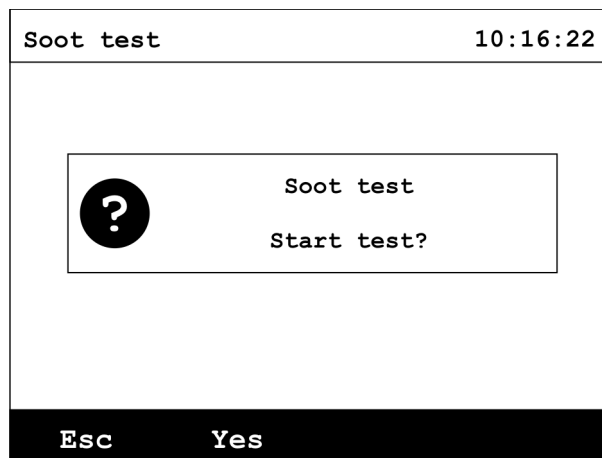
Drawing 26.   **Screen of confirmation of Soot measurement**

7. Measurement lasts for 60 seconds. During the measurement observe flow value on the flow meter and, if necessary, regulate the pump efficiency using *(+), (-) function keys.*

```
Soot test                10:16:22

  Pump regulation        150
➡ Soot test

  ┌─────────────────────────────┐
  │                             │
  │ Measurement in progess 55   │
  │                             │
  └─────────────────────────────┘


      Set the flow to 100l/h

  Esc     Start     (+)      (-)
```
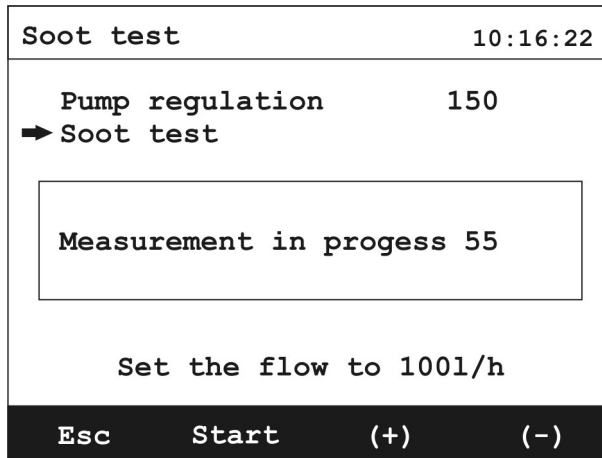
Drawing 27.   **Soot measurement screen.**

8. When the measurement is finished read the soot level from paper filter (compare it with the paper scale) and enter the result into the analyser.

```
Results printing...      10:16:22


         Set soot level
        ┌──────────────┐
        │ 0000.0 °B    │
        └──────────────┘




  Esc       OK        C
```
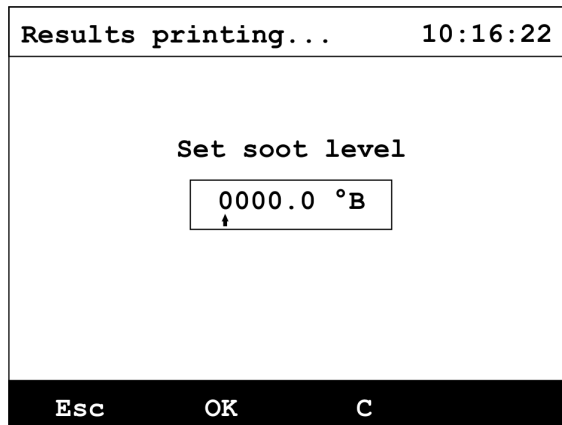
Drawing 28.   **Screen for entering the soot level into the analyser**

5.3.5. Print options

When you press function key *Print* you will be moved to this screen:

```
┌─────────────────────────────────────┐
│ Print options          10:26:27     │
├─────────────────────────────────────┤
│➡ Current results:      Format: 2    │
│  Report/ On-board mem: Format: 3    │
│  Raport/ MMC/SD card:  Format: 3    │
│                                     │
│                                     │
│                                     │
│                                     │
│                                     │
│    Esc       OK      Data           │
└─────────────────────────────────────┘
```
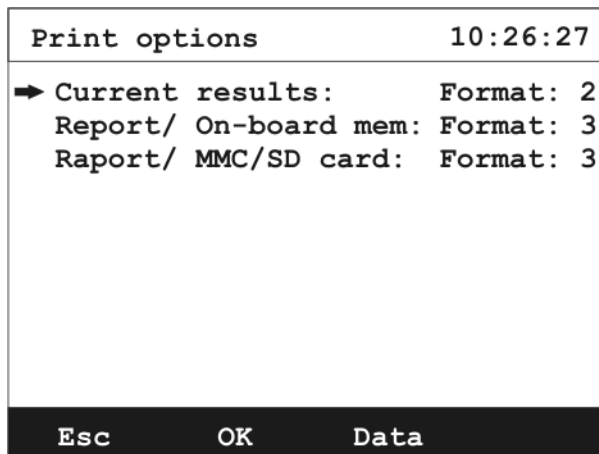
Drawing 29.   **Printing options screen.**

Print options screen contains 3 printing options to choose from:

- *Current results* – in this case current measurement results will be printed.

