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Manual

Instruction manual for
Smoke measuring equipment
MIC type EC-912

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including 1 annexes

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Version 3
d. 29-10-2015

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List of symbols

I	[A]	current
U	[V]	voltage
R	[Ω]	resistance
τ	[s]	time constant
p	[Pa]	pressure
t	[°C]	temperature
h	[%]	relative humidity

List of subscripts and abbreviations

MIC		Measuring Ionization Chamber
MIREX		Measuring InfraRed EXtinction
FCU		Flow Control Unit
MCU		MIC Control Unit
CC		Control Cabinet
VP		Vacuum Pump
CAL		Calibration
GND		Ground
CH (C)		Chamber
CHO		Chamber, equilibrium
in	(i)	input
out	(o)	output
C.W.		Clockwise
C.C.W.		Counter clockwise

1. General information

WARNING
THE MEASURING IONIZATION CHAMBER EC-912-10
CONTAINS A WEAK RADIOACTIVE SOURCE. DO NOT
ATTEMPT TO DISMOUNT THE MIC WITHOUT FOLLOWING
THE SAFETY PRECAUTIONS GIVEN IN SECTION 5.1.1 .

1.1 Introduction

Smoke density can be measured using several different techniques. However, for reference measurements of smoke density in connection with testing of ionization smoke detectors for automatic fire detection systems, it is advantageous to use a measuring instrument based on the ionization chamber principle. This is because of the complex nature of smoke, which means that measuring errors are likely to occur if the reference measuring instrument reacts to other properties of the smoke than the detector under test.

Different reference ionization chambers have been developed in the past. [1][3][4]. However, since the measuring characteristics of the ionization chamber depend on several parameters, including the design of the ionization chamber, it is important to reach international acceptance of one particular ionization chamber design in order that measuring results may be comparable in general.

The measuring ionization chamber (MIC) which is the smoke sensor in smoke measuring equipment EC-912 has reached this status. The chamber, which is originally designed by Cerberus AG, Switzerland [2][3], has been included in the European standards for smoke detectors [5][6] issued by CEN[1] and the UL[2] standards UL 217 and UL 268 [8][9]. Furthermore, the chamber has now been specified in recent "ISO[3] 7240-7 Fire detection and alarm systems" for point smoke detectors and great interest for the chamber has been shown by several countries.

The MIC instrument can be used alone or in combination with different types of optical smoke measuring equipment as for instance the MIREX type EC-911 (MIC/MIREX system designation EC-910) which also complies with the European standards for smoke detectors [5][6].

[1] CEN: European Committee for Standardization

[2] UL: Underwriters Laboratories Inc.

[3] ISO: International Organization for Standardization

1.2 General description

The smoke measuring equipment EC-912 comprises a measuring ionization chamber, a control cabinet and a vacuum pump as shown in Fig. A.1.1 in Annex 1.

The control cabinet (CC) comprises a control unit for the measuring ionization chamber, a flow control unit and a power supply.

The CC can also accommodate a control unit for the optical smoke measuring equipment MIREX type EC-911 and a calculator unit type EC-913.

The measuring ionization chamber (MIC) is placed in the location where the smoke density is to be measured. The MIC is provided with a wind shield which makes the measurements of the device independent of air movement in the location where it is mounted. This wind shield, however, makes it difficult for the smoky air to merge into the measuring volume, so air is sucked through the MIC by a vacuum pump (VP).

The air passes the flow control unit (FCU) on its way from the MIC to the VP. In the FCU the air can be set to a flow rate with needle valve. An exchangeable filter is inserted before the flow meter in order to reduce smoke deposits in this instrument.

The current in the MIC, which is a measure of the smoke density, can be measured with the MIC control unit (MCU). The current in the MIC is transformed into a proportional voltage in a built-in amplifier in the MIC. This voltage is fed to the MCU and transformed to an expression for smoke density which can be presented on the display of the MCU. Furthermore, a recorder output is provided. The MCU is provided with an electrical calibration facility for check and setting of zero point and full scale deflection of the measuring system.

1.3 Applications

As mentioned in the introduction, the MIC smoke measuring equipment EC-912 is intended for reference measurements of smoke density in type approval tests of smoke detectors. The following two applications are typical in this area:

a) Smoke tunnel (box) measurements.

The smoke measuring equipment is used to measure the actual smoke density in the smoke tunnel where the detector under test is subjected to a slowly increasing smoke density. The sensitivity of the detector is expressed in terms of the value of smoke density measured at the moment of response. The detector sensitivity under specific reference conditions and the change in sensitivity due to variations in the operating parameters environment etc., are measured in this way.

b) Measurements during fire sensitivity tests.

The smoke measuring equipment is used to measure the smoke density under the ceiling in the fire test laboratory, where the detectors under test are subjected to different test fire categories. The smoke readings are used for determining if the test fires are correctly reproduced.

The smoke measuring equipment can also be used in other applications, where measurements of smoke density are needed.

1.4 Specifications

1.4.1 System specifications

Measuring accuracy:	The overall measuring accuracy of the whole system is limited by the measuring accuracy of the MIC, which is better than ±4% of full scale reading (X = 1) for $0 \le X < 0.9$.
Mains supply:	115 to 230 Vrms, 50 to 60 Hz without switch-over. Power consumption max. 120 W independent of the applied voltage. Mains supply for vacuum pump, see Section 1.4.5.
Cabinet:	19 inch desktop/subrack cabinet with power supply for MIC, MIREX and Calculator unit (optional).

The subunits are intended for operation in normal laboratory environment. However, the measuring ionization chamber may be applied in the temperature range 0-100°C.

1.4.2 Measuring Ionization Chamber (MIC) type EC-912-10

General:

The MIC is designed to fulfil the specification in EN54-7. See Ref. [6].

Radioactive source:

Isotope:	Am 241
Activity:	129.5 kBq (3.5 µCi) ±5%
Average ∀-energy:	4.5 M eV ±5%
Mechanical construction:	Americium oxide embedded in gold between two layers of gold. Covered with a hard gold alloy. The source is in the form of a circular disc ø = 27 mm, which is mounted in a holder in such a way that no open cut edges are accessible.

Ionization chamber:

Chamber quiescent current:	I_{CHO} = 100 pA
Chamber impedance:	$R_{CHO} = 1.9 \bullet 10^{11}\ \Omega \pm 5\%$

The characteristics are measured in aerosol free air at:

Air pressure:	p =1.013 • 10^5 Pa (760 mm Hg)
Air temperature:	t = 25°C
Rel. humidity:	h = 48%

Measuring time delay τ # 10 sec. where τ is defined as the time from the moment when the MIC is subjected to a smoke step function to the moment when the output has reached 63% of its final value. The figure for τ is based on a flow rate of 30 1/min.

Relative smoke sensitivity: $\frac{X}{X_R MIC} = 1.00 \pm 3\%$,

where X_RMIC is the smoke density measured with DELTA's standard chamber MIC, type EC 23095-1 Serial no. 830101.

Refer to Section 5.2 and the certificate of calibration for further details.

Output: Multipole connector for the cable to the CC.

1.4.3 MIC Control Unit (MCU) type EC-912-20

Readout:	3.1 digit LCD display. Chamber voltage or smoke density X can be selected. With calculator unit (optional) also smoke density Y and Y_{20} can be displayed.
Recorder output X:	0.0 to 10.0 VDC corresponding to a smoke density X of 0.00 to 1.00.
Recorder output Uc:	Approx. 14 to 25 VDC corresponding to the chamber voltage.
Recorder output Y:	0.00 to 11.00 VDC corresponding to a smoke density Y of 0.00 to 11.00 (not active without the calculator unit).
Recorder output Y_{20}:	0.00 to 11.00 VDC corresponding to a smoke density Y_{20} of 0.00 to 11.00 (not active without the calculator unit).

1.4.4 Flow Control Unit (FCU) type EC-912-40

Flow rate:	Adjustable between 0-50 1/min
Filter:	Replaceable filter element : EC999-01.

1.4.5 Vacuum Pump (VP), Thomas type VTE 3

Technical data:

Mains voltage:	230 V ±10%, 50-60 Hz
	115 V ±10%, 60 Hz
	100 V ±10%, 50-60 Hz
Motor rating:	Approx. 0.15 kW
Capacity:	3.5 $m^3/h \approx$ 58 1/min, 50 Hz
	4.2 $m^3/h \approx$ 70 1/min, 60 Hz
Degree of protection:	IP54
Weight:	6.5 kg
l x w x h	209 x 152 x 165[4] mm

[4] To top of pipe branches

2. Installation

2.1 Preparation for use

2.1.1 Unpacking

Unpack the smoke measuring equipment and remove tape strips etc. used for fixing during transportation.

