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MINI-INSTRUMENTS

MINI-MONITOR

SERIES 900

Scintillation Mini-Monitor

with types 41, 42A/B & 44A/B probes

MANUAL

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Morgan

MINI-INSTRUMENTS LIMITED

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Scintillation Mini-Monitor

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Our instruments are subject to continuous development and minor changes in detail may occur which are not incorporated in this manual.

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CONTENTS

1. GENERAL DESCRIPTION

1.1 Basic monitor

The monitor is designed for use in teaching, research, hospital and industrial laboratories. When fitted with a suitable probe it will measure contamination down to the accepted levels and indicate γ or X-ray background intensity.

The monitor is powered by easily available primary cells or may be mains operated from a small power unit similar to those used on calculators. In addition rechargeable cells can be used which are recharged by using a similar power unit.

The probe is connected to the monitor by either an extensible co-axial cable or a standard cable. It may be used remotely or attached to the case by a clip. A meter registers the counting rate on a semi-logarithmic scale thus making range changing unnecessary. An internal speaker, which may be switched off, gives an audible indication of intensity.

The monitor has a warning alarm adjustable to trip at any selected level on the scale. It can be made inoperative during normal use but will respond on overload.

1.2 Probe attachments

The monitor is available with different probes, each identified as a separate model. It is not recommended to exchange probes owing to the need to re-adjust the internal controls. This is good radiation safety practice as it avoids the monitor being maladjusted when most needed.

The monitor is normally supplied with an extensible cable terminated by a PET series 100 plug. Most portable scintillation probes having a single output socket are suitable. The following probes were designed, or are suitable, for use with this instrument:–

Mini Instruments:–	γ ray probe type 41 & 41S
	X ray probe types 42A & 42B
	γ ray well probe type 43
	X ray probe types 44A & 44B

Nuclear Enterprises:–	α ray probes types AP2 & AP3
	β ray probe type BP4
	α - β ray probe type DP2
Hilger Analytical:–	Large area probe type P5525

The probe may be used further from the monitor than allowed by the extensible cable. Up to 15 metres of low capacity co-axial cable is acceptable.

2. OPERATING INSTRUCTIONS

2.1 Controls

There are two external controls:–

(a) A four position rotary switch labelled with symbols OFF, BAT, ON, SPEAKER OFF.

(b) A screwdriver control to set alarm level.

2.2 Battery

The state of the battery is indicated on the meter when the switch is turned to the position marked "bat". In this position the battery is subjected to a current drain in excess of that used in normal use. In order to ensure that the battery is satisfactory the pointer should be observed for a short while to see if it falls below the green sector. If so the battery should be changed or if rechargeable, put on charge.

The reading depends upon the type of cell used. New primary cells read near the top of the green scale but rechargeables read in the middle.

Battery replacement The battery is contained within the rear compartment. A half turn on the screw lets down the flap to reveal the six cells contained in a removable holder. Take out the holder and replace the cells in the correct polarity. The label on the hinged flap suggests some suitable replacement types. Make sure the monitor is off before connecting the press studs as an accidental reversal may damage the circuit.

2.3 Mains operation

The monitor may be mains operated by using a separate power unit. For electrical safety reasons it MUST use a "DOUBLE INSULATED" isolating transformer. The unit supplied by Mini-Instruments Ltd is recommended as it conforms to the appropriate specifications. The same unit also provides the charging current when rechargeable cells are fitted. Mains units are available for 210-250V, 50Hz and 110-120V, 60Hz; output 12-18 volts d.c. at 75mA.

The unit is plugged into the jack socket on the right hand side of the case. A green LED glows when in use. When the power unit is plugged in, the internal batteries are disconnected but make sure that the internal charge switch is "off" if the cells are *not* rechargeable.

There is no internal fuse in the monitor. Should a failure occur that overloads the mains power unit a thermal protection device cuts off the mains input. The thermal device is not resettable.

2.4 Battery charge

The mains unit can be used to replenish rechargeable cells. When the cells are exhausted plug in the mains unit and switch the charge switch within the battery compartment over to "charge". The charge rate is 45 mA and charging is complete in 16h. Do NOT charge primary cells. When the charge is complete switch off the charger at the mains.

2.5 Setting the alarm

The alarm level is variable from zero to beyond the limit of the scale. It is set by using a test source to give the desired level and adjusting the front panel control with a small screwdriver. The alarm resets when the radiation level falls below the trip level. If the control is turned fully clockwise the alarm is disabled for all levels on the scale. The alarm is not disabled for overscale conditions providing this adjustment is correctly made: see section 5.5. In addition the alarm is not switched out by the "speaker off" position.

2.6 Paralysis time correction

The monitor has an internal paralysis time of 50 µs. Counts are lost as given by the formula in section 5.4 but no correction need be applied as the meter scaling is adjusted to compensate.

3. THE SCINTILLATION PROBE

The probes have been designed to offer a small convenient detector for most X and γ ray monitoring applications.

Each probe contains a suitable crystal detector, photo-multiplier tube and associated electronics. A complete specification of each probe is given in section 7.

The photo-multiplier tube is shielded against moderate magnetic fields by a μ-metal shield and the crystal is partially shielded with lead to reduce background radiation. The dynode resistor chain and pre-amplifier are sealed into the base unit which is held in the probe by a circlip. With the clip removed, the base, photo-multiplier and crystal slides out as one unit.

A monitor supplied with a probe is correctly set for immediate use. A probe supplied separately may need adjustments to be made to some internal controls for correct operation. Refer to the section on the relevant probe for details of the procedure.

The following sections contain much useful information on the function of each probe but no responsibility can be taken for the accuracy of any statements applied to an individual probe. If it is required to make accurate measurements the probe should be calibrated against the radiation or nuclide in question.

3.1 SCINTILLATION PROBE TYPE 41

The scintillation probe type 41 is a general purpose probe with a useable energy range between 20 keV and 2 MeV. The crystal diameter is 19 mm and its length is 25 mm. A lead cylindrical shield reduces the background count by about four times and it functions as a collimator with low energy gammas. Gammas with energies above 500 keV increasingly penetrate the shield so the probe becomes non-directional. A full specification can be seen in section 7.

Figure 1 shows the probe's photon detection efficiency from 20 keV to 5 MeV. Figure 2 shows the calculated response in counts s^{-1} to an absorbed dose rate in air of 1 μGy h^{-1} over a similar energy range. The response to 1 μGy h^{-1} of ^{137}Cs radiation is approximately 90 counts s^{-1}.

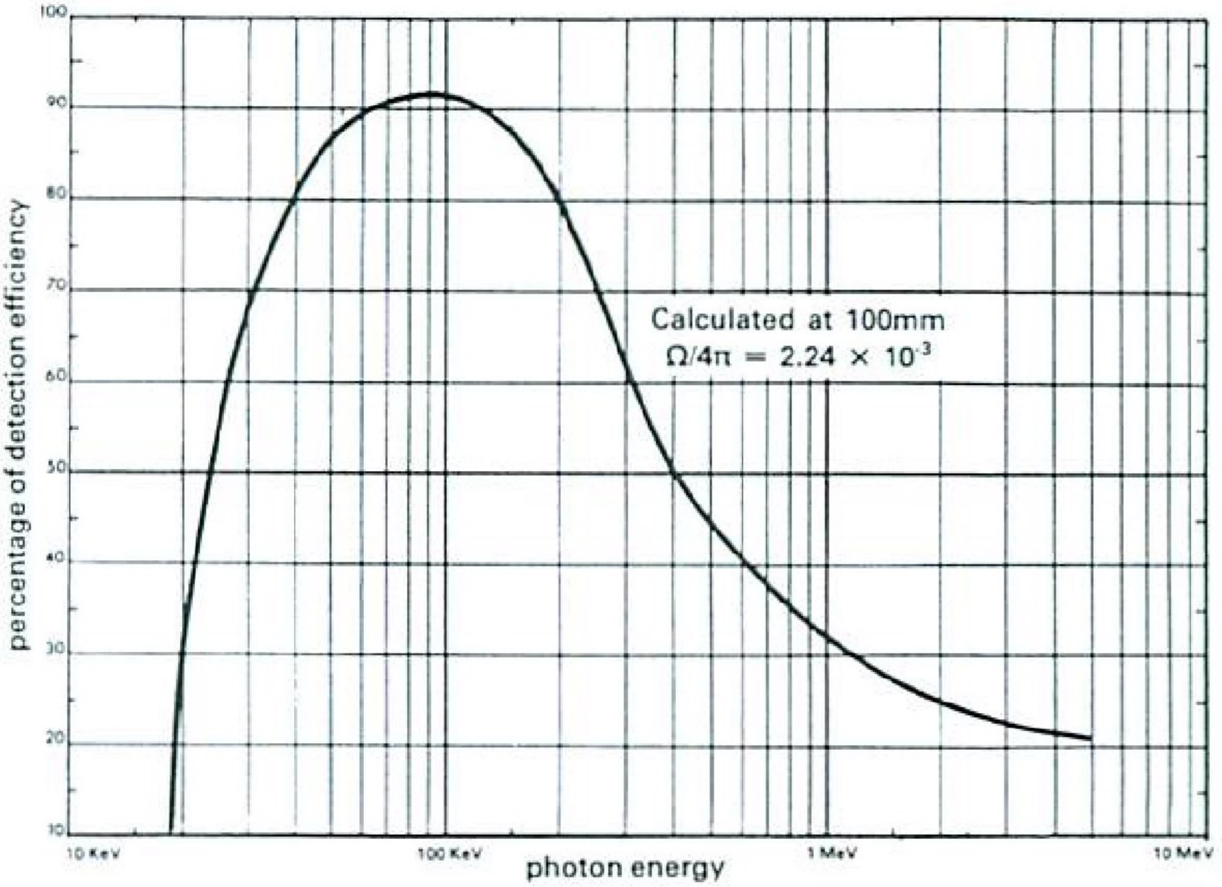


Fig. 1 Photon detection efficiency of type 41 probe

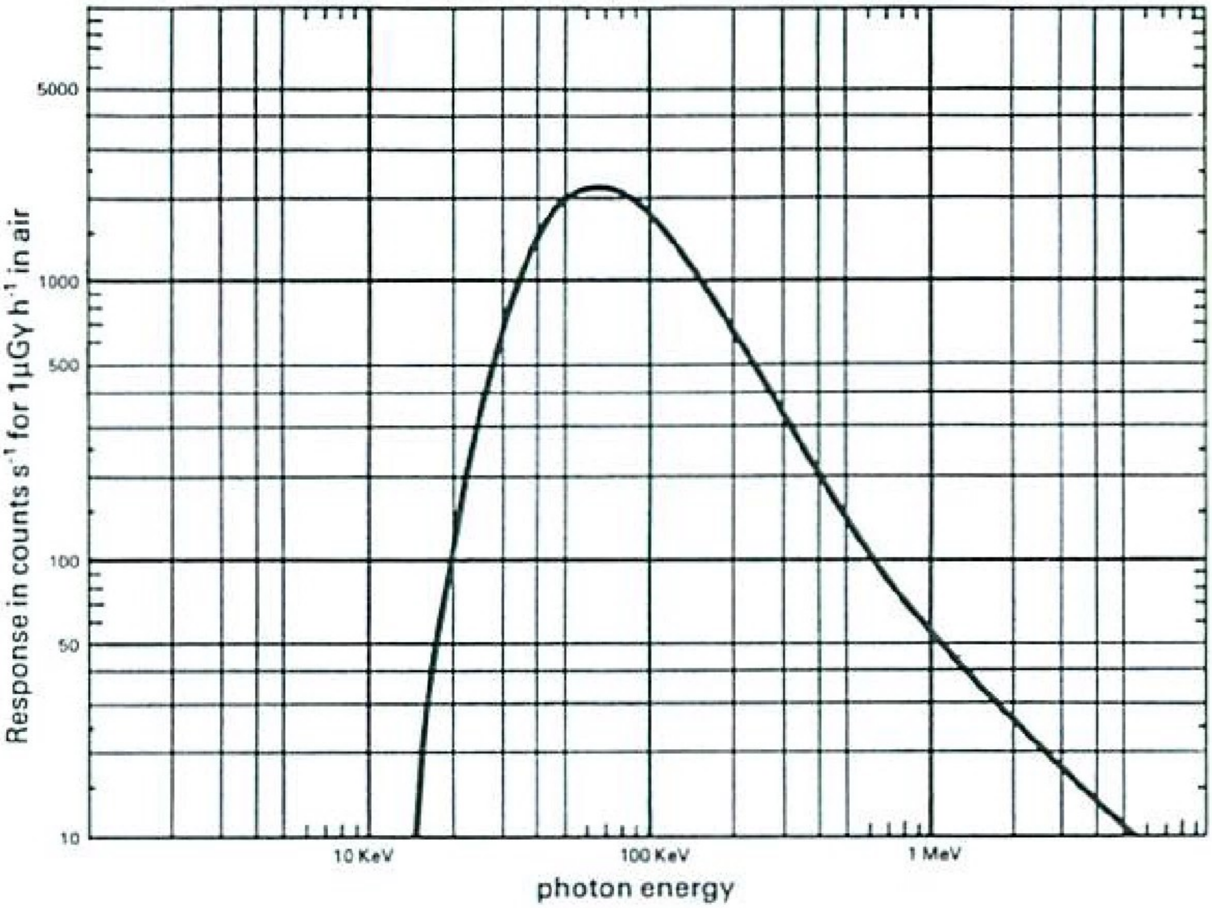


Fig. 2 Gamma dose response of type 41 probe

Table 1 shows the calculated response to 1 μCi (37k Bq) of each of a selection of radio-nuclides. The nuclides in brackets are $\beta - \gamma$ emitters so contamination is better found using a thin window G-M tube (Mini-instruments model E). The figures at one metre, however, serve as a guide for waste disposal purposes. A correction for air absorption is included.

Table 1

Nuclide (1 μCi)	counts s^{-1} at 20 mm	counts s^{-1} at 1 m
(^{22}Na)	1270	1.07
^{51}Cr	73	0.058
^{55}Fe	0	0
^{57}Co	1360	0.74
^{58}Co	571	0.48
(^{60}Co)	666	0.58
^{67}Ga	1080	0.63
^{75}Se	1790	1.15
^{99m}Tc	1200	0.69
^{109}Cd	855	0.39
^{111}In	2610	1.63
^{113}In	588	0.41
^{123}Te	1590	0.89
^{123}I	1990	0.92
^{125}I	1610	0.75
^{133}Ba	2800	1.53
(^{131}I)	723	0.55
(^{137}Cs)	487	0.37
(^{170}Tm)	124	0.059
(^{192}Ir)	1520	1.19
^{195}Au	1610	0.77
(^{226}Ra)	849	0.68
^{241}Am	654	0.30

Note 20 mm is approximately the distance from the end of the probe to the crystal.

Owing to scattering from the collimator the sensitivities are generally higher than the values quoted.

Refer to B.L. Diffey, Radiation Protection Dosimetry Vol 4 No 2 1983 p115-117 for details on the method of calculation.

