

# **OPAX 2000 II SMOKEMETER**

**USER'S MANUAL**

**Rel. 2.1/INT/LED**

**Code:**



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**1. DISCLAIMER**

Protech reserves the right to make changes without further notice to any product herein to improve reliability, function or design. Protech does not assume any liability arising out of the application or use of any product described herein. Protech is registered trademark of Protech S.p.A.

**CAUTION**

**A calibration filter is enclosed with every OPAX 2000 II unit. Be careful not to lose or damage the filter and keep it clean for periodical use.**

**Losing or damage to the filter will void any warranty on that item.**

**Loss or damage of the filter will incur a non-warranty service call plus the cost of a new filter.**

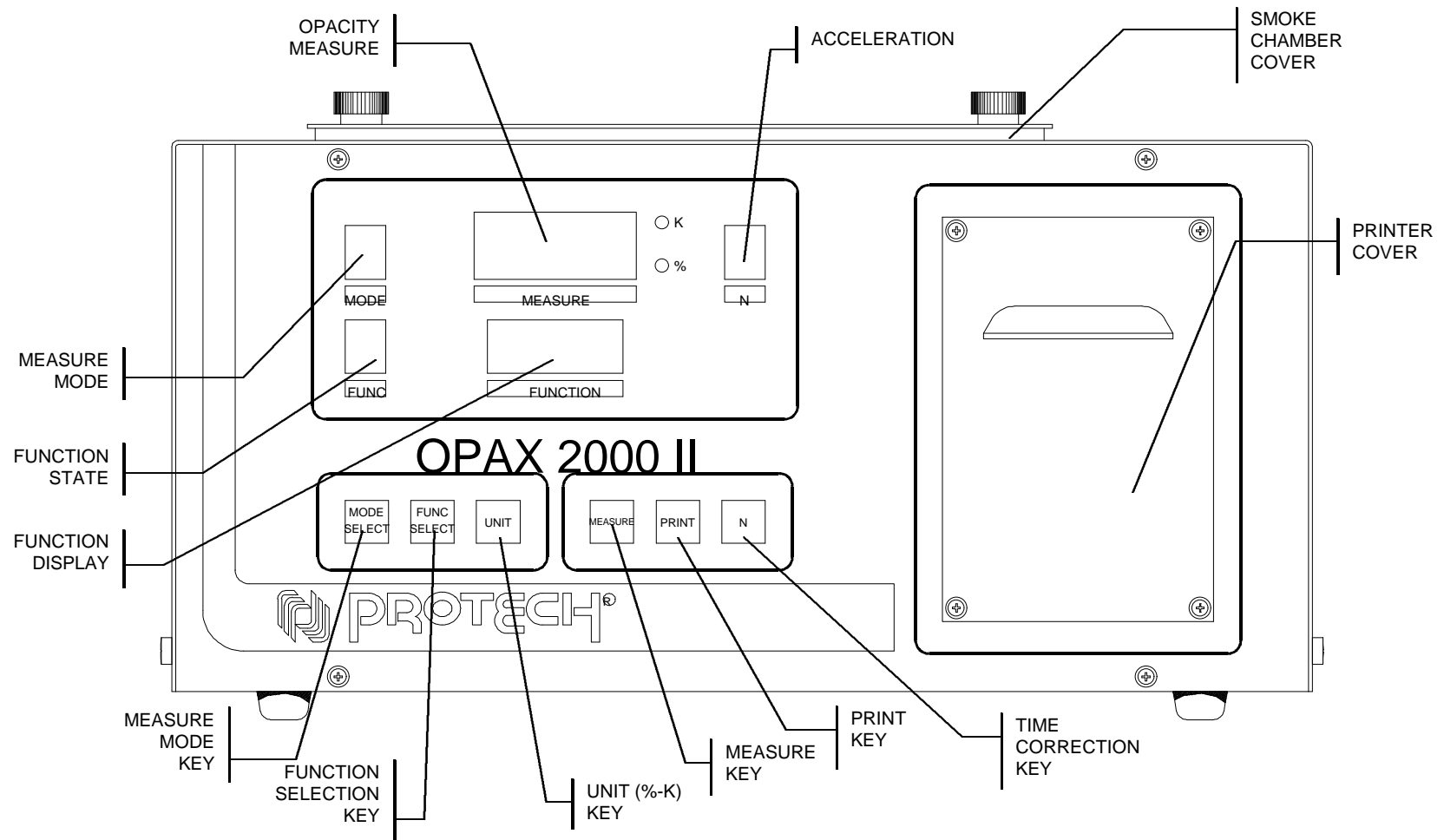
## **2. OVERALL DESCRIPTION**

OPAX 2000 II is a partial flow smokemeter (opacimeter) suitable for measuring the smoke exhaust of a diesel engine. The instrument is designed according to ISO 3173 directive, CUNA NC 005/11 and to EEC 72/306 directive.

The instrument can carry out statutory checks according to the above specifications, and also continuous reading on the sampled exhaust.

