AIRBORNE DUST MONITOR AMIZ – 2007

OPERATION MANUAL

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CONTENTS

1. INTRODUCTION

Airborne dust monitor AMIZ-2007 is designed for automatic measurement of airborne dust concentration of ambient air. The monitor is also equipped with meteorological sensors for measurement of temperature, atmospheric pressure and relative humidity of ambient air. Optionally the monitor can be equipped with wind speed and wind direction sensors providing useful information regarding the environment conditions at which the dust concentration is measured.

The AMIZ-2007 monitor is designed for operation in a monitoring network, or as an individual monitor. The principle of operation is based on measurement of dust deposited on air filter tape from known volume of air. The air volume is determined by pumping (air flow) period, as the air flow rate is kept constant. The mass of dust deposited on air filter is determined by the attenuation of beta radiation of Pm-147 source.

Operation of the monitor is controlled by a microprocessor system . The microprocessor unit, apart from control of measuring cycle, processes measuring signals from the measuring head, computes dust concentration and stores the results of measurement in microprocessor memory. The results of measurements are displayed at local liquid crystal display (LCD) and are stored in monitor memory.

In case the AMIZ-2007 monitor operates as independent individual unit (not in monitoring network) it is programmed with a local keyboard, and measuring results stored in the memory are transmitted to an external laptop by USB port. In case the monitor operates in a monitoring network, transmission of measuring results and remote communication with an external computer is done in wireless manner by means of mobile phone network GSM and internet connection.

2. TECHNICAL DATA

- Three modes of operation
  CC – automatic continuous
  CA – automatic
  C0 - manual single

- Measuring ranges

Concentr. subrange [μg/m3]	Measuring cycle [hh:mm]	N Measuring subrange [Z]
5 .. 7	24:00	Z1
10 .. 140	12:00	Z2
20 .. 280	6:00	Z3
40 .. 570	3:00	Z4
65 .. 900	2:00	Z5
150 .. 2000	1:00	Z6
380 ..5000	0:30	Z7

- Air inlets
  For total dust suspended — GPF4-09
  For particles 0 ... 10 μm diameter — PM-10
  For particles 0 ... 2.5 μm diameter — PM=2.5

- Measuring sensitivity at 24 measuring cycle — 5 μg/m3

- Temperature measuring range: -30 .. +60 °C
- Relative humidity measuring range: 0 .. 99 %
- Atmospheric pressure measuring range: 895 .. 1150 hPa
- Radiation source: Pm-147, approx. 74 MBq
  74 MBq (2 mCi)
- Radiation detector: GM type LND 7231
- Shift of air filter tape after measurement: approx. 15 mm
- Fiber glass air filter according to: DIN 24184 and
  VDI 2463-1
  Air filter reel inner diameter: ϕ20 mm
  Air filter tape dimensions (width x length): 20 mm x 40 m
- Time of exploitation of 1 reel air filter:
  - at 1 h measuring cycle: 111 working days
  - at 24 h measuring cycle: 7.3 years
- Air filter dust deposition area: 1 cm^2
- Mass of dust deposited on air filter: 100 .. 1600 μg
- Air flow through air inlet and suction pipe according to: VDI 2463-5
- Air flow rate: 1 m^3/h ±2%
- Air pump with graphite vanes type: VT 4.4 prod. Becker
  - maximum air flow rate: 4 m^3/h
  - mains voltage: 220 .. 240 V
- Programming monitor from:
  - keyboard at installation [lace
  - external computer remote, wireless
- Presentation of measuring results:
  - at LCD AMIZ local LCD
  - printer hardcopy CENTRONICS
  - transmission to an external computer: USB
  - at computer monitor in control room diagrams, tables
- Storage in microprocessor memory of measuring results: 300 measurements
- Operating ambient temperature +5 °C ... +30 °C
- Mains voltage 230 V ±10%, 50 Hz, 2A
- Dimensions: 450 x 390 x 280 mm
- Weight: approx. 25 kg
- Electrical installation with eart clamp PN-76/T-06500
- Dimensions: 450 x 450 x 360 mm
- Weight: approx. 25 kg
- Electric installation with earth terminal: class I according to
  PN-76//T-06500

3. CONSTRUCTION AND PRINCIPLE OF OPERATION

3.1. Principle of operation

The principle of measurement of dust concentration is based on measurement of dust deposited on air filter from known volume of air. The mass of dust deposited on air filter is determined by the attenuation of beta radiation of Pm-147 source. As the air flow is kept

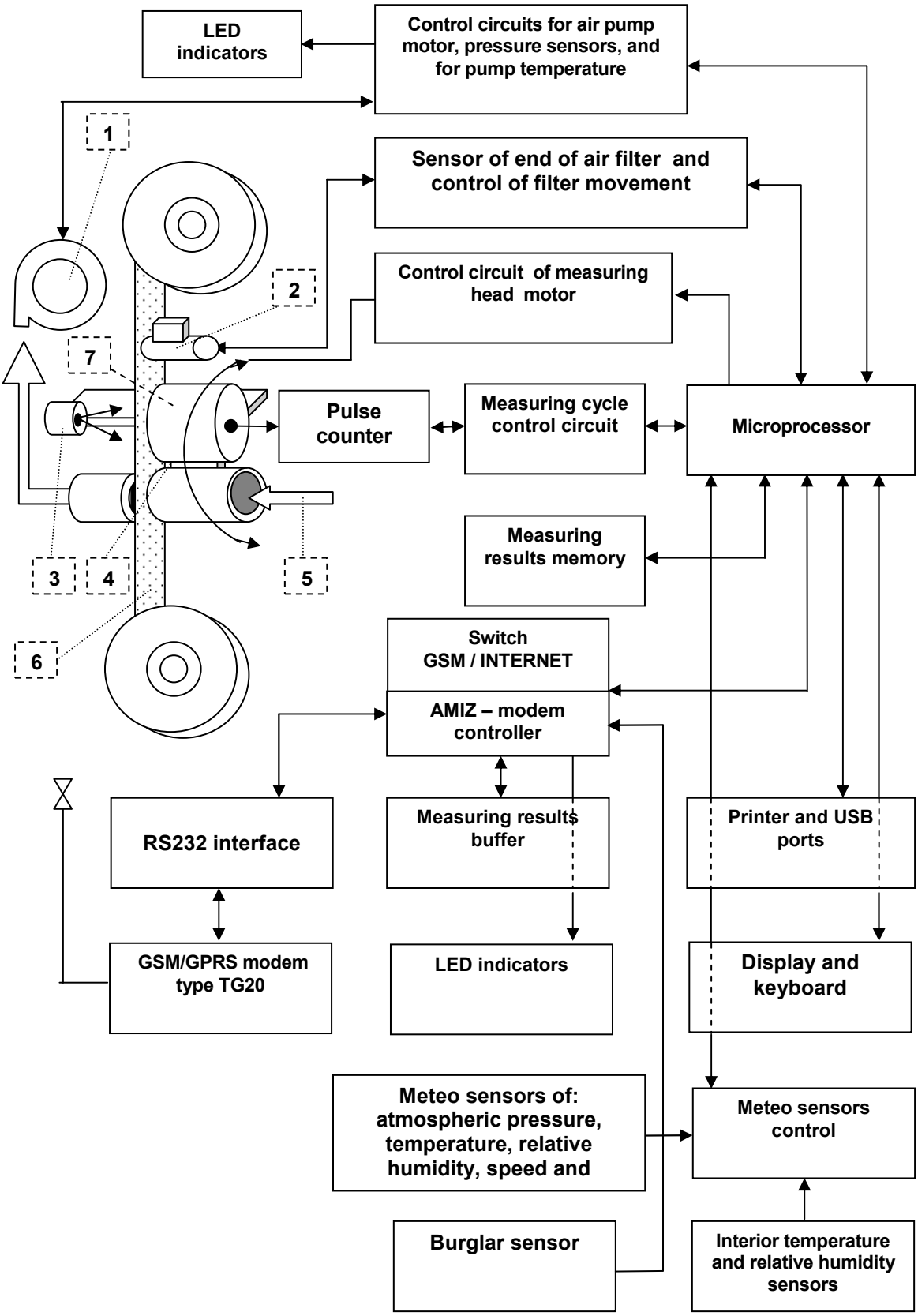


Fig.1. Block diagram of AMIZ-2007 monitor.
1. air pump with temperature sensor, 2. Motor of filter movement, 3. Radiation source, 4. Measuring head, 5. Air inlet, 6. Air filter tape, 7. GM radiation detector.

constant 1 dm^3/h, the volume of air is determined by pumping (air flow) period. Block diagram of the monitor is shown in Fig. 1. Operation of the monitor is carried out under microprocessor control. Apart from controlling the measuring cycle, the microprocessor processes the signal from the measuring head and computes the dust concentration in air. The data of meteorological sensors are also read out and processed by the microprocessor.. The measuring results are displayed at local LCD display, they are stored in monitor memory and are sent to the control center where they are presented in a form of diagrams, tables and reports, are stored for archive purposes, Transmission of measuring results and remote communication with the monitor is carried out in a wireless manner with the use GSM mobile phone network or internet. It is also possible to print directly the measuring results with a printer connected to the CENTRONICS socket.

The monitor is constructed in a form of free standing unit in a housing of eurocard.
The monitor consists of:

- Measuring head, signal processing circuits, data and transmission control
- Air pump
- Standard (total dust) air inlet
- Set of sensors of temperature, relative humidity, pressure of air and inside the rooom (kiosk) where the monitor is placed

Optionally, on request of the user the monitor can be equipped with:

- Sensors (unit) for measurement of wind direction and speed
- Printer
- Air inlet type PM-10 (cuts off dust particles with diameter > 10 μm), or PM-2.5 (cuts off dust particles with diameter > 2.5 μm).
- Uninterruptible Power Supply, UPS
- Burglar system (two channels for any use)
- Kiosk with outfit

3.2. Pneumatic system

Block diagram of the pneumatic system of AMIZ-2007 monitor is shown in Fig. 2.
The flow of air through air filter F is forced by air pump AP that producers an underpressure in the lines of pneumatic system. Constant air flow through the filter 1 m^3/h ± 2% is ensured by air flow controller AFC. The constant air flow is maintained in such a manner that some underpressure is produced under the filter in respect to the atmospheric pressure. The underpressure increases with the increase of dust mass deposited on the filter. The underpressure is measured by pressure sensor PS. In case the mass of dust deposited on air filter is too high and the underpressure reaches 50 kPa, a signal is sent to control unit, the air pump is switched off and the measuring cycle is shortened. Two pneumatic actuators: holdfast of sucker to air filter actuator FHA, and collimator closing actuator CCA are activated by the underpressure produced by the air pump AP. The first of the actuators tightens pneumatic connection between the sucker pipe and the air filter, the other closes the collimator (aperture) in radiometric system support (Fig. 3 pos. 7).

The pressure underneath the air filter is continuously monitored and is shown at monitor display. The underpressure produced by the air pump is an indicator of wear out of graphite vanes of the pump. The inlet of the pump should be connected to the suction stub SS situated at rear panel of the monitor.