Sensitivity to other radiations

The probe is not sensitive to alpha radiation.
The probe is opaque to β radiation with energies below 1 MeV.
There are no figures for neutron response.

Probe adjustment

To set up a probe without a source locate the HV and overload controls and turn to a minimum (anti-clockwise). Connect the probe and switch on. Slowly raise the HV potential. Initially the count rate is low, between 1 and 10 counts s^{-1}, but it rises sharply due to photo-multiplier noise emission. Set the control to just below where noise starts. The probe may now be used but it is advisable to check against a suitable source. An ^{129}I source emitting 28 keV X rays is brought near to the crystal until the counting rate is about 500 counts s^{-1}. The control is turned back until the counting rate has fallen sharply away. The two positions of the control should be quite distinct and by setting the control half way the probe is now sensitive over its useful range with a minimum of background noise. Now turn to the maintenance section to set the overload control.

3.2 Scintillation probe type 42A and 42B

This probe is designed for detection of low intensity X rays where a short lead collimator becomes an advantage. The low background count of 1.5 to 3 counts s^{-1} is derived from using a crystal of 1 mm thickness. The crystal diameter is 23 mm. A full specification can be seen in section 7.

There are two crystal window materials. The type A probe has an aluminium window 0.05 mm thick and the type B probe a beryllium window 0.25 mm thick. A 70% transmission is obtained for X ray energies of 10 keV and 4 keV respectively. At the high energy end both probes fall to 50% efficiency at 100 keV.

Figure 3 shows the calculated photon detection efficiency and figure 4 shows the response in counts s^{-1} to an absorbed dose rate in air of 1 μGy h^{-1} over the sensitive photon energy range. The response to 1 μGy h^{-1} of ^{137}Cs radiation is approximately 10 counts s^{-1}.

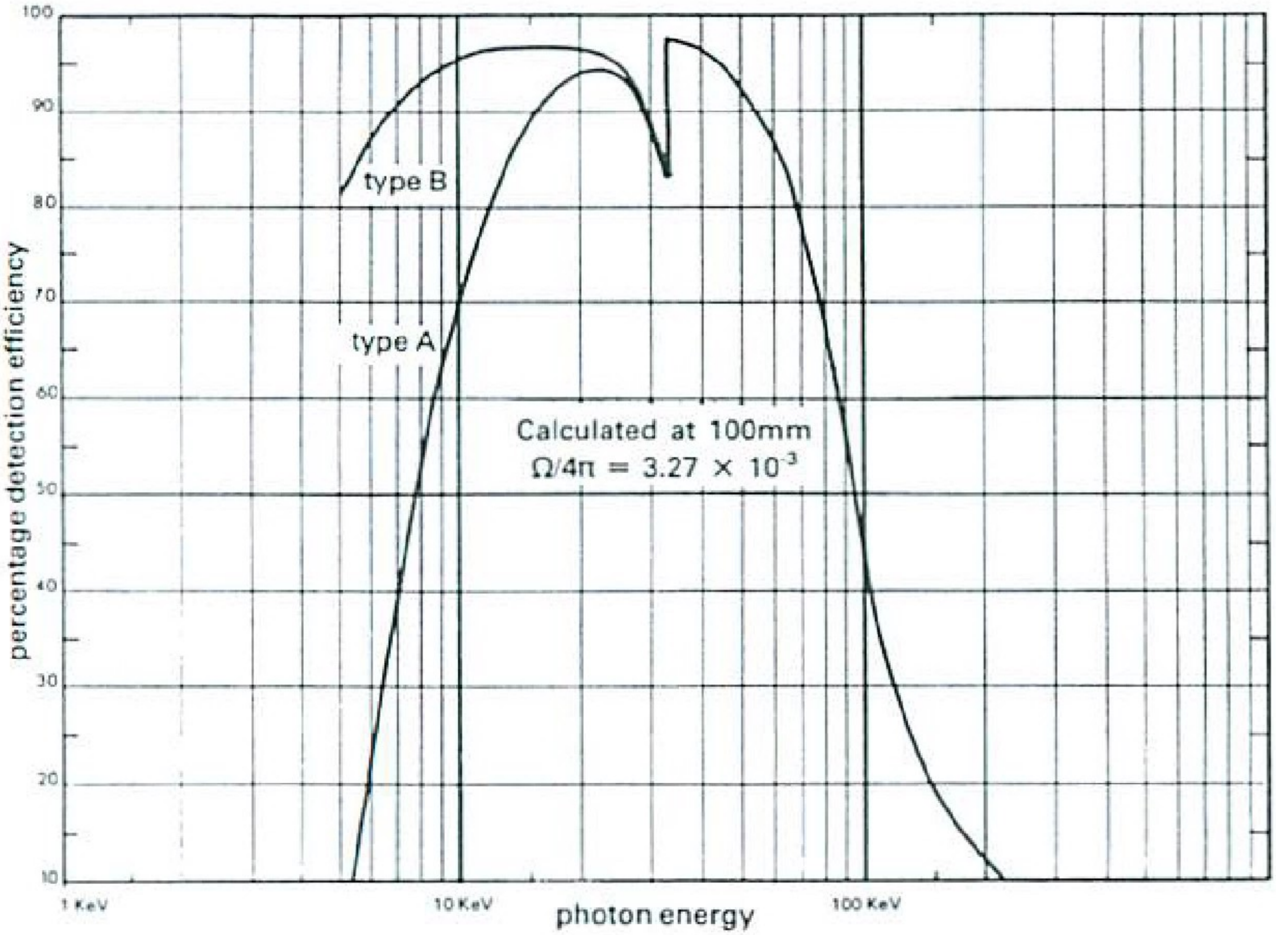


Fig. 3 Photon detection efficiency for type 42 probe

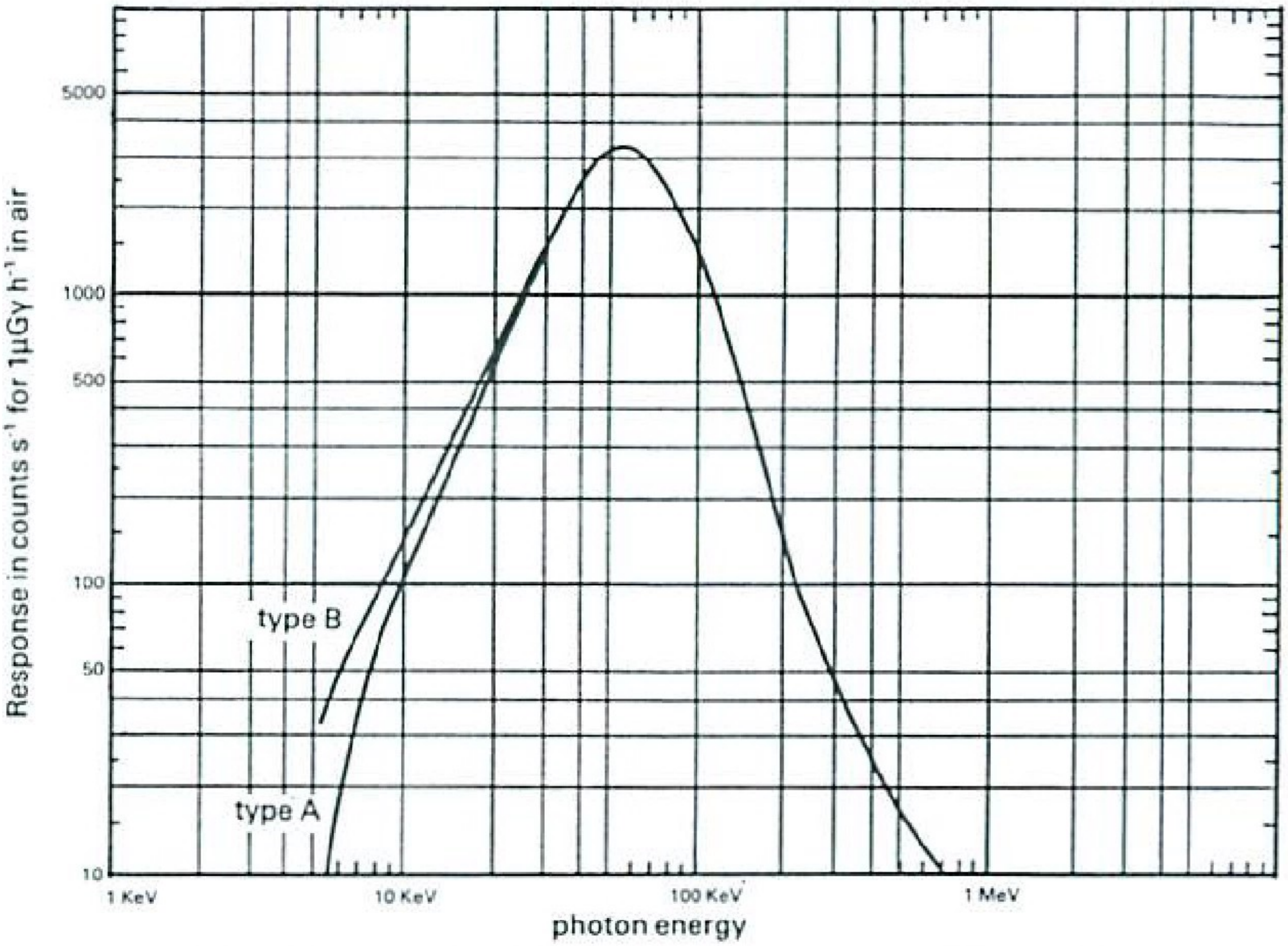


Fig. 4 Gamma dose response of type 42 probe

Spot contamination measurements

Table 2 shows the calculated sensitivity to 1 μCi (37k Bq) of each of a number of common radio-nuclides. The figures at one metre can be used to estimate waste disposal activity. Attenuation of the intervening air is included in the calculation but not, of course, the waste material.

Table 2

Nuclide (1 μCi)	counts s^{-1} at 20 mm type A	type B	counts s^{-1} at 1 m type A	type B
(^{22}Na)	195	194	0.091	0.091
^{51}Cr	45	409	0.007	0.013
^{55}Fe	103	530	0.007	0.031
^{57}Co	1220	2020	0.45	0.53
(^{58}Co)	231	549	0.055	0.089
(^{60}Co)	94	93	0.044	0.044
^{67}Ga	1340	1810	0.49	0.50
^{75}Se	1610	1910	0.64	0.73
^{99m}Tc	669	675	0.31	0.31
^{109}Cd	2390	2450	1.13	1.15
^{111}In	2480	2520	1.17	1.18
^{113m}In	587	597	0.28	0.28
^{123m}Te	1480	1490	0.70	0.71
^{123}I	2320	2340	1.10	1.11
^{125}I	3320	3350	1.57	1.60
(^{131}I)	254	254	0.12	0.12
^{133}Ba	3470	3490	1.7	1.7
(^{137}Cs)	232	233	0.11	0.11
(^{170}Tm)	159	158	0.077	0.076
(^{192}Ir)	334	333	0.157	0.157
^{195}Au	1910	1910	0.92	0.92
(^{226}Ra)	148	148	0.069	0.069
^{241}Am	1620	1690	0.74	0.77

Note The calculated figures include soft X ray emissions from sources. The higher values of sensitivity quoted for the beryllium window probe can only be achieved with negligible absorption above the source and a well adjusted probe.

The bracketed nuclides emit charged particles. The figures include contributions from X, γ and annihilation radiations only.

Thyroid monitoring

The type 42 probe can be used to monitor ^{125}I uptake in the thyroid. Phantoms have been used to determine the sensitivity and it is estimated that a burden of 0.1 µCi (3.7 kβq) gives a figure of 25-35 counts s^{-1} with the probe held on the neck over one lobe.

Sensitivity to other radiations

The aluminium window of the type A probe is 50% transparent to β emitters with a maximum energy of 500 keV. The corresponding figure for the beryllium window probe is 1 MeV.

There are no figures for neutron sensitivity.

Probe adjustment

To set up a probe without a source locate the HV and overload controls and turn to a minimum (anti-clockwise). Connect the probe and switch on. Slowly raise the HV potential. Initially the count rate is low, between 1 and 3 counts s^{-1}, but it rises sharply due to photo-multiplier noise emission. Set the control to just below where noise starts.

While the probe may now be used, it is important to confirm its sensitivity to soft X rays. The type B probe should be tested using 5 keV radiation from ^{55}Fe. With a count rate of approximately 500 adjust the HV to locate a short plateau and set half way along.

The type A probe may sometimes be set using ^{55}Fe but it is easier to use an ^{129}I source with a 28 keV X ray. Set the HV ⅔ up the plateau from the knee. Check for some sensitivity to ^{55}Fe.

Check in either case that the noise background is acceptable and then turn to the maintenance section to set the overload control.

3.3 Scintillation probe type 44A and 44B

The scintillation probe type 44 is designed for contamination monitoring of electron capture and isomeric transition nuclides. The scintillation crystal is mounted close to the front of the probe to obtain a high collection efficiency. Unwanted radiation on the back of the crystal is reduced by a short lead shield. A full specification can be seen in section 7.

There are two crystal window materials. The type A probe has an aluminium window 0.05 mm thick and the type B probe a beryllium window 0.25 mm thick. A 70% transmission is obtained for X ray energies of 10 keV and 4 keV respectively. Good transmission at low energies is essential since the K X rays for electron capture nuclides are often most abundant.

Figure 5 shows the calculated photon detection efficiency and figure 6 shows the response in counts s^{-1} to an absorbed dose rate in air of 1µGy h^{-1} over the sensitive photon energy range. The response to 1 µGy h^{-1} of Cs^{137} radiation is 65 counts s^{-1}.