Key features are as follows:

- opacity (smoke) measurement based on the visible light absorption of the exhaust gas as detected by a photo cell;
- spectral response corrected to be similar to the photopic response of the human eye, as suggested by the ISO standard;
- regulation at known temperature of the smoke chamber to ensure proper gas sampling;
- automatic multi-repetition test capability to comply with the above mentioned legislation, by computing the average values accordingly;
- free acceleration smoke (FAS) measurement capability;
- partial flow sampling system to ensure best results and immunity against environmental fluctuations;
- infra-red remote control to allow remote operation from the driving seat of the vehicle under test;
- built-in 24-column impact printer to print all the relevant data according to the test method;
- compact and portable;
- large and bright led displays to ensure good visibility;
- plastic membrane functional keypad with led indicators for ease of use and protection against dust and oil;
- Factory-selectable 110/220/240 Vac or 12 Vdc power supply;
- easy maintenance and re-calibrating feature for periodical replacement of the light source.
- standard RS-232 interface for data link.



PICTURE 1 - FRONT PANEL

**3. THE DISPLAYS**

The front panel of the OPAX 2000 II contains five displays:

display **MEASURE (% - K)**:

Immediately after switch on the display MEASURE shows:

"EEC" in case of setup for EEC 72/306 directive;

"CUn" in case of setup for CUNA NC 005/11 standard.

Then, in the measure phase, opacity values are shown on this three digits display in K [1/m] units from 0.00 to 9.99 or in percentage from 00.0% to 99.9% . The display can also show the average, current or the peak value of opacity of FAS according to the requirement of the operator.

This same display is also used to advice the operator of the occurrence of various conditions of working: a "rEF" message is shown every time the equipment carries out an autozero, lasting maximum 10 sec.; an error flashing message is also shown by the instrument flashing "Exx", where "xx" is the error code (see later chapter describing the errors and their meaning).

display **MODE** :

this one-digit display is used to define the meaning of the measure display. Immediately after switch on an "L" is present on this display . Other characters are then displayed following proper pressing the MODE SELECT key as follows:

CHARACTER	Measure display showing ...
<b>L</b>	the selected legislation (CUNA/CEE)
<b>A</b>	the average (computed) value of previous accelerations according to the legislation or a progressive number of the next acceleration
<b>C</b>	the opacity in continuous mode.
<b>P</b>	the peak value of opacity during FAS

**display FUNCTION :**

this display shows parameters such:

- temperature of the smoke chamber,
- differential pressure,
- rpm,
- photo-cell channel voltage,

defined by the digit displayed on the FUNC display.

**display FUNC:**

the user can select the proper parameter to be shown pressing the FUNC SELECT key.

CHARACTER	Function display showing ...
-----------	------------------------------

<b>t</b>	the regulated temperature of the smoke chamber
----------	--

<b>P</b>	the differential pressure in the smoke chamber (cm H <sub>2</sub> O)
----------	--

<b>r</b>	the rpm.
----------	----------

<b>u</b>	the voltage (mV) on the photo-cell.
----------	-------------------------------------

**Display N:**

it is used during FAS test and holds the progressive number of the next acceleration going from 1 to 0 for a maximum of ten in case of setup with directive EEC, or maximum five in case of setup for CUNA.

#### **4. THE KEYBOARD AND LED INDICATORS**

- The **MODE SELECT** key allows for selection of the displayed value on the MEASURE display. When the equipment is in its stand-by state (EEC/CUNA on display MEASURE) the legislation can be selected on the MEASURE display. When the equipment is in operative state, after pressing the MEASURE key, the measurements of opacity (A - average, C - continuous and P - peak) are displayed by successively pressing the MODE SELECT key.

- The **FUNC SELECT** key allows for selection of the displayed value on the FUNCTION display. The parameters **t** - temperature, **P** - pressure, **r** - rpm, **u** - the voltage are displayed by successively pressing the FUNC SELECT key.

- The **UNIT** key allows for selection of the measuring unit between K (scale 0 to 9.99) or % (scale 0 to 99.9). The selection made by the operator is displayed by the K led or the % led which glows accordingly.

- The **MEASURE** key starts every measurement of opacity in the OPAX 2000 II.

Every time a measurement is required, pressing this key from the stand-by state (CUn/EEC on display MEASURE) causes the instrument to enter its operative state, prompting the operator for the first acceleration (a "-1-" flashing on the measure display).

This key acts as an on/off switch causing the equipment to change from an operating to a non-operating state.

Every time that the MEASURE key is pressed in stand-by, an autozeroing phase is started ("rEF" on the measure display) by aspirating fresh air into the smoke chamber. The autozero can be done even with the sampling hose in the exhaust pipe, as air sampling is achieved by internal electrovalve.

Pressing the measure key in operating state aborts any test in progress and reverts to stand-by state.

**Keeping pressed the MEASURE key for 2 sec. during operative state, the equipment switches to the next acceleration.**

**NOTE:** Use this function when smokes have low opacity levels and the equipment doesn't step to the next acceleration prompt after each throttle release.

- The **PRINT** key, prints out data recorded during the FAS test and can be used several times to obtain more prints, before doing the next zeroing (rEF) using the MEASURE key. Print-out of FAS tests is enabled after sixth (EEC) acceleration or at the end of second and fifth (CUNA) acceleration.

When, in Continuous mode of opacity reading (see ch. 9.3), the user presses the PRINT key, no matter what acceleration is running, the instrument prints out the following data:

- the opacity value in K,
- the opacity value in %,
- the differential pressure in the smoke chamber (cm H<sub>2</sub>O),
- the regulated temperature of the smoke chamber (°C).