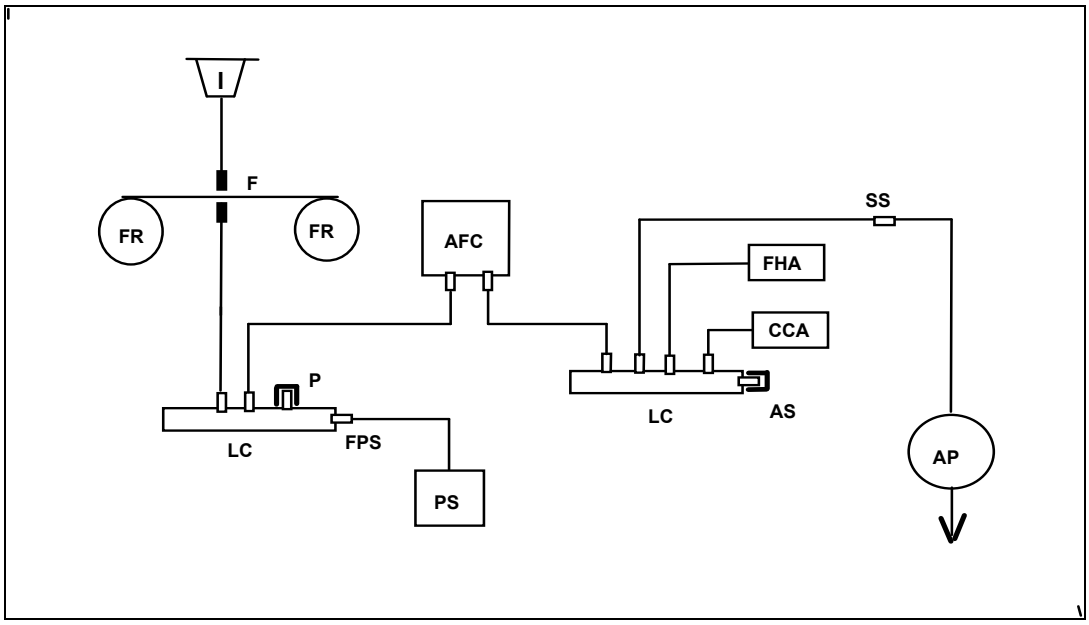


Fig. 2. Block Diagram of pneumatic system.

I - air inlet,
F - air filter,
LC - pneumatic line connector,
AFC - air flow controller,
P - stub for additional pressure sensor,
FPS - stub for filter underpressure sensor,
FR - Filter reel
FHA - holdfast of sucker to air filter,
CCA - collimator closing actuator,
AS - stub for air pump pressure sensor,
SS - suction stub,
AP - air pump,
PS - electronic pressure sensor.

3.3. Monitor construction

The monitor consists of four parts. The main part is the unit containing rotary measuring head. The construction and basic functions of particular parts are described below.

3.3.1. Air inlet

Dusted air enters the monitor through the air inlet made of material disabling generation of electrostatic charge. From the top the air inlet is protected against rain by a roof. The air enters through wire-netting cylindrical wall. protecting the monitor against suction of leaves, insects etc. into the monitor. The wire-netting can be removed and cleaned from deposited dirt on it or wet snow. The air inlet is connected with the measuring head of the monitor by means of an air inlet extension, made of stainless steel pipe, smooth inside to avoid deposition of dust along the pipe. The air inlet together with air inlet extension is installed in a passage in the roof of a measuring kiosk. The passage should be tight to protect the measuring head against rain. Standard inlet GPF4-09, shown in the picture, allows to enter into the measuring head for total dust in the air independently on dust particle diameter.

In place of standard air inlet a PM-10 or PM –2.5 air inlet can be installed cutting off dust with particle size greater than 10 μm (PM-10), greater than . 2.5 μm. (PM-2.5) See the picture at left. The air inlets PM-10 and PM-2.5 are optional.

3.3.2. Air pump

The air pump employed in the monitor is a carbon graphite rotary vane type pump type VT4.4. with maximum air flow 4.1 m^3/h.. The pump when switched on produces underpressure beneath the air filter, forcing thus the flow of the air through the filter. The pump is produced by: Gebr. Becker GMBH, Germany. The pump is equipped with temperature sensor, securing the pump motor against failure.

3.3.3. Measuring head

Measuring head is designed to stabilize the air flow through the air filter, to control deposition of dust on the filter, to carry out radiometric measurements of clean and dusted filter, and to make measurements of reference samples.

The front view of the main unit of the monitor is shown in Fig. 3. Placement of keyboard, display and control lamp (indicators) are shown in Fig. 4. The rear view of the monitor and placement of the elements at rear plate is shown in Fig. 5.

The basic assembly of the monitor is the rotary measuring head (deposition of dust on air filter and measurement of radiation attenuation by the dust), Fig. 3. The rotary assembly has two limit positions. In one of the positions of detector (4) and radiation source (6), that are separated by air filter and are mechanically coupled, when they are rotated into left limit position, attenuation of dust deposited on the filter is measured. In the other position when the source and detector are rotated into right limit position, the suction pipe (3) is pressed against the filter by a holdfast of sucker, air pump is switched on, and dust is deposited on the filter. In this right position attenuation of radiation of another piece of clean is measured. The attenuation of radiation of clean piece of air filter is measured at the beginning and at the end of measuring cycle. The clean filter attenuation serves for compensation of ambient pressure and temperature variation within long periods of dust deposition. The rotary assembly in Fig. 3. Is shown in such (right) position.

Air flow through the filter take place thanks to underpressure produced by the air pump below the filter. Geiger Mueller high voltage is switched on only when measurement of radiation attenuation is made. After measurement of attenuation is finished, the voltage is decreased to half of its value. Thanks to such solution the life of GM is prolonged, and there is no need to exchange the GM due to wear within many years of monitor operation

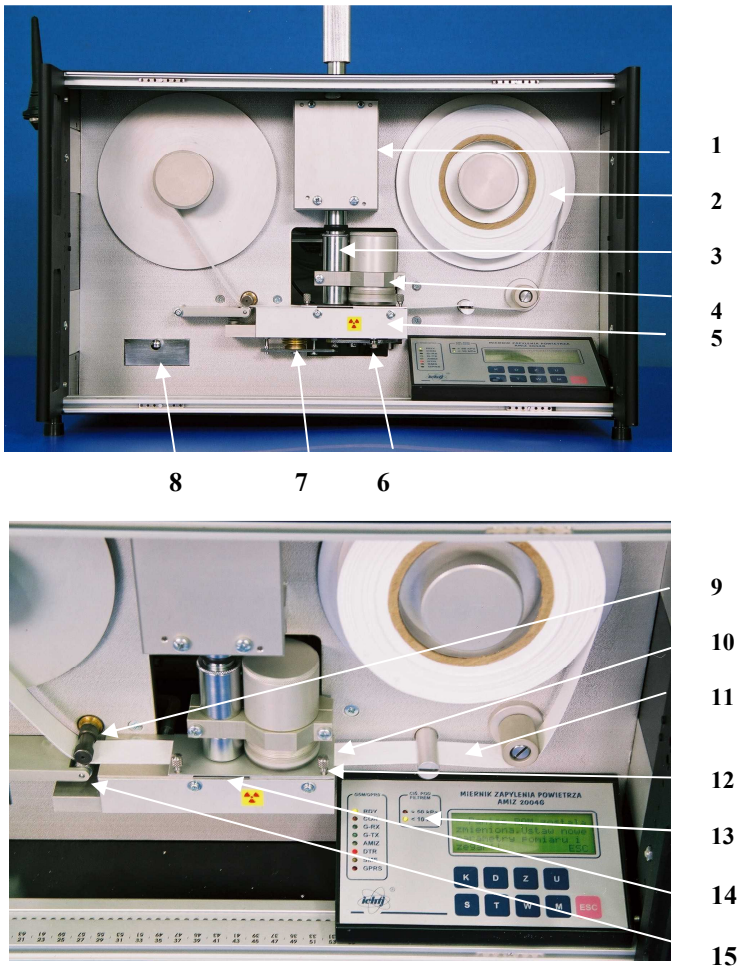


Fig. 3. Front view of the main block of AMIZ-2007
1 pneumatic holdfast of sucker to air filter,
2 air filter reel
3 sucker
4 GM radiation detector,
5 radiometric system support,
6 radiation source Pm-147,
7 collimator (aperture) closing pneumatic actuator
8 holder for reference samples
9 Filter movement driving roll
10 air filter guide cover,
11 air filter tape,
12 fastening screw fastening filter guide
13 Underpressure indicators <10 kPa, and >50 kPa
14 Gap for reference sample position in filter guide,
15 Filter holdfast

Fig. 4. Keyboard, display and LED control indicators
Pomiar-measurement, No – number, godz – hr.

Control indicators GSM/INTERNET indicate operation of GSM/GPRS operation, namely:
RDY - system ready for operation
CON - connection with server or modem at PC
G-RX - modem TG20 is receiving
G-TX - modem TG20 is transmitting
AMIZ - AMIZ is transmitting or receiving
DTR - module ready / busy
SMS - sending SMS
GPRS - connection with internet

Control indicators CIS POD FILTREM (UNDERPRESSURE UNDER AIR FILTER)
Indicate underpressure. When underpressure is 10 ... 50 kPa both indicators are off.

The electronic unit of the monitor consists of three parts: measuring, control-driving and communications circuits with the control center. The measuring channel contains radiation source Pm-147, GM detector with electronics and high voltage power supply of the detector. At the output of measuring channel normalized TTL pulses are received from the detector of beta radiation. The measuring channel ensures counting and count rate processing from clean, not dusted filter, from dusted filter and from reference sample.

Control driving mechanism contains: drives for rotary measuring head, for air filter movement (shift) filter, circuit for switching on/off air pump, electronic relay signaling lack of filter band. The circuits controls the mechanism rotary measuring assembly and the air pump. Microprocessor command starts rotation of the rotary measuring head, air pump is switched on/off, GM high voltage is on/off, air filter is moved, measuring results are stored in the monitor memory, and are displayed at local display, or printed. The control driving assembly contains such circuits as:

- AMIZ microcomputer system AMIZ modem controller
- Control and driving circuits, and circuit for pulse counting
- Input / output circuits CENTRONICS, USB
- Control and reading circuit for display and keyboard

- Sensor circuits of temperature, pressure, relative humidity and speed and direction of wind

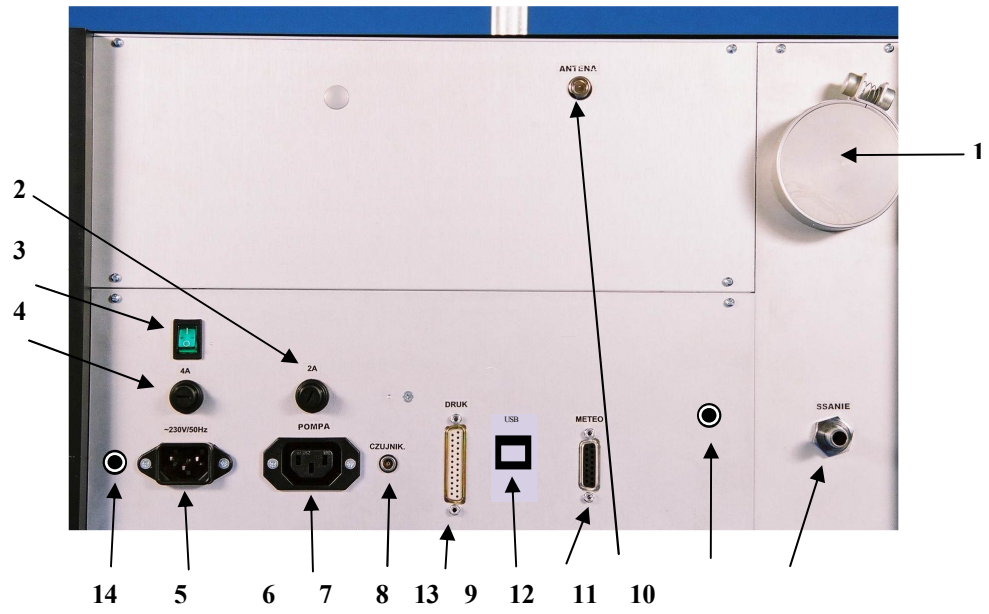


Fig. 5. Rear view of the monitor
1 - air flow controller
2 – air pump fuse 2A
3 – mains switch
4 – main fuse 3A
5 – mains 230V AC socket
6 – air pump socket 230V AC
7 – socket for temperature sensor of air pump
8 – printer socket CENTRONICS
9 – socket for meteorological sensors
10 – connector stub for air pump connection
11 – burglar sensors socket
12 – antenna socket
13 – USB socket
14 – UPS socket

The monitor operates continuously in a periodic measuring cycles. The length of the measuring cycle determines the measuring range of dust concentration. The interval length of measuring cycle is selected from 7 subranges: 30 min., 1h, 2h, 3h, 6h, 12h, 24h. A measuring subrange actually selected can be automatically switched up or down, if dust mass deposited on the air filter is too high or too low (in automatic mode CA of operation)

Transmission system of measuring results and remote system of communication with the control center contains module GSM with modem TG20, as shown in Fig. 6.