- *Report from on-board memory:* – screen with a choice of report to be printed from the internal memory will be initialised.

- *Report from MMC/SD card:* – screen with a choice of report to be printed from the memory card will be initialised*.

Printout will contain information about the time when the results were performed, fuel setting, averaging time setting, customer and results.

Optionally you can choose between 8 formats of data printing options. First 4 are factory default settings and they can include only some of measurement results in the printout. The remaining 4 are set for each analyser separately depending on all installed sensors.

Formats of printing settings:

- *Format 5* – designed for printing current results; includes mainly values of volume concentrations of measured gases.

- *Format 6* – designed for printing reports; includes mainly values of volume concentrations of measured gases.

- *Format 7* – designed for printing current results; includes values of mass concentrations of measured gases.

- *Format 8* – designed for printing reports; includes values of mass concentrations of measured gases.

5.3.6. Menu

To get to the menu from the results screen you have to press the right arrow key or any of the numerical keys. A screen visible below will be displayed:

```
Menu                    10:26:27

➡ Measurement parameters
  Settings
  On-board memory
  Gas conditioner
  Clock / Calendar
  Service




    Esc     Enter     Data
```
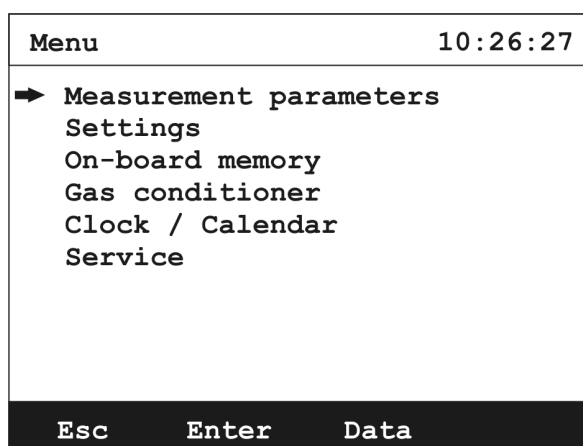
Drawing 30.   **Menu screen.**

A description for all options in the menu is listed below.

5.3.6.1. Measurement parameters

This screen is described in chapter 5.3.1

5.3.6.2. Settings

```
┌─────────────────────────────────┐
│ Settings            10:26:27    │
├─────────────────────────────────┤
│➡ Pressure unit:          HPa    │
│  Temperature unit:        °C    │
│  Relative concent. unit: mg/m3  │
│  Language:           English    │
│  Contrast:                 5    │
│  Main pump:              65%    │
│  External pump:          Yes    │
│  CO sensor protection:   Yes    │
│                                 │
├─────────────────────────────────┤
│   Esc    Change    Data         │
└─────────────────────────────────┘
```

Drawing 31.   **Settings screen.**

This screen allows access to the following options:

● *Pressure unit* – pressure unit can be changed between: *Pa*, *hPa*, *mmH2O*, *inH2O*.

● *Temperature unit* – temperature unit can be changed between *°C* and *°F*.

● *Relative concentration unit* – relative concentration unit can be changed between *mg/m3* and *ppm*.

● *Language* – changing the analysers language.

● *Contrast* – contrast of the screen can be set between the value of 0 and 5.

● *Main pump* – setting pump's efficiency. Values between 50% and 100% are possible with the interval of 5%. This setting can be used only if the next setting (external pump) is set to NO.

● *External pump* – this option allows switching the main pump off and makes cooperation with external pump possible.

● *CO sensor protection* – if this setting is turned on it automatically ventilates the gas channel every time when the CO measurement range is exceeded.

Values in each setting can be changed with arrow keys left/right or with the *Change* function key.

5.3.6.3. Internal memory

```
 On-board memory          10:26:27

    No.     Date      Hour  Cust.   Time
 ➤ #00012¹ 12/08/06  11:10 K0010   3min
   #00012² 12/08/06  11:13 K0010   3min
   #00012³ 12/08/06  11:16 K0010   3min
   #00013  12/08/06  12:36 K0013   2sec



    Esc      Print     Erase  →MMC/SD
```

Drawing 32. **Example screen of the content of the internal memory.**

This screen allows access to the reports stored in the internal memory. Up to 4 separate reports can be stored in this memory.