The PRINT key also acts as a paper feed command for the instrument when pressed and held down until the feeding of paper is obtained.

- The **UNIT** key is used (when displaying opacity) to select the proper measurement unit K or %; the K led lights up when the K measuring unit is selected on the measure display. The % led lights up when the % measuring unit is selected on the measure display.

- The **N** key is used to set up date and time. See proper chapter for details.

## **5. THE PRINTER**

The built-in printer is a 24-column impact EPSON printer. The paper roll and the ink ribbon cartridge are of standard type easy and quick to replace.

The printer will print the measurements and the average value according to selected legislation requirements, giving a complete report suitable for official check and for injection tuning as well.

The printout contains the following data:

- date and time;
- the peak value of all test (% and K);
- the peak of RPM of accelerations;
- the accelerations valid marked with a "#" character;
- the description:

"AVERAGE CALCULATED AS:  
CEE LEGISLATION 72/306"

in case of EEC test;

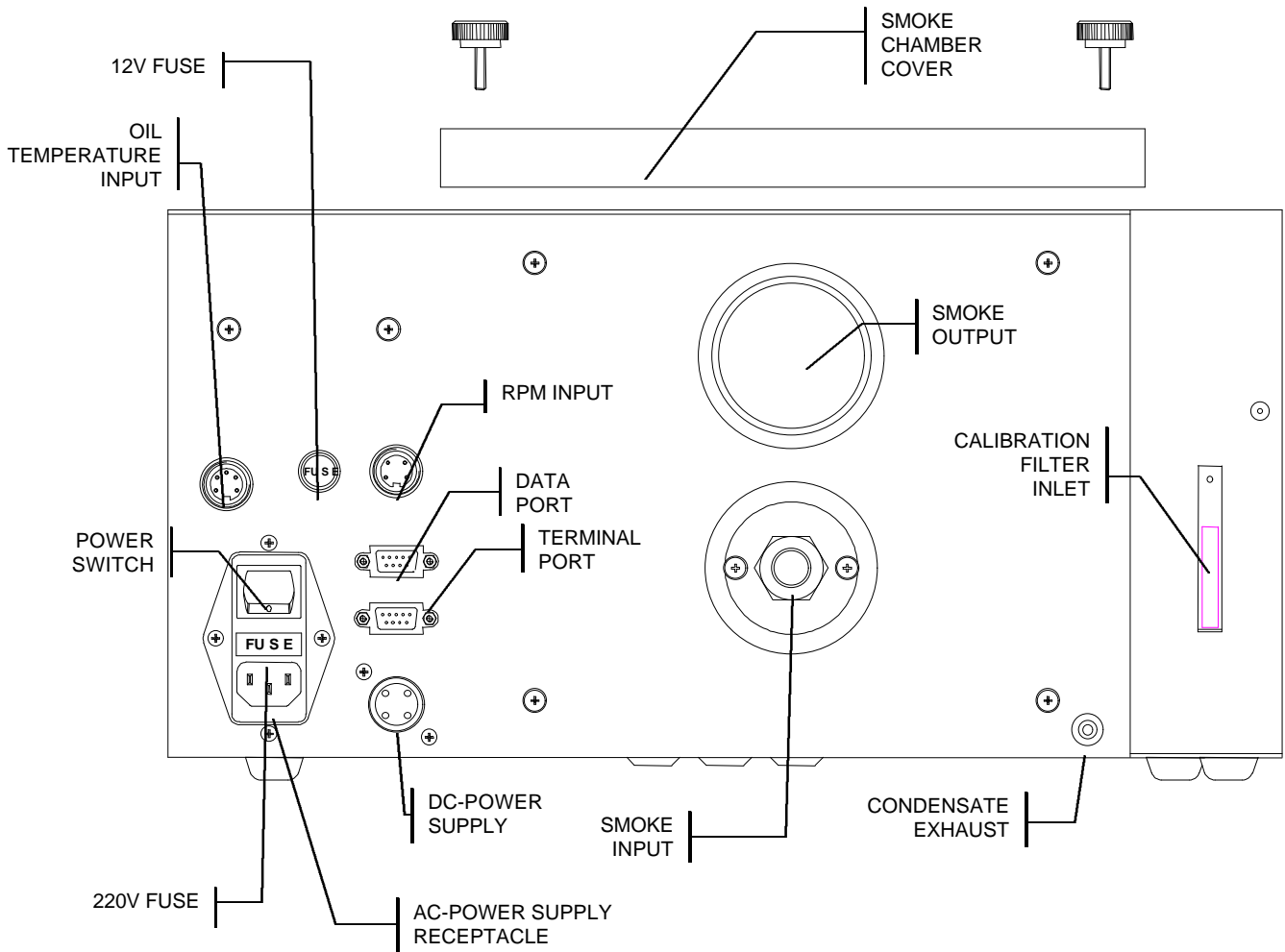
"AVERAGE CALCULATED AS:  
LAW N.615 OF 13-07-66"

- the maximum pressure on the chamber during a test;
- the average RPM during the accelerations;
- the average temperature on chamber;
- the average vehicle oil temperature;
- the zero drift at the end of the test.