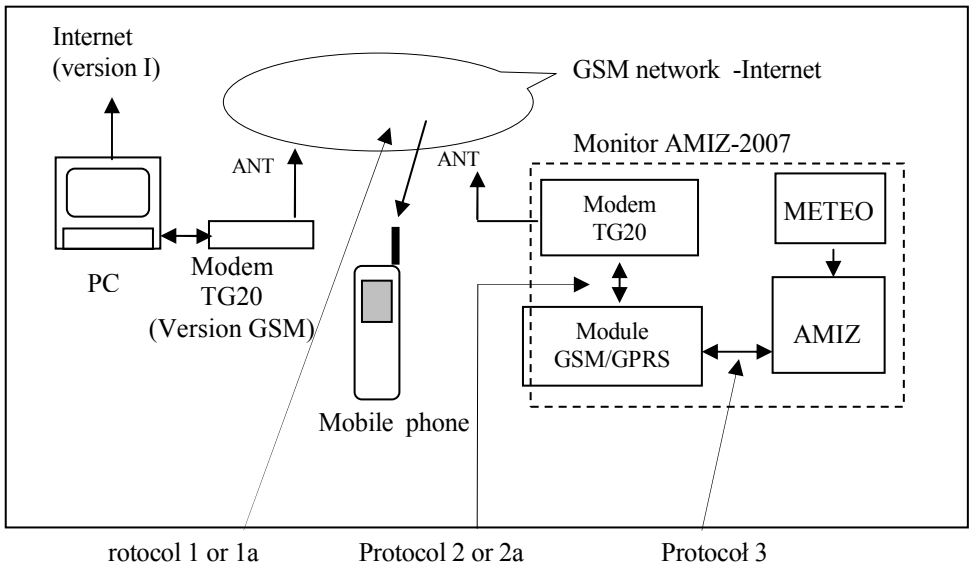


Fig. 6. Communication system between the blocks of the monitor and control center.

Monitor AMIZ communicates with the PC computer of center control through the GSM mobile phone network or internet. SMS communicates concerning any improper operation of the monitor AMIZ-2007 are sent by the monitor to selected (programmed) mobile phone.

3.3.4. Set of meteorological sensor

The AMIZ-2007 monitor is equipped with external meteorological sensor for measurement of ambient air parameters, as follows:

Basic sensors:

- temperature sensor in the range –30 ... +60 °C
- relative humidity in the range: 10 ... 90 %
- air pressure in the range: 895 ... 1150 hPa

Optional sensors:

- wind speed in the range: 0 ... 60 m/s
- wind direction in the range: 16 directions (covering 360 °)

Results of measurements of meteorological parameters are stored in the memory of the monitor together with dust concentration. They permit to the user to see what are the meteorological conditions at which the dust concentration is measured.

4. OUTFIT

4.1.Set of reference foils

For recalibration of dust monitor two foils fixed in special holders are used. One of the foils imitates radiation attenuation by clean air filter, about 7 mg/cm^2, the other the attenuation by the filter with some mass deposited on it. About 50-80% of the deposited on the filter at the filter is clogged. During the recalibration procedure, at the place of operation of the dust monitor, the air filter is removed from the filter guide and the foils are successively introduced into a slot in air filter guide in the place of the air filter. The slot is situated in the middle of the filter guide, (see Fig. 3 pos. 14). The mass per area of one of the foils is approx. 7 mg/cm^2, close to the real mass per area clean filter. The mass per area of the other foil correspond to 50 .. 80 % of maximum dust mass that can be deposited on the filter without clogging. The reference mass samples are marked with two numbers: number of the set of reference samples and number of the reference, eg. marking: "02 - 1" means: mass reference No. 1 from the set of references No. 2.

4.2. Reference nozzle and blind plate.

For checking up proper operation and tightness of pneumatic system a nozzle and a blind plate are used. They have a form of a thin plate with rubber seal. When checking the pneumatic system, the air filter is removed from the filter guide and the nozzle and blind plate are successively introduced into the slot in the filter guide in the place of the air filter. The nozzle (a plate with a small hole) is used to check up if the air flow of the dust monitor is correct, and eventually to adjust the air flow. At the flow rate (1 m^3/h ± 2%), a drop of pressure approximately 20 kPa is produced across the nozzle. The exact pressure drop is given in the certificate. The blind plate is used to check up the tightness of the suction system and to check wear out of the vanes of the air pump. At tight pneumatic system and good conditions of pump vanes the underpressure should be equal to 85 kPa. As the wear out of the pump vanes increases the uderpressure drops down. At the pressure lower than 65 kPa the tigthness of pneutmatic system shoulkd be checked and the pump vanes should be replaced.

4.3. Air filter tape

The air filter material of the dust monitor comply with the requirements of EWG((DIN24183; VDI 2463-1). The filter materila is an inorganic fiber glass with mass per area 7 mg/cm^2 ±10% and filtration coefficient 99.98% for oil fog 0.3 μm. A tape made from this material 30 or 40 m long has the form of a reel with internal diameter 28 mm or 70 mm.. One reel of the filter is sufficient for 2500 measurements, which at 30 min. measuring cycle ensures 52 days of dust monitor continuos operation. At 24 h measuring cycle the filter lasts 83 months at continuos operation. Standard outfit of the gauge includes two reels of the air filter.

4.4. Simulator of pump temperature

The simulator STP04 is used to set temperature threshold of air pump at which the pump is switched off. This is done to avoid pump failure due excess temperature of the pump.

4.5. Antenna assembly

Antenna together with connecting cables and support ensures wireless communication in mobile phone system and in internet. The antenna should be installed outside the monitor in such a way as to ensure the highest possible strength of the signal.

5. MEASUREMENTS

AMIZ-2007 control and processing block ensures required control of operation of the monitor. It controls air filter drive (shift), proper setting of radiometric rotary set and switches on/off the air pump. It enables to read out the meteorological gauges of: wind speed and direction, ambient temperature, pressure and humidity of air. Finally the control and processing block collects signal from measuring head, carries out computations, and controls operation of the parallel and serial port, and wireless communication with the computer of control centre.

Dust concentration is computed from the relations:

$$C = \frac{\ln(\frac{N_0}{N_x}\frac{N_2}{N_1})\,k - m_o}{Q\,t}$$ for measuring cycle > 3 hr

or

$$C = \frac{\ln(\frac{N_0}{N_x})\,k - m_o}{Q\,t}$$ for measuring cycle ≤ 3 hr

where:

N_o - count number from clean filter,
N_1 - count number from reference (filter) at the beginning of measuring cycle
N_2 - count number from reference (filter) at the end of measuring cycle
N_x - count number from dusted filter
m_o - (offset) correction mass, μg,
k - calibration coefficient,
Q - pump air flow, m^3/h.
t - pumping time, h,
C – dust concentration, $\mu g/m^3$.

Count numbers N_0, N_1, N_2, N_x are corrected by dead time of measuring channel, mainly GM dead time from the relation:

$$r = \frac{m}{1 - m\tau}$$

N= r t - real count number,
r – real count rate, cps,
m - measured count rate cps,
τ - deat time of measuring channel (30 μs)
t - counting time, s.

During the measuring cycle, independently from its interval length, 100 measurements are made by meteorological gauges. After the measuring cycle is finished, wind directions are computed as percentage participation of 16 directions during the measuring cycle. Wind speed is

given as average speed for particular direction. For remaining meteorological gauges average value are computed. The results or meteorological measurements are stored in monitor memory together with dust concentration

Measurement of atmospheric pressure; range from 895 to 1150 hPa

$$P = \frac{0{,}095 + \frac{Vout}{VCC}}{0{,}0009} \quad [hPa]$$

where: P – measured pressure, hPa,
Vout – sensor output voltage, V,
VCC – power supply voltage, V,
In memory is stored pressure decreased by 895 hPa (0 – 255 hPa; 1 byte)

Measurement of pump pressure; range from 0 to –99 kPa

$$P = \frac{\frac{Vout}{VCC} - 0{,}04}{0{,}009} \quad [kPa]$$

where: P – measured pressure, kPa,
Vout – sensor output voltage, V,
VCC – power supply voltage, V,

Measurement of relative humidity; range from 0 to 99 %

$$RH = \frac{Vout - V0rh}{S} * \frac{1}{1{,}0546 - 0{,}00216 * t} \quad [\%]$$

Temperature correction

where: RH – relative humidity, %,
Vout – sensor output voltage, mV,
V0rh – sensor voltage at 0% humidity (given in certificate), mV,
S – slope (given in certificate), mV / %,
t – ambient temperature, .°C

Measurement of ambient temperature and pump temperature

Range from –30 to +60 °C for ambient temperature measurement
from 0 to + 99 °C for pump temperature measurement

$$T = \frac{Vout}{10} - 273{,}15 \quad [^{o}C]$$

where: T – measured temperature, °C,
Vout –sensor output voltage, mV.

5.1. Measuring cycle

Illustration of time sequence of operation of driving mechanisms and pulse counting is shown in Fig. 7. The measuring cycle can run with preconditioning of the filter, i.e. with preliminary air flow (pumping) through the filter (F), or without the preconditioning.

5.2. Period of measuring cycle

The period of measuring cycle, Z, can be programmed directly from the keyboard of the monitor or remotely from central computer, starting from 30 min to 24 h in seven subranges. This period is automatically changed in automatic mode CA of operation . The cycle period is changed when deposited dust mass is lower than set (programmed) low mass threshold, or dust mass is higher than upper mass threshold. If the mass deposited is too low the next measuring cycle is made longer. If the deposited mass is too high, the next measuring cycle is made shorter by one step.

From the point of view of programming of the measurements of dust concentration, the measuring cycles can be divided into:

- CA- automatic measurement of dust concentration. When dust mass deposited on the air filter is too low (<100 μg) the successive measuring cycle is automatically increased to the next longer one. In case the deposited dust mass is too large (> 1600 μg) the next measuring cycle is automatically decreased to the next shorter one.
- CC - continuos measurements. There is no automatic variation of measuring cycle (making it shorter or longer) if the mass of deposited dust is to small or too large.
- CO - single measurement. Only one measuring cycle is made, then the monitor ends measurements.

Both the CA and CC cycle of operation shorten the current measuring cycle. In the CA cycle of operation the next measuring cycle is made shorter, whereas in CC cycle of operation the next measuring cycle remains unchanged..

To stabilize attenuation of air filter to beta radiation, before a measuring cycle starts, atmospheric air is forced through the filter for a period of 300 s. This interval is called "preconditioning" of the filter and is marked in the diagram with letter "F" (air pump switched on) . During the preconditioning interval reference piece of filter is measured (N_1) too. For measuring cycles equal or longer than 1 h (measuring ranges Z= 1 ... 6) filter preconditioning is automatically switched on.