Description of a single line of the screen of internal memory:

- *#00012^1* – serial number of the report. Digit 1 informs that it is the first report of the set of 3.

- *12/08/04 11:10* – date and time of the measurement

- *K0010* – customer number

- *3min* – averaging time of the results. In case of XL report this value indicates the time of measurement.

Each of the reports can be moved to the memory card (→ *MMC/SD function key*; point 6.4.3) or can be deleted.

To delete a report highlight it and press *Delete* function key, you will then see the confirmation screen like the one below:

```
┌─────────────────────────────────────┐
│ Erasing reports          10:16:22   │
│                                     │
│                                     │
│       ┌───────────────────────────┐ │
│       │ ⚫ #00012 12/08/06 11:10 K0010│ │
│       │ ❗    Erase report?       │ │
│       └───────────────────────────┘ │
│                                     │
│                                     │
│     Esc      All      Yes           │
└─────────────────────────────────────┘
```
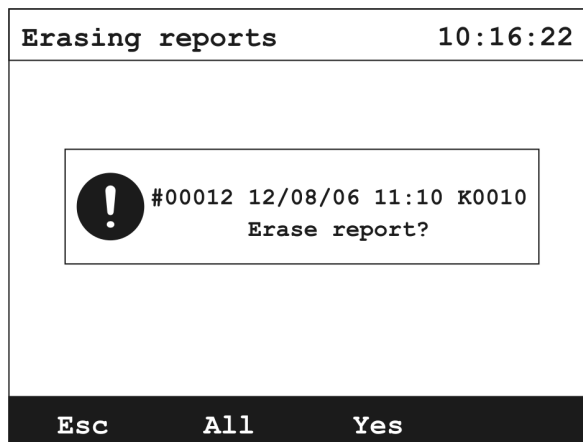
Drawing 33.   **Internal memory erasing process confirmation screen.**

Pressing the *All* function key will erase all the reports stored in the internal memory of the analyser.

5.3.6.4.   *Gas conditioner*

```
┌─────────────────────────────────────┐
│ Gas conditioner          10:26:27   │
│                                     │
│                      Is   Set       │
│                     ─────────────   │
│ ➡ Pump settings:     30    50  %    │
│   Hose temperature: 100   130 °C    │
│   Cooler temp.:       6     3 °C    │
│                                     │
│         ┌─────────────────────┐     │
│         │   *** STATUS ***     │     │
│         └─────────────────────┘     │
│                                     │
│   Esc      (+)      (-)    On/Off   │
└─────────────────────────────────────┘
```

Drawing 34.   **Gas conditioner screen.**

This screen shows settings for the external gas conditioning unit **PGD-100** that can work in cooperation with the **GA-60**.

(+) and *(-)* function keys allow changing settings for the conditioning unit (gas dryer). Setting available include: pump efficiency, heated hose temperature and the temperature of cooling unit.

The column Is displays the set values read from the conditioner while Set shows setting entered by the user manually through the analyser OR the conditioner.
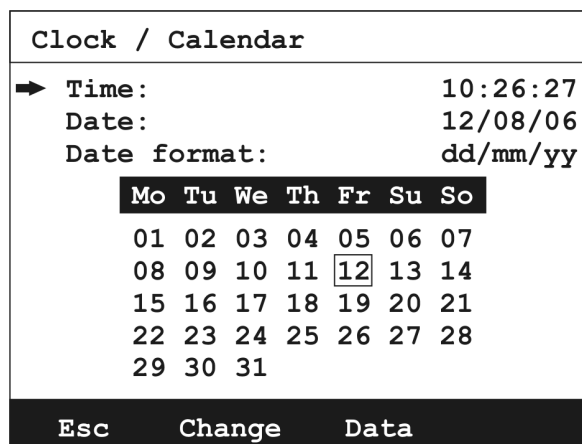
Possible communicates in the Is column include:

● *„---"* – unknown parameter (the dryer is not switched on).

● *„???"* – parameter reading error.

● *„140"* – current value.

The field below the parameter settings is used to communicate current status of the dryer to the user. It includes:

● *Ready* – the dryer communicates with the analyser and it keeps the set values (temperature of the heated hose and the cooler).

● *Not ready* – the dryer communicates with the analyser but it did not reach set parameters values (the hose temperature and the cooler).

● *ERROR* – displayed when no heated hose is connected to the analyser, when the hose overheats or when it cannot reach set temperature.

● *OFF* – the dryer is connected to the analyser, but switched off.