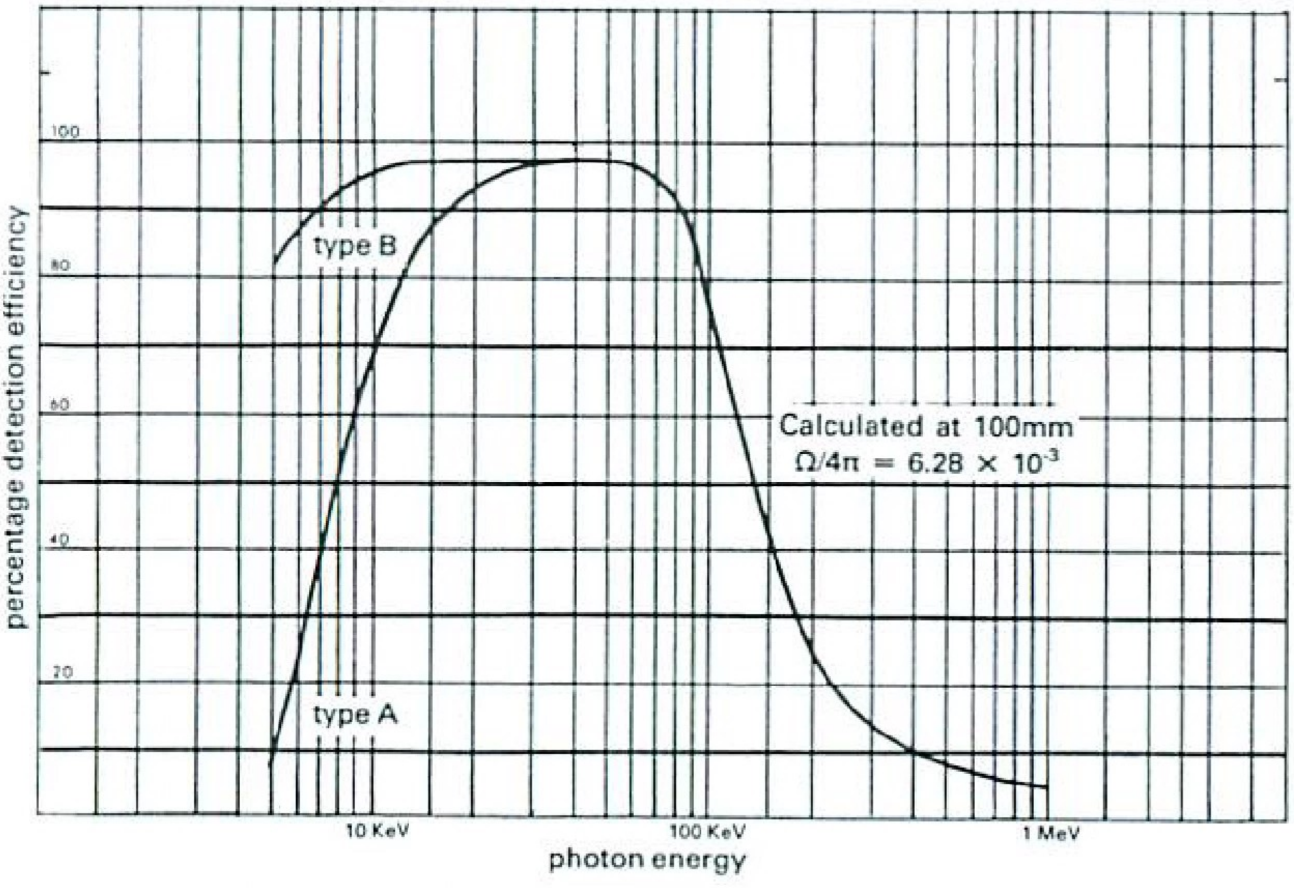


Fig. 5 Photon detection efficiency of type 44 probe

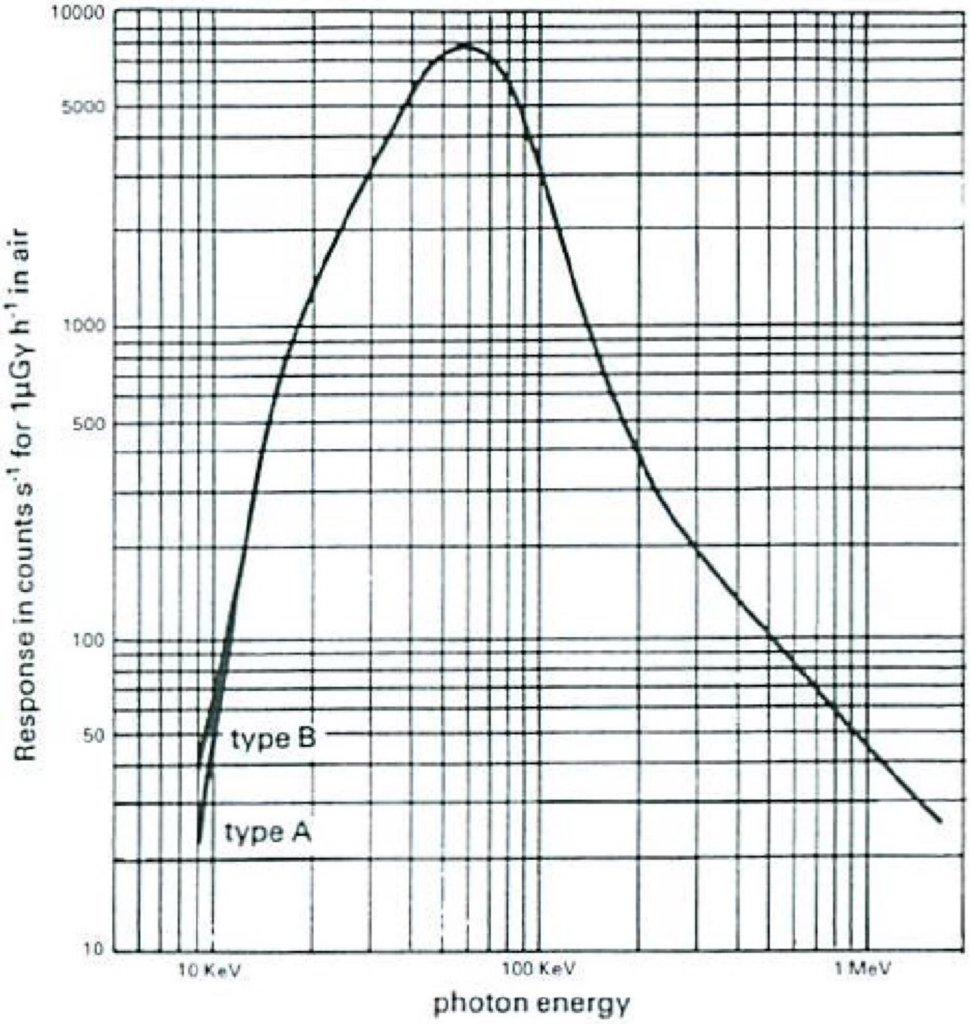


Fig. 6 Gamma dose response of type 44 probe

Spot contamination measurements

Table 3 lists the sensitivity of each probe to a number of common electron capture nuclides. Contamination is rarely evenly distributed and the figures given at 10 mm enables an estimation for spots of activity. The figures at one metre can be used to estimate waste disposal activity. Attenuation of the intervening air is included in the calculation but not, of course, the waste material.

Table 3

Nuclide (1 μCi) (37k Bq)	counts s^{-1} at 10 mm type A	type B	counts s^{-1} at 1 m type A	type B
$(^{22}\mathrm{Na})$	1920	1910	0.43	0.43
$^{51}\mathrm{Cr}$	197	1510	0.030	0.043
$^{55}\mathrm{Fe}$	256	1860	0.013	0.061
$^{57}\mathrm{Co}$	6760	9840	1.61	1.66
$(^{58}\mathrm{Co})$	1240	2630	0.22	0.28
$(^{60}\mathrm{Co})$	935	929	0.21	0.21
$^{67}\mathrm{Ga}$	6250	8170	1.37	1.58
$^{75}\mathrm{Se}$	8310	9590	1.87	2.05
$^{99m}\mathrm{Tc}$	4560	4560	1.10	1.10
$^{109}\mathrm{Cd}$	8540	8790	2.22	2.27
$^{111}\mathrm{In}$	11500	11700	2.87	2.90
$^{113m}\mathrm{In}$	2490	2530	0.63	0.64
$^{123m}\mathrm{Te}$	7190	7230	1.81	1.81
$^{123}\mathrm{I}$	10300	10400	2.62	2.64
$^{125}\mathrm{I}$	12200	12300	3.21	3.25
$(^{131}\mathrm{I})$	1650	1640	0.39	0.39
$^{133}\mathrm{Ba})$	12700	14600	3.8	3.8
$(^{137}\mathrm{Cs})$	1240	1240	0.31	0.31
$(^{170}\mathrm{Tm})$	658	655	0.17	0.17
$(^{192}\mathrm{Ir})$	2820	2810	0.65	0.65
$^{195}\mathrm{Au}$	8360	8310	2.22	2.21
$(^{226}\mathrm{Ra})$	1430	1420	0.32	0.32
$^{241}\mathrm{Am}$	5880	6210	1.51	1.57

Note The calculated figures include soft X ray emissions from sources. The higher values of sensitivity quoted for the beryllium window probe can only be achieved with negligible absorption above the source and a well adjusted probe. The bracketed nuclides emit charged particles. The figures include contributions from X, γ, and annihilation radiations only.

Uniform contamination measurements

Table 4 is a list of common electron capture radio-nuclides. The figures in counts s^{-1} is the response to a probe 10 mm above a uniformly contaminated surface of 100 cm^2 area. It can be seen that the beryllium window probe is only an advantage for the first two or three radio-nuclides where soft X rays are the only component.

Table 4

Nuclide ($10^{-4}\mu Ci\ cm^{-2}$)	counts s^{-1} at 10 mm type A	counts s^{-1} at 10 mm type B
^{51}Cr	0.23	1.8
^{55}Fe	0.25*	2.1
^{57}Co	8.1	12
^{67}Ga	7.2	9.7
^{75}Se	10	12
^{99m}Tc	5.8	5.8
^{109}Cd	9.8	10
^{111}In	14	14
^{113m}In	3.0	3.0
^{123}I	12	12
^{125}I	13*	14*
^{123m}Te	8.7	8.8
^{133}Ba	17	17
^{195}Au	9.8	9.8

*NRPB calibration on a sample probe

Sensitivity to other radiations

The aluminium window of the type A probe is 50% transparent to β emitters with a maximum energy of 500 keV. The corresponding figure for the beryllium window probe is 1 MeV.

As an example 1 DL of contamination from $^{90}Sr/^{90}Y$ gives about 6 counts s^{-1} in either probe. It is not recommended to use these probes for β contamination or β surface dose measurements owing to their high bremsstrahlung and γ efficiency.

There are no figures for neutron response.

Probe adjustment

To set up a probe without a source locate the HV and overload controls and turn to a minimum (anti-clockwise). Connect the probe and switch on. Slowly raise the HV potential. Initially the count rate is low, between 1 and 10 counts s^{-1}, but it rises sharply due to photo-multiplier noise emission. Set the control to just below where noise starts.

While the probe may now be used, it is important to confirm its sensitivity to soft X rays. The type B probe should be tested using 5 keV radiation from ^{55}Fe. With a count rate of approximately 500 adjust the HV to locate a short plateau and set half way along.

The type A probe may sometimes be set using ^{55}Fe but it is easier to use an ^{129}I source with a 28 keV X ray. Set the HV ⅔ up the plateau from the knee. Check for some sensitivity to ^{55}Fe.

Check in either case that the noise background is acceptable and then to the maintenance section to set the overload control.

3.4 OPERATING OTHER PROBES

The Mini-Instruments well probe type 43 can be used with this monitor. By switching off the pulse noise and adjusting the alarm level it becomes a rapid device for accepting or rejecting samples.

Other manufacturers' probes having a single input for signal and HV can be connected provided the dynode chain resistance is not less than 20 Megohms. The Hilger Analytical large area probe type P5525 contains a pre-amplifier and connects directly.

Nuclear Enterprise probes do not contain a pre-amplifier and a circuit modification to provide a more sensitive input is easily effected. Referring to the circuit diagram, remove R_{28} and replace with 180k. (See also component list)

With this modification all the N.E. probes listed will operate the monitor.

4. PRECAUTIONS

The company believes it has taken all reasonable precautions to ensure that the correct use of these monitors does not endanger the health and safety of any person but it is essential that persons using these monitors should be trained to interpret the results sensibly and be aware of their limitations.

4.1 Monitoring precautions

(a) Make sure that the battery is in good order. Do not perform the battery check too hastily or it will not give a true indication of battery charge.

(b) Make sure that the monitor is working by noting if it is responding to background. It is sensible to check the monitor with a radioactive source to see if it is giving the expected reading and audible signal. The test source need not be traceable but a consistant source to tube geometry should be maintained.

(c) The probe determines the performance of the monitor. Make sure the correct probe is chosen for the radiation you wish to monitor.

(d) Some X ray machines and particle accelerators produce radiation in short pulses. If the intensity of the radiation in these pulses is sufficient to cause a response at a rate exceeding an order of magnitude less than the pulse repetition frequency then non-linearity of response will occur. In the limit the monitor indicates pulse repetition frequency and not the radiation intensity.

(e) The meter reading of scintillation monitors is prone to fall back at very high radiation levels. This monitor contains an overscale circuit to maintain full meter reading but its operation depends upon correct adjustment of an internal control.

The user should check that full scale is maintained at the highest possible radiation intensity that may be encountered. See also Section 5.5 Overscale adjustment.

(f) All probes are fragile. If you drop it, it may not work again.

(g) The monitor is not tropicalised or ruggedised and will not work if dropped into a pond or run over by a tank!

4.2 Precautions special to beryllium windows (type B probes)

Beryllium compounds are very toxic. The windows on the type B probes are made of beryllium metal and in this form beryllium does not constitute a significant health hazard. It is prudent, however, to take simple precautions. Avoid handling the metal without cause but if handled wash the hands immediately after contact. Never handle with a cut or abrasion without first covering the affected part.

Do NOT attempt to clean the window with abrasives, acids or alkalis since this creates dust and toxic compounds. If the window needs decontaminating use a weak non-caustic detergent with cotton wool swab sticks and wear gloves. Dispose the waste material in toxic waste containers. Unwanted crystals should be treated as toxic waste.

In the event of a fire beryllium oxidises readily producing toxic fumes. Seek informed medical advice if in doubt.

5. MAINTENANCE

The instructions that follow are written to help owners make certain repairs themselves. An expertise beyond that necessary to operate the monitor may be required and the company cannot be responsible for damage incurred to monitors or persons while carrying out these instructions. If there is doubt the monitor should be returned to the manufacturer.

The components are mounted on a printed circuit board attached to the meter and switch. Access to preset controls can be gained by removing the front panel of the box.

5.1 Scintillation probe replacement

The probe contains components which can be damaged by a sharp knock. The glass photo-multiplier may suffer electrode structure damage which will affect the operating characteristics or cause complete failure.

If the window of the type 42 or 44 probe is punctured the crystal will deteriorate rapidly and have to be replaced.

The probe can be dismantled but care must be taken not to apply pressure to the window when attempting to slide out the unit.

WARNING Before attempting to dismantle a type B probe read section 4.2 on the precautions to be taken with beryllium.

5.2 HV supply

The PM tube HV supply can be varied from 600 to 1500 volts. The control for adjusting the HV is R18 anti-clockwise rotation increases the potential. The voltage is best measured using a high resistance meter, at least 20kohm/V, connected between the junction of R22/C11 and OV.

5.3 Meter zero adjustment

The mechanical zero is set on the meter barrel and any adjustment must be made with the monitor switched off. The pointer must rest at approximately 1mm below the scale zero. With the monitor switched on the electrical zero control R34 is now adjusted to bring the pointer back to the scale zero. Owing to background radiation it must be adjusted with the probe disconnected. Allow several minutes for the meter to settle before making the adjustment.