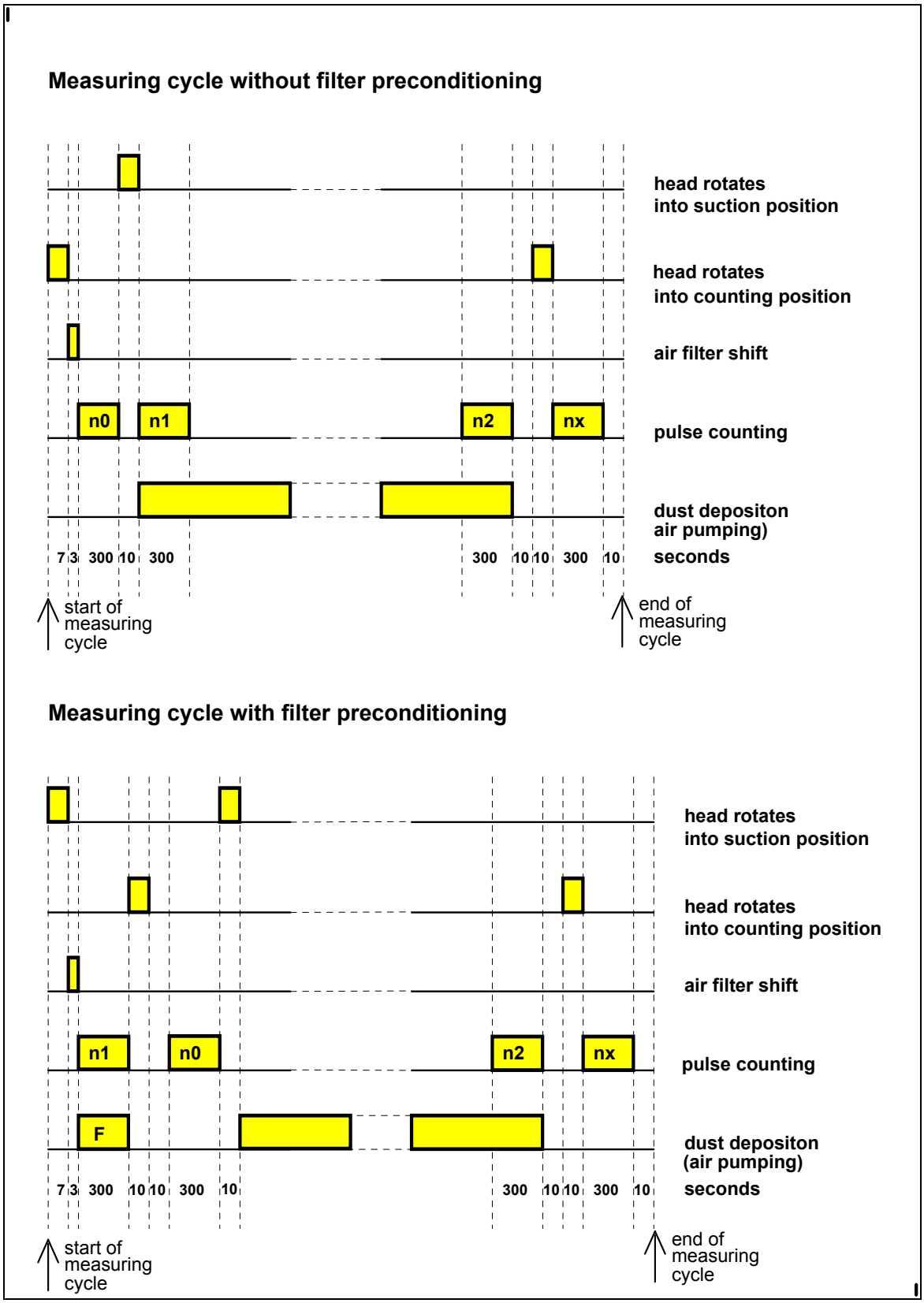


Fig.7. Graphic presentation of driving mechanisms operation and counting intervals for measuring cycle with air filter preconditioning, and no filter preconditioning.

Dust concentration measurement requires that the head (measuring rotary set) is rotated to counting or to suction (dust deposition) position. Rotation of the measuring head lasts approx. 3 s, but time interval foreseen for the rotation of the measuring head is set with some reserve to 7 .. 10 s. Additional 10 sec are foreseen before the start of rotation of the head when air pump was working and was switched off. This is due to the fact that some time is needed until underpressure in the pneumatic system disappears (suction pipe keeps strongly the air filter when underpressure exists).

To eliminate errors resulting from variation of atmospheric pressure, temperature and drift of electronics during the measuring cycles longer than 3 h, a piece of clean filter is measured at the beginning and the end of measuring cycle as reference N_1, N_2. These measurements allows for compensation of the mentioned errors.

5.3. Selection of pumping interval

An important condition for proper exploitation of the dust monitor is correct selection (programming) of air pumping time. Random error of measurement of mass deposited on the air filter, due to the statistical fluctuations of ionization radiation, is determined from the equations:

$$s(m) = k\sqrt{1/N_o + 1/N_x}$$ for measuring range Z= Z4 .. Z7

$$s(m) = k\sqrt{1/N_o + 1/N_1 + 1/N_2 + 1/N_x}$$ for measuring range Z=Z1 .. Z3

where:

N_o - count number from clean filter,

N_1 - count number from reference filter at the start of measuring cycle,

N_2 - count number from reference filter at the end of measuring cycle,

N_x - count number from dusted filter,

k - calibration coefficient,

The computations show that, for typical values of No, N1, N2, Nx and k, the error of measurement of dust mass deposited on the air filter is ± 10 μg for the measuring cycle without reference measurements, and ± 13 μg for the measuring cycle with reference measurement. The conclusion can be drawn, that to secure satisfactory accuracy of measurement some minimal dust mass has to be deposited on the air filter. Such minimal dust mass deposited is 100 μg. The relative random error in such a case will amount to ± 10 % and ± 13 % respectively. It means that in places where dust concentration is low, longer measuring cycle (longer dust deposition interval) should be used in respect to the places with high dust concentration. In connection with that the measuring range in continuos "CC" mode of operation should be so selected that the mass of deposited dust is higher than 100 μg, or the automatic mode "CA" of operation should be selected, ensuring the measuring range, that the deposited dust mass is not lower than 100 μ g, is set automatically.

The upper limitation of dust deposited on the air filter is the mass that results in "clogging" the filter by dust particles. The clogging mass depends on consistence and clogging properties of the dust in exploitation conditions and can vary from 0.5 mg/cm^2 to 4.o mg/cm^2. The dust monitor is equipped with underpressure sensor that signal "clogging" of the filter. In such a case the measuring cycle is terminated earlier than it was earlier programmed.

5.4. Influence of chemical composition of dust

Attenuation (absorption) of beta radiation, that is employed in the gauge to determine the mass of deposited dust, depends mainly on interaction of beta particles with the electrons of measured medium, i.e. on the ratio of the atomic number to the atomic mass Z/A of component elements of the dust. For the elements that most frequently create the dust as: : 0, N, Mg, Al, Si, P, K, Ca, the ratio Z/A varies in the range 0.500 ... 0.482., i.e. the ratio can be considered as contanst with satisfactory approximation An error due to chemical composition of dust can be expected if the dust contains considerable amount (more than 20%) of heavy elements such as Pb, Hg, or Tl where the Z/A ratio is smaller than 0.4. In practise these eror are negligible low.

For illustration the computed relative measuring error of dust concentration, when the dust contains 10% of Cr or Pb is 0.3% for Cr and 0,7 % for Pb, when calibration was carried out with the dust without any Cr or Pb.

6. MONITOR EXPLOITATION

6.1. Installation of the monitor

Mechanical installation

- Unpachj and put the monitor in a selected measuring place
- Install outside the kiosk, above its roof the air inlet, and with inlet extension pipe connect the air inlet with the suction pipe of the monitor.
- Place the air pump close to the monitor and connect the stub PUMP at the rear plate of the monitor with elastic pipe to the pump inlet
- Connect elastic pipe, about 1 m long, to the exhaust stub of the pump and place the other end of the pipe outside the measuring kiosk.
- Install outside the measuring kiosk meteorological sensors: of temperature, relative humidity, atmospheric pressure, and the sensors of wind speed and wind direction. The sensors for wind speed and wind direction should be installed at least 8 m above the earth surface, and the north pole indicator (short handle) should be directed to the north. The wind speed and wind direction sensors are optional.

Electrical connections

- Connect the cable of meteorological sensors to the socket METEO at the rear plate of the monitor
- Connect mains cable to the mains socket 230V/50-Hz at the rear plate of the monitor. Connect the other end to an uninterruptible power supply (if used – optional) or directly to mains voltage 230 V, 50 Hz.
- Connect mains cable of the printer (if used – optional) to mains 230 V, 50 Hz, and the multiwire cable to the socket CENTRONICS at the rear plate of the monitor

6.2. Alarm threshold setting

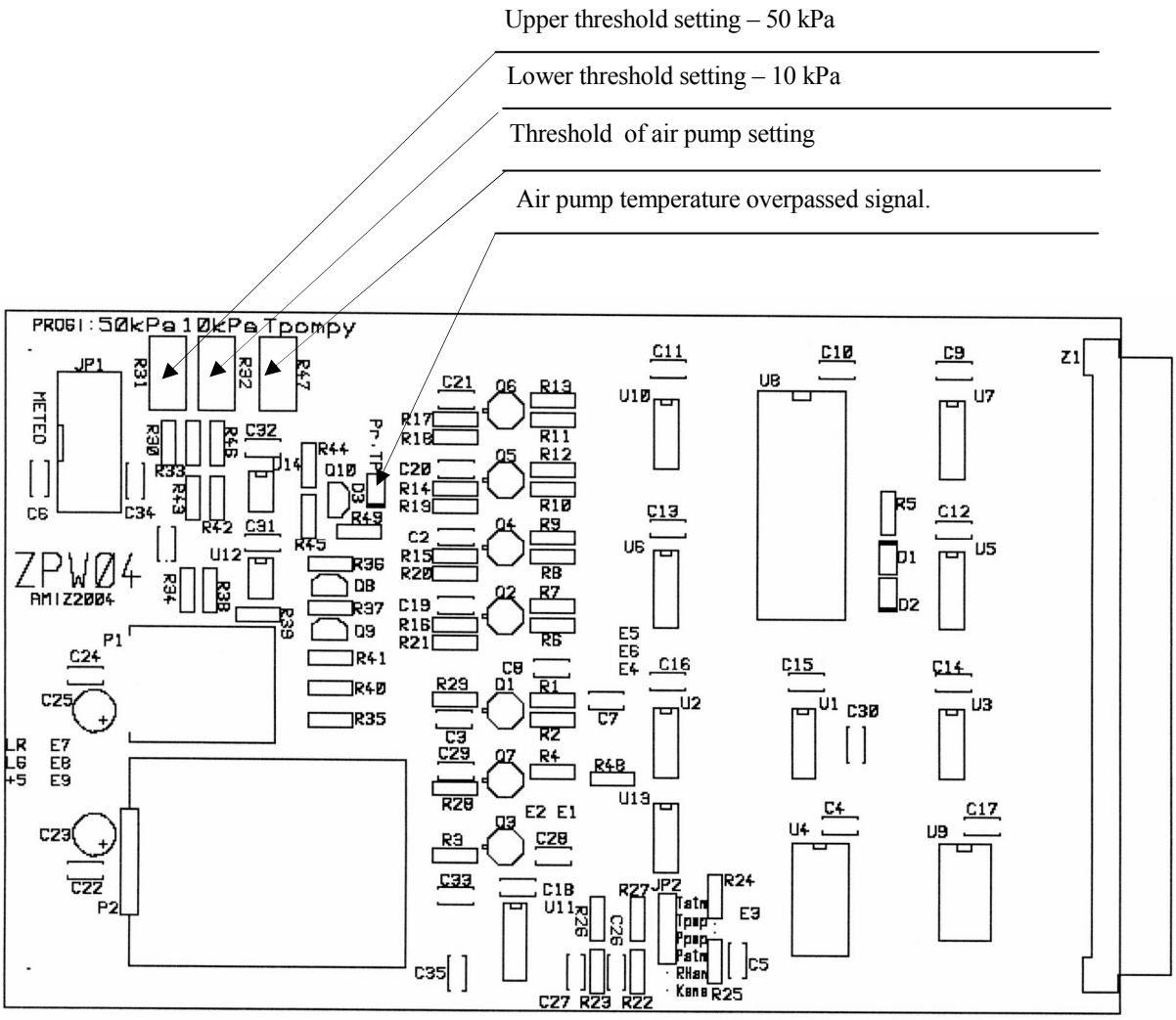


Fig. 8. Displacement of control elements

ATTENTION. Other potentiometers not indicated in this diagram may not be regulated

Setting pressure thresholds

- Switch off the monitor. Unscrew the upper cover of the monitor. Connect the sensor simulator ST04 to the socket TP at rear plate of the monitor. Connect the air pump (p-neumatic pipe and mains cable. Switch on the monitor and activate function TEST (press key [T]), and then function SENSORS READOUT (press key [D]). The rotary measuring head is set in position of air suction, channel 1 is set, air pump is switched on.
- Using air choke instead of air filter, set the underpressure after the air choke 10 kPa (the pressure is shown at the display). Rotate the potentiometer R32 at ZPW04 board shown in Fig. 8 (second board from the rear of the monitor) until the LED indicator 10 kPa at the front plate of monitor switches on/off.