● *NO DRYED* – the dryer does not communicated with the analyser.

5.3.6.5. Clock / Calendar

```
┌─────────────────────────────────┐
│ Clock / Calendar                │
├─────────────────────────────────┤
│➡ Time:                10:26:27  │
│  Date:                12/08/06  │
│  Date format:         dd/mm/yy  │
│    ▐Mo Tu We Th Fr Su So▌        │
│     01 02 03 04 05 06 07        │
│     08 09 10 11 │12│ 13 14      │
│     15 16 17 18 19 20 21        │
│     22 23 24 25 26 27 28        │
│     29 30 31                    │
├─────────────────────────────────┤
│  Esc     Change     Data        │
└─────────────────────────────────┘
```
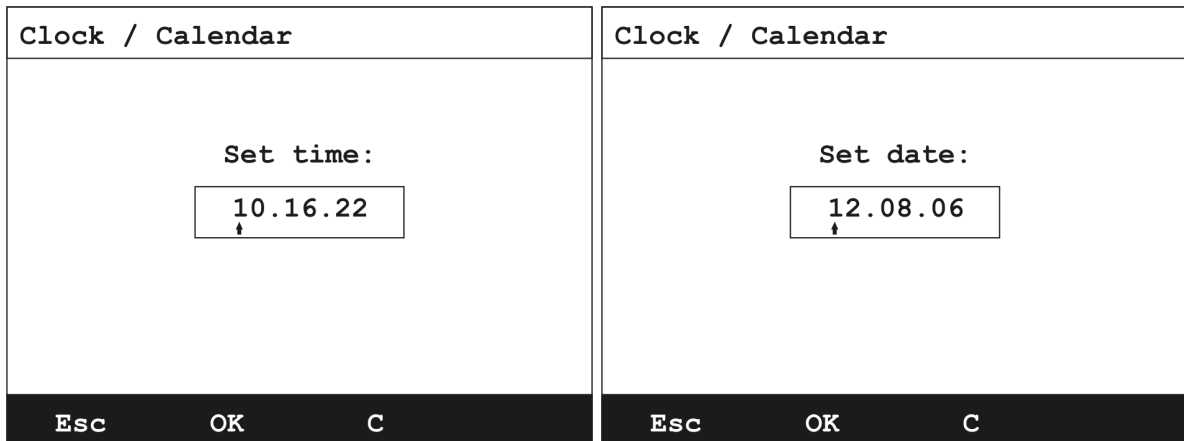
Drawing 35.   **Calendar screen.**

This screens allows changing the analysers clock. Arrow keys up/down allow to choose between setting Time, Date and Date Format.
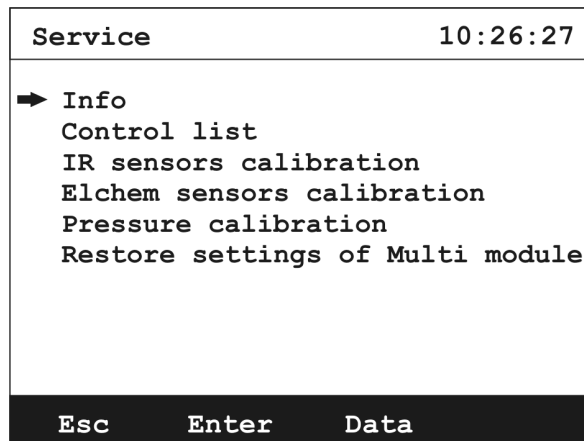
The function key Change opens a screen with particular setting:

```
┌──────────────────────────┐  ┌──────────────────────────┐
│ Clock / Calendar         │  │ Clock / Calendar         │
│                          │  │                          │
│                          │  │                          │
│        Set time:         │  │        Set date:         │
│      ┌──────────┐        │  │      ┌──────────┐        │
│      │ 10.16.22 │        │  │      │ 12.08.06 │        │
│      └──────────┘        │  │      └──────────┘        │
│          ▲               │  │          ▲               │
│                          │  │                          │
│                          │  │                          │
│                          │  │                          │
│   Esc     OK      C      │  │   Esc     OK      C      │
└──────────────────────────┘  └──────────────────────────┘
```

Drawing 36.   **Screens allowing date and time setting.**

Date format setting includes to variants: day / month / year or month / day / year.
Lower part of the Clock / Calendar screen contains a month time calendar.

5.3.6.6.   *Service*

```
┌──────────────────────────────┐
│ Service            10:26:27   │
│                              │
│  ➡ Info                      │
│    Control list              │
│    IR sensors calibration    │
│    Elchem sensors calibration│
│    Pressure calibration      │
│    Restore settings of Multi module │
│                              │
│                              │
│                              │
│   Esc     Enter    Data      │
└──────────────────────────────┘
```

Drawing 37.   **Service screen**

This screen gives access to basic functions of the analyser as well as to the more complex settings.