Check that the following items are enclosed in the shipment:

1	Measuring Ionization Chamber, type EC-912-10
1	Allen wrench, 1.5 mm metric
15 m	P.V.C. hose
1	multicable (10 m cable with connectors with yellow coding)
1	control cabinet with MIC Control Unit, type EC-912-20 and Flow Control Unit, type EC-912-40.
1	mains cord with plug (female)
1	vacuum pump, Thomas type VTE 3
1	instruction manual
1	certificate of calibration

Inspect the items for possible damage due to transportation and report to the forwarding agency as soon as possible if damages are found.

Check for correct operating voltage rating of the VP.

2.1.2 Mains cord

Plugs corresponding to the type of electrical outlet in concern have to be mounted on the mains cord to the CC and VP, in accordance with the following information:

Control cabinet:	3-wire mains cord:		
	Brown	-	live
	Blue	-	neutral
	Green/yellow	-	ground (chassis)

Vacuum pump: 3-wire mains cord:
See connection information on the lid of the terminal housing

Consult an electrician for proper mains installation.

Note: The MIC must be earthed through the mains connection (green/yellow wire).

2.1.3 Performance check

Check the performance of the smoke measuring equipment as follows:

a) Interconnect the MIC and the CC (rear side) with the multicable, the MIC connectors have yellow insulation rings. Align the code marks and push the plug gently into the connector when fitting the cable.

b) Connect a voltmeter (range 0-10 VDC) to recorder output X on the rear of the CC.

c) Connect the CC to the mains and switch on power. The MCU display shall light up, the MODE indicator shall indicate Uc mode and the CAL ON indicator shall light up.

d) Press the MCU MODE button to indicate mode X. The MCU display may read a value deviating from 1.00.

e) Adjust the offset trimmer on the MCU until the display reads 1.00. The correspon-ding recorder output voltage shall be 10.0 VDC.

f) Press the MCU CAL button. The CAL ON indicator shall extinguish. The display may read a value deviating from 0.00.

g) Adjust the Uc trimmer on the MCU until the display reads 0.00. The correspond-ing recorder output voltage shall be 0.0 V.

h) Press the CC MODE button to indicate mode Uc. The display shall read a value between 14.0 and 25.0 (19.0 is typical). The voltage on recorder output Uc at the rear of the MCU shall be the same as the value on the display.

i) Connect the VP and air outlet on the rear of the FCU with a piece of hose.

j) Turn the flow meter needle valve in the FCU fully C.W.

k) Connect the VP to the mains and switch on power. The ball in the flow meter on the FCU shall stay in its lowest position.

l) Turn the flow meter needle valve C.C.W. until the middle point of the ball indicates approx. 30 1/min. Block the air inlet on the rear panel of the FCU with a finger and control that the ball drops to its lowest position. Fasten the finger screws on the filter unit and checks for other leaks if this does not happen.

Attention: Do not remove your finger from the air inlet before the VP has been switched off and stopped. Otherwise, the ball may be damaged by collision with the flow meter needle valve.

2.2 Installation of Measuring Ionization Chamber (MIC)

The MIC is intended for mounting on a plane surface (e.g. wall, ceiling, etc.) in the location in concern, as shown in Fig 2.2. A circular opening in the mounting surface 10-12 cm in diameter is adequate. Care should be taken that the cable and hosing are not bent sharply. Keep a distance of min. 12 cm to objects behind the mounting surface.

The MIC should not be mounted too close to devices which may be sensitive to air movements since the air flow through the MIC causes slight disturbances in the surrounding air. The nominal flow rate of 30 1/min. corresponds to a mean air velocity of approx. 4 cm/sec. in the plane of the air entrance openings in the chamber housing. Since the air velocity decreases rapidly with the distance from the entrance openings, a spacing of 10 cm or more between the MIC and other devices is usually sufficient.

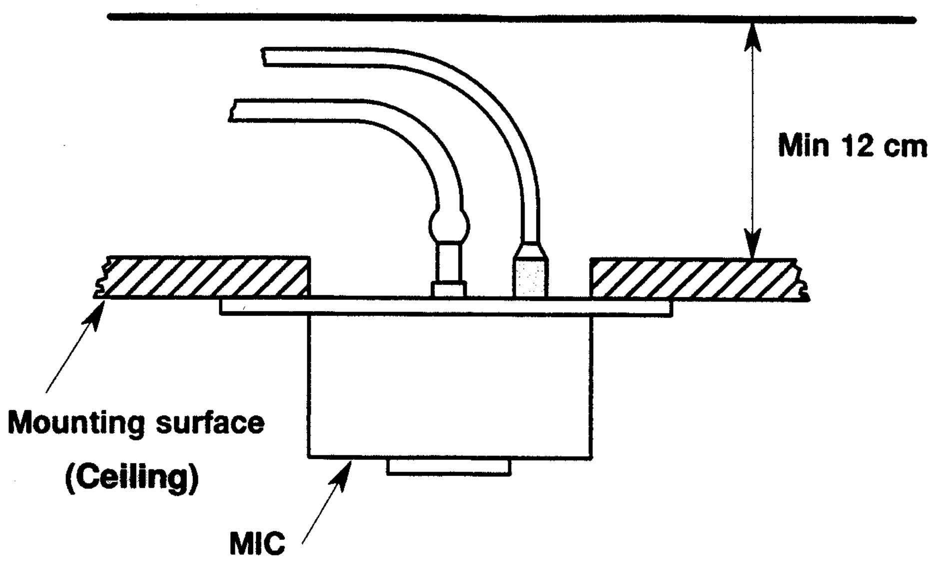
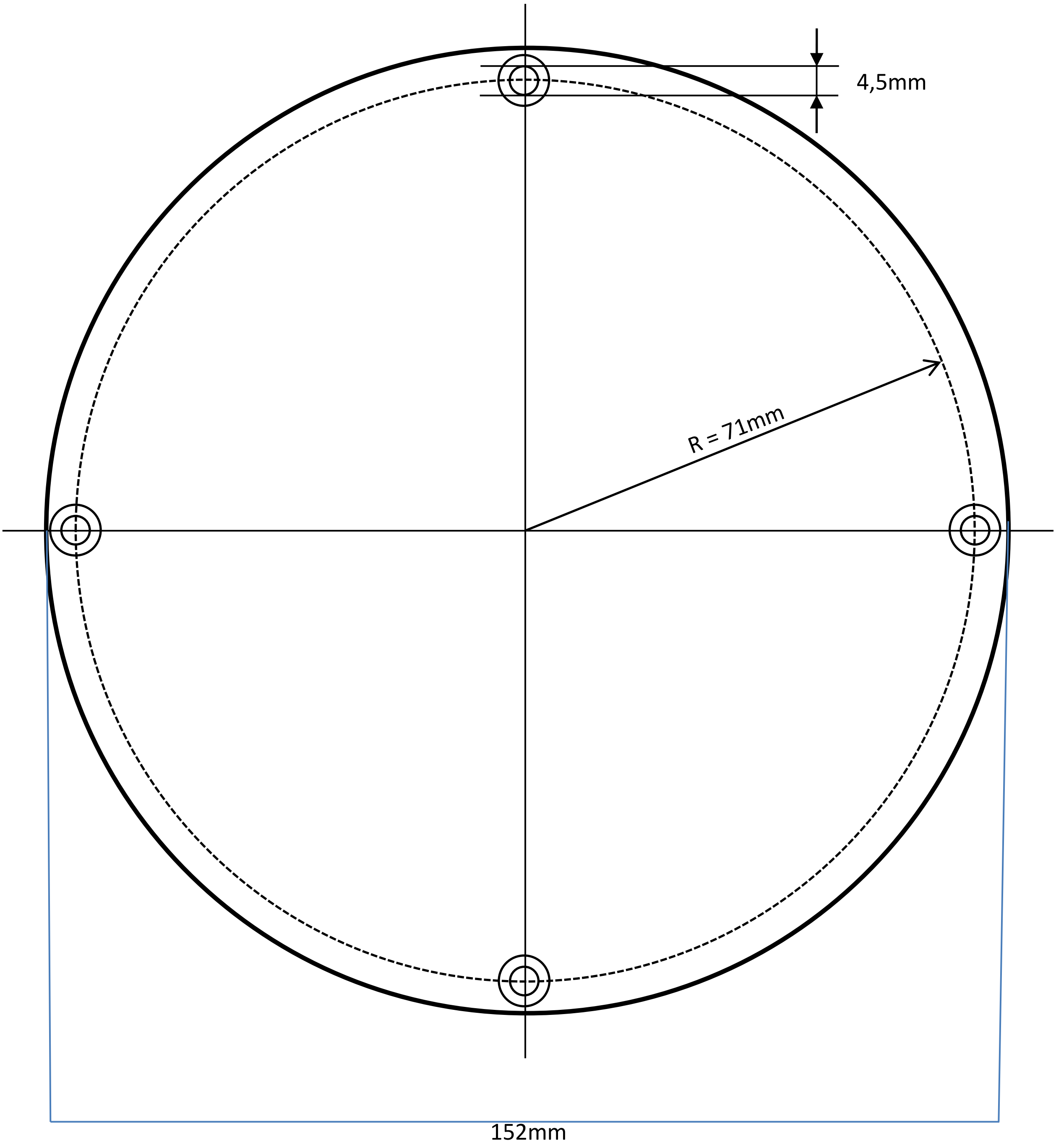


Fig. 2.2 Mounting of MIC

MIC chamber mounting holes



2.3 Installation of Vacuum Pump (VP)

Smoke measuring equipment EC-912 is delivered with a vane-type vacuum pump Thomas type VTE 3. The VTE 3 pump is quiet in operation (noise level 58 dBA with exhaust hose). The pump is provided with a factory-set bypass valve, which prevents damage in case the inlet is blocked. An outlet is provided, from where the smoky air can be led to the outside via a hose. So, the VTE 3 pump can be placed in a suitable place in the laboratory.
Refer to the installation instructions from Thomas in : Pump spec. 2012 BA187-EN.