**6. THE REAR PANEL**

On the rear panel the following devices are provided:

- The measuring chamber gas exhaust (the big hole at the top)
- The gas inlet fitting (the medium hole in the middle)
- The condensate outlet from the measuring chamber (the small hole at the bottom)
- The 220/240 Vac power socket with fuse and on/off switch
- The 12 Vdc (10.5 - 16.0 Vdc) power supply socket to be used instead of the mains
- The fuse holder for the 12 Vdc power inlet
- The RS-232 interface connector
- Room for a connector for an optional RPM probe
- At the right side a small vertical slot used to insert the calibration filter provided with each unit to perform calibration or periodical check as required by the authority in some countries.



**PICTURE 2 - THE REAR PANEL**

## **7. ACCESSORIES**

### **7.1. STANDARD ACCESSORIES**

The following accessories are provided as a standard with every OPAX 2000 II unit:

- the exhaust sampling hose
- a set of 3 sampling probes to comply with any kind of vehicle
- 12 Vdc power cord and battery
- the RS-232 interface for data link
- 220/240 Vac power cord
- an optical filter for calibration control in the range 40-60%
- this manual

### **7.2. OPTIONAL ACCESSORIES**

Optional extras for the OPAX 2000 II are:

- the trolley
- the RPM interface connector and probe
- the oil temperature probe

**WARNING:** possible malfunctions may occur if direct sunlight falls on the infrared receiver situated on the front panel of the instrument.

In such a case changing the position of the instrument is recommended. This interference may, on rare occasions, cause a test to be aborted.

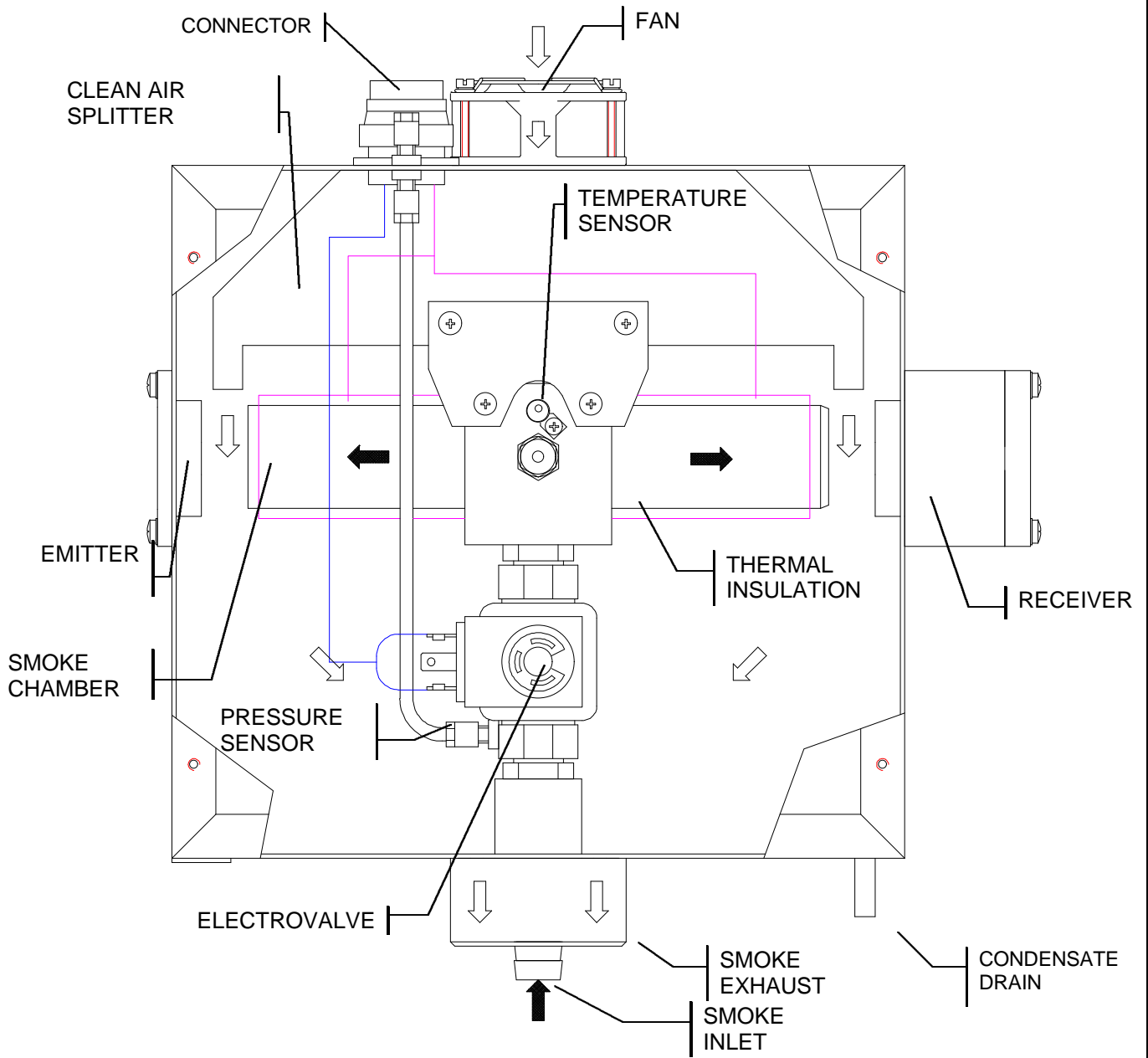
In this case, re-do the test.