5.3.6.6.1.   Info

```
GA-60 info              10:26:27

Software:                   0.20
Serial #:               07499360
Report #:                  #0019

Installed sensors:
┌──────────────┬──────────────┬──────────────┐
│ ■ O2         │ ■ CO2        │ □ CH4        │
│ ■ CO         │ ■ NO         │ ■ NO2        │
│ □ NOx        │ ■ SO2        │ □ H2S        │
│ □ H2         │ □ NH3        │ □ Cl2        │
│ □ HCl        │ □ ---        │ □ ---        │
└──────────────┴──────────────┴──────────────┘

    Esc               Data
```

Drawing 38.   **Info screen.**

This screen contains basic information about the analyser like: software version, serial number, number of the last saved report, and a list of all installed in the analyser sensors.

5.3.6.6.2.   Control list

This option is only available for the authorised madur services.

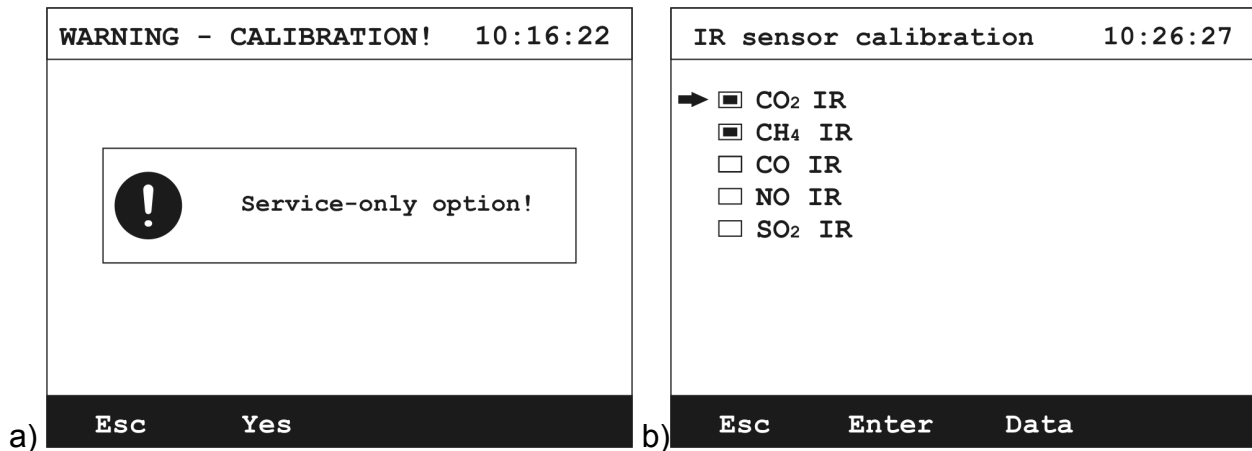### 5.3.6.6.3.   IR sensors calibration

Attention!

IR sensors calibration performed by untrained member of staff can cause loss of correct analyser's setting and in consequence make further measurement impossible.

Madur company strongly discourages changing settings in this menu without a proper training!!!

IR sensor calibration from the analyser is only a small correction of 1 or 2 calibration points – the factory set shape of the curve will not change, this operation will only move the curve on the graph.
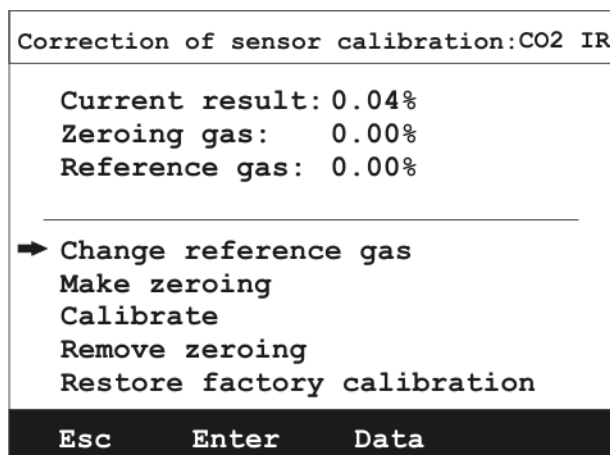
Choosing this setting will lead to a Warning confirmation screen for making sure that the setting was not accessed by mistake, going forward is possible with they *Yes* function key:


```
WARNING - CALIBRATION!   10:16:22



          ┌──────────────────────────┐
          │                          │
      ⚠   │   Service-only option!   │
          │                          │
          └──────────────────────────┘




     Esc      Yes
```
a)

```
IR sensor calibration      10:26:27

➤  ◼ CO₂ IR
   ◼ CH₄ IR
   ☐ CO  IR
   ☐ NO  IR
   ☐ SO₂ IR




     Esc      Enter      Data
```
b)

Drawing 39.   **IR sensors calibration: a) warning screen, b) a list of all possible IR sensors.**

IR sensors calibration screen displays a list of all sensors possible to install in the analyser. All already present sensors are marked with a ◼ badge. After choosing the sensor to be calibrated press the *Enter* function key to go to the calibration process.