2.4 Installation of Control Cabinet (CC)

The CC is housed in a 19 inch cabinet which can be used as a desktop cabinet or as a subrack for mounting in a 19 inch rack system. The CC is delivered as a desktop cabinet with a bottom plate with four feet. If the CC is to be installed in a 19 inch rack system the whole bottom plate has to be removed, by unscrewing the four screws in the bottom plate.

3. Operation

3.1 Operating controls, connectors and indicators

The function of the controls, connectors and indicators located on the different units of smoke measuring equipment EC-912 is defined as follows:

3.1.1 Measuring Ionization Chamber (MIC)

Multipole connector: The male connector of the multicable fits into this connector. Align the code marks and push the plug gently into the connector. Do not use force. When disconnecting the cable, be sure to pull on the fluted part of the connector and never on the cable.

Air outlet: Pipe branch for hose to air inlet on rear of FCU.

3.1.2 Control Cabinet (CC)

Rear plate (see Fig. A.1.4 in Annex 1)

Mains switch: The mains switch is part of the EMI filter and mains plug assembly placed on the left at the rear of the cabinet.

Sockets calibration: A short between these sockets (red-blue) initiates the automatic calibration function when the calculator unit (optional) is plugged into the CC. Calibration may be activated e.g. from a data acquisition system for remote calibration of the system.

Sockets lock: A short between these sockets (red-blue) disables the automatic calibration function when the calculator unit (optional) is plugged into the CC. Lock may be activated, e.g. from a data acquisition system, to avoid unintended calibration during smoke measurements.

Sockets m/Y: A voltage which is proportional to the measured extinction module m [dB/m] from the MIREX divided with the measured smoke density Y from the MIC is present on these sockets when the MIREX Control Unit (optional) and the calculator unit (optional) are plugged into the CC.

Connector MIC: The female plug of the multicable fits into this connector. Align the code marks and push the plug gently into the connector. Do not use force. The plug on the cable is secured with a locking system which avoids unwanted disconnecting. When disconnecting the cable, be sure to pull on the fluted part of the connector and never on the cable.

Sockets U_c: The actual chamber voltage U_c is present on these sockets.

Black: Ground Red: Output voltage
14.0 VDC ≤ Uc ≤ 25.0 VDC
Load impedance ≥ 100 k

Sockets X: A voltage which is proportional to the measured X signal is present on these sockets.

Black: Ground Red: Output voltage
0.0 VDC for X = 0.00
10.0 VDC for X = 1.00
Load impedance ≥ 100 kΩ

Sockets Y: A voltage which is proportional to the measured Y signal is present on these sockets when the calculator unit (optional) is plugged into the CC.

Black: Ground Yellow: Output voltage
0.00 VDC for Y = 0.00 (X = 0.00)
11.00 VDC for Y = 11.00 (X = 0.91)
Load impedance ≥ 100 kΩ

Sockets Y_{20}: A voltage which is proportional to the measured Y_{20} signal is present on these sockets when the calculator unit (optional) is plugged into the CC.

Black: Ground Yellow: Output voltage
0.00 VDC for Y_{20} = 0.00
11.00 VDC for Y_{20} = 11.00
Load impedance ≥ 100 kΩ

Note: The calibration sockets and the lock sockets must be shorted with a potential free contact e.g. a switch or a relay.

3.1.3 MIC Control Unit (MCU)

Front panel (see Fig. A.1.3 in Annex 1)

MODE button: With this button, different display modes can be selected. Without the calculator unit chamber voltage U_c and smoke density X can be selected. With the calculator unit (optional) also smoke densities Y and Y_{20} can be selected.

CAL button:	When the CAL button is pressed indicator ON light up and the MIC is now ready for offset calibration by means of the offset trimmer.
Offset trimmer:	Screwdriver trimmer for offset calibration.
U_c trimmer:	Screwdriver trimmer for adjustment of the chamber voltage.
Calculator area:	The two colour indicator in this area is only active when the calculator unit (optional) is plugged into the CC, and has the following indications:

Steady green:	Normal status of MIC after calibration. X = 0.00 prior to measurement.
Flashing red:	Automatic calibration function is active. Wait for steady green indication.
Steady red:	Calibration error.

3.1.4 Flow Control Unit (FCU)

Front panel (see Fig. A.1.3 in Annex 1)

Flow meter valve:	Needle valve for adjustment of air flow rate in the range 0-50 1/min. The flow rate is indicated on the flow meter and read at the middle of the ball.

Rear panel (see Fig. A.1.4 in Annex 1)

Air inlet:	Pipe branch for hose to air outlet on MIC.
Air outlet:	Pipe branch for hose to air inlet on VP.
Finger screws:	Screws for disassembling the filter unit.

3.1.5 Vacuum Pump (VP)

Pump spec. 2012 BA187-EN.

Air inlet:	Pipe branch for hose to air outlet on rear of FCU.
Air outlet:	Pipe branch for hose to appropriate place.
Bypass valve:	Valve for adjustment of minimum pressure. The bypass valve is fitted to ensure that the pressure does not drop below 150 mbar, when the inlet is blocked. The bypass valve is adjusted by

DELTA to a minimum pressure of approx. 500 mbar. This setting is locked with lacquer and should not be changed unless the new setting is controlled with a manometer.

3.2 Smoke density measurements

3.2.1 Measuring set-up

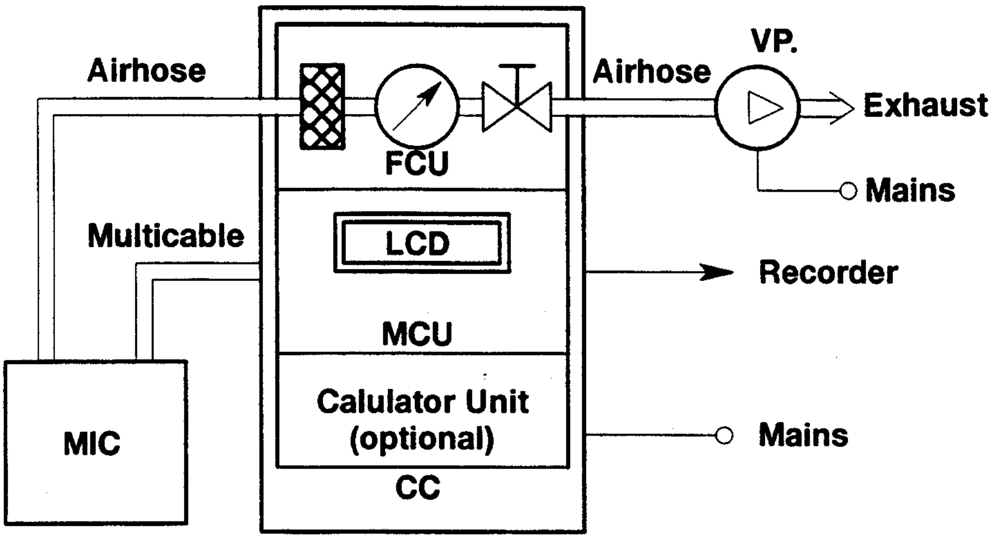


Fig. 3.2.1 Measuring set-up principle

Connections:

a) Air hose between air outlet on MIC and air inlet on FCU.
b) Air hose between air outlet on FCU and air inlet on VP.
c) Multicable between MIC and the MIC connector on the rear of the CC.
d) Cable between recorder outputs at the rear of CC to recorder (if used).
e) Mains cord for VP and CC.