5.4 Meter calibration

The calibration potentiometer R31 is situated at the bottom centre of the printed circuit board. To recalibrate inject square pulses of a few volts via a 100pF(2kV) capacitor into the probe input pin (junction of R22/C14). The pulse repetition rate will need to be corrected to allow for paralysis time correction built into the scale. The table below relates the scale with the pulse repetition frequency (PRF).

$$\text{Input pulse rate} = \frac{\text{Scale reading}}{1 + \text{Scale reading} \times \text{paralysis time}}$$

This correction is shown in the table below:–

Scale reading	Input pulse rate
5000	4000
1000	952
500	488
100	99.5
10	10

When injecting a signal at the top end of the scale the speaker note can change abruptly. This is normal and it does not indicate a change of counting rate in the ratemeter circuit as displayed on the scale.

5.5 Overload setting

An overload circuit ensures that the meter pointer remains over maximum deflection for radiation intensities exceeding many times the maximum scale reading. The adjustment depends on the HV setting and PM tube and must be done whenever either is changed. The control for setting the overload alarm point is the potentiometer R20.

To adjust the alarm set the function switch to the 'speaker off' position and turn the control fully clockwise. Using a strong source to send the meter well over the maximum scale mark, adjust the control to sound the alarm. Check that the alarm stops sounding when the source is moved to a position where the reading is equal to the maximum scale mark on the meter. If necessary re-adjust the control until this condition is met.

The adjustment can also be done without a source using a digital voltmeter connected across the potentiometer to the 5.8 volt line. Set the reading to 0.25 – 0.3 volts lower than the point where the alarm sounds. The adjustments must be done with the probe connected and set to the correct HV.

Because of complications introduced by the overscale setting, it is not recommended to use one instrument with a variety of probes. In case of difficulty, technical advice from the company should be obtained.

6. SERVICE AND GUARANTEE

With normal care and attention this monitor should give many years of service without attention.

If any fault occurs to the monitor within two years of purchase (one year for the PM tube) that is due, in our opinion, to a manufacturing error then it will be repaired or replaced without charge.

If a fault occurs outside the guarantee period the company or its agents will service the equipment. A note explaining what you believe to be wrong is often helpful. If the customer wishes to repair the fault himself the company will give technical help. However the company does not wish to abrogate its prime responsibility to its customer to third parties and service organisations. If these organisations are employed they should be instructed to return the equipment, untampered, to us for service or repair*.

The company will not be responsible for damage or loss occurring in transit to the company whether or not properly packed but emphasis cannot be made strongly enough on the need to ensure adequate packing before returning for servicing.

The address is:

Service Department,
Mini-Instruments Ltd,
15 Burnham Business Park,
Springfield Road,
Burnham on Crouch,
Essex, CM0 8TE

tel: 01621 783282, fax: 01621 783132

*OVERSEAS CUSTOMERS SHOULD RETURN INSTRUMENTS BY AIR PARCEL POST, NOT AIR FREIGHT.

7. SPECIFICATION

7.1 Monitor specification

Box size	180w × 110d × 165h mm overall
Weight	0.95 kg
Material	Coated aluminium
Batteries	Standard AA cells IEC R6
(6 cells)	Alkaline AA cells IEC LR6
	Rechargeable cells IEC KR15/51
Life at 4 h/day	Standard cells – 60 h
	Alkaline cells – 150 h
HV supply	600 – 1500 V at 50 μA max.
Sensitivity	Voltage input – 100 mV neg.
	Charge input – 10 pC
Input impedence	3000 ohms approx
Input time constant	2.5 μs
Response time	1 to 10 c/s – $<$ 3.5 s
	10 to 100 – $<$ 2 s
	100 to 1000 – $<$ 1 s
Paralysis time	50 μs
Linearity	±10% to 2000 counts s^{-1}
Overload circuit	Yes
Temperature range	−10 to +50 °C
Humidity	not to exceed 85% non-condensing

7.2 Scintillation probe type 41

Mechanical

Overall length	220 mm
Overall diameter	41 mm
Weight	0.7 kg
Probe material	Aluminium – black anodised
Sodium iodide crystal size	19 mm dia 25 mm long
Window area	2.8 cm^2
Window weight	300 mg cm^{-2} of aluminium approx
Depth of crystal below window	16 mm approx
Background shield thickness	5.65 mm lead

Electrical

Photomultiplier type	EMI 9924 B
Dynode chain resistance	56 Megohm
Cable socket	Single PET type 100
Output impedance	1500 ohms approx
Maximum pulse height	1 volt negative
Pulse width	5 µs in 3000 ohms load
Maximum cable length	15 m approx
Operating voltage	600 – 900 volts

7.3 Scintillation probe type 42A

Mechanical

Overall length	195 mm
Overall diameter	41 mm
Weight	0.48 kg
Probe material	Aluminium – black anodised
Sodium iodide crystal size	23 mm dia 1.0 mm thick
Window area	4.1 cm^2
Window weight	14 mg cm^{-2} of aluminium
Crystal depth below front face	16 mm approx
Background shield thickness	3.1 mm lead

Electrical

Photomultiplier type	EMI 9924B
Dynode chain resistance	56 Megohm
Cable socket	Single PET 100
Output impedence	1500 ohms approx
Maximum pulse height	1 volt negative
Pulse width	5 µs in 3000 ohms load
Maximum cable length	15 m approx
Operating voltage	600 - 1000 volts

7.4 Scintillation probe type 42B

Mechanical

Overall length	195 mm
Overall diameter	41 mm
Weight	0.48 kg
Probe material	Aluminium – silver anodised
Sodium iodide crystal size	23 mm dia 1.0 mm thick
Window area	4.1 cm^2
Window weight	46 mg cm^{-2} of beryllium
Crystal depth below front face	16 mm approx
Background shield thickness	3.1 mm

Electrical

Photomultiplier type	EMI 9924B
Dynode chain resistance	56 Megohm
Cable socket	Single PET type 100
Output impedence	1500 ohms approx
Maximum pulse weight	1 volt negative
Pulse width	5 μs in 3000 ohms load
Maximum cable length	15 m approx
Operating voltage	600 – 1000 volts

7.5 Scintillation probe type 44A

Mechanical

Overall length	188 mm
Overall diameter	50 mm
Weight	0.64 kg
Probe material	Aluminium – black anodised
Sodium iodide crystal size	32 mm dia 2.5 mm thick
Window area	8 cm^2
Window weight	14 mg cm^{-2} of aluminium
Crystal depth below front face	3 mm
Background shield thickness	3.1 mm lead

Electrical

Photomultiplier type	EMI 9902KB07
Dynode chain resistance	56 Megohm
Cable socket	Single PET type 100
Output impedence	1500 ohms approx
Maximum pulse height	1 volt negative
Pulse width	5 µs in 3000 ohms load
Maximum cable length	15 m approx
Operating voltage	700 – 1200 volts

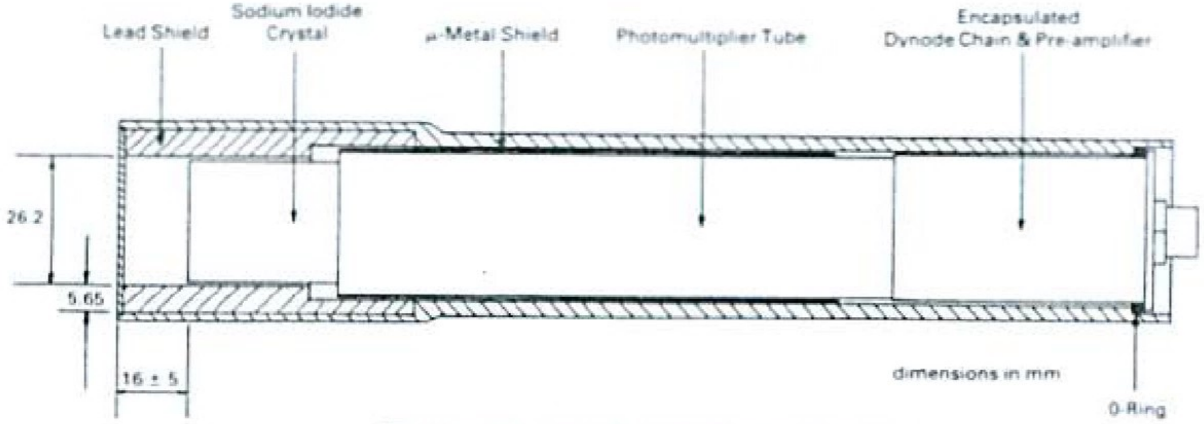
7.6 Scintillation probe type 44B

Mechanical

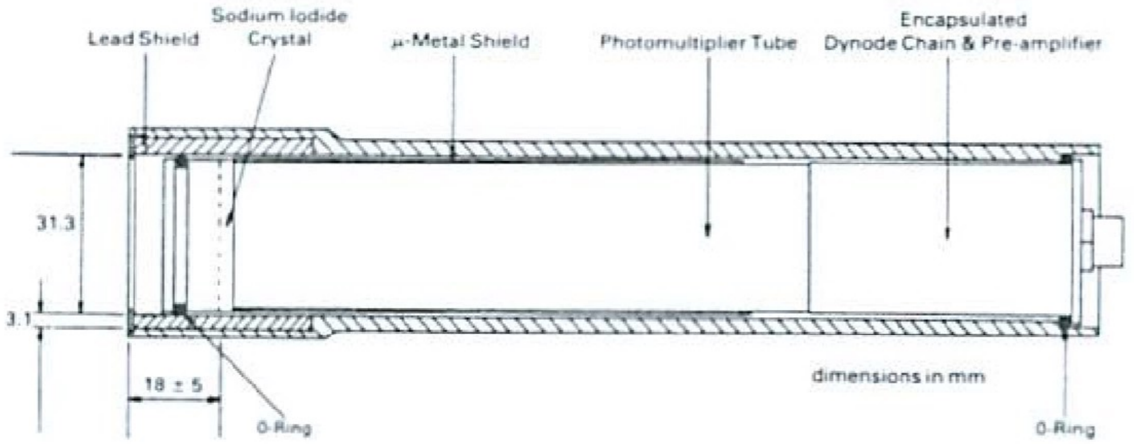
Overall length	188 mm
Overall diameter	50 mm
Weight	0.64 kg
Probe material	Aluminium – silver anodised
Sodium iodide crystal size	32 mm dia 2.5 mm thick
Window area	8 cm^2
Window weight	46 mg cm^{-2} of beryllium
Crystal depth below front face	3 mm
Background shield thickness	3.1 mm

Electrical

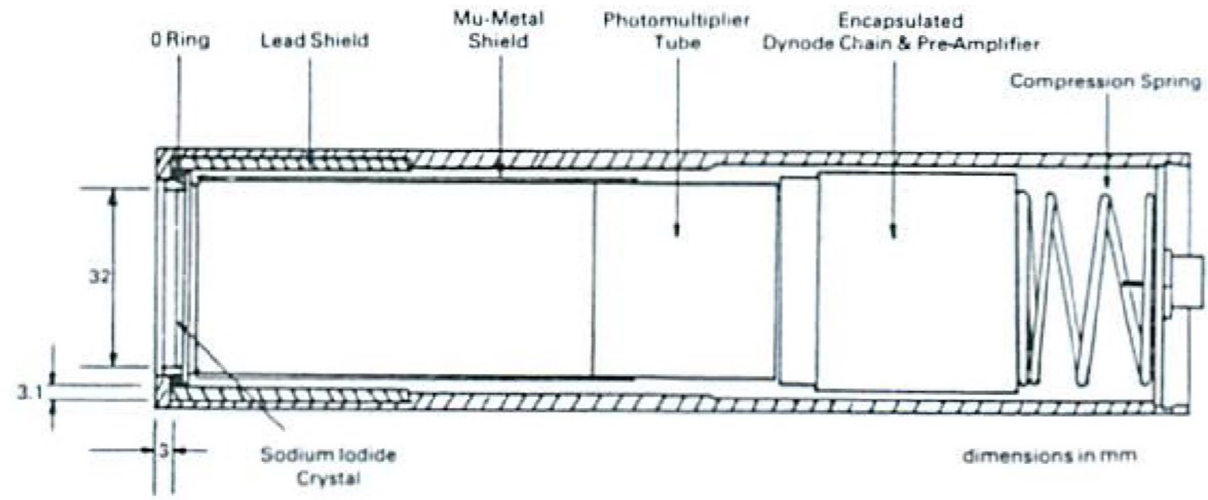
Photomultiplier type	EMI 9902KA
Dynode chain resistance	56 Megohm
Cable socket	Single PET type 100
Output impedence	1500 ohms approx
Maximum pulse height	1 volt negative
Pulse width	5 µs in 3000 ohms load
Maximum cable length	15 m approx
Operating voltage	700 – 1200 volts



Type 41 probe construction



Type 42 probe construction



Type 44 probe construction

8. CIRCUIT DESCRIPTION

The circuit diagram is given at the end of the manual. The circuit operation is as follows:

(a) **Battery input stabilising circuit** The line voltage of the monitor is 5.8 ± 0.2 volts and is set by the reference diode D4. IC2 is the comparator coupled to the series control TR1.

(b) **HV Converter** Transistor TR4 coupled to the transformer T1 forms the flyback converter circuit. IC3 forms a gated oscillator to provide the drive for TR3 and TR4. The output voltage is stabilised by negative feedback via a resistive divider to a gate in IC3 which controls the oscillator frequency. Adjustment to the divider and hence the HV level is provided by R18. The waveform across the secondary winding of T1 is half wave rectified to provide the detector voltage. Voltage doubling is used for the scintillation monitors and other detectors operating above 600V.

(c) **Input amplifier** TR5 and TR6 form an amplifier with a gain determined by feedback. It reverses the phase of the input pulse and supplies a positive signal to a monostable circuit IC4b which determines the paralysis time. The input requires negative pulses exceeding 100mV into approximately 3000 ohms.

(d) **Ratemeter circuit** Two analogue outputs form IC5 are combined to give a signal nearly proportional to the log of the input pulse rate. This output is applied to an operational amplifier IC6a which drives the meter. The potentiometer R31 sets the meter scale and R34 the meter zero.

(e) **Audio output** The speaker derives its power from IC7 which produces a 300μs pulse when triggered by the monostable (IC4b). This connection is switched at the front panel to suppress the pulse output. A similar but unswitched connection from the comparator sets off the timer to give the alarm.

(f) **Comparator** The comparator IC6b compares the potential on the set alarm control with an output from the meter amplifier IC6a. If the latter is greater the comparator trips and sets off the timer. A little hysteresis is applied to smooth out the random nature of the input.

(g) **Overload circuit** Excess current drawn through the probe when in a radiation flux exceeding many times the scale limit causes the comparator formed by IC4d to trip thus maintaining the deflection of the meter. The potentiometer R20 sets the limit when this occurs.