**8. TECHNICAL DATA**

- Opacimeter type: partial sampling
- Gas measuring chamber:

Partial flow sampling method  
Smoke equivalent column 200 mm  
Air/exhaust switching electrovalve  
Temperature sensor  
Pressure transducer  
Removable top cover for cleaning optical surfaces  
Internal fan blower to aspirate and clean.  
Condensate outlet.

- Design according to ISO 3173, EEC 72/306, CUNA NC 005/11.
- Light source: green LED with peak wavelength of 569 nm
- Sensor: silicon photodiode with corrected spectral response similar to the photopic curve of the human eye (peak response 550 nm)
- Heated smoke chamber
- Reference temperature of the smoke chamber: 90°C (+/-10%)
- Operating ambient temperature : 2 - 40°C
- Calibration: microprocessor controlled using a supplied neutral density filter in the range 40 - 60%; other filters are available upon request for more comprehensive checks in a broader range of opacity
- Power supply: 110/220/240 (Factory selected) Vac +10/-15% or 10.5 to 16 Vdc
- Power consumption typical: <100 W
- Dimensions : 420 x 210 x 400
- Weight: 18 Kg.



**PICTURE 3 - SMOKE BENCH**

## **9. USE OF THE SMOKE METER**

### **9.1. INSTALLATION AND SWITCH ON**

**WARNING: Never place the smokemeter in the exhaust smoke plume.**

Install the instrument on a trolley (so that the instrument is in a higher position than the exhaust pipe of the vehicle); then connect the black hose to the gas inlet on the rear panel of the instrument as shown on the next page. The takeup tip will be connected to the other end of the hose.

When measuring opacity always operate on a well warmed engine in order to have correct smoke values.

The probe should be situated where the smoke distribution is approximately constant.

Connect the correct power supply, 220/240 Vac or 12 Vdc according to requirements.

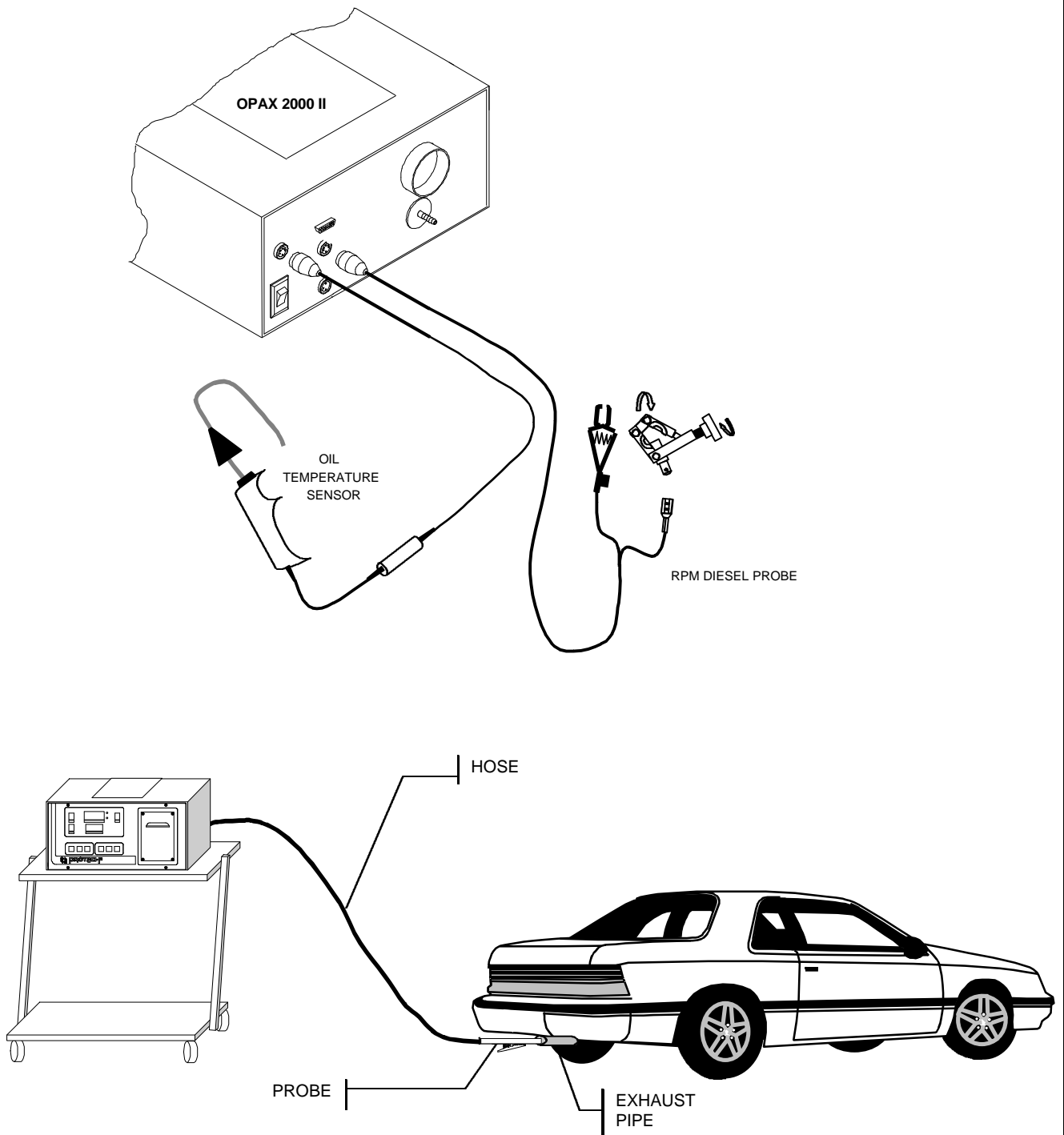
**WARNING:** when using the optional DC supply, ensure that the red clip is connected to the positive and the black clip to the negative. No damage will occur by a polarity inversion, but the instrument will not work.