Setting air pump temperature thresholds

- After the function SENSORS READOUT is activated (key [D] pressed), select channel 2. Set the requested temperature by rotating the potentiometer of STP04 simulator, the temperature is shown at monitor display.
- Rotate the potentiometer R47 at the board ZPW04 until the LED indicator D3 at the plate switches on/off.

6.3. Putting the monitor in operation

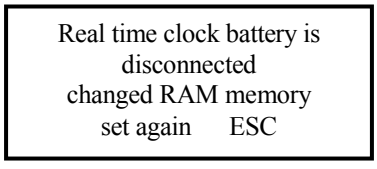
Switch on the mains voltage with the mains switch at the rear plate of the monitor.. In case the monitor is equipped with uninterruptible power supply, mains voltage of the power supply should first be switched on, and then the mains of the monitor. If the monitor is equipped with a printer, before the printer is used, its mains should be switched on.

Start menu is displayed indicating that the monitor is ready for operation:

Start window

no wind	- monitor not equipped with wind speed and direction sensors
[K]	- calibration of the monito by user
[T]	- monitor test
[S]	- rotary head driving mechanism and air pump check up
[U]	- delete measuring results from the memory
[ESC]	- go to the next step

After about 20 sec LED indicators RDY and DTR are on, showing that the monitor is logged in to GSM or Internet.
If within 60 sec since the moment the start window is displayed no key is pressed, automatic start of measuring cycle is initiated and proper SMS is sent. Such solution ensures automatic start of operation of the monitor when the mains appears again after a mains failure. The measurement is carried out with the measuring parameters set earlier (see chap. 5.2.2). If memory biasing battery and of real time clock is faulty, the following information is displayed:



In this case start of measurement is hold up, SMS is sent. Intervention of the user service is necessary. The measuring cycle is initiated only when the start window is displayed.

6.4. Monitor functions

6.4.1. Start of measurement

After mains voltage is switched on, the window is displayed

Ichtj ver no wind AMIZ – 2007 NETWORK LOGIN Kal,Tst,Sgl,Ukas, ESC

Window 1

no wind - monitor not equipped with wind speed and direction sensors
[K] - calibration of the monitor by user
[T] - monitor test
[S] - rotary head driving mechanism and air pump check up
[U] - delete measuring results from the memory
[ESC] - go to the next step

If within 60 sec since the moment the window 1 is displayed no key is pressed, automatic start of measuring cycle is initiated and new window is displayed (example):

10.01.04 15:00 P0001 CC, Z:7:30 min 00h:30 Measur n0 P:ookP D-Tp/Cp, Stp, Me Wy, Tg

Window 2

10.01.04 - date of start of measurement, day, month, year
15:00 - time of start of measurement, hr, min,
P 001 - current (successive) number of measurement
CC - continuous mode of measurement
Z7:30 - measuring period subrange Z7 (30 min.)
00h30 - time till the end of measurement hr, min.,
Measur n0 - clean filter is measured, n_o,
P:-00kP - underpressure, 0 kPa,
[D] - read out of underpressure or temperature of air pump,
[S] - stop measuring cycle,
[M] - read out of meteorological sensors,
[W] - read out of measuring results,
[T] - test of module GSM
[ESC] - display light on / off

During the measurement is carried out successive information on n_o and n_x counting, air pump switching, rotary head rotation, etc. are displayed:. underpressure at air filter, remaining time, date and time, are actualized every 10 sec.

Start of measurement can initiated manually when window 1 is displayed by pressing for about 1 sec ESC key

```
10.01.04      15:30      P0002
CC, Z:7:30 min     00h:30
--------------------------------
Str, Ust, Zeg, Me, Wy, Tg
```

Window 3

[S] - start of measurement,
[U] - setting of measuring parameters,
[Z] - date and time setting,
[M] - meteo sensors read out,
[W] - read out of dust concentration measurement,
[T] - test of module GSM,

Pressing key [S] when window 3 is displayed measurement of dust concentration is initiated.. New measurements starting from number 1 can also be made when window 1 is displayed, i.e. after mains is switched on, by pressing the key [U]. In this case new window is displayed and the user is asked to confirm that the measuring results and parameters stored in the memory will be deleted.

```
Are you sure you want  delete
measuring results and set new
parameters ?
T – yes,    ESC - no
```

ESC - return to window 1

6.4.2. Measuring cycle setting

After key [U] is pressed when window 3 is displayed new window is displayed allowing for Setting new data (example):

```
Measuring parameters
CC, Z7:30 min   m0 yy  ug
k: xxxxxx ug
          Kur,  Zmi, ESC
```

setting

CC - continuous measurement, other possible modes: CO- single measurement, CA- automatic measurement
Z7:30 min - measuring range 7, other possible ranges 1, 2, 3, 4, 5, 6
k:xxxxxx - calibration coefficient
m0 - correction mass,
[K] - cursor shift,
[Z] - change value under cursor position,
[ESC] - return to previous window.

With [K] key, cursor can be moved to successive position, key [U] increases the selected (under cursor) value by +1. It should be remembered that non meaning zeros (at front of a number) should be written down. Sign of correction mass can be set . In case of selection of the mode of operation, the change flows the pattern: C0-CC-CA-C0 etc. Each change is directly actualized.

6.4.3. Setting of date and time

After pressing key [Z] when window 3 is displayed , a window is displayed:

```
DD.MM.RR  hh.mm
-

          K, Z,  ESC
```

[K] - cursor movement
[Z] - change by +1 of a value (number) selected by cursor
[ESC] - return to previous window

A warning is displayed in case improper value is entered. It should be entered again. After correct value is entered program returns to the main menu.

6.4.4. Read out of measuring results

After key [W] is presed when window 3 is displayed, a new window appears permiting to select date of measuring results and review of measuring results

```
DD.MM.RR   enter date

T - USB
          K, Z, W, D, ESC
```

readout

K] - cursor movement to next position
[Z] - change of value by +1 selected by cursor
[W] - display of measuring results
[D] - print of measuring results
[T] - transmission of measuring result with USB
[ESC] - read out of measuring results starting from the date displayed

Window is displayed showing parameters the results of measurements

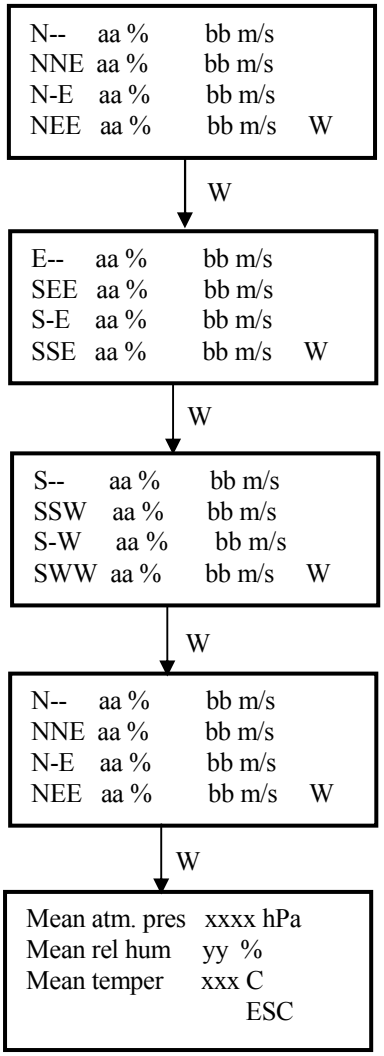
```
DD.MM.RR   gg:mm   P. nnn
m=xxxxug    v=y.yym3
c=zzzz ug/m3    Z3,CC
s=0030 ug/m3    D,W,ESC
```

DD.MM.RR gg:mm - date and time of measurement
P. nnn - number of measurement
m=xxxx ug v=y.yym3 - mass of collected dust and volume of air sample
c=zzzz ug/m3 Z3,CC - dust concentration, measuring range, mode of operation
s=0030 ug/m3 - mean dust concentration from the beginning of the day
[D] - next measurement
[W] - display mean value of meteorological sensors
[ESC] - exit from this option

In case no results are stored at the selected date, announcement NO MEASUREMENTS is displayed.

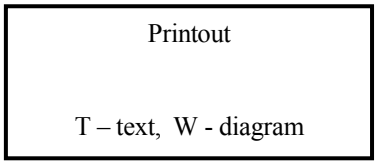
After key [D] is pressed successive results of measurements, that are stored in the memory, are displayed

After key [W] is pressed measuring results of pressure, relative humidity and ambient temperature are displayed. When the monitor is equipped with wind sensors. wind speed and wind direction are also displayed:



6.4.5. Printing measuring results

After key [D] is pressed when the window readout (chap 6.4.4) is displayed, new window is displayed enabling selection of the form of printout:



printout

In case of text printout, key [T] pressed, measuring results are printed starting from the date entered until the last (current) measurement. The printout can be intrrupted pressing and keeping the ESC key for a while. An example of one text printout is given below

IChTJ Zakł. III Warszawa, 2007
* AMIZ-2007 G/I*
24.02.07 14:02

Measurement No. 001/01 24.02.04 14:02
CC FO Z7 k: 8800 corr mass -30
n0:01621015 n1:01766032 n2:01763428 nx:01614884
- dust deposition time: ..... 0.31 h
- air volume ....: 0.31 m3
- mass of deposited dust..... 3 ug
- dust concentration: 9 ug/m3
- mean dust concentration.....:..... 9 ug/m3

optional

wind:
N :01%,03 m/s NN-E: 00%,00m/s N-E : 00%,00m/s N-EE: 00%,00m/s
E :00%.00m/s S-EE: 00%,00m/s S-E : 00%,00m/s SS-E: 00%,00m/s
S :00%,00m/s SS-W: 00%,00m/s S-W : 02%,03m/s S-WW: 06%,02m/s
W :20%,03m/s N-WW: 31%,03m/s N-W : 30%,03 m/s NN-W: 06%,02m/s
Temperature : +20C
Relative humidity : 88%
Atmospheric pressure : 1009 hPa
Measurement terminated at .: 14:32

No 001/01 - first measurement made / date of the measuremt / time of the measurement
CC - continuou mode of operation
F0 - measurement without filter preconditioning
k - calibration coefficient
n0 - count number from clean filter,
n1 - count number from reference filter at the beginning of measurement
n2 - count number from reference filter at the end of measurement
nx - count number from dusted filter

Attention. If higher number of measuring results is to be printed, i.e. longer printing time is required, attention should be paid if enough time is left till the end of the running measuremnt. Directly after measurement is finished the measuring result is printed out and then print out of measuring results from the memory follows. It has higher priority than printout from the memory. In such a case if threre is not enough time to make printout, unclear printout is achieved.

In case [W] key is pressed when printout window is displayed, new window is displayed asking for scale of the diagram:

Scale = x
Max value: yyyy ug/m3
Z – change, W - printout

x - number of the scale 0 ... 9 and corresponding max dust cincentration: 100, 200, 300, 400, 500, 1000, 2000, 4000, 5000 ug/m^3

yyyy - max dust concentration connected with the scale selected

Ten different scales can be selected, i.e. max dust concentration can be determined. the scale and the max value are displayed in the window. The cursor is set in the position of scale number, and in the line below the max dust concentration is displayed. As default the diagram size x= 5 and corresponding dust concentration 1000 ug/m^3 is set. Using the [Z] key the requested size of the diagram is set. Pressing [W] key the printout is initiated. The diagram of avearge day dust concentration is printed starting from the date declared until the last measurement stored in the memory. Similarly as in text printout, the printout can be interrupted by presssing ESC key. An example of a diagram is given in Fig. 9.