3.2.2 Measuring procedure

a) Turn the flow meter needle valve in the FCU fully C.W.

b) Switch on the mains to the VP and turn the needle valve on the FCU slowly C.C.W. until the flow meter reads 30 1/min. Rate of flow is read at the middle point of the ball.

c) Switch on the mains on the control cabinet and allow the instrument to stabilise for about 15 min.

d) Press the MODE button on the MCU to indicate mode X.

e) Press the CAL button on the MCU (CAL ON indicator lights up) and adjust the offset trimmer until the display reads 1.00 or the recorder output X is 10.0 VDC.

f) Press the CAL button again (CAL ON indicator extinguish) and adjust the Uc trimmer on the MCU until the display reads 0.00 or the recorder output X is 0.0 VDC.

g) Subject the MIC to the smoke exposure the density of which shall be measured.

h) Subject the MIC to aerosol-free air and repeat point e) and f) before the next smoke density measurement. Also check the rate of air flow, point b).

If the calculator unit (optional) is plugged into the CC procedures d - f are replaced by the following procedure:

d) Press the MODE button on the MCU to indicate mode X, Y or Y_{20}.

e) Press the CAL button on the calculator unit and wait until the flashing red indica-tor on the MCU becomes steady green.

f) The display shall now read 0.00 independent of the chosen mode.

4. Theory of operation

4.1 General working principle for ionization chambers for smoke density measurements

The use of ionization chambers as smoke sensors is well known and the associated theory outlined in the literature.

The working principle for the ionization chamber for smoke density measurements is shown in Fig. 4.1.

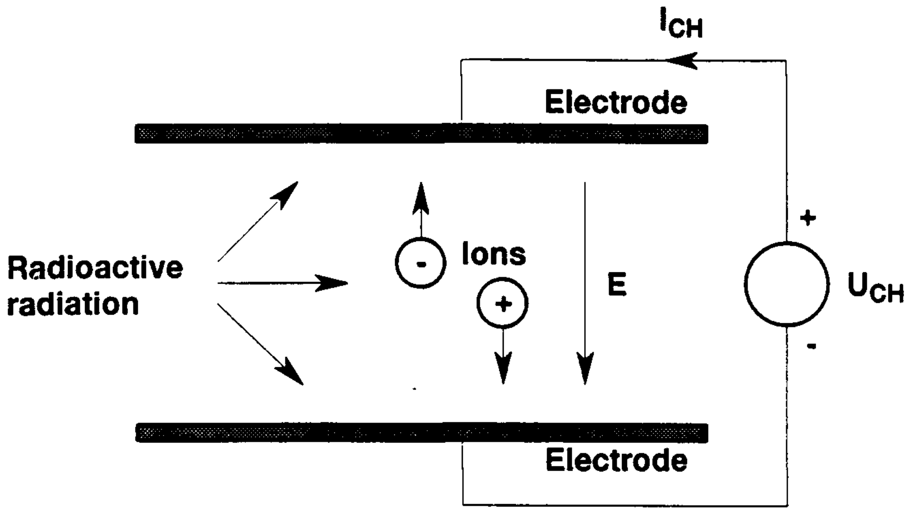


Fig. 4.1 Working principle for ionization chamber

The chamber consists of a pair of electrodes between which a volume of atmospheric air is present. The electrodes are connected to a voltage source U_{CH} so an electrical field E is applied to the air. Radioactive radiation from a small radioactive source bombards the air and ion pairs are created between the electrodes. The positive and negative air molecules forming the ion pairs are deflected towards the negative and positive electrode, respectively. Some of the ions recombine before they reach the electrode surfaces and become neutral air molecules. Other ions exchange electrons with the electrode surfaces. This electron exchange results in a small electrical current I_{CH} in the external circuit.

When the air between the electrodes is clean, the ions formed move to the electrode with a certain mean velocity and each ion which does not recombine in the volume contributes to the current. However, if smoke particles penetrate the volume between the electrodes, the ions and the smoke particles will be attached to each other with a certain probability. Since the smoke particles are much heavier than the ions, the mobility of ions attached to smoke particles is greatly reduced and the probability for recombination increased. So, their contribution to the external current becomes negligible. Thus the external current is a function of the smoke particle density in the measuring volume.

The smoke density can be defined in terms of X as follows:

$$X = \frac{I_{CHO} - I_{CH}}{I_{CHO}} \qquad (0 \leq X \leq 1) \qquad (4.1.1)$$

I_{CHO} [A] is the chamber quiescent current (clean air)
I_{CH} [A] is the chamber current when smoke is present

It appears from eq. 4.1.1 that X = 0 in clean air and X = 1 when the smoke density is infinite.

Smoke density can also be expressed in Y-values which are related to the X-values as follows [1]:

$$Y = X \cdot \frac{2 - X}{1 - X} \qquad (4.1.2)$$

The Y-value can also be transferred to a value related to a chamber voltage of 20 V. This Y_{20}-value is related to the Y-value as follows:

$$Y_{20} = \frac{Y}{U_c} \cdot 20 \qquad (4.1.3)$$

The advantage of expressing the smoke density in terms of Y and Y_{20}-values is that these values are proportional to the number of smoke particles per unit volume.

Besides smoke density, the X, Y, and Y_{20}-values depend on the design of the ionization chamber and a number of environmental parameters.

So, the readings obtained from different ionization chamber configurations cannot be compared unless the correction factor for the chambers is known, e.g. from calibration.

4.2 Measuring Ionization Chamber (MIC)

4.2.1 Ionization chamber design

The MIC has a parallel plate electrode configuration in which the radioactive source (Am 241) is part of one of the electrodes. This configuration provides a measuring volume in which the ionization is uniform and approx. parallel to a constant electrical field.

The air is sucked through the chamber in order to reduce wind dependence, but the air in the measuring volume between the electrodes is stationary since the sucked air flows in a duct which is separated from the measuring volume by means of a wire mesh. Smoke is transferred from the air flow to the measuring volume by diffusion.

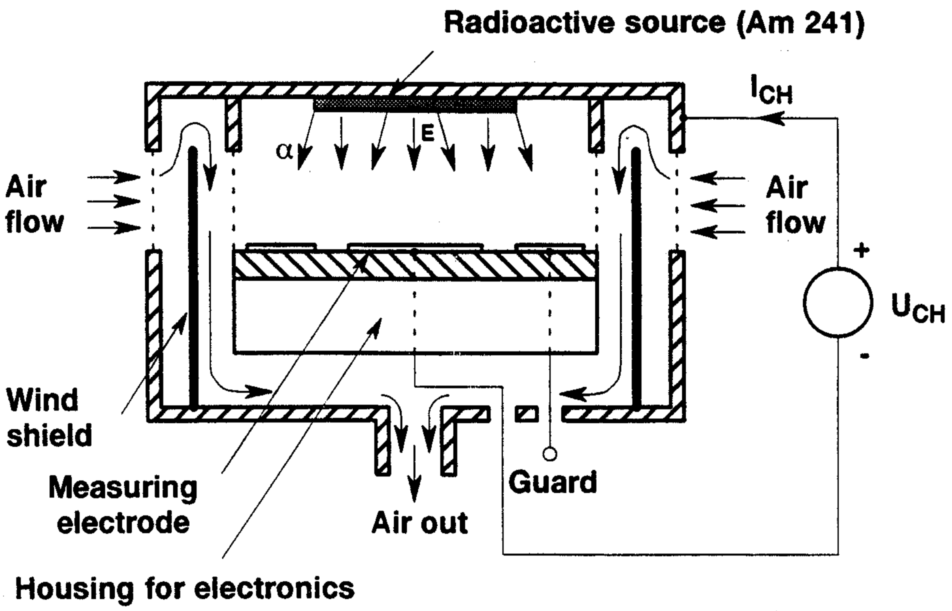


Fig. 4.2.1 Principle of ionization chamber design in the MIC

The radioactive source is mounted in a holder which may be unscrewed for cleaning purposes, refer to Section 5.1.1.

The chamber is operated in the proportionality range with a clean air quiescent current of 10^{-10}A (100 pA) corresponding to a chamber voltage of approx. 19 V.

4.3 Electronics for impedance transformation

An impedance transforming circuit is built into the MIC. The principle of the impedance transforming circuit is shown in Fig. 4.2.2. The circuit converts the ionization current at a high impedance level to a proportional voltage at a low impedance level. So, the length of the connecting cable between the MIC and the CC becomes uncritical.

The relay, which is shown in Fig. 4.2.2, is used for calibration of the impedance transforming circuit and the MCU. This facility will be described in Section 4.3.