On the rear panel, move the ON/OFF switch to "on". The smoke-meter will switch on and start its self check by showing the "8" number on all digits, turning on all the leds for a short time and printing a "preamble".

Finally the printer will stop the preamble and the MEASURE display shows the legislation selected and the FUNCTION display showing the actual temperature of the smoke chamber.

**NOTE: the equipment normally requires maximum 15 min warm up time after switch on to stabilize the halogen lamp and to achieve the nominal temperature (80-100°C +/-10%) of the smoke chamber. During this time, and whilst the smoke chamber temperature is below 70°C, the equipment remains showing the temperature, and the user must not use the instrument until the warm up time is elapsed and the proper temperature has been achieved.**

At the end of the warm up time the equipment is ready to operate.



PICTURE 4 - PROBES CONNECTION

**9.2. USE OF THE INSTRUMENT WITH EEC AND CUNA TEST**

- a) START ENGINE which should already be at running temperature. Depress the accelerator pedal until engine attains its governed speed and then release the accelerator to idle. Repeat this several times in order to purge the exhaust pipe of loose dust and carbon.
- b) Insert the probe in the exhaust pipe using the adapter provided. Assure it is well fixed to the tailpipe and that the hose has a descending course.
- c) Connect the RPM diesel probe (optional) following the instruction of its manual
- d) Insert the oil temperature probe (optional) in the oil level dipstick housing of the vehicle
- e) Select the legislation pressing the MODE SELECT key then press the MEASURE key.

**NOTE:** This operation must be performed every time a new measurement is to be done.

The display changes, showing "rEF" and the equipment starts a new autozero.

At the end of the zeroing phase the instrument is in its operative state and is ready to operate.

The MODE display shows "A"  
The MEASURE displays is blinking "-1-"  
The N display shows "1"

During operations all the instrument's check facilities for errors/warnings are active: in case of any occurrence see chapter 13 for details.

- f) With the measure display flashing "-1-" the operator can sit in the vehicle driver's seat and commence the accelerations required by the FAS test. The operator must, for each acceleration, depress the accelerator sharply to full fuel position and on attaining governed speed remain there for a time of approximately 2 sec, then release the accelerator. At that time the OPAX 2000 II starts a delay of 5-6 sec at the end of which it prompts the operator for a new acceleration; blinking on the MEASURE display indicates the next acceleration is required.

**NOTE:** Keeping pressed MEASURE key for 2 sec. during operative state, the equipment achieves the next acceleration. Use this function when smokes have low opacity levels and the equipment doesn't step to the next acceleration prompt after each throttle release.

- g) Repeat acceleration and idling procedure for a minimum of five (CUNA) or six (EEC) accelerations up to a maximum of ten. As soon as the instrument shows an average value of opacity ("A" on MODE display) the test can be completed. Note that for the first five accelerations NO AVERAGE value can be shown (this value must be computed using four readings out of SIX accelerations as a minimum) and on the MEASURE display dashes are shown along with the number of the incoming acceleration; if at the end of the fifth (CUNA) or sixth (EEC) acceleration a VALID average exists, its value is shown. At this time the test is at its end.

At the end of the test or at any time between accelerations, when an available average is shown, the operator can print the results using the PRINT key of the instrument. The OPAX 2000 II will start printing out data showing "Prt" on the MEASURE display.

**NOTE: the print out takes some seconds because the instrument must perform first a check for any zero drift which may have occurred during the test.**

During the FAS test the operator can abort at any time the process and start again, simply by pressing the MEASURE key. This acts as a command to return back to stand by state (all dashes on display).

**NOTE: 10 minutes after the last time a key was pressed the machine will automatically switch to stand by state (dashes an all displays).**

### 9.3. OTHER MEASUREMENTS

As above described, other parameters are available on the FUNCTION display, whichever the state of the instrument is, as follows:

- "t" the temperature of the smoke chamber
- "P" the differential pressure in the smoke chamber.
- "r" the RPM.
- "u" the voltage of the photo-cell.

To select the proper parameter press the FUNC SELECT pushbutton.

When the user is entered into operative state (after a pressure of the MEASURE key and an autozero "rEF") other opacity measurements are available, independent of the selected CUNA or EEC legislation, making use of the display MEASURE to show the value and, using the MODE SELECT key with MODE display, to define the measurement meaning as follows:

- "C" opacity in continuous mode.
- "P" opacity peak value.

In continuous mode it is possible to measure the "running" value of opacity (e.g. using the provided calibration filter), while the "peak value" mode can be used during FAS test to ascertain each peak acceleration opacity value while doing.