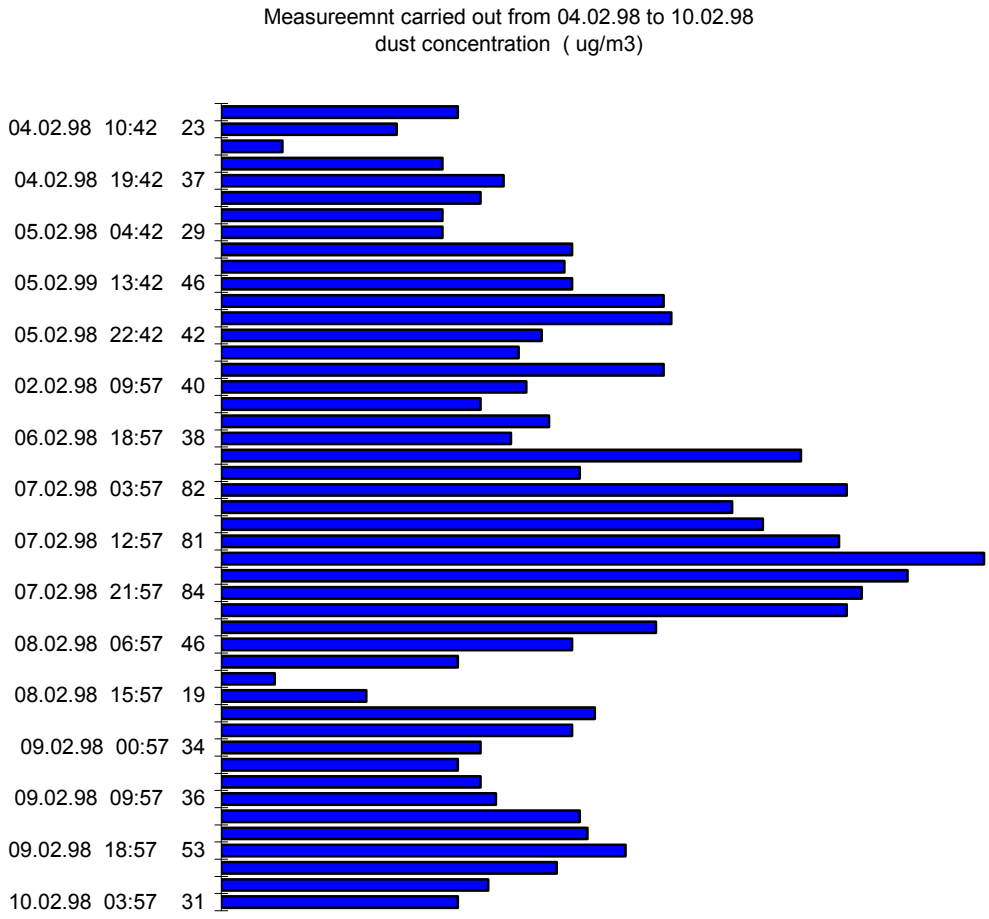


Fig. 9. An example of dust concentration diagram

6.4.6. Read out of meteorological sensors

Any time wind speed, wind direction, air pressure, air temperature temperature and relative humidity can be read out in the AMIZ-2007 monitor. To do this press the key [M] when window 2 or window 3 is displayed. Mew window is opened showing the measured parameters (example)

Atm. pres	0996 kPa	
Rel Hum	99 %	
Air temp	+10 °C	
Wind S-S	05 m/s	ESC

[ESC] – exit from the window

The meteorological sensors are read out periodically every 10 s. The indications displayed are the 10 min readings. Ten measuring results stored in the memory are average values within the period of measuring cycle of dust concentration.

6.4.7. Transmission of measuring results by USB

After key [T] is pressed when window setting is displayed, new window is opened prompting the user to make necessary connection

Connect USB cable initiate
receiving in PC computer
Press T - transmission

To start transmission of the measuring results from the monitor AMIZ-2007 to an external computer (laptop):

- Make cable connection of USB ports
- Set transmission parameters in the external computer
  - 8 bit - word
  - parity - no
  - 1 bit - stop
  - 38400 b/s - transmission speed
- Initiate USB to receive the data in the external computer
- Press the key [T] in the monitor AMIZ-2007

Transmission is initiated and message TRANSMISSION is displayed. Starting from the first measurement stored in the memory the measuring results are transmitted till the last measurement. End of the transmission is signalized by an information. By pressing key ESC the monitor returns to window 3. The measuring results are transmitted in the format as below.

Transmission format of each record

NNNN_DD_MM_RR_GG_II CR		- meas. number, day, month, year, time
0.mmmmmmE+/-CC CR		- air pump operation time, h,
0.mmmmmmE+/-CC CR		- volume of air pumped, m^3
0.mmmmmmE+/-CC CR		- dust mass, μg,
0.mmmmmmE+/-CC CR		- dust concentration, ug/m3
0.mmmmmmE+/-CC CR		- mean dust concentration till now, ug/m^3,
0.mmmmmmE+/-CC CR		- calibration coefficient
N_pp%_vv CR	optional	- wind direction %, and speed, m/s
NNEpp%_vv CR		- wind direction %, and speed, m/s
NE-pp%_vv CR		- wind direction %, and speed, m/s
NEEpp%_vv CR		- wind direction %, and speed, m/s
E--pp%_vv CR		- wind direction %, and speed, m/s
SEEpp%_vv CR		- wind direction %, and speed, m/s
SE-pp%_vv CR		- wind direction %, and speed, m/s
SSEpp%_vv CR		- wind direction %, and speed, m/s
S--pp%_vv CR		- wind direction %, and speed, m/s
SSWpp%_vv CR		- wind direction %, and speed, m/s
SW-pp%_vv CR		- wind direction %, and speed, m/s
W--pp%_vv CR		- wind direction %, and speed, m/s
NWWpp%_vv CR		- wind direction %, and speed, m/s
NW-pp%_vv CR		- wind direction %, and speed, m/s
NNWpp%_vv CR		- wind direction %, and speed, m/s
+/- tt CR		- mean air temperature, °C
ww CR		- relative humidity %
aaaa CR		- atmospheric pressure, hPa.
DD_MM_RR_GG_II CR LF		- end of measurement, day, month, year, time

Meaning of symbols

N,NNE,NE....	- wind direction: nord, nord nord east, nord east .....
RR	- year
MM	- month
DD	- day
GG	- hour
II	- minute
pp	- wind direction in %
vv	- wind speed in m/s
+/--tt	- temperature
ww	- relative humidity
aa	- percent of time from this wind direction
bb	- average wind speed from this direction
yy	- relative humidity, %,
zzz	- ambient temperature, °C.
aaaa	- atmospheric pressure, hPa

Exponential number format: 0.mmmmmmE+/-CC CR
Such format is equivalent to
$0.mmmmmmE+/-CC = 0.mmmmmm10^{\pm CC}$

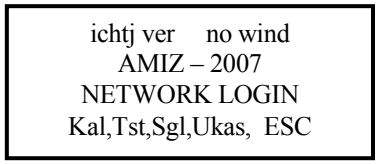
where: 0.mmmmmm - fraction value in the range: 0.100000 .. 0.999999
CC - two digit exponent number
± - positive or negative sign of exponent number
CR - carriage return
LF - line feed
_ - space

In case the monitor is not equipped with wind direction and speed sensors zeros are placed instead of wind speed and wind direction

Attention.
If the monitor operates in a network, it should be left with the window 2 displayed (basic menu). If it is left with other window open, it will be impossible to read out measuring parameters and to control the monitor.

7. CONTROL FUNCTIONS

The monitor program is equipped with series of functions allowing to control and to check up proper operation of the monitor. These functions are used when servicing the monitor. After mains voltage is on, for a period of 1 minute a window is displayed, during that period control fumctions can be called.

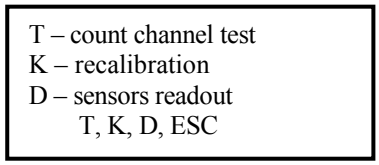


Window 1

no wind - monitor not equipped with wind speed and direction sensors
[K] - calibration of the monitor by user
[T] - monitor test
[S] - rotary head driving mechanism and air pump check up
[U] - delete measuring results from the memory
[ESC] - go to the next step

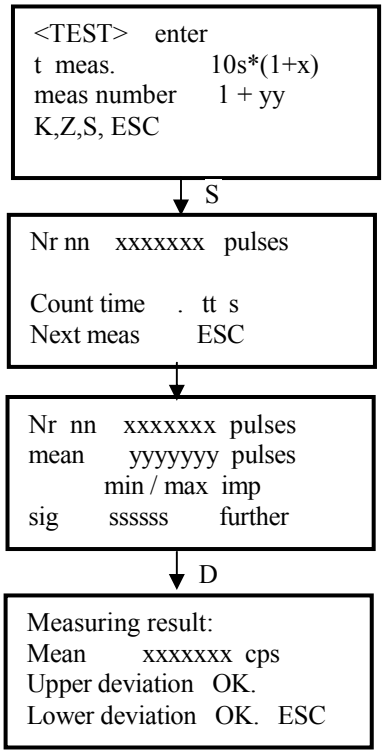
When key [T] is pressed new windows are open allowing for use control procedures.

7.1. check up of pulse counting channel



Check up

When the key [T] is pressed the procedure of check up of pulse counter is initiated:



x - possible 1 – 8, counting time
yy – possible 0 – 99, number of measurem
[K] – cursor shift
[Z] – change of digit
[S] – start counting
[ESC] - return to previous menu

Nr.nn –nn measureemnts is carried out
xxxxxx – count number
nn – number of successive measurement
tt - counting time of single measurement, s
ESC – interruption of measurement

xxxxxx – count number of last measurement
yyyyyy – mean count number
min, max - observed min and max counts
sssss - standard deviation
further – go to next window

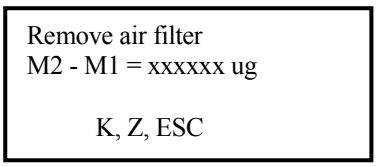
xxxxxx – mean count rate, cps
Upper standard deviation OK. if correct
Lower standard deviation OK. if correct

After the measurement is finished, mean count rate and standard deviation is computed and displayed. Thje mean count rate should be in the range 1500 – 5000 cps

7.2. Recalibration of the monitor

Recalibration of the monitor is carried out by measuring two mass reference samples, that are included into the monitor outfit. The mass M1 of one of the reference sample is near the average mass of clean filter. The mass M2 of the other reference sample is higher. The mass difference of the two samples represents mass of dust collected on the filter, and is given in the certificate (chap. 11). During the recalibration procedure, in proper time, operator is asked to accept the difference mass of the reference samples M2-M1, or to introduce new mass if needed. Introduction of new M2-M1 mass difference exists only in case the reference samples are changed. To carry out the recalibration of the monitor proceed as follows:

- Press key [K] when the window check up is displayed, the procedure of recalibration is initiated and the window is displayed :instructing the user to remove air filter and to enter mass difference M2-M1



M2-M1 = xxxxx ug, mass of dust wrutten in monitor certificate
[K] - cursor shift,
[Z] - change of digit selected by cursor
[ESC] - return to previous menu

- Remove filter and insert mass reference
- Remove the cover of the monitor, see Fig. 3.
- Unscrew two screws fastening filter guide cover, (see Fig. 3, pos. 12) and take the cover (pos. 10) out
- Pull down the filter holdfast (pos. 15) and remove the filter (pos 11). Screw the filter holder again.
- Take the reference samples from the sample holders (pos. 8) and insert reference mass M1 into the gap of reference sample position (pos. 14). The mass reference samples have double marking e.g. "02-1" means mass reference M1 from the set of references No. 2.
- Employing keys [K] and [Z] write down correct mass diference M2-M1 given in the monitor certificate and accept it by pressing key [ESC].
- Follow the instructions displayed

The following operations are carried out during recalibration procedure

- Pulse count rate N_1 is measured in 600 sec period from mass reference M1,
- Pulse count rate N_2 is measured in 600 sec period from mass reference M2,
- New calibration coefficient is computed from the relation:

$$k = \frac{M_2 - M_1}{\ln(N_1/N_2)} \quad [\mu g]$$

The calibration, k, is defined by the relation describing attenuation of beta radiation against mass dust deposited on air filter

$$N_x = N_0 \, e^{-m/k}$$

N_x - count number of pulses from dusted filter with dust mass deposited on the filter, m [ug]
No - count number of pulses from clean filter (m=0)
k - calibration coefficient..