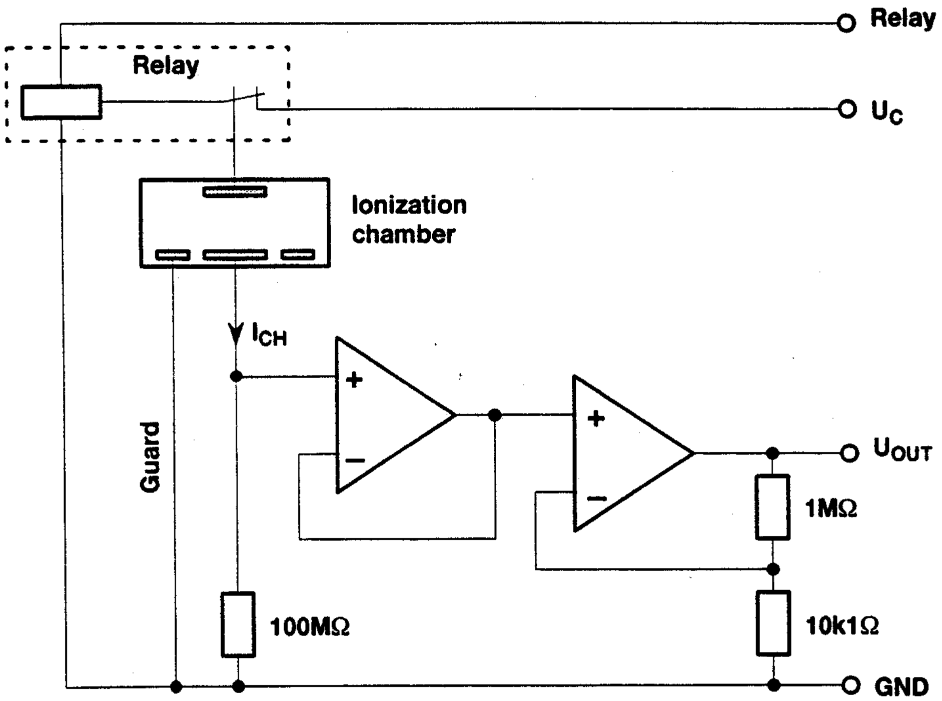


Fig. 4.2.2 Principle of MIC impedance transforming circuit

4.4 MIC Control Unit (MCU)

The low impedance voltage from the MIC is first amplified 100 times by a differential amplifier. Then the voltage is inverted and the offset voltage set by the offset trimmer on the front of the MCU is added. This resulting voltage is transferred to the display and the recorder output X when the MCU is in X mode.

During calibration the relay in the MIC disconnect the chamber voltage and the chamber current becomes zero. The voltage to the MCU also becomes zero and the offset trimmer is then used to adjust the X value to 1.00.

The voltage from the Uc trimmer is amplified and used for adjustment of the chamber voltage in the MIC. The chamber current is proportional to the applied chamber voltage and the chamber voltage is used to adjust the chamber current to 100 pA in aerosol free air. A chamber current of 100 pA equals a X value of 0.00.

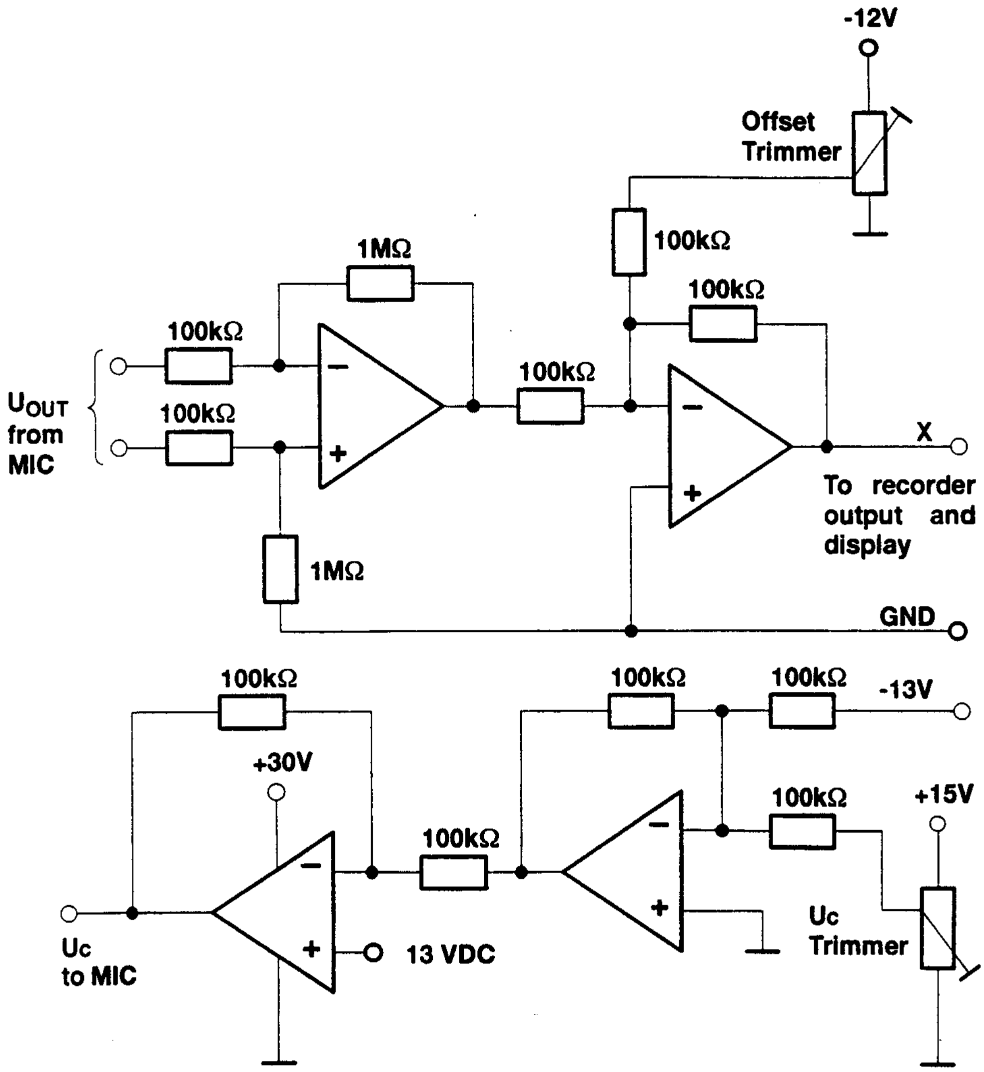


Fig. 4.2.3 Principle of MCU analogue circuit

5. Maintenance and service

5.1 Periodic maintenance

5.1.1 Measuring Ionization Chamber (MIC)

The MIC should be cleaned at regular intervals since smoke deposits in the ionization chamber especially on the radioactive source and the electrode assembly can affect the measuring characteristics. Smoke deposits on the radioactive source will increase the clean air chamber resistance while smoke on the electrode assembly may cause leakage currents.

Cleaning of the radioactive source:

The holder for the radioactive source may be unscrewed for cleaning, without dismounting other parts of the MIC, by loosening the locking screw (refer to Fig. A.1.2 in Annex 1) and unscrewing the source holder. Make sure that the serial number of the source corresponds to the ionization chamber (see note in Section 5.2*)*.

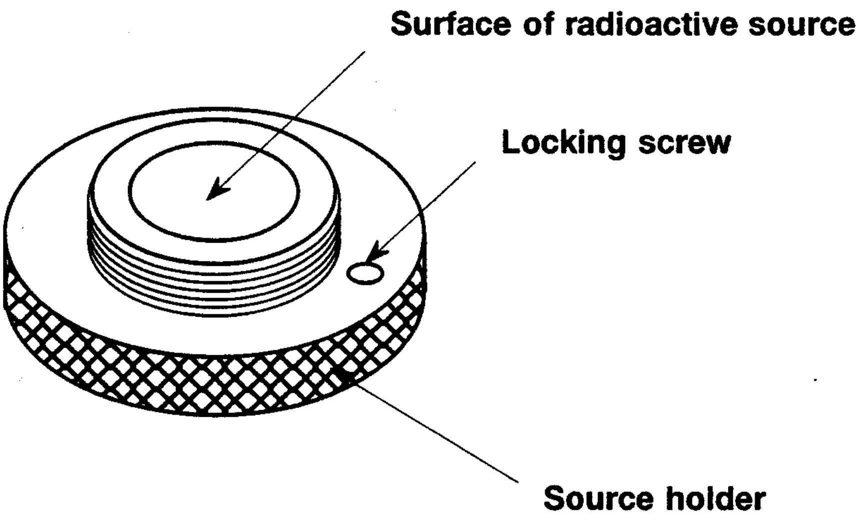


Fig. 5.1.1 Holder with radioactive source

The following procedure and precautions should be followed for radiation protection reasons:

a) Never touch the surface of the radioactive source (see Fig. 5.1.1) with your fingers, use disposable gloves during the work.
b) Avoid scratching the surface with hard metal tools or the like.
c) Keep a distance of at least 10 cm from the unscrewed source holder to your eyes.
d) Do not take the source holder apart.
e) Clean the surface of the source with paper tissues wetted with alcohol. Do not touch the tissues with your fingers, use plastic tweezers.
f) Dispose the tissues in a metal container marked "radioactive disposal". Leave the container to the competent national authority for destruction when filled up.
g) Never leave the source holder on the table after cleaning. Screw it into the MIC and fasten the locking screw.
h) Wash your hands after having cleaned the radioactive source.