## **10. PERIODICAL CLEANING OF THE INSTRUMENT**

After a number of tests depending on the opacity levels found and usually no more often than several days, the optical surfaces of the smoke chamber tend to become dirty.

In the case of a high level of dust the instrument automatically prompts the user with an error message "E03" (see later chapter 13 – Error Codes - ) requiring the cleaning of the optical surfaces .

It is in any case recommended to clean the optical surfaces in the smoke chamber on periodical basis (example: weekly, depending on the amount of work) in order to keep the instrument at its best.

Please refer to the proper chapter - How to clean the smoke chamber - to carry out the job.

In the following a drawing shows the smoke chamber of the instrument as seen with the top cover removed.

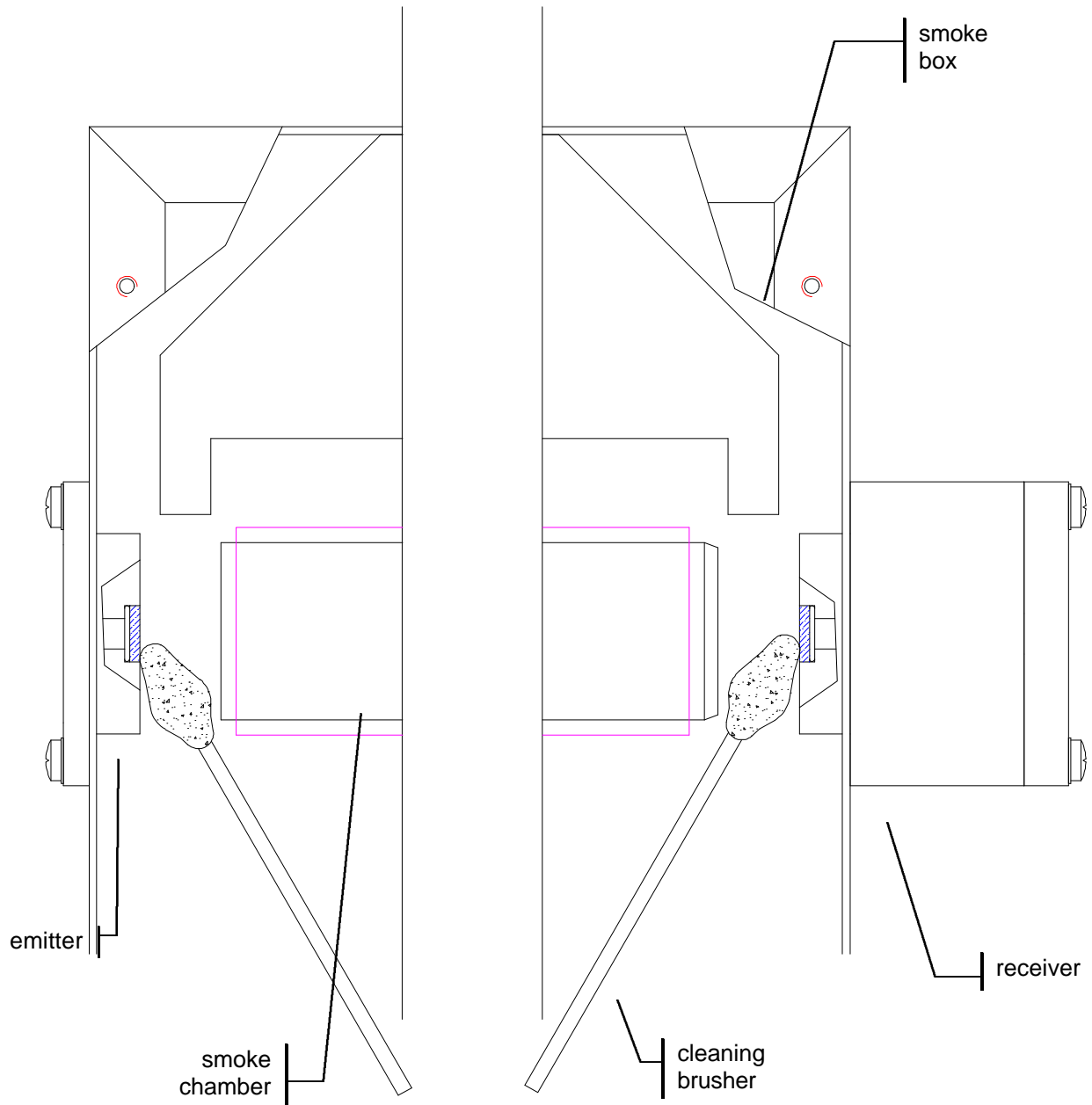
### **10.1. HOW TO CLEAN THE SMOKE CHAMBER**

**WARNING: the smoke chamber (the black cylinder in the center) is kept at 90-100°C during normal working; be careful while operating inside the chamber to avoid any burn or trouble to hands.**

**WARNING: never use compressed air to clean the chamber, you will damage the pressure sensor inside the instrument and void any warranty.**

To clean the measuring chamber proceed as follows (refer to drawing on next page):

- Turn off the smoke-meter and unplug it from the power supply.
- Remove the top cover of the chamber by undoing the four top screws
- Clean the glass windows of the lamp and photocell and the reflecting mirror using some cotton wool or a little brush.
- Re-fit the top cover of the chamber and firmly tighten the four retaining screws. Do not use a spanner; hand tight is sufficient.