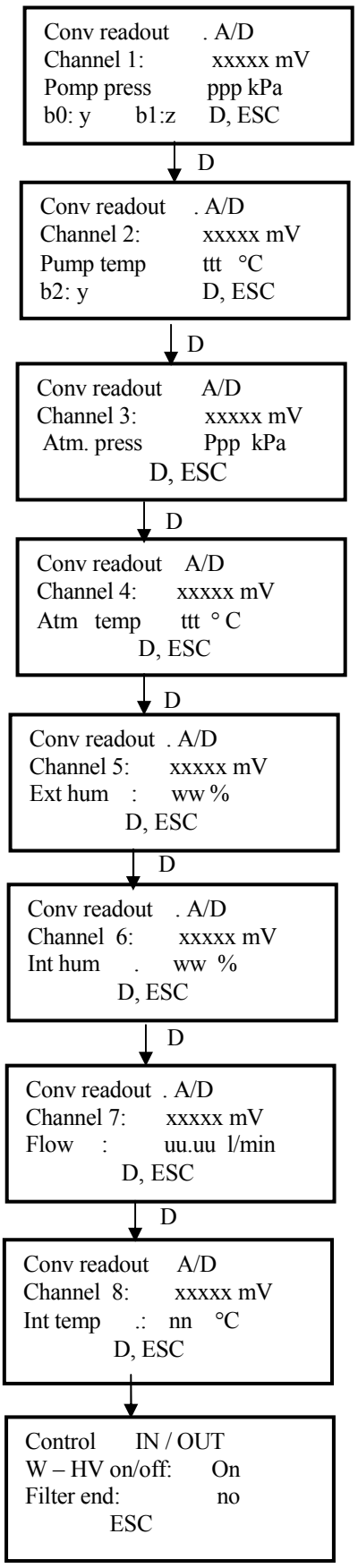
- The new and old calibration coefficient is displayed for

old k=xxxxx new k=yyyyy T- accept ESC – no

- Accepted new calibration coefficient is automatically stored in the monitor memory. If not accepted the old calibration coefficient remains in the monitor memory If the new coefficient differs by more than 5 % from the old one, it is recommended that the calibration is repeated..

7.3. Check up of air pump and A/C converters

After the key [D] is pressed when the window "check up" is displayed, a procedure of checking up the monitor system is initiated, and the successive windows are opened



xxxx – indication of pump pressure converter, mV
ppp - corresponding pressure, hPa
y=0 – pressure > 10 kPa, y = 1 pressure > 10 kPa
z=0 – pressure < 50 kPa, z=1 pressure >50 kPa

xxxx – indication of pump temperature converter, mV
ttt – corresponding temperature, °C
y= 0 temperature > permissible
y=1 temperature < permissible
temp. permissible programmed 0 – 99 °C

Atmospheric pressure

Ambient temperature

Relative humidity external

Relative humidity internal

Air flow, l/min

Internal temperature

on – GM high voltage is on or off
no – no end of filter, yes – end of filter
ESC – return to the window check up

7.4. Check up of rotary head

When the window 1 is displayed (chap. 6.4.1) and key [S] is pressed new window is open

K – rotate to measur	
Z – rotate to succion	
M – pomp on / off	pp kPa
T – filter	ESC

drives

[K] – rotary head rotates into position radiation measurement
[Z] – rotary head rotates into position air suction
[M] – switching on /off air pump
pp - underpressure produced by air pump, kPa
[T] – movement (shift) of air filter into next measuring position
[ESC] – exit from the window

These procedures allows for check up of correct operation of the drives of the rotary head, movement of the air filter and switching air pump on /off.

Pressing key [K] causes rotation of the measuring head (radiation source couple with GM counter plus air sucker) into position of measurement of radiation attenuation by the filter (clean or dusted).

Pressing key [Z] causes rotation of the radiometric head into position of air suction across the filter, and for measurement of another piece of clean filter as reference.

Pressing key [M] causes switching on off air pump turn and turn. Produced by the pump underpressure is also displayed,

Pressing key [T] causes movement (shift) of air filter about 15 mm into the next measuring position.

7.5. Check up of air flow controller

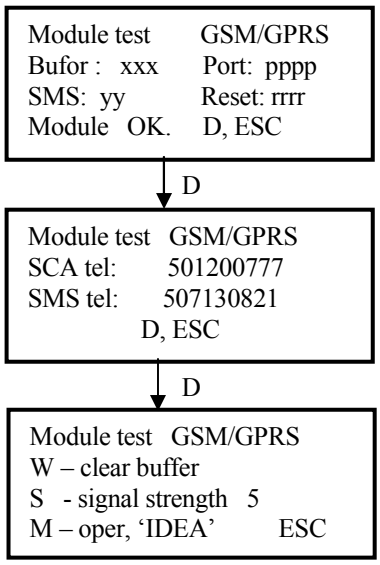
The procedure of switching air pump described in chap. 6.4 permits also for checking up the ar pump, tightness of pneumatic system, and the air flow controller, with the help of reference nozzle and blind plate described in chap. 4. To check up the tightness and underpressure of the pneumatic system, and the air flow controller proceed as follows:

- Remove the air filter and insert blind plate
- Remove the cover of the monitor, see Fig. 3.
- Unscrew two screws fastening filter guide cover, (see Fig. 3, pos. 12) and take the cover (pos. 10) out
- Pull down the filter holdfast (pos. 15) and remove the filter (pos 11). Screw the filter holder again.
- Take the blind plate from the sample holders (pos. 8) and insert the plate into the gap of reference sample position (pos. 14) with rubber sealing down.. The blind plate has double marking e.g. ”02-3” means blind plate (reference 3) from the set of references No. 2
- Press key [Z] when window “drives” is displayed (chap. 7.4). The rotary measuring assembly rotates into suction position

- Press key [M] when the window “drives” is displayed. The air pump starts to operate.
- Read out underpressure, p1, that is produced by the pump. The underpressure should be not lower than 65 kPa. If the pressure is lower check if there is no air leakage in the pneumatic lines (pipes). If there is no leakage rotary vanes of the air pump should be replaced.
- Press key [M] when “drives” window is open. The air pump is switched off.
- Remove the blind plate (reference 3) from the gap and insert nozzle plate (reference 4) with a small hole in it with rubber sealing down
- Press key [M] when “drives” window is open. The air pump starts operation
- Read out underpressure, p2, produced by the air pump. The underpressure p2 shoul be equal to the underpressure p2 given in monitor certificate.. In case the measured is different from that given in the certificate by more than ± 2% , regulation (adjustment) of the air flow controller should be made. See chap. 9.

7.6. Check up of module GSM/GPRS

After key [T] is pressed when window 2 is displayed, series of windows are open allowing for check up of the GSM/GPRS module, of signal strength, and logged in mobile phone network (GSM – General System for Module communication, GPRS – Global Packet Radio Service).



xxx - number of meas results in module, possible up to 90
yyy - number of SMS sent since monitor switched on
pppp - port number (internet)
rrrr - number of reset of TG20 module
[D] - further
[ESC] - return to previous menu

SCA – service central address, phone number of operator servicing SMS
SMS – phone number to which AMIZ send SMS (default)
The phone number for SMS is programmed in PC of control center

[W] – clears GSM buffer of measuring results
[S] - signal strength is displayed , possible 0 – 5.
[M} - displays operator name of GSM network, e.g. . ”PL IDEA”
[ESC] – exit from GSM check up

During the operation of the dust concentration monitor, in alarm situations the following SMS are sent

- Automatic start of measurement (e.g. after mains failure)
- AMIZ system failure – stop of measurements
- Measuring cycle shortened (air pump underpressure higher than 50kPa)
- Air pump underpressure lower than 10 kPa - stop of measurement
- Air filter band near to end
- Overflow of measuring results buffer
- Alarm inputs active
- Problems with internet connection
- Problems with server connection
- Mains failure 220AC, operation with UPS
- Mains recovery 220AC
- Alarm signals

8. RADIOLOGICAL PROTECTION

8.1. Radiation source

The air dust monitor is equipped with beta radiation source, that is used for measurement of dust deposited on air filter. The main technical data of the radiation source are:

- Encapsulated beta radiation source: Pm-147, ϕ13 x 3 mm
- Activity of the source: 74 MBq (2 mCi),
- Maximum radiation energy: 0.23 MeV,
- Decay time: 2.6 years,

Every 2.6 years (decay time) the activity of the source decreases to 50% of its initial activity. The initial activity 74 MBq is greater than needed for proper operation of the monitor. To decrease radiation intensity of the new source, at the top of the source additional radiation attenuating foils are placed, that with elapse of time (years) are removed. This enables to prolong the life of the source in the dust monitor for approx. 10 years of operation. Radioactive material (isotope) can not spread out, if the encapsulation of the source is not demaged/.

The radiation source is placed in the rotary radiometric set of the measuring head (see Fig. 3 pos 6). The place where the radiation source is situated inside the measuring head is marked with a warning sign in a form of a red three-leaf clover according to the standard PN-67/7-08002-2. (red clover). The dust monitor was granted permission certificate D-13739 (dated 9. March 2004) of Polish National Inspectorate of Nuclear Safety and Radiological Protection for production , service, handling of the monitor containing radioactive sources.

8.2 Radiation hazard analysis

As the radiation source is of enclosed type, no radioactive material can escape from the source and get out from the monitor into the environment. The beta radiation from the source, by means of a collimator, is directed only in the direction of the radiation detector. There is no beta radiation in all other directions, as the source is housed in steel container with wall thickness sufficient to cut off completely the radiation. Also the radiation entering radiation detector is totally absorbed by the detector gas. detector walls and its housing. There is no health hazard for personnel of the gauge or of the measuring station where the monitor is installed. Bremstrahlung radiation does not exceed the level of background radiation. The only potential hazard exists for the naked eyes when the source is installed, replaced, cleaned, attenuating foil removed and during the tightness test of the source. During such operations the eyes should be protected using lenses or organic glass plate.

Note: The check up of radiation source tightness, in routine preservation activities, and a removal of attenuation foil from the source should be entrusted to the producer or to an inspector of radiological protection.

Any preservation of the source or removal of attenuation foils should be noted in data and maintenance sheet (chap. 11). If any lack of tightness of the radiation source is found, proceed as in case of radiation accident (see chap. 8.4). To liquidate radiation sources that are no longer of any use, proper authorities responsible for nuclear safety in the country of the user should be notified.