The calibration process of the IR sensor from the analyser level is a simple transformation (movement and/or rotation) of a factory set curve (saved in the analysers internal memory). The transformation is based on 2 calibration points, zero gas (gas value that the analyser zeroed the sensors) and reference gas (measured values).


```
Correction of sensor calibration:CO2 IR

   Current result: 0.04%
   Zeroing gas:    0.00%
   Reference gas:  0.00%
   _____

➤  Change reference gas
   Make zeroing
   Calibrate
   Remove zeroing
   Restore factory calibration
     Esc      Enter      Data
```

Drawing 40.   **IR sensor calibration screen.**

In the top part of the screen 3 values are displayed:

- 🔘 *Current result* – presents measured gas concentration

- 🔘 *Zeroing gas* – gas concentration for the zero point (concentration zero 0%)

◉ *Reference gas* – gas concentration in the reference point (gas of known concentration, set by the user)

Bottom part of the screen includes calibration options for selected sensor:

◉ *Change reference gas* – displays screen with setting for the new concentration value of reference gas:

```
Reference gas:              10:16:22


    Enter reference gas value:
        ┌─────────────┐
        │  000.00 %   │
        └─────────────┘
             ↕


    Esc        OK        C
```

Drawing 41.   **New concentration value for reference gas screen.**

◉ *Make zeroing* – this option will lead (through the confirmation screen) to setting a new first point for the sensor calibration for the gas sensor (if the analyser is measuring at the moment) called point zero.

◉ *Calibrate* – setting the second calibration point with the concentration value measured from the reference gas.

◉ *Remove zeroing* – removes the point for zero gas. In this case the curve will be moved based on 2 points (entered value of concentration for reference gas and factory set zero point).

◉ *Restore factory calibration* – this option restores factory settings to the course of the curve.

To change the factory setting of the curve of the IR sensor you have to:

1. Allow the analyser to sample fresh air through the gas probe and heated hose and observe measurement results on the screen under Current result.

2. After the results will stabilise zero the sensor with the Make zeroing option.

Attention!

When calibrating the NO sensor, before the zeroing, analyser must be ventilated with pure 100% nitrogen gas. If this operation is not possible, value of the reference gas must be raised by 15 ppm.
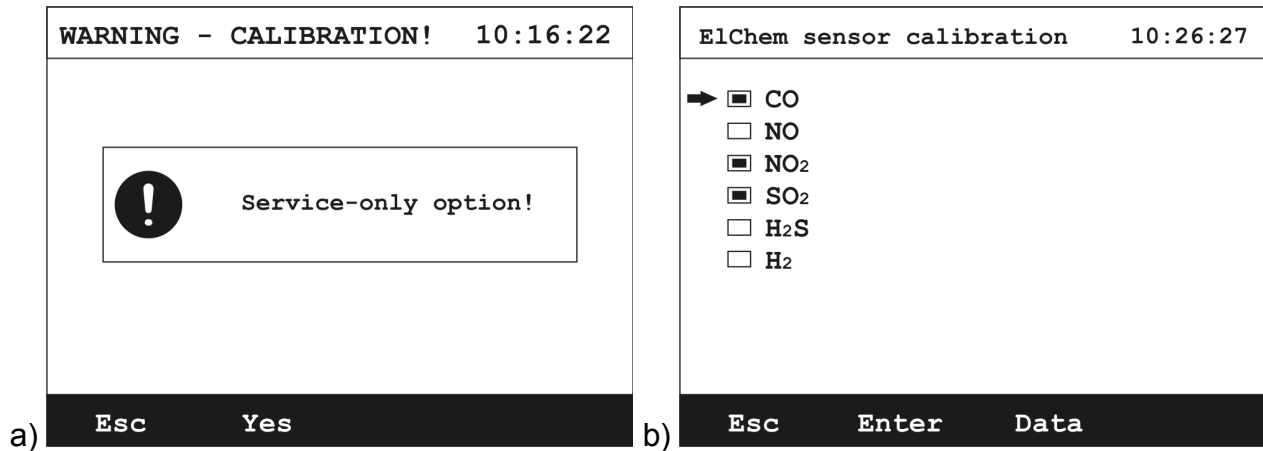
3. Allow the analyser to sample the reference gas (with known concentration) through the gas probe and heated hose and let the sensor measure it.