9. COMPONENT LIST AND CIRCUIT DIAGRAM

Resistors

All Resistors MFR4 except where stated otherwise

R_1	330R	R_{25}	4K7
R_2	27R	R_{26}	39K
R_3	390R	R_{27}	22K
R_4	47K	R_{28}	68K
R_5	6K8	R_{29}	1MO
R_6	82K	R_{30}	1 MO
R_7	22K	R_{31}	2KO potentiometer
R_8	4M7	R_{32}	7K5
R_9	100K	R_{33}	180R
R_{10}	470R	R_{34}	100K potentiometer
R_{11}	330K	R_{35}	180R
R_{12}	68R	R_{36}	82K
R_{13}	180R	R_{37}	10K
R_{14}	10R	R_{38}	10K
R_{15}	400M thick film	R_{39}	24K
R_{16}	220K	R_{40}	10K
R_{17}	820K	R_{41}	330K
R_{18}	2MO potentiometer	R_{42}	22K potentiometer
R_{19}	100K	R_{43}	4M7
R_{20}	220K potentiometer	R_{44}	47K
R_{21}	1MO	R_{45}	47K
R_{22}	100K	R_{46}	10K
R_{23}	3K3	R_{47}	120K
R_{24}	10K		

Capacitors

C_1	100nF Ceramic	C_{14}	1n0F ceramic 2KV
C_2.	47nF Ceramic	C_{15}	4n7F ceramic
C_3	470μF electrolytic	C_{16}	1n0F polystyrene
C_4	100nF ceramic	C_{17}	2n2F 1% polystyrene
C_5	22pF ceramic	C_{18}	100nF 5% polyester
C_6	220pF polystyrene	C_{19}	4μ7F electrolytic
C_7	4n7F ceramic	C_{20}	1μF electrolytic
C_8	10nF 1kV ceramic	C_{21}	100nF ceramic
C_9	10nF 1kV ceramic	C_{22}	4n7F ceramic
C_{10}	10nF 1kV ceramic	C_{23}	100nF ceramic
C_{11}	6n8F ceramic 2KV	C_{24}	4n7F ceramic
C_{12}	100nF ceramic	C_{25}	100nF ceramic
C_{13}	100μF electrolytic	C_{26}	2n2F polystyrene

Diodes

D_1	IN4001
D_2	BZX83 C9V1
D_3	IMO5120
D_4	ICL8069
$D_{5,6,10\text{-}15}$	IN4148
$D_{7\text{-}9}$	BY584

Integrated Circuits

IC_1	LM317
IC_2	7611DCPA
IC_3	HEF4001
IC_4	HEF4013
IC_5	HEF 4066
IC_6	LM392N
IC_7	TLC555CP

Transistors

TR_1	BC328
$TR_{2,5,6}$	BC548B
TR_3	BC 558
TR_4	BC639

Meter

M_1	500μA taut band moving coil

The ratemeter may be configured with a probe not manufactured by Mini Instruments Ltd. If the probe has no pre-amplifier it may be necessary to modify the input circuit. If this is done R_{26} is increased in value to provide more sensitivity eg. a value of 180K is fitted if the monitor is used with an AP2 probe. The maximum recommended value for R_{26} is 330K.

Series 900 Mini-monitor

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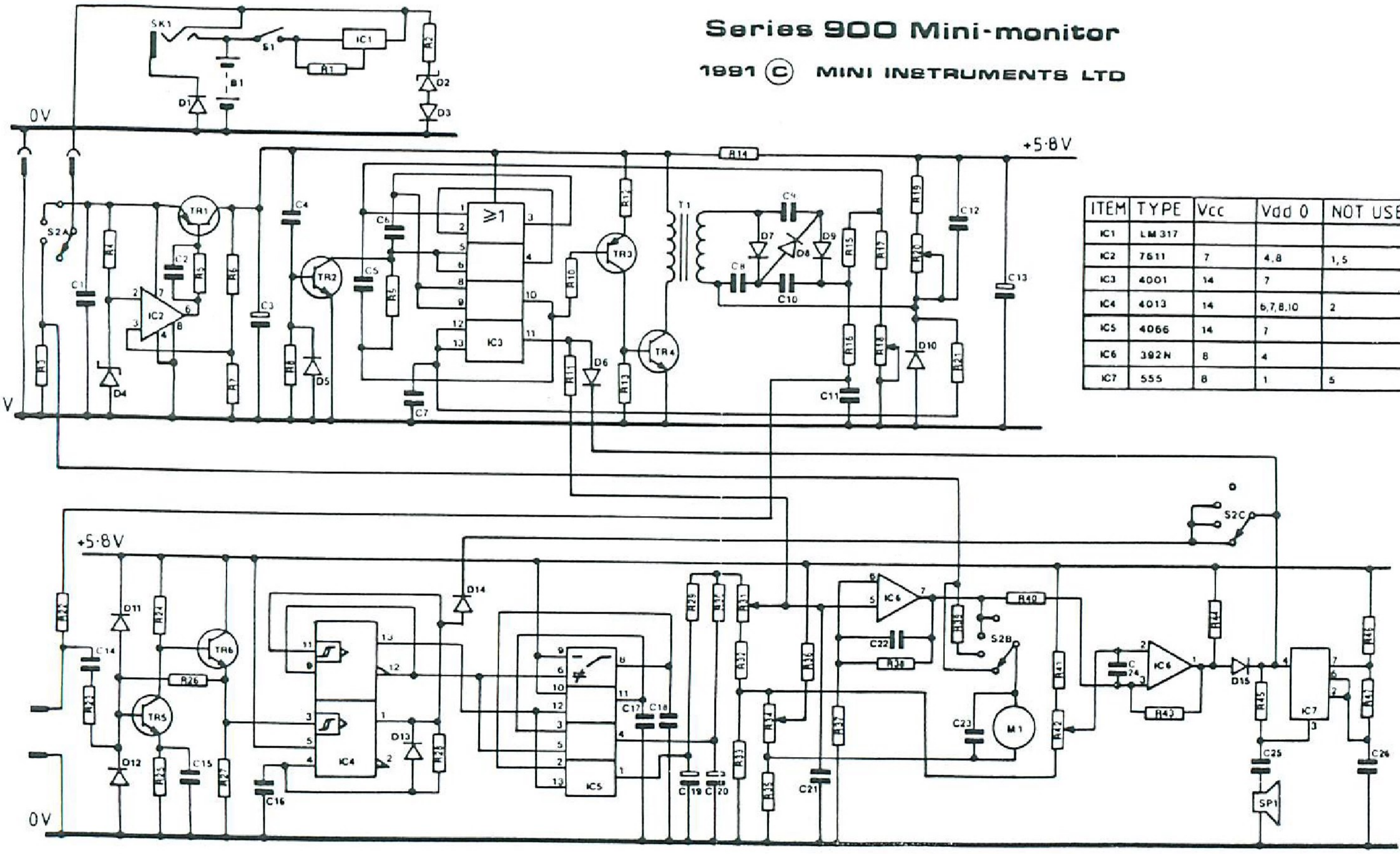
ITEM	TYPE	Vcc	Vdd 0	NOT USED
IC1	LM 317			
IC2	7611	7	4, 8	1, 5
IC3	4001	14	7	
IC4	4013	14	6, 7, 8, 10	2
IC5	4066	14	7	
IC6	392N	8	4	
IC7	555	8	1	5



MINI-INSTRUMENTS LIMITED

MINI-MONITOR

SERIES 900

MODELS E, EL, S, SL & X

Our instruments are subject to continous development and minor changes in detail may occur which are not incorporated in this manual.

Issue 2
January, 1986

1. GENERAL DESCRIPTION

1.1 Basic monitor

The monitor is designed for use in teaching, research, hospital and industrial laboratories. When fitted with a suitable probe it will measure contamination down to the accepted levels and indicate γ or X-ray background intensity.

The monitor is powered by easily available primary cells or may be mains operated from a small power unit similar to those used on calculators. In addition rechargeable cells can be used which are recharged by using a similar power unit.

The probe is connected to the monitor by either an extensible co-axial cable or a standard cable. It may be used remotely or attached to the case by a clip. A meter registers the counting rate on a semi-logarithmic scale thus making range changing unnecessary. An internal speaker, which may be switched off, gives an audible indication of intensity.

The monitor has a warning alarm adjustable to trip at any selected level on the scale. It can be made inoperative during normal use but will respond on overload.

1.2 Probe attachments

The monitor is available with different probes, each identified as a separate model. It is not recommended to exchange probes owing to the need to re-adjust the internal controls. This is good radiation safety practice as it avoids the monitor being maladjusted when most needed.

(a) **Model S** This is a general purpose monitor employing a glass G-M tube of active length 64 mm and a wall thickness of 30 mg cm^{-2} representing a half value layer for 700 keV β's. It is suitable for penetrating β emitters like ^{90}Sr, ^{32}P and also ^{36}Cl but it is not suitable for ^{3}H, ^{14}C, ^{35}S and ^{45}Ca. It is also suitable for β-γ emitters providing there is a penetrating β emission.

The G-M tube is protected from damage by a holder surrounding the tube except for an open grille at one side. By presenting the back of the holder to the source the β component of a β-γ emitter can be screened out. With the G-M tube withdrawn from the holder it may be used as a dip liquid counter. Remember to take great care of the thin glass.

(b) **Model SL** This differs from the previous model by using a longer G-M tube having an active length of 120 mm. It is approximately twice as sensitive when presented to sufficiently large contaminated areas.

(c) **Model E** This model uses a thin end window G-M tube of thickness 1.5 – 2.2 mg cm^{-2} and area 6.4 cm^2. It is suitable for estimating the lower contamination limits from ^{14}C, ^{35}S, ^{45}Ca and ^{131}I as well as the more penetrating β emitters but not ^{3}H. The G-M tube is contained in a black anodised holder fitted with a stainless steel grille to protect the fragile window. A plastic cap is supplied to cover the window when not in use. Care must be taken in replacing the cap to avoid imploding the window.

The tube is sensitive to α particles and can estimate contamination levels down to about 2×10^{-4} μCi cm^{-2} (7 Bq cm^{-2}). While it is not sufficiently sensitive to monitor down to the recommended levels for uniform α contamination it is ideal for finding hot spots.

(d) **Model EL** This model uses an organic quenched end window G-M tube having an area of 19.6 cm^2 and window thickness 1.5 – 2.5 mg cm^{-2}. It is recommended for soft β monitoring. The counting rate is limited to 600 counts s^{-1} and the life of the tube is limited to approximately 2×10^8 counts. The mica window is very fragile so the tube must be handled with care. The sensitivity to α contamination is sufficient to measure down to $10^{-4}$$\mu$Ci cm^{-2} (3.5 Bqcm^{-2}).

(e) **Model X** The G-M tube for this model is mounted in a small anodised aluminium holder. The end window diameter is 17 mm and the mica thickness is 2.5-3.0 mg cm^{-2}. The small size and convenient mounting of the tube makes it particularly useful for locating X-ray leakage points from crystallographic apparatus. The model may also be used as a contamination monitor having a sensitivity about ⅓ of the model E for the more penetrating β emitters although it is not recommended for this purpose.

The probe may be used further from the instrument than allowed by the extensible cable. Up to 15 metres of low capacity co-axial cable is acceptable.

2. OPERATING INSTRUCTIONS

2.1 Controls

There are two external controls:

(a) A four position rotary switch labelled with symbols OFF, BAT, ON, ON SPK OFF.

(b) A screwdriver control to set alarm level.

2.2 Battery

The state of the battery is indicated on the meter when the switch is turned to the position marked "bat". In this position the battery is subjected to a current drain in excess of that used in normal use. In order to ensure that the battery is satisfactory the pointer should be observed for a short while to see if it falls below the green sector. If so the battery should be changed or if rechargeable, put on charge.

The reading depends upon the type of cell used. New primary cells read near the top of the green scale but rechargeables read in the middle.

Battery replacement The battery is contained within the rear compartment. A half turn on the screw lets down the flap to reveal the six cells contained in a removable cage. Take out the cage and replace the cells in the correct sense. The label on the hinged flap suggests some suitable replacement types. Make sure the monitor is off before connecting the press studs as an accidental reversal may damage the circuit.

2.3 Mains operation

The monitor may be mains operated by using a separate power unit similar to the ones for pocket calculators. It must supply at least 9 volts at 15 mA. For reasons of electrical safety the unit MUST be marked "DOUBLE INSULATED" or carry the sign of a double square. A mains unit is available from the company which is also designed to operate as a battery charger.

The unit is plugged into the jack socket on the right hand side of the case. A green LED glows when in use. The internal battery is cut out but make sure the internal charge switch is off if the cells are not rechargeable.

Mains units for the following supplies are available:-

210 – 250 V, 50 Hz and 110 – 120 V, 60 Hz
Output 12 – 18 volts at 75 mA

There is no internal fuse in the monitor. Should a failure occur that overloads the mains unit a thermal device cuts it off. The thermal device is not resettable.

2.4 Battery charge

The mains unit can be used to replenish rechargeable cells. When the cells are exhausted plug in the mains unit and switch the charge switch within the battery compartment over to "charge". The charge rate is 45 mA and charging is complete in 16h. Do NOT charge primary cells. When the charge is complete switch off the charger.

2.5 Setting the alarm

The alarm level is variable from zero to beyond the limit of the scale. It is set by using a test source to give the desired level and adjusting the front panel control with a small screwdriver. The alarm resets when the radiation level falls below the trip level. If the control is turned fully clockwise the alarm is disabled for all levels on the scale. The alarm is not disabled for overload conditions providing this adjustment is correctly made: see section 5.5. In addition the alarm is not switched out by the "speaker off" position.

3. INTERPRETATION OF METER READING

3.1 Contamination measurements

Table 1 shows the approximate counting rate in pulses per second from a uniformly contaminated surface of 100 cm^2 for different models. These measurements were obtained from specially prepared non-absorbent surfaces contaminated with hard, medium and soft β emitters.

The figures are given with the normal protective grille in place. For models E and EL they have a transparency of approximately 80%. Grilles having greater tube protection but lower transparency are available.

TABLE I

Nuclide	$E\beta$ max MeV	counts s^{-1} above background for 1 Bq cm^{-2} on 100 cm^2		
		Model S/SL 5cm from surface	Model E 1cm from surface	Model EL 1cm from surface
$^{90}Sr/^{90}Y$	0.55/2.3	1/2.2	1.8	4.8
^{204}Tl	0.77	5/1.1	1.3	3.8
^{147}Pm	0.22	–	0.9	1.9
^{14}C	0.16	–	0.65	1.3
^{238}Pu	α emitter	–	0.7	1.5
^{55}Fe	(e.c.)	–	0.01	0.11

3.2 Beta surface dose measurements

Approximate surface dose rate measurements can be made with end window G-M probes. The figures given in Table II give a dose equivalent rate of 1 $\mu Sv.\ h^{-1}$ to skin tissue. The figures for ^{147}Pm are subject to wide variations and should be used for guidance only.