8.3. Installation and replacement of radiation source

After about every 2-3 years of operation of the monitor attenuation foil from radiation source should be removed. To remove the foil, or to replace the source, proceed as follow, see Fig. 10:

- Take out the plate with warning radiation sign (red three-leaf clover). To do this unscrew two screws fastening it to radiometric system support Fig. 2, item 3. Access to radiation source container is made available when the radiation sign is removed, see fig. 6.
- Unscrew the nut 8 (fig. 10).
- Take out centering washer 7.
- Take out container 3 together with the radiation source from the support plate 1, and put it on a sheet of clean paper, collimator 5 down.
- Unscrew the holder nut 4.
- Remove up container housing 3 from the holder nut 4.
- Take away the spring 2.
- Turn up the collimator 5 with holder nut 4. The radiation source 9 falls down on a sheet of paper. The tightness of the radiation source can also be checked if needed, at this stage.
- Remove one of the attenuation foils at the top of the source 9, or the source 9 itself (depending which is needed). There are a few attenuating foils (not shown in Fig. 6).
- Check up the tightness of radiation source (if needed).
- Insert the source collimator 7 into holder nut 4, collimator downwards.
- Insert radiation source 9 into the collimator active side downward.
- Put onto the source 9 the spring 2 and the container housing 3.
- Screw holder nut 4 on container housing 3.
- Turn the container collimator upwards and insert it into support plate 1.
- Put on centering washer 7 and screw up the nut 8.
- Screw up the radiation warning sign plate.
- Make note in data sheet (chap. 11.4) when, what and by whom anything was done with the source.

Note: 1. The operation of removing attenuation foil, replacement of radiation source or check up of its tightness should be carried out by a qualified personnel.

2. During these operations, protect your eyes against beta radiation, with glasses or organic glass plate. Manipulate the radiation source with pincers. Never take the source with bare fingers.

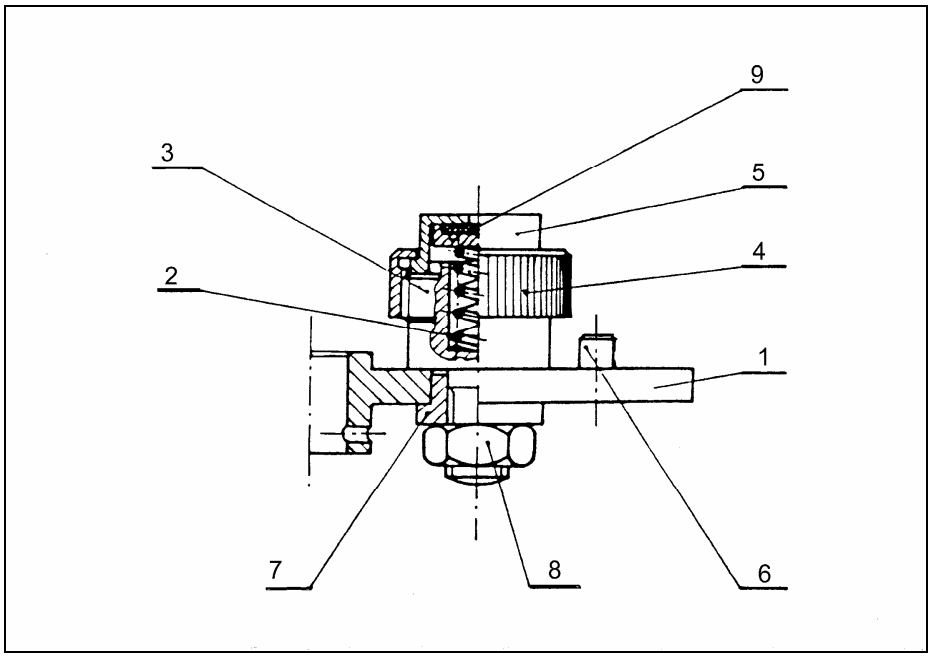


Fig. 10. Radiation source container in the measuring head of dust monitor AMIZ-2007.
1 - source container support plate,
2 - spring,
3 - source container,
4 - collimator holder nut
5 - source collimator,
6 - extreme position limiter of radiometric set
7 - centering washer,
8 - fastening screw,
9 - radiation source.

8.4. Proceeding during radiation accident

A radiation accident is an unpredicted event that can lead to loss of tightness of radiation source causing an irradiation hazard to persons, at which the individual dose is not higher than 5 mSv (0.5 rem) for whole body irradiation.

The radiation source used in the dust monitor does not present any serious hazard. . Correspondigly to the kind of the accident proceed as follows:

- withdraw all people from the hazard zone,
- protect the access to the zone against the people
- label the zone with appropriate warning signs.
- inform the radiation protection supervisor and the manager about the accident
- inform proper organization responsible in the country for radiation safety and radiological protection.

9. PERIODICAL CHECK UPS

- **Cleaning monitor from dust**

The sucker (Fig. 3 pos 3), air inlet and air inlet extension pipe should be cleaned every 2 years of dust monitor operation. In particular cases when the dust concentration is high they should be cleaned in shorter periods. The cleaning can be done after disconnection the air inlet,

disconnection of the extension pipe of air inlet form the measuring head and after disconnection and removing the sucker from the measuring head.

To clean the air inlet, the roof and wire-netting cylindrical wall have to be taken off. Before the sucker is removed for cleaning, secure first radiation source against dirt and dust from the sucker. Unscrew screws (pos 12) and take out cover (pos 10) of filter guide , see Fig. 3, and insert some thin plate under the sucker. Disassemble sucker (pos 3). Flush the dirty components with compressed air.

Replace air filter tape in the air flow controller in the periods one month to several months, depending on dust concentrationof the environment measured. To do so unscrew protecting ring of the air flow controller, Fig. 5 pos 1, and take it away. Replace the old dirty air filter tape with a new one. The filter tape is of the same sort as the air filter used in dust concentration measurements.

- **Pulse counting channel check up**

The check up of counting channel should be carried out once a year, and when any improper operation of the monitor is observed. The check up of the pulse counting channel is carried according to the explanation given in chap 7.1. Correct pulse count rate should be contained in the range 1500 – 5000 cps. The most probable cause of too low pulse count rate natural decay of beta radiation source. Relative pulse count rate against time varies according to the relation

$$\frac{R_t}{R_0} = \exp(-\frac{0.693}{\text{decay time}} * \text{time})$$

where:

R_t	- count rate after time t(years)
R_0	- count rate of new source
decay time	- 2.6 years
time	- elapsed time, years

In case thr count rate is too low plastic a foil attenuating radiation intensity of the source should be removed, eventually the old source should be replaced with new one, as described in chap. 8.3. Replacement of the source can be carried out by an inspector of radiological protection only. In case of improper operation of the monitor due to other reasons, professional, technical service should be involved.

- **Racalibration of the monitor**

Recalibration of the monitor is carried out according to the description given in chap. 7.2

- **Fuses**

- Main fuse 3 A is located at the rear plate of the monitor above the 230 V socket
- Air pump fuse 2 A is located at the rear plate of the monitor obove the power supply socket of the pump
- The fuse 200 mA for electronic circuits is located inside the monitor in a socket situated in the bus board. It can be accessed after upper cover of the monitor is removed (unscrewed)

- **Check up of air pump**

The check up should be carried out once a year, or in the case too low underpressure is produced by the pump.. Check up of the pump is carried out with the blind plate that is included in the outfit of the monitor, using the procedure described in chap.7.3. The underpressure produced by the air pump should be greater than 65 kPa (about 80 kPa). In case the underpressure is too low:

- :Make sure that during the measurement of underpressure the rubber seal of the plate was in down position
- Check the tightness of the lines (pipes) of pneumatic sustem. To do this take off upper part of housing and check all pipes if they are not damaged
- Check if the collimator closing pneumatic actuator (Fig. 3 pos 7) acts correctly and the stopper is not damaged
- Check if the graphite vanes of the air pump are not worn out, eventually replace them. It is recommended to replace the vanes when the ubderpressur is lower than 75 kPa. Preventively the vanes should be replaced after a year of operation of the monitor, even if the underpressure is higher.

- **Check up of air flow controller**

Check up of the air flow controller should me made once a year, and in case improper operation oif the air flow controller is suspected. The air flow check up is carried using the nozzle plate and program function described in chap. 7.3. The underpressure measured with nozzle plate (reference 4) should be equal to the underpressure p2 given in the monitor certificate. In case the underpressure measured differs more the ± 2% from p2 given in the certificate, the air flow controller should be checked up and eventually adjusted (regulated). To do this proceed as follows.

- Check if ambient temperature and pressure are close to the temperature and pressure at which the underpressure was measured and is given in the certificate (chap. 11). If they differ then the correct underpressure should be equal to:

$$p2_x = p2_0 \frac{P_x}{P_A} \frac{T_A}{T_x}$$

where:
$p2_0$ - underpressure p2 measured at temperature T_A and pressure P_A.
P_x, T_x - pressure and temperature during check up measurement.

- Make sure that during the p2 pressure measurement the rubber sealing of the nozzle plate was in bottom position (below the plate)
- Adjust air flow controller. To do this:
  - Unscrew protecting ring of the air flow controller, Fig. 5 pos 1, and take it away together with glass fiber filter.
  - A small hole filled with plasticine will be visible. To get to the adjusting screw of the air flow controller clean the hole from plasticine.
  - Adjust the screw in such away as to get the same pressure p2- given in the certificate, chap. 11.

- After adjustment is finished, secure the screw with plasticine, and screw again the protecting ring. Be sure to not forget to put the fiber glass filter together with the ring, which protects the small nozzle in the controller against clogging by dust..

- In case adjustment does not work, the air flow controller should be checked and cleaned. This operation should be carried out by qualified personnel, or by the producer.

10. MONITOR COMPONENTS

The dust concentration monitor AMIZ-2007 contains the following components

• Dust monitor AMIZ-2007 main block	1 unit
• Air inlet extension pipe 1.5 m ;ong	1 unit
• Standard air inlet GPF4-09 (for total suspended dust)	1 unit
• Set of sensors for temperature, pressure and relative humidity	1 unit
• Air pump VT 4.4. (prod. Becker, Germany)	1 unit
• Air filter band in rolls	2 units
• Simulator of air pump temperature	1 unit
• Antenna with cable and support	1 unit
• 4 Reference samples (dust mass and pressure)	1 set
• Cable for meteorological sensors	1 unit
• USB cable with controller program (CD-ROM)	1 unit
• Air pump cable	1 unit
• Operation manual (English)	1 unit

Optional components

• Needle printer EPSON LX-300, or similar	1 unit
• UPS-750 uninterruptible power supply 750 VA, or similar	1 unit
• Additional air inlet extension pipe	1. 5 m long
• Air inlet PM=10 or PM-2.5	1 unit
• Sensors of wind direction and wind speed with cable	1 set
• Burglar alarm system	2 channels

11. CERTIFICATE OF AMIZ-2007

- Serial number of dust monitor AMIZ-2007 .....
- Type / serial number of air pump: .....
- Serial number of meteorological sensors set .....
- Radiation source
  - form of source .....
  - source certificate number .....
  - Source activity (MBq) .....
  - date of production .....
  -

Reference samples

- Serial number of mass regerence M1 .....
- Serial number of mass reference M2 .....
- Difference of mass M2-M1 (ug) .....
- Serial number of blind plate for p1 underpressue measurement .....
- Serial number of nozzle plate for p2 underpressure measurement .....

Optional equipment

- Type / serial number of printer .....
- Type / serial number of air inlet .....
- Serial number of uninterruptible power supply (UPS) .....

Control data od the monitor

- Air flow (m^3/h) .....
- Pulse count rate from clean filter (cps) .....
- Pulse count rate from mass reference M1 (cps) .....
- Pulse count rate from mass reference M2 (cps) .....
- Underpressura p1 at blind plate (kPa) .....
- Underpressure p2 at nozzle plate (kPa) .....
- Calibration coefficient (ug) .....
- Air temperature when underpressure was measured (°C) .....
- Air pressure when underpressure was measured (hPa) .....

.....
date and signature of inspector

Monitor AMIZ-2007 conforms with the following standards

- PN-EN ISO 9001 - concerning quality of the product
- 73/23/EEC - directive concerning low voltage devices
- 91/68 EEC - directive concerning CE marking
- Dz.U. Nr. 137 poz 1153 - Polish law concerning permission for handling devices containing radioactive sources
- D-13739 + appendix - Permission of State Inspectorate for Radiological Protection for production
- PN-67/7-08002-2 - concerning warning mark (symbol) about ionization radiation
- PN-76/T-06500 - concerning electrical installation with earth connector