4. Enter gas concentration value in the reference gas setting.

5. After the reading under current results stabilises calibrate with the Calibrate option.

6. Check if the current results reading equals the reference gas concentration value. If not, repeat calibration and this time extend time of tests for the reference gas and fresh air.

5.3.6.6.4. *ElChem sensors calibration*

Attention!

Electrochemical sensors calibration performed by untrained member of staff can cause loss of correct analyser's setting and in consequence make further measurement impossible.
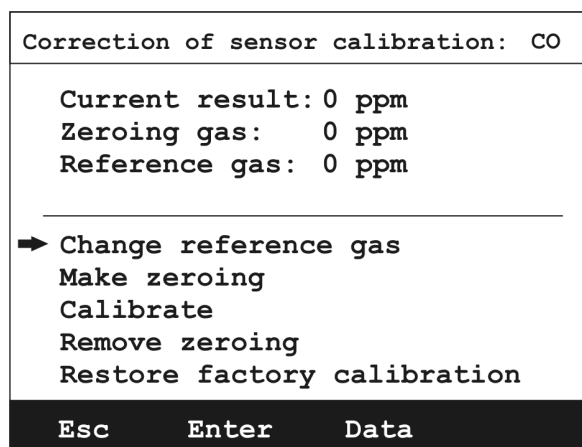
Madur company strongly discourages changing settings in this menu without a proper training!!!

Choosing this setting will lead to a Warning – confirmation screen for making sure that it was not accessed by mistake, going forward is possible with they Yes function key:


```
WARNING - CALIBRATION!   10:16:22



      ┌──────────────────────────┐
      │                          │
   ❗  │   Service-only option!   │
      │                          │
      └──────────────────────────┘



    Esc      Yes
```
a)

```
ElChem sensor calibration    10:26:27

 ➡ ◼ CO
   ☐ NO
   ◼ NO₂
   ◼ SO₂
   ☐ H₂S
   ☐ H₂




    Esc     Enter     Data
```
b)

Drawing 42.   **Electrochemical sensors calibration: a) warning screen, b) a list of all possible IR sensors.**

Similarly to IR sensors, all sensors available for calibration will be visible in the sensor list and are marked with the ◼ badge. The calibration screen will be displayed after the sensor is chosen and function key Enter is pressed.


```
Correction of sensor calibration: CO

   Current result: 0 ppm
   Zeroing gas:    0 ppm
   Reference gas:  0 ppm
   ─────────────────────────────
 ➡ Change reference gas
   Make zeroing
   Calibrate
   Remove zeroing
   Restore factory calibration

    Esc     Enter     Data
```

Drawing 43.   **Electrochemical sensor calibration screen.**

Electrochemical sensor calibration process is the same as in case of IR sensors.

The calibration curve for the electrochemical sensor is in fact a straight line, that can be set simply with a use of only two calibration points (for zero gas and reference gas).
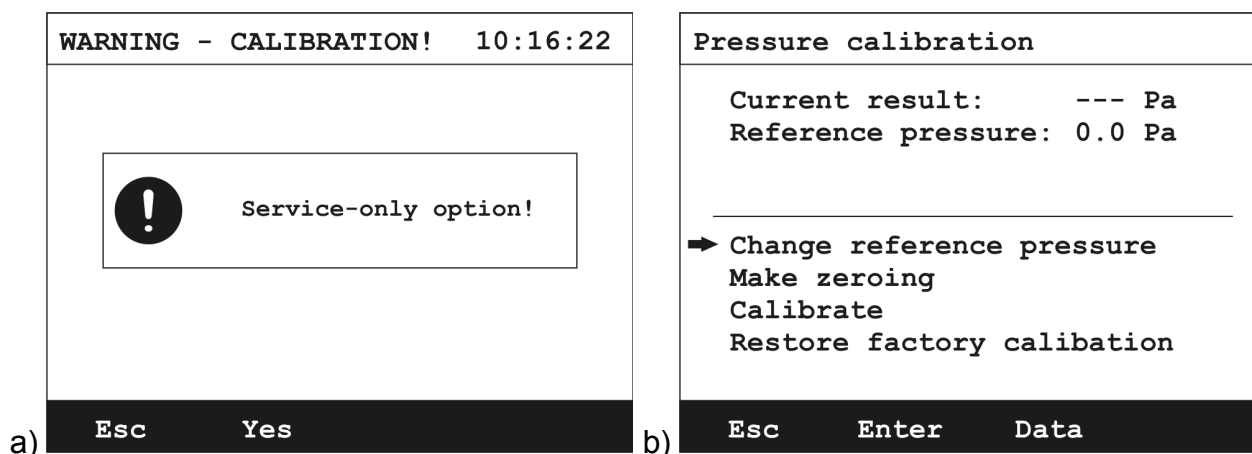
5.3.6.6.5. *Pressure calibration*

Attention!