Cleaning of ionization chamber:

Attention should be given to the fact that the insulating materials (polycarbonate[5]) in the MIC, especially the electrode support plate can be attacked by a number of liquids. So, it is highly recommended to follow the procedure below. Modern cleaning techniques, such as ultrasonic, should not be used. Furthermore, the amount of cleaning liquid should be kept to a minimum to avoid ingress to the electronic housing.

For your information a list of liquids to which polycarbonate is claimed to be resistant, respectively **not** resistant is given below. The list should not be regarded complete.

Polycarbonate is resistant to:

Alcohol (Ethanol)
Benzine
n-Butyl or sec-Butyl Alcohol (1- or 2-Butanol)
Cyclohexane
Acetic Acid, 10%

Polycarbonate is NOT resistant to:

Bases
Organic Solvents
Acetone
Chloroform (Trichloromethane)
Carbon Tetrachloride (Tetrachloromethane)
Toluene
Xylene

[5] Brand names: LEXAN, MAKROLON

a) Dismount the MIC housing by loosening the three screws around the holder for the radioactive source and gently pulling the housing from the mounting plate.
b) Clean the inside of the housing with paper tissues with a little alcohol. The radioactive source shall be unscrewed and cleaned separately as described above.
c) Clean the measuring electrode, the guard ring and the insulating electrode support plate with paper tissues with a little alcohol, avoid excessive liquid.
d) Allow the parts of the MIC to dry before assembling.

Assembling:

Be careful not to leave any fingerprints or other impurities on the internal parts of the MIC during assembling.

a) Assemble the MIC by pressing down the housing and aligning the three distance pieces with the three holes in the housing and fasten the screws. Make sure that the alignment marks on the housing and mounting plate match.
b) Screw the holder with radioactive source in the top of the housing and fasten the locking screw (Allen screw 1.5 mm, metric).

5.1.2 MIC Control Unit (MCU)

No maintenance of the MCU is required.

5.1.3 Flow Control Unit (FCU)

The maintenance of the FCU concerns cleaning of the flow meter and needle valve and exchange of filter element.

Cleaning of flow meter:

Before cleaning the flow meter is has to be dismounted from the FCU and disassembled in the following way:

a) Remove the FCU from the CC by loosen the four screws in the front plate, remove the two air hoses from the pipe branch on the rear plate and on the filter and pull out the FCU by pressing on the filter unit.
b) Remove the four screws in the rear plate, loosen the hose connections on the flow meter and remove the rear plate with the filter and the two hoses.
c) Loosen the four screws holding the flow meter mounting plate and pull back the mounting plate with the flow meter approx. 5 cm. The screws are accessible through holes in the two side profiles of the FCU and can slice in the two slices in the side profiles.
e) Remove the two screws holding the flow meter to its mounting plate and pull out the flow meter.
d) Turn the flow meter needle valve fully C.C.W. and pull out the needle. Remove the upper hose connector and unscrew the rest of the needle valve with a 16 mm ratchet socket.

e) Remove the screw on the top of the flow meter and take out the ball by inverting the flow meter and allowing the ball to fall into your hand.

The flow tube, needle valve and ball can now be cleaned with a little pure soap and water and a bottle brush. Avoid the use of benzene, acetone, carbon tetrachloride, alkaline detergents, caustic soda, liquid soaps which may contain chlorinated solvents, etc. and avoid prolonged immersion. Remove the soap water by rinsing with clean water and allow the flow meter to dry before assembling.

To assemble the flow meter and the FCU just follow the above instructions in the opposite order. A little stop cock grease or petroleum jelly on the O-rings will help maintain a good seal as well as facilitate assembly.

Exchange of filter element:

The filter unit is incorporated in the FCU to reduce the smoke deposits in the flow meter. The filter element can be exchanged by dismounting the removable part of the filter unit on the rear of the FCU (refer to Fig. A.1.4 in Annex 1). The filter unit is intended for filter element EC 999-01 manufactured by DELTA. This part is pressed into the fixed filter unit and the filter unit assembled. (Refer to Fig. 5.1.2).

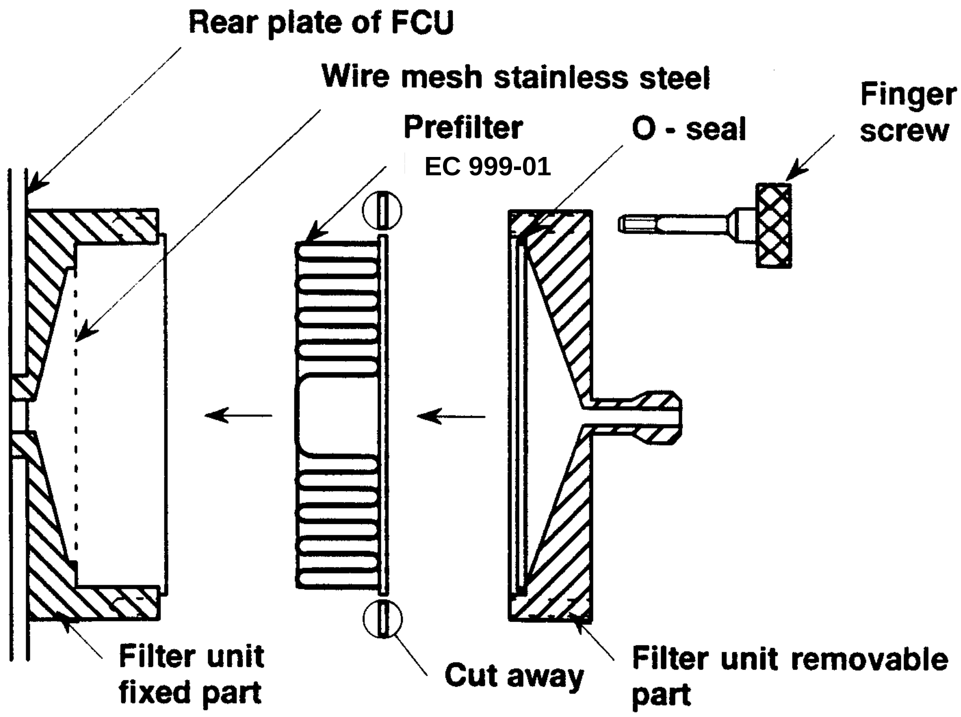


Fig. 5.1.2 Exchange of filter element

The filter element may be blocked by smoke more or less rapidly depending on the type of smoke measured. In some applications it may be more practical to replace the MSA filter with a 10-12 mm thick polyurethane filter cut circular with a diameter of 68 mm.

The consequence of this is of course that cleaning of the flow meter is needed more often. A filter combination which prevents smoke deposits in the flow meter and gives acceptable operating times without filter exchange should be aimed at.

When assembling the filter unit make sure that the O-seal remains in position in the removable part.

Check the filter unit for tightness by the method outlined in Section 2.1.3 k and 1, after assembling filter unit.

5.1.4 Vacuum Pump (VP)

The Thomas type VTE 3 pump contains an inlet filter and rotor blades which should be checked regularly.

5.2 Smoke calibration

The MIC was calibrated with smoke before shipment. The calibration was performed in a smoke tunnel where the smoke density was slowly increased while smoke density readings were taken simultaneously with the MIC under test and a MIC type EC 23095-1 serial number 830101, which we have nominated as standard at DELTA.

The test procedure, set-up and results from this smoke calibration are issued in a separate certificate of calibration which is included in the technical documentation of the smoke measuring equipment in concern.

Regular smoke calibration of the MIC is not absolutely necessary, since the sensitivity of the MIC is determined mainly by the mechanical construction of the ionization chamber and thus stable when properly maintained. However, the smoke calibration can be repeated at DELTA if required.

Note: Before the smoke calibration, the electrode distance and the active area of the radioactive source of the individual measuring ionization chambers have been adjusted. So, be sure that the serial number of the radioactive source corresponds to that of the MIC.

5.3 Possible errors and hints

5.3.1 Flow system

If it is not possible to adjust the flow rate on the flow meter to 30 1/min then there is either a leak or a block in the VP, the FCU or the hose connections. First check the performance of the VP and the FCU as described in Section 2.1.3 point i) -l) by using a short new piece of hose. If the performance of the VP and FCU is OK there is either a leak or a block in the hose connections. Inspect the hose connections for a possible leak or block and replace the damaged hose connection. If the performance of the VP and MCU is not OK then there is probably a block in the filter for the MCU, in the flow meter or in the filter for the VP. Refer to Section 5.1.3 for cleaning of flow meter and exchange of filter element in the FCU.

5.3.2 Electronics

The mains fuse is in the mains plug assembly which is placed on the left at the rear of the CC. First remove the mains plug and then remove the fuse holder with a screwdriver. On delivery a replacement fuse is placed inside the fuse holder.