TABLE II

Nuclide	Eβ max MeV	counts s^{-1} above bkgd for 1 μSv. h^{-1} to skin	
		Model E	Model EL
$^{90}Sr/^{90}Y$	0.55/2.3	4.1	8.8
^{204}Tl	0.77	1.7	4.2
^{147}Pm	0.22	6.9	4.3

3.3 Gamma flux measurements

G-M tubes used for beta monitoring display a wide range of sensitivity to the range of γ radiations available. For this reason figures are quoted for selected γ emitters shown in Table III. Reference to Figures 1 to 4 show how the response varies with energy for the G-M tubes used in series 900 monitors.

TABLE III

γ sensitivity in counts s^{-1} per μGy. h^{-1} in air				
γemitter	Model S/SL	Model E	Model EL	Model X
^{60}Co	5/11	3.0	11	2.5
^{137}Cs	4/9	2.7	7	2
^{192}Ir	3/7	2.4	6	2
^{85}Kr γ's	3.5/8	2.5	6	2
^{241}Am	20/45	13.15	40	15

3.4 X-ray leakage detection

Model X has been used over many years for X-ray machine leakage detectors. The sensitivity curve does not allow accurate measurement (see Fig. 1) but it shows adequate sensitivity at the low energies. The philosophy for X-ray leakage is find it, then stop it. The monitor may be used with confidence for locating leakage from small cracks which larger and more cumbersome detectors may fail to find.

3.5 Paralysis time correction

There is a fixed paralysis time of 100μs for models S, E and X and 300μs for model EL. The counting loss correction is allowed for in the meter scaling. The maximum correction is 20%.

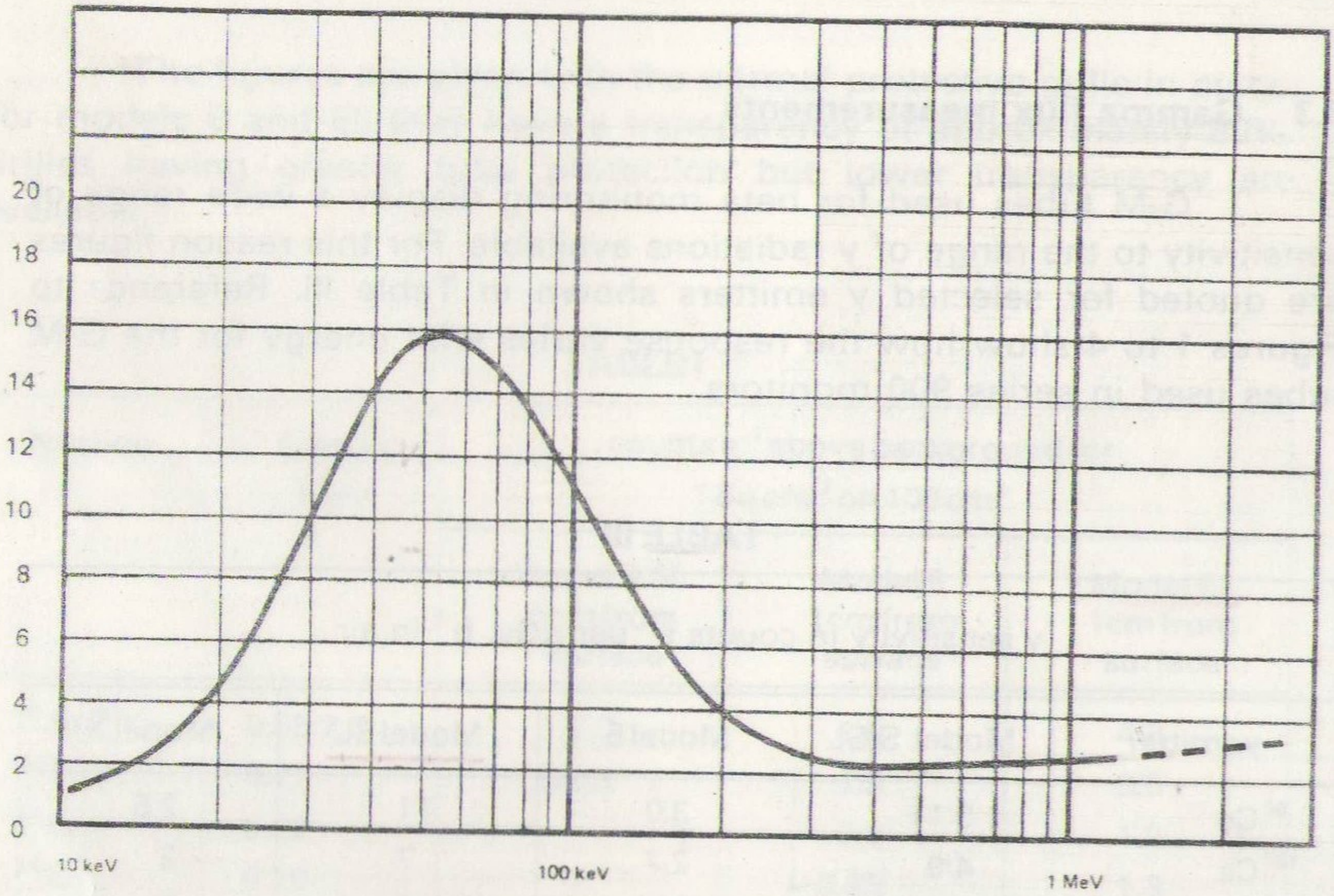


Fig. 1 Energy response of a ZP 1481 G-M tube (model X) (end on with plastic cap fitted)

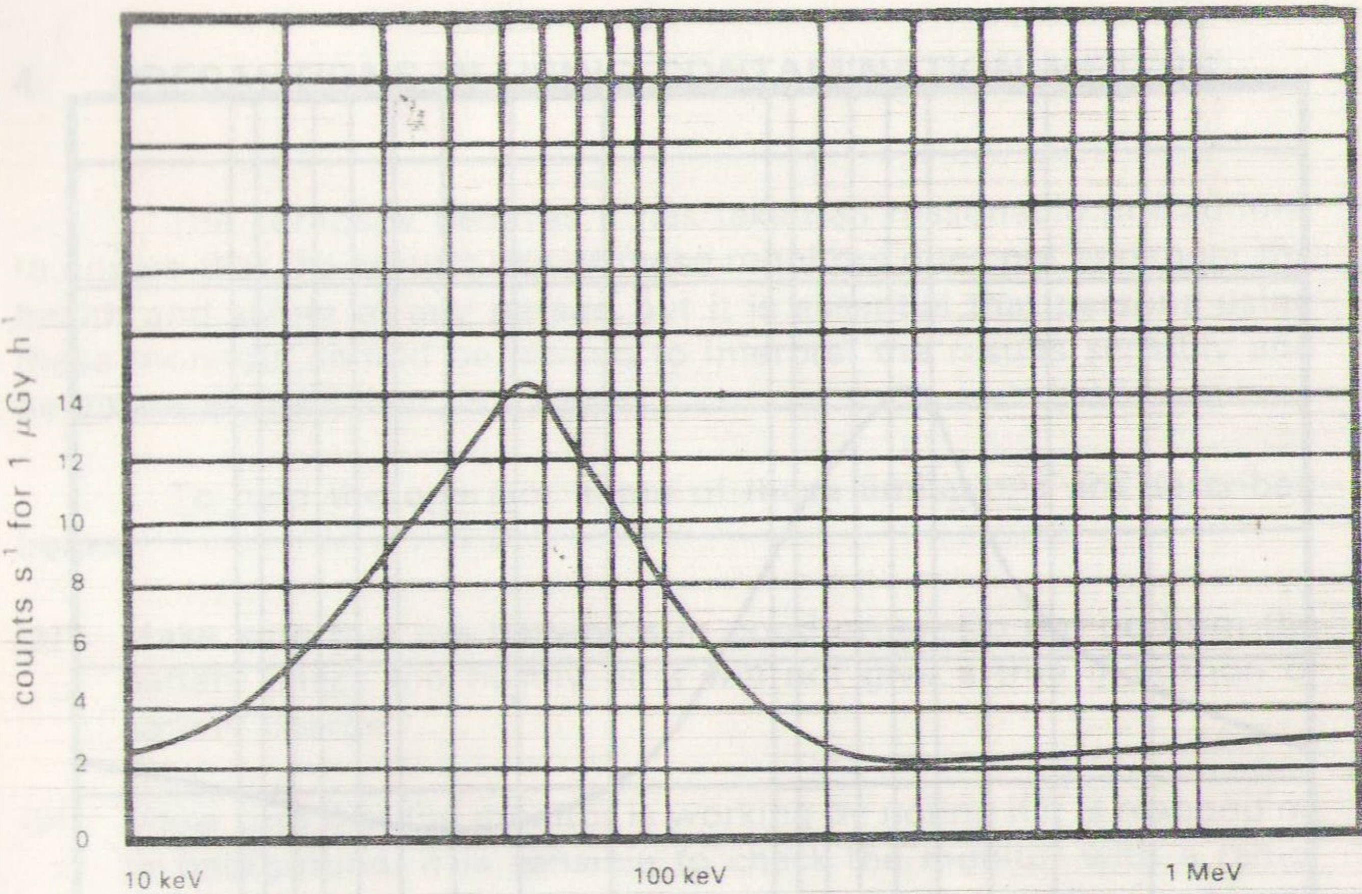


Fig. 2 Energy response of 7231 G-M tube (Model E)
(with acknowledgements to NRPB)

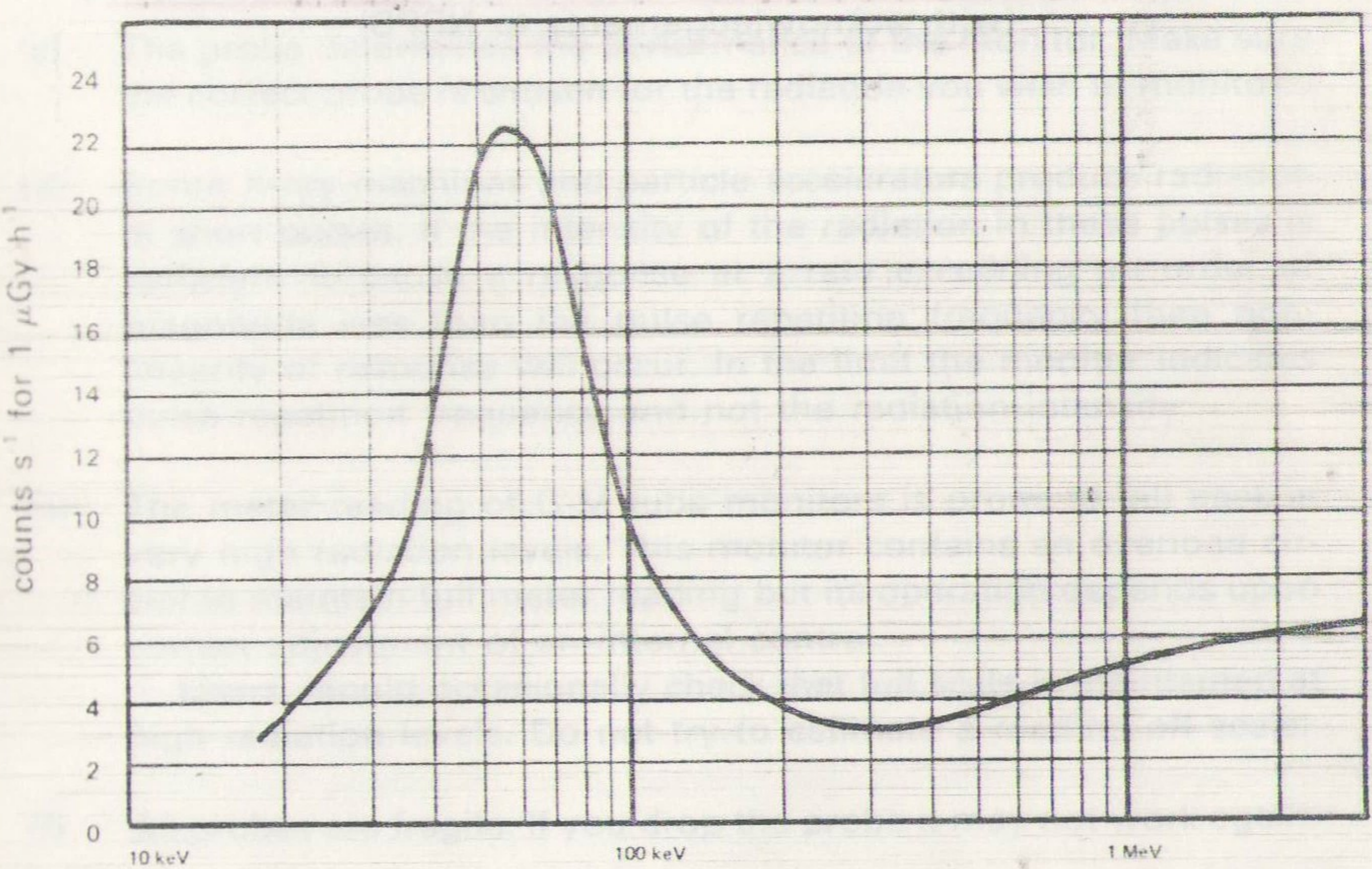


Fig. 3 Energy response of a B6H G-M tube (Model S)
(B12H tube, model SL gives approximately twice the above response)