Pressure calibration performed by untrained member of staff can cause loss of correct analyser's setting and in consequence make further measurement impossible.

Madur company strongly discourages changing settings in this menu without a proper training!!!

Choosing this setting will lead to a Warning – confirmation screen for making sure that it was not accessed by mistake, going forward is possible with they *Yes* function key:

```
WARNING - CALIBRATION!   10:16:22

   ┌─────────────────────────────┐
   │  ❗   Service-only option!   │
   │                             │
   └─────────────────────────────┘

    Esc      Yes
```
a)

```
Pressure calibration

   Current result:      --- Pa
   Reference pressure: 0.0 Pa
   _____

➡  Change reference pressure
   Make zeroing
   Calibrate
   Restore factory calibation

   Esc     Enter     Data
```
b)

Drawing 44.   **Pressure calibration: a) warning screen, b) a list of all possible IR sensors.**

The calibration curve for pressure sensor is (like in case of electrochemical sensors) a straight line, that can be set simply with a use of only two calibration points.

In the top part of the screen 2 values are displayed:

● Current results– presents currently measured pressure value.

● *Reference pressure* – known pressure value set by the user.

Bottom part of the screen includes calibration options for pressure sensor:

⬤ *Change reference pressure* – displays screen with setting for the new value of reference gas:

```
Reference pressure:        10:16:22


       Enter reference pressure:
             000.00 hPa
                ↕


    Esc        OK        C
```
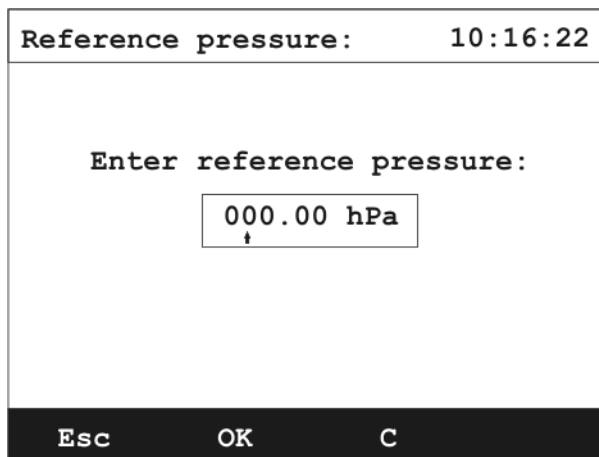
Drawing 45.   New pressure value for reference pressure screen.

⬤ *Make zeroing* – this option will lead (through the confirmation screen) to setting a new first point for the pressure sensor calibration(pressure measurement connector should be disconnected)

⬤ *Calibrate* – setting the second calibration point (pressure measurement connector should be connected to the reference pressure)

⬤ *Restore factory calibration* – this option restores factory settings to the course of the straight line for the pressure sensor.

5.3.6.6.6.   Restore settings of the Multi module

This option restores factory setting to the electrochemical, NDIR and pressure sensors.

5.4.   Ending work with the analyser

Before you switch the analyser off:

⬤ Remove the gas probe from the chimney or disconnect the gas hose from the gas dryer,

⬤ ventilate the analyser and/or the gas dryer with fresh air to remove any tested gas particles from the devices and sensors.

⬤ After about 3 minutes of ventilation the analyser (and/or the gas dryer) can be switched off with a switch on the right side of the front panel.

6. TIPS ON HOW TO USE THE ANALYSER

6.1. Electrochemical gas sensors

⬤ Try to avoid exceeding sensors range.

⬤ Sensor can react unexpectedly to some substances that are not typically present in the combustion gas sample tested. Try to avoid cleaning the analyser with chemical substances as the they can cause sensors destabilisation or can even lead a sensor damage.

⬤ Never switch off the analyser before the gas gas system is ventilated.

⬤ The analyser should be stored in a dry, cold place to minimise sensors wear.

6.2. Service

In time electrochemical sensors loose their parameters, so the analyser should be serviced and recalibrated regularly.

7. COMPUTER SOFTWARE

MadCom computer software is used for communication with the **GA-60** (and other madur gas analysers). It allows preview of current measurements results, reading results stored on a memory card and printing.

Functions of this software are described in a separate users guide.