PICTURE 5 - CLEANING OF THE OPTICAL SURFACES

## **10.2. THE SMOKE INLET ELECTROVALVE**

If the smoke-meter remains inactive for a long period of time, a block on the smoke inlet electrovalve may occur due to smoke residues which can effectively glue the valve seal to the seat.

In this case the smoke-meter will warn an error or the opacity display will remain at zero during any test.

To restore normal operation in most cases it is enough to tap on the rubber holder on the top of the electrovalve or on the brass part. Use only a screwdriver for this, not a hammer.

It is not necessary to call a service engineer.

## **11. USER CALIBRATION**

With every instrument a calibration filter is supplied; inscribed on it the opacity calibration value can be found.

To perform a calibration check do as follows:

- 1) Switch on the equipment.
- 2) Wait around five minutes.
- 3) Press the MEASURE key whilst holding down the UNIT key. The MODE display shows "F" and the instrument does an autozeroing "rEF".
- 4) Now the operator should insert in the slot provided in the rear right side of the OPAX 2000 II the reference filter.

**WARNING: Ensure the filter is clean before insertion.**

- 5) Check the reading on the MEASURE display is the same of the filter value +/- 1.0%.
- 6) In case of an error GREATER than in 5) adjust the filter reading with the MODE SELECT key to increase, UNIT key to decrease.

**NOTE:** holding down the key automatic reading update is achieved.

- 7) At the end of the above steps press the **PRINT** key to STORE inside the instrument the new calibration.

The opacimeter is now ready for normal working.

**12. REAL TIME CLOCK: DATE/TIME SETUP**

When the "N" key is pressed the equipment shows:

- 1)
  - "A" on the MODE display
  - "xx" on the MEASURE display
  - "C" on the N display

The instrument displays two digits indicating the current stored **year**. Act on MODE SELECT and UNIT keys to increase and decrease respectively the value of current year, if needed. Then press the MEASURE key.

- 2)
  - "M" on the MODE display
  - "xx" on the MEASURE display
  - "C" on the N display

The instrument displays two digits indicating the current stored **month**. Act on MODE SELECT and UNIT keys as described above. Then press the MEASURE key.

- 3)
  - "d" on the MODE display
  - "xx" on the MEASURE display
  - "C" on the N display

The instrument displays two digits indicating the current stored **day**. Act on MODE SELECT and UNIT keys as described above. Then press the MEASURE key.

- 4)
  - "H" on the MODE display
  - "xx" on the MEASURE display
  - "C" on the N display

The instrument displays two digits indicating the current stored **hour**. Act on MODE SELECT and UNIT keys as described above. Then press the MEASURE key.

- 5)
  - "n" on the MODE display
  - "xx" on the MEASURE display
  - "C" on the N display

The instrument displays two digits indicating the current stored **minute**. Act on MODE SELECT and UNIT keys as described above. Then press the MEASURE key.

- 6)
  - "-" on the MODE display
  - "--" on the MEASURE display
  - "C" on the N display

The **PRINT** key in this phase causes the termination of the real time clock set-up procedure and a return to normal run.

The MEASURE key return to phase 1).

**13. ERRORS CODES**

During all the operating states, the smoke-meter is capable of detecting anomalies and malfunctions.

The instrument alerts the operator by means of a code shown on the display; every code is related to a specific fault and the instrument may stop working in the event of fatal faults. On every occurrence of a fault the MEASURE display starts blinking three digits as follows:

"Exx"

where E means "error", "xx" is the code of the error as follows:

- \* **ERROR 01** - PHOTOELECTRIC DARK SIGNAL TOO HIGH -  
CALL FOR TECHNICAL ASSISTANCE.
- \* **ERROR 02** - NO SIGNAL WITH THE LAMP ON -  
CALL FOR TECHNICAL ASSISTANCE.
- \* **ERROR 03** - ZERO SIGNAL LEVEL TOO LOW -  
TO FIX: SEE MAINTAINANCE "HOW TO CLEAN THE  
SMOKE CHAMBER"
- \* **ERROR 04** - PRESSURE LEVEL TOO HIGH (>70 cm OF WATER) -  
CALL FOR TECHNICAL ASSISTANCE.
- \* **ERROR 05** - RTC SYSTEM FAULT -  
NEEDS A NEW SET UP OF DATE AND TIME.
- \* **ERROR 06** - PRINTER NOT FOUND OR FAULTY -  
THE EQUIPMENT MAY WORK PROPERLY BUT CANNOT  
PRINT OUT DATA. CALL FOR TECHNICAL ASSISTANCE.
- \* **ERROR 07** - ZERO DRIFT GREATER THAN 0.2 K AT THE END OF A  
SEQUENCE. THE CAR/LORRY EXHAUST GAS IS TOO  
DARK TO BE MEASURABLE. SEE MAINTAINANCE "HOW TO  
CLEAN THE SMOKE CHAMBER" AND CLEAN IT.
- \* **ERROR 08** - POWER VOLTAGE TOO LOW  
LIMITS ARE : -15% ON MAINS OR 10.5 Vdc
- \* **ERROR 09** - POWER VOLTAGE TOO HIGH  
LIMITS ARE : +10% ON MAINS OR 16.0 Vdc

If you call the service engineer, please specify which error code is displayed: it will be useful in order to speed up fault rectification.