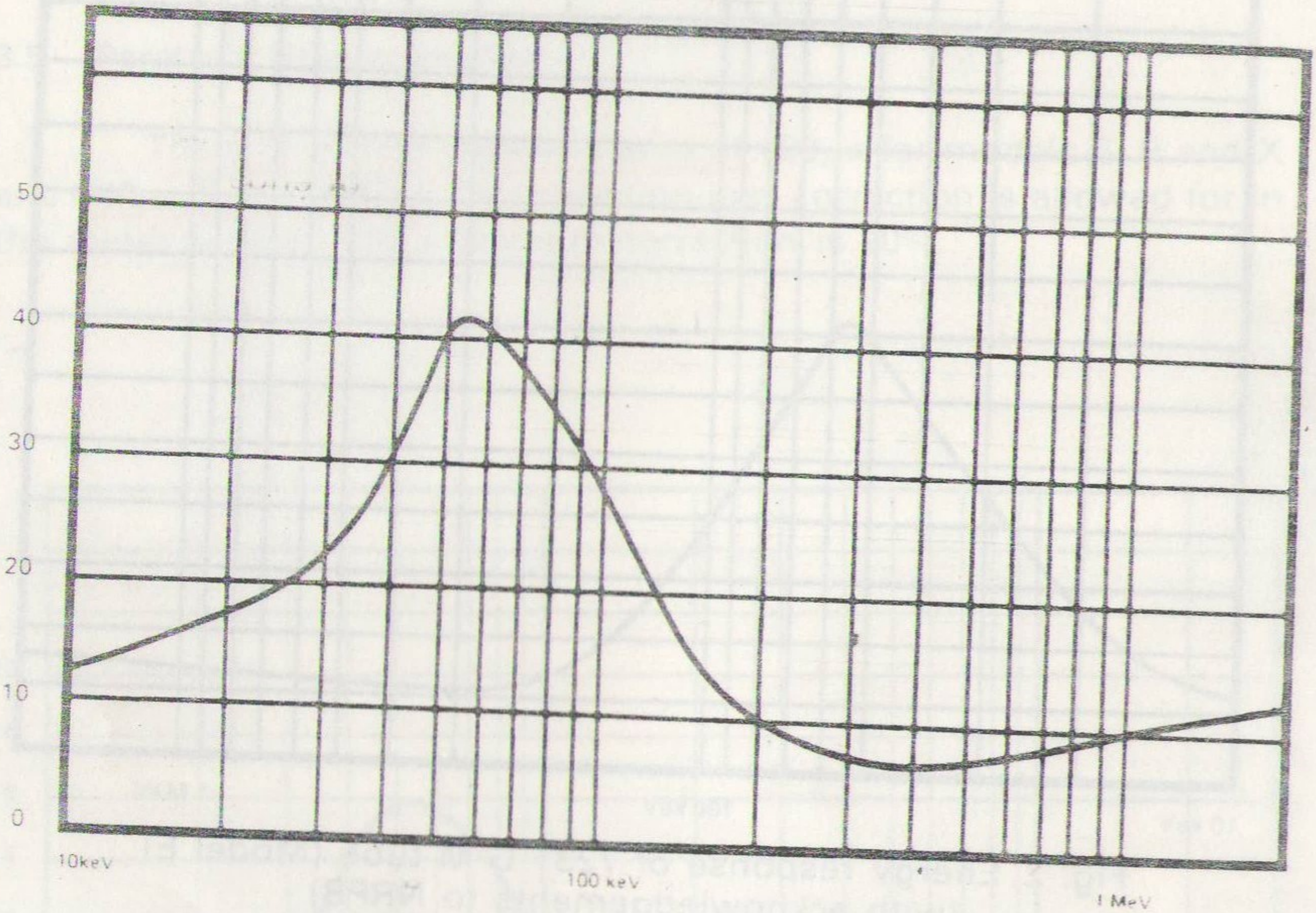


Fig. 4 Energy response of DN212 (model EL) without plastic cap (with acknowledgements to NRPB)

4. PRECAUTIONS IN USING CONTAMINATION METERS

The company believes it has taken all reasonable precautions to ensure that the correct use of these monitors does not endanger the health and safety of any person but it is essential that persons using these monitors should be trained to interpret the results sensibly and be aware of their own limitations.

To help the operator some of these limitations are described below:

(a) Make sure that the battery is in good order. Do not perform the battery check too hastily or it will not give a true indication of battery charge.

(b) Make sure that the monitor is working by noting if it is responding to background. It is sensible to check the monitor with a radioactive source to see if it is giving the expected reading and audible signal. The test source need not be traceable but a consistent source to tube geometry should be maintained.

(c) The probe determines the performance of the monitor. Make sure the correct probe is chosen for the radiation you wish to monitor.

(d) Some X-ray machines and particle accelerators produce radiation in short pulses. If the intensity of the radiation in these pulses is sufficient to cause a response at a rate exceeding an order of magnitude less than the pulse repetition frequency then non-linearity of response will occur. In the limit the monitor indicates pulse repetition frequency and not the radiation intensity.

(e) The meter reading of G-M tube monitors is prone to fall back at very high radiation levels. This monitor contains an overload circuit to maintain full meter reading but its operation depends upon correct adjustment of an internal control.

Users should occasionally check that full scale is maintained at high radiation levels. Do not try to estimate a reading off scale.

(f) All probes are fragile. If you drop the probe it may not work again.

(g) The monitor is not tropicalised or ruggedised and will not work if dropped into a pond or run over by a tank!

5. MAINTENANCE

The instructions that follow are written to help owners make certain repairs themselves. An expertise beyond that necessary to operate the monitor may be required and the company cannot be responsible for damage incurred to monitors or persons while carrying out these instructions. If there is doubt the monitor should be returned to the manufacturer.

The components are mounted on a printed circuit board attached to the meter and switch. Access to preset controls can be gained by removing the front panel of the box.

5.1 G-M tube replacement

All the G-M tubes may be replaced by the user. The replacement is obvious for the S and SL models but the end window models need a tool to remove the circlip (Anderton type HD2) but long nosed pliers will do. Great care is required in replacing the large area tube as the circlip is against the front window. When removing the old tube make a note of how the wires are connected. In particular the model X tube has the lead carrying the resistor attached to the pin within the crescent on the bakelite base.

If the replacement tube is identical to the one discarded it is likely that no internal controls need be adjusted. However you may be statutorily required to check the response. In particular you must be sure that the overload setting is correctly adjusted. See 5.5.

5.2 EHT Supply

The G-M tube EHT supply can be varied between 300 and 800 volts (1500 volts for model EL). The control is placed near the transformer at the 4 o'clock position. A clockwise rotation increases the potential. The voltage is best measured using a high resistance meter (AVO model 8) at the resistor junction sited 10 o'clock from the fixing bolt. The reading is approximately 25 volts down owing to meter loading.

5.3 Meter zero

The mechanical zero set is on the meter barrel. Any adjustment must be made with the monitor switched off. The design of the circuit requires the zero to be set a little below the zero mark on the scale. This is in order so do not adjust it back.

The electrical zero potentiometer is situated above the calibration potentiometer. Owing to background radiation it must be adjusted with the tube disconnected. Allow time for the meter to settle. Adjust the electrical zero to return the pointer to the scale zero.

5.4 Meter calibration

The calibration potentiometer is sited at the bottom centre of the printed circuit board.

To re-calibrate inject square pulses of a few volts via a capacitor of about 10 pF into the input. The pulse repetition rate will need to be corrected to allow for the paralysis time correction incorporated in the scale.

$$\text{Input pulse rate} = \frac{\text{Scale reading}}{1 + \text{Scale reading} \times \text{paralysis time}}$$

This correction is shown in the table below:-

Scale reading	pulse repetition frequency	
	Models S, SL, E & X	Model EL
2000	1667	—
1000	909	—
500	476	435
200	196	189
100	99	97
50	50	49
10	10	10

5.5 Overload adjustment

An overload circuit described in 8 (g) ensures the meter pointer is hard off scale for radiation intensities exceeding 100 times the maximum scale reading. The adjustment depends upon the probe type and EHT supply. The potentiometer is sited on the circuit board at 2 o'clock from the transformer.

First turn the set alarm control maximum clockwise. Using a strong source to send the meter hard off scale adjust the overload control to set off the alarm. Then reset the alarm to the desired position. In case of difficulty the company should be consulted.

6. SERVICE AND GUARANTEE

With normal care and attention this monitor should give many years of service without attention.

If any fault occurs to the monitor within two years of purchase (one year for the G-M tube) that is due, in our opinion, to a manufacturing error then it will be repaired or replaced without charge.

If a fault occurs outside the guarantee period the company or its agents will service the equipment. A note explaining what you believe to be wrong is often helpful. If the customer wishes to repair the fault himself the company will give technical help. However the company does not wish to abrogate its prime responsibility to its customer to third parties and service organisations. If these organisations are employed they should be instructed to return the equipment, untampered, to us for service or repair.

The company will not be responsible for damage or loss occurring in transit to the company whether or not properly packed but emphasis cannot be made strongly enough on the need to ensure adequate packing before returning for servicing.

The address is:

Service Department,
Mini-Instruments Ltd.,
8 Station Industrial Estate,
Burnham on Crouch,
Essex CM0 8RN
Tel: Maldon (Essex) (0621) 783282
Telex: 995445 MINMON G

7. INSTRUMENT SPECIFICATION

The calibration and test information in this manual is drawn from a number of sources but the company wishes to acknowledge especially the help and guidance given by the National Radiological Protection Board.

		900EL	900E	900S	900X
Surface Area Response	^{14}C 10x10cm distributed source 1cm from probe ^{90}Sr/^{90}Y as above but 5cm away	1.4 counts s^{-1} per Bq cm^{-2}	0.65 counts s^{-1} per Bq cm^{-2}	1 counts s^{-1} per Bq cm^{-2}	
Dependence of response on source position	^{14}C 1cm dia 1cm from probe	-25% at 1.75cm off axis			
Intrinsic error	^{14}C ^{90}Sr/^{90}Y	<± 50%	<± 50%	<± 30%	
Linearity of indication	From 1 count s^{-1} to 1000 counts s^{-1}	± 10% (500 cps)	± 10%	± 10%	± 10%
Resolution time	Included in scale graduation	300 μs	100 μs	100 μs	100 μs
Overload	100 times FSD	indicates over full scale	indicates over full scale	indicates over full scale	indicates over full scale
Variation of β response with energy	Nuclide — Eβmax MeV	counts s^{-1} per Bq cm^{-2}			
	^{90}Sr/^{90}Y — 2.27	4.9	1.8	1.0	
	^{204}Tl — 0.77	3.8	1.35	0.5	
	^{147}Pm — 0.23	2.2	0.95	no response	
γ response	^{137}Cs — 0.66 MeV	7[illegible] counts s^{-1} per $\mu Gy\ h^{-1}$	2.7 counts s^{-1} $\mu Gy\ h^{-1}$	4[illegible] counts s^{-1} $\mu Gy\ h^{-1}$	2 counts s^{-1} $\mu Gy\ h^{-1}$

α response	^{241}Am small area source in contact with grille	0.14 counts s^{-1} per Bq	0.14 counts s^{-1} per Bq	none	—
Neutron response	^{241}Am/Be neutrons	$<.3$ counts s^{-1} per $\mu Sv\ h^{-1}$	—		
Battery life at 4 hours/day	Alkaline cells Standard cells	~300 h ~150 h	~300 h ~150 h	~300 h ~150 h	~300 h ~150 h
Mass per area of entrance window	E, EL & X mica S & SL glass	1.5-2.5 mg cm^{-2}	1.5 – 2.2 mg cm^{-2} —	25-35 mg cm^{-2}	2.5-3.0 mg cm^{-2}
Area of window		19.6 cm^2	6.4 cm^2	10 cm^2	2.25 cm^2
Area of window obscured by grille	open grille 1cm^2 holes Wire grille	~20% ~40%	~20% ~50%	~20% —	none —
End cap superficial density	plastic cap Side wall of holder	~100 mg cm^{-2} —	~100 mg cm^{-2} —	— ~350 mg cm^{-2}	~50 mg cm^{-2} —
Background		~1 count s^{-1}	~¼ count s^{-1}	~1 count s^{-1}	~½ count s^{-1}
Statistical fluctuations	count rate for ± 20% coeff of variance inc bg above	4 counts s^{-1}	3.5 counts s^{-1}	4 counts s^{-1}	3.5 counts s^{-1}
Response time to reach 63% of change	1-10 counts s^{-1} 10-100 counts s^{-1} 100-600 counts s^{-1} 100-1000 counts s^{-1}	3.5 s 2.5 s 1 s —	4 s 1.5 s — $<$ 1 s	4 s 1.5 s — $<$ 1 s	4 s 1.5 s — $<$ 1 s
Temperature range	-10°C to +40°C	$<$ 10% change	$<$ 10% change	$<$ 10% change	$<$ 10% change
Humidity	Not to exceed (non-condensing)	85%	90%	90%	90%

8. CIRCUIT DESCRIPTION

The circuit diagram is given at the end of the manual. The circuit operation is as follows:

(a) **Battery input stabilising circuit** The line voltage of the monitor is 5.8 ± 0.2 volts and is set by the reference diode. J1/2 is the comparator coupled to J3 and the series control J4.

(b) **Oscillator** Transistor J6 coupled to the transformer T1 form the oscillator circuit. L2 supplies the necessary feedback to maintain oscillation. The amplitude of the oscillation is limited by the diode D2 whose potential is set by VR1. The emf from the tertiary winding L3 is half wave rectified for the low voltage G-M tubes and voltage doubled for the organic tube.

(c) **Input amplifier** J9 is an amplifier with a gain determined by feedback. It reverses the phase of the input pulse and supplies a positive signal to the CMOS monostable coupled gates which determines the paralysis time. The input requires negative pulses exceeding 100 mV into approximately 3000 ohms.

(d) **Ratemeter circuit** Two analogue outputs are combined to give a signal nearly proportional to the log of the input pulse rate. This output is applied to an operational amplifier which drives the meter. The potentiometer VR4 sets the meter scale and VR3 the meter zero.

(e) **Audio output** The speaker derives its power from a timer IC which produces a 300μs pulse when triggered by the monostable. This connection is switched at the front panel to suppress the pulse output. A similar but unswitched connection from the comparator sets off the timer to give the alarm.

(f) **Comparator** The comparator compares the potential on the set alarm control with an output from the meter amplifier. If the latter is greater the comparator trips and sets off the timer. A little hysteresis is applied to smooth out the random nature of the input.

(g) **Overload circuit** Excess current drawn through the probe when in a radiation flux exceeding many times the scale limit causes J7/8 to conduct thus maintaining the deflection of the meter. The potentiometer VR2 sets the limit when this occurs.

9. COMPONENT LIST AND CIRCUIT DIAGRAM

Integrated circuits		LM317, 4001, 4013, 4066, LM392, CM555
Reference diode	RD	ICL8069
Zener diode	Z	BZX83 C9V1
Transistors	J_1, J_2, J_{10}	BC548B
	J_3, J_5, J_7, J_8, J_9	BC558
	J_4	BC328
	J_6	BC338
Diodes	D_1	1N4001
	D_2, D_5, D_6, D_7, D_8	1N4148
	D_3, D_4	GEA6
	LED	IMO 5120

Resistors All carbon film ⅛ watt 5% unless otherwise stated.