Recorder output X should follow the reading on the display with a factor of 10 when the MCU is in X mode and the recorder output Uc should follow the display reading when the MCU is in Uc mode. If this is not the question then either the load impedance on the recorder output is to low (load impedance ∃ 100 kΩ) or the MCU electrical circuit is malfunctioning. Refer to Section 5.4 if the latter is the matter.

If the chamber voltage Uc necessary for calibrating the MIC is greater than 25 V, the radioactive source is probably covered with smoke deposits and needs cleaning. Refer to Section 5.1.1 for cleaning of the radioactive source.

5.3.3 Electrical leakage

The leakage current in the MIC can be checked by dismounting the holder for the radio-active source as described in Section 5.1.1 and following this procedure:

a) Press the MCU MODE button to indicate mode Uc and adjust the Uc trimmer on the MCU until the display reads 25.0.
b) Press the MCU MODE button to indicated mode X.
c) Press the MCU CAL button. The CAL ON indicator shall light up.
d) Adjust the Offset trimmer on the MCU until the display reads 1.00.
e) Press the MCU CAL button. The CAL ON indicator shall extinguish
f) Notice the display reading XLEAK.

The leakage current in the MIC is: $I_{LEAK} = 100 \bullet (1.00 - X_{LEAK})$ [pA]

The leakage current in the MIC should be less than 1 pA. If the leakage current in the MIC is greater than 1 pA the electrode assembly is probably covered with smoke deposits and needs cleaning. Refer to Section 5.1.1 for cleaning of ionization chamber.

5.4 Service and repair

If necessary, consult:

DELTA
Alarm & Security Systems
Venlighedsvej 4
DK-2970 Hørsholm
Denmark

Tel. +45 72 19 40 00
Fax +45 72 19 40 01
e-mail customercentre@delta.dk
http://certification.madebydelta.com/mic/

for repair advice, spare parts delivery, etc.

6. References

[1] H.H. Gilson & J.P. Hosemann: Messkammer nach dem Kleinionenanlagerungsprincip zum quantitativen Nachweis von Aerosolpartikeln. Forschungsberichte des Landes Nordrhein-Westfalen Nr. 2336 Westdeutscher Verlag Opladen 1973.

[2] A. Scheidweiler, Cerberus AG: The ionization chamber as smoke-dependent resistance.

[3] A. Scheidweiler, Cerberus AG: Description of the Measuring Ionization Chamber (MIC).

[4] P.E. Burry: Standard Ionization Chambers. Tagungsbericht zum 7. internationalen Vortragsseminar über Probleme der automatischen Brandentdeckung, Aachen 5. und 6. März 1975. Page 243-255.

[5] CEN, European Committee for Standardization: EN54-9: Fire sensitivity test. July 1982.

[6] CEN, European Committee for Standardization: EN54-7:2000 Point type smoke detectors. Detectors using scattered light, transmitted light or ionization. December 2000.

[7] M. Avlund: ECR-71: Reference Measurements of Smoke Density, ElektronikCentralen, May 1977.

[8] Underwriters Laboratories Inc. UL 217, single and multiple station smoke alarms.

[9] Underwriters Laboratories Inc. UL 268, smoke detectors for fire protective signalling systems.

Annex 1
Figures

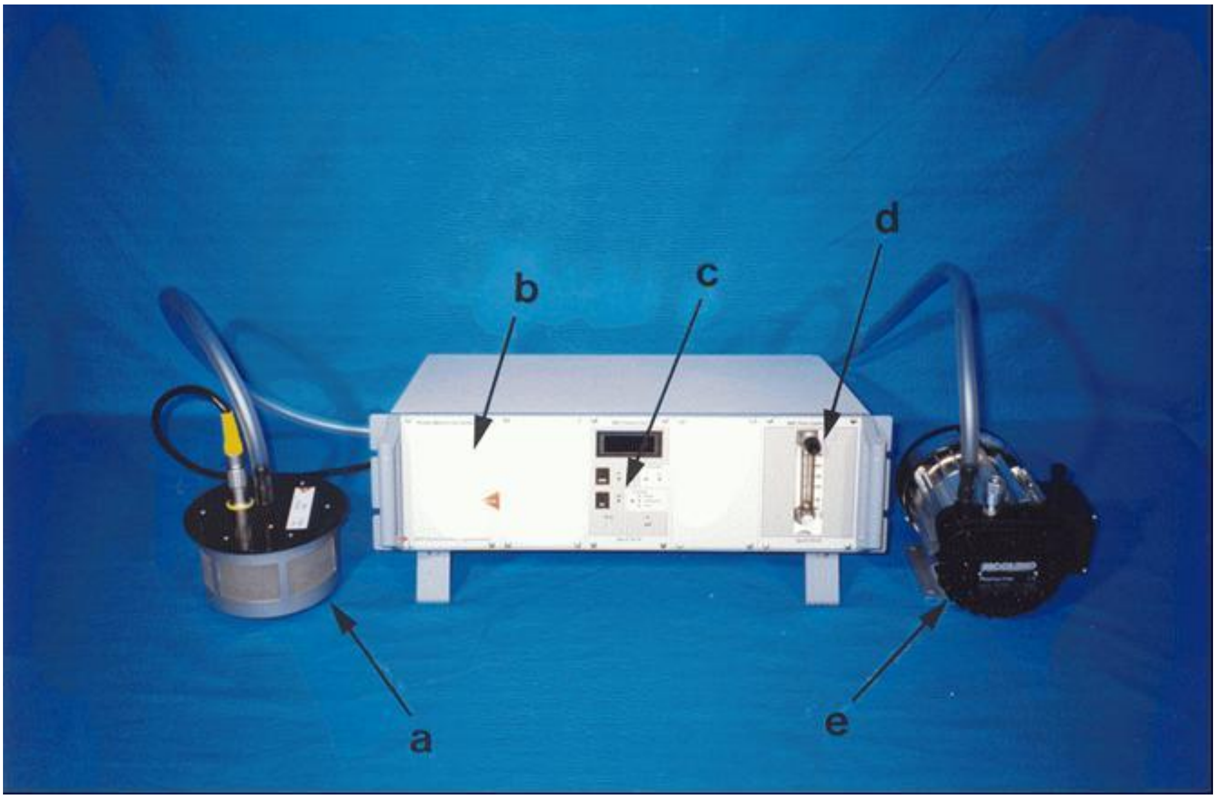


Fig. A.1.1 Smoke measuring equipment EC-912

a Measuring Ionization Chamber (MIC) EC-912-10
b Control Cabinet (CC) EC-910-10
c MIC Control Unit (MCU) EC-912-20
d Flow Control Unit (FCU) EC-912-40
e Vacuum Pump, (VP) Thomas type VTE 3

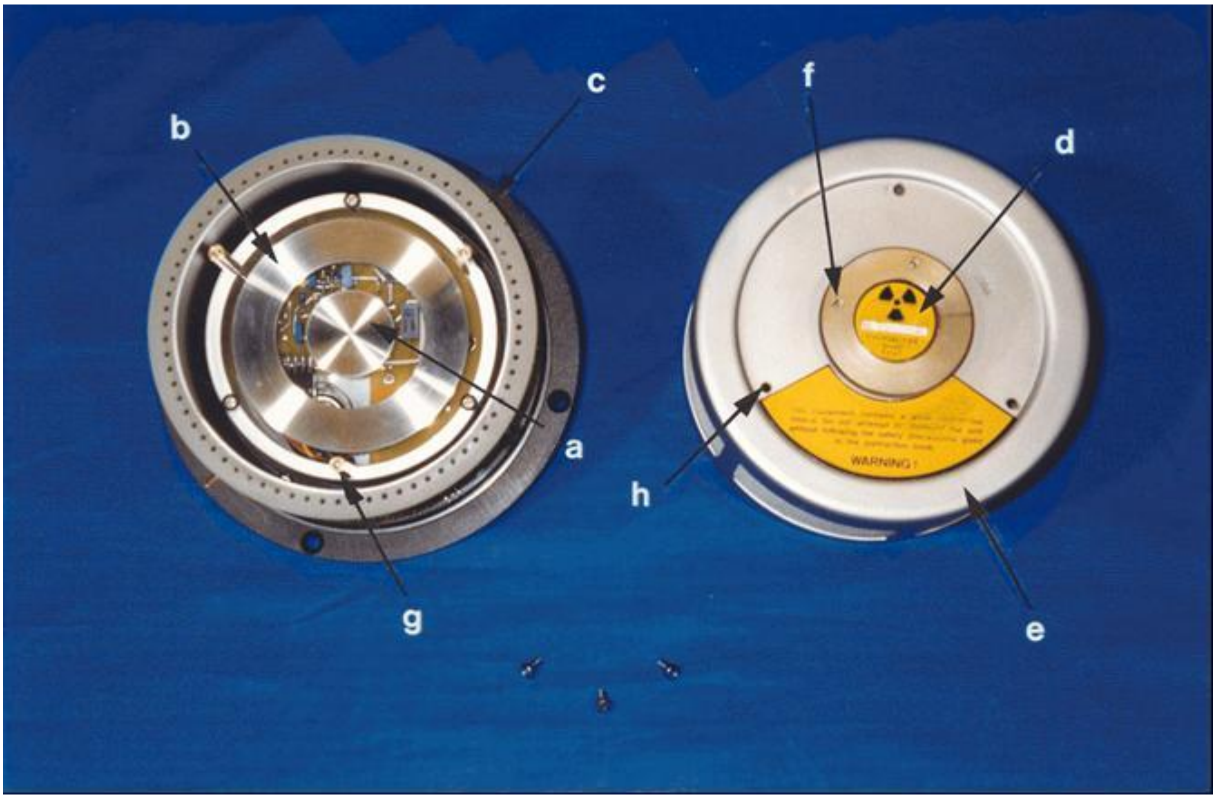


Fig. A.1.2 Measuring Ionization Chamber (MIC) EC-912-10 with chamber housing removed

a Measuring electrode
b Guard ring
c Wind shield
d Radioactive source holder
e Chamber housing
f Locking screw for radioactive source holder
g Distance pieces for chamber housing
h Holes for screws to distance pieces

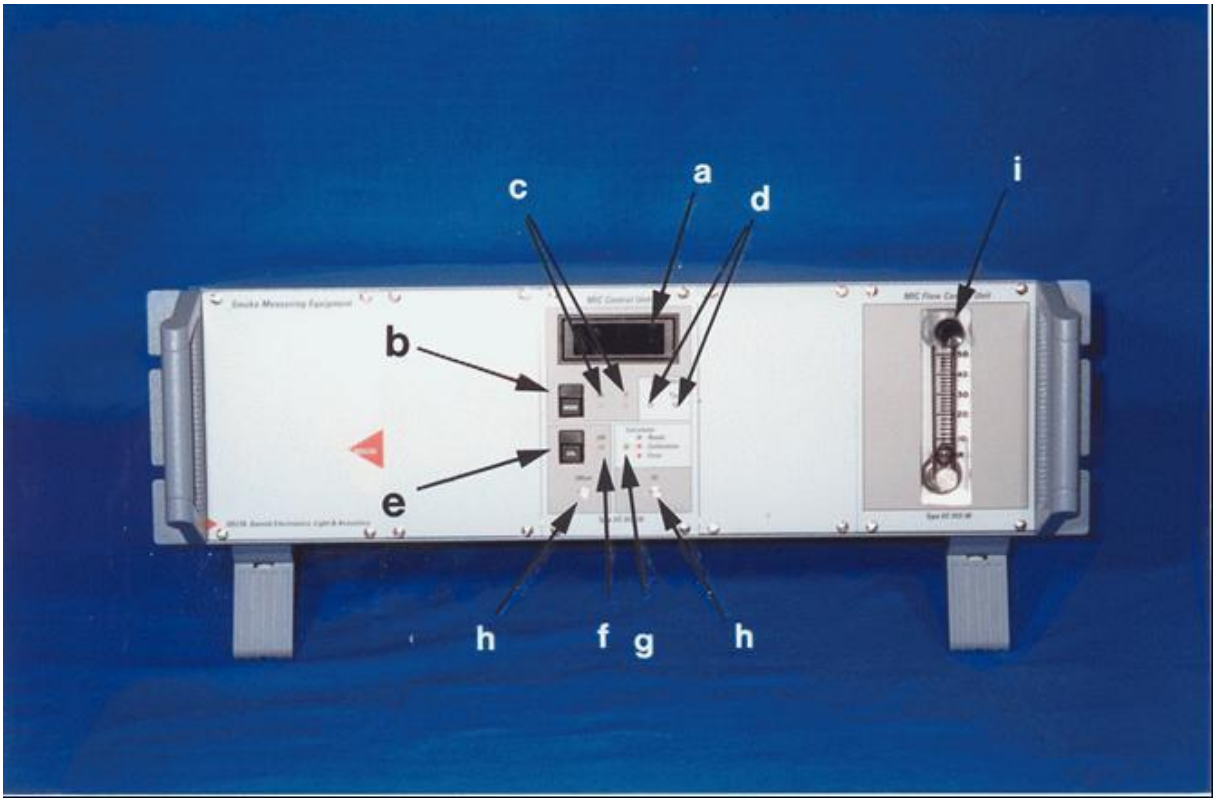


Fig. A.1.3 Front of control cabinet EC-910-10 with MIC control unit EC-912-20 and flow control unit EC-912-40

a 3.1 digit LCD display
b Mode selector button
c Mode indicators Uc and X
d Mode indicators Y and Y_{20} (only active with calculator unit)
e Calibration button
f Relay ON indicator
g Calibration status indicator (only active with calculator unit)
h Trimmers for offset and chamber voltage adjustments
i Flow meter needle valve

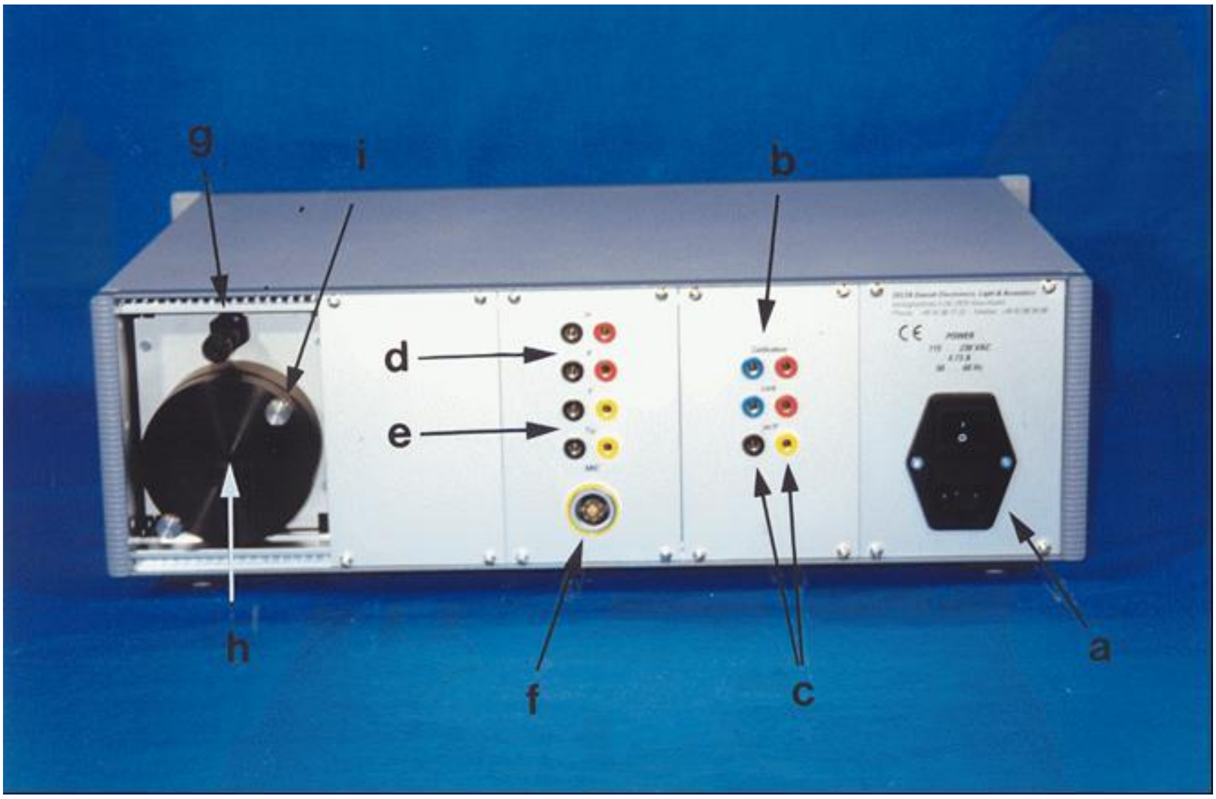


Fig. A.1.4 Rear of control cabinet EC-910-10 with flow control unit EC-912-40

a EMI filter with mains switch, mains socket and fuse holder
b Digital inputs for remote calibration (only active with calculator unit)
c Analogue recorder output m/Y (only active with calculator unit)
d Analogue recorder output for chamber voltage Uc and smoke density X
e Analogue recorder outputs for smoke density Y and Y_{20} (only active with calculator unit)
f Connector for multicable to MIC
g Air outlet pipe branch for hose to vacuum pump
h Air inlet pipe branch for hose from MIC
i Finger screws for disassembling of filter unit