R_1	330R	¼ watt	R_{22}	See table below	
R_2	27R		R_{23}	10K	
R_3	390R	1 watt	R_{25}	See table below	
R_4	15K		R_{26}	1M	2% m.f.
R_5	6K8		R_{27}	1M	2% m.f.
R_6	10K		R_{28}	180R	2% m.f.
R_7	82K	2% m.f.	R_{29}	10K	2% m.f.
R_8	22K	2% m.f.	R_{30}	180R	2% m.f.
R_9	10K		R_{31}	100K	
R_{10}	4K7		R_{32}	10K	
R_{11}	10K		R_{33}	22K	2% m.f.
R_{12}	470R		R_{34}	680R	2% m.f.
R_{13}	2K7		R_{35}	150K	
R_{14}	4K7		R_{36}	10K	
R_{15}	100K		R_{37}	4M7	
R_{16}	See table below		R_{38}	47K	
R_{17}	3K3		R_{39}	47K	
R_{18}	150K	2% m.f.	R_{40}	10K	
R_{19}	220K	2% m.f.	R_{41}	120K	
R_{20}	6K8		R_{42}	G-M tube current limiter	
R_{21}	330K				
			VR_4	50R	
VR_1	22K		VR_5	22K	
VR_2	See table below				
VR_3	100K				

Series 900 Mini-monitor

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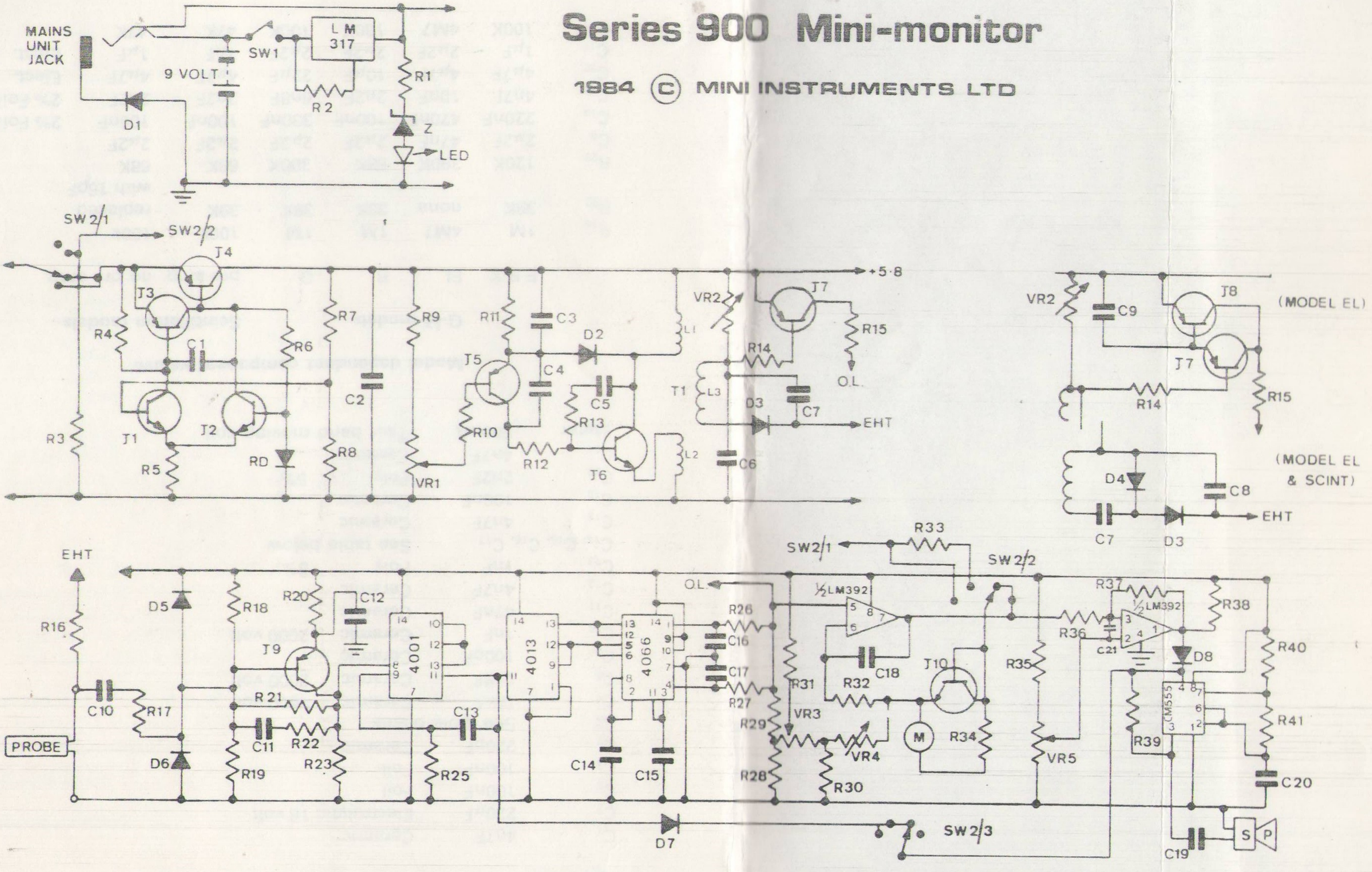

Features –
- Audible indication of radiation intensity
- Presettable audible alarm
- Battery or AC operation using a separate power unit
- Lightweight aluminium case
- Supplied with alkaline batteries, manual and test/calibration certificate

A MINI 900 RADIATION MONITORS

The Mini 900R, G and D radiation monitors are equipped with energy compensated GM probes. The 900X uses an uncompensated probe to extend the low energy response. All comply with IEC395 requirements.

B MINI 900 CONTAMINATION MONITORS

All Mini 900 contamination monitors comply with IEC325 requirements. The Type E and Type EP range are equipped with thin end-window GM probes suitable for detecting soft beta radiation, e.g. from ^{14}C.

C MINI 900 SCINTILLATION MONITORS

These monitors have logarithmically scaled meters with 0.5 s^{-1} to 5,000 s^{-1} markings and comply with IEC325 requirements. The Type 42 and Type 44 ranges are equipped with thin end-windows scintillation probes suitable for detecting soft X-rays. The 44B provides enhanced X-ray performance below 10 keV.

Mini 900 Series Ratemeters

Mini 900 radiation monitors are well established in education, medicine and industry as reliable, convenient and inexpensive. They are equipped with a choice of GM probe, matching logarithmically scaled meter and extensible cable. Mini 900E and Mini 900EP15 are available scaled in counts per second or counts per minute.


B


A


C

MINI 900 Series for Radiation Control

Type	Scale Range	Energy Range	GM Detector	Radiations
900R	0.5 – 500 mSvh-1	45 keV – >1.5 MeV	Compensated	Gamma X-Rays (>75 kVp source)
900G	0.5 – 500 mSvh-1	55 keV – >1.5 MeV	Compensated	Gamma only
900D	0.5 – 1,000 mSvh-1	30 keV – >1.5 MeV	Partially Compensated	Gamma X-Rays (>45 kVp source)
900X	0.5 – 2,000 s-1	>10 keV	Uncompensated	X-Rays (as a relative check device)

MINI 900/2SL Environmental Dose Rate Meter – Page 10.

MINI 900 Series for Contamination Control

Type	Window	Sensitivities			
		Alpha (^{238}Pu)	Beta (^{14}C)	Beta ($^{90}Sr/^{90}Y$)	Gamma (^{137}Cs)
E	6.4 cm^2	0.6 s^{-1} for 1 $Bqcm^{-2}$	0.7 s^{-1} for 1 $Bqcm^{-2}$	1.8 s^{-1} for 1 $Bqcm^{-2}$	2.2 s^{-1} for 1 $mSvh^{-1}$
EP15FL	15.5 cm^2	0.9 s^{-1} for 1 $Bqcm^{-2}$	1.3 s^{-1} for 1 $Bqcm^{-2}$	4.0 s^{-1} for 1 $Bqcm^{-2}$	5.0 s^{-1} for 1 $mSvh^{-1}$
EP15 *Replacement for Type EL*	15.5 cm^2	0.9 s^{-1} for 1 $Bqcm^{-2}$	1.3 s^{-1} for 1 $Bqcm^{-2}$	4.0 s^{-1} for 1 $Bqcm^{-2}$	5.0 s^{-1} for 1 $mSvh^{-1}$
EP100	100cm^2	6 s^{-1} for 1 $Bqcm^{-2}$	30 s^{-1} for 1 $Bqcm^{-2}$	49 s^{-1} for 1 $Bqcm^{-2}$	25 s^{-1} for 1 $mSvh^{-1}$
S	6.4 cm sensitive length		–	1 s^{-1} for 1 $Bqcm^{-2}$	5 s^{-1} for 1 $mSvh^{-1}$
SL	12.0 cm sensitive length		–	2 s^{-1} for 1 $Bqcm^{-2}$	10 s^{-1} for 1 $mSvh^{-1}$ (^{60}Co)

Scintillation Probes for Contamination Control

Type	Approximate Sensitivities		
	Radiation	Contamination	Background
41	1,000 s^{-1} due to 10 μSvh^{-1} (^{137}Cs)	130 s^{-1} due to 3.7 kBq ^{99m}Tc at 20 mm	3 – 8 s^{-1}
41S	3,500 s^{-1} due to 10 μSvh^{-1} (^{137}Cs)	–	20 – 30 s^{-1}
42A	–	330 s^{-1} due to 3.7 kBq ^{125}I at 20 mm	2 – 3 s^{-1}
44A	–	3.8 s^{-1} due to 3.7 kBq ^{125}I at 20 mm	4 – 8 s^{-1}
44A	–	1.6 s^{-1} due to 3.7 kBq ^{99m}Tc at 20 mm	–
44A	–	1.4 s^{-1} due to 3.7 kBq ^{57}Co at 20 mm	–
44B	–	180 s^{-1} due to 3.7 kBq ^{55}Fe at 10 mm	–

MINI

MONITOR

The 900 series Mini-Monitor

Scintillation Monitors for Contamination Control

The mini-monitor is well established in teaching, research, hospital and industrial laboratories as a reliable, convenient and inexpensive contamination meter.

The 900 series has the following features:

* *A large logarithmically scaled meter with an open scale at the lower end to show background levels of contamination while displaying high levels without switching.*
* *A speaker to give an audible estimate of radiation intensity.*
* *An alarm which can be set to trip at any level on the scale.*
* *Battery or mains operation using a separate power unit. Included is an internal constant current charger for rechargeable batteries.*
* *Lightweight aluminium case.*
* *A comprehensive manual containing tables and curves of response to different radiations and other useful information.*
* *The monitor conforms to the requirements of the International Electrotechnical Commission publication 325.*

Specification

Weight	*1.0kg without probe.*
Size	*180w by 110d by 165 mm overall.*
Batteries	*6 type AA cells, alkaline (IEC LR6) or rechargeable (IEC KR 15/51).*
Battery life	*Approximately 120 hours at 4 hours/day.*
Meter range	*0.5 to 5000 counts s^{-1}.*
Paralysis time	*Scale corrected to give true count rate.*
Ratemeter integration time	*1 to 4 seconds set to match count rate.*
Radiation detector	*Most portable scintillation probes having a single cable termination are suitable.*
HV supply	*600–1500 volts set internally.*
Overload protection	*Provision to indicate excess tube current.*
Mains power	*12–18 volts D.C. from mains unit.*

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The 900 series Mini-Monitor

The 900 Series Mini-Monitor Scintillation Probes

GAMMA SCINTILLATION PROBE TYPE TYPE 41
Sodium iodide crystal 19mm dia by 25mm thick. Suitable for energies from 25keV upwards. A lead cylinder surrounds the crystal giving the probe directional properties as well as reducing background.
Diameter 400mm Length 210mm.
Sensitivity
10μSv h^{-1} (1mR/h) ^{137}Cs approx 1000 counts s^{-1}
3.7kBq (0.1μCi) of ^{99m}Tc at 20mm approx 130 counts s^{-1}
Background 3–8 counts s^{-1} depending on locale.

GAMMA SCINTILLATION PROBE TYPE 41S
Similar to type 41 but without lead shielding and has a larger sodium iodide crystal (25mm dia by 38mm thick) for increased sensitivity. Suitable for energies from 25keV upwards. The probe is essentially omni-directional for medium and high energy gamma radiation.
Diameter 38mm Length 217mm.
Sensitivity
10μSv h^{-1} (1mR/h) ^{137}Cs approx 3500 counts s^{-1}
Background 20–30 counts s^{-1} depending on locale.

X-RAY SCINTILLATION PROBE TYPE 42A
Sodium iodide crystal 23mm dia by 1mm thick with a 14mg cm^{-2} aluminium window. This probe has a higher sensitivity than the Type 41 for γ energies below 60keV to a minimum of 10–15 keV. An integral lead collimator makes it particularly useful for ^{125}I thyroid monitoring and deep vein thrombosis location.
Diameter 40mm Length 187mm.
Sensitivity
3.7kBq (0.1 μCi) of ^{125}I at 20mm approx 330 counts s^{-1}
Background 2–3 counts s^{-1} depending on locale.

X-RAY SCINTILLATION PROBE TYPE 42B
This probe is the beryllium window version of the type 42 and detects very low γ energies down to 5keV. The response above 15keV is almost identical to the 42A.
Window weight 47mg cm^{-2}.

SCINTILLATION PROBE TYPE 44A
(as illustrated on front)
The sodium iodide crystal (32mm dia by 2.5mm thick) is mounted on the front surface of the probe to facilitate monitoring of large contaminated areas. It is suitable for a range of energies from approximately 15keV to 250keV. It is also β sensitive for energies above 500keV.
Diameter 50mm Length 180mm. Aluminium window weight 14mg cm^{-2}.
Sensitivity
3.8, 1.6 & 1.4 counts s^{-1} for 1Bq cm^{-2}
(2.7 x 10$^{-5}\mu$Ci cm^{-2}) of ^{125}I, ^{99m}Tc, ^{57}Co respectively.
Background 4–8 counts s^{-1} depending on locale.

SCINTILLATION PROBE TYPE 44B
This probe is the beryllium window version of the above and extends the sensitivity down to approximately 5keV making it useful for ^{55}Fe. 3.7kBq (0.1μCi) of ^{55}Fe at 10mm approx 180 counts s^{-1}.
Window weight 47mg cm^{-2}.

ELECTRICAL SPECIFICATION

Socket outlet:	Single PET 100 series for single output + H.V. supply.
Dynode chain:	approximately 55Mohms.
Preamplifier:	sealed unit giving a maximum of 1 volt negative pulse into a minimum load of 1000 ohms.

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MINI INSTRUMENTS LIMITED

MINI MONITOR

TYPE 5.40 METER

Our instruments are subject to continuous development and minor changes in detail may occur which are not incorporated in this manual.

CONTENTS

1. GENERAL DESCRIPTION

1.1 Basic Instrument. Type 5-40

The instrument is designed for use in teaching, research, hospital and industrial laboratories where work with radio-isotopes is carried out.

The instrument uses transistors, mounted with all other components, on a printed circuit board. It is powered by transistor radio batteries having a good shelf life. The performance is unaffected by the batteries running down and no 'set battery' control is necessary.

The probe is connected to the instrument by either an extensible cable or a standard coaxial cable. It may be used remotely or attached to the top of the case by a clip. A meter registers the counting rate on a partly logarithmic scale thus making range changing unnecessary. An internal speaker, which may be switched off if desired, gives an audible indication of intensity.

1.2 Probe attachments

The instrument is normally supplied with an extensible cable terminated by a PET series 100 plug. Most portable scintillation probes having a single output are suitable. The following scintillation probes were designed, or are suitable, for use with this instrument:—

Mini Instruments :—	γ ray probe type 5-41 X ray probe type 5-42 γ ray well probe type 5-43
Nuclear Enterprises :—	α probes type AP2 and AP3 β probe type BP4 α-β probe type DP2

2. OPERATING INSTRUCTIONS

2.1 Controls

There are two external controls; a rotary switch with three positions — off, battery check and on — and a speaker on/off switch.

2.2 Batteries

The state of the batteries is indicated on the meter when the switch is turned to the centre position marked 'bat chk'. In this position the batteries are subjected to a current drain similar to when the instrument is counting at its maximum rate. In order to ensure that the batteries are satisfactory the meter pointer should be observed for some seconds in order to detect if a downward drift occurs. If the reading falls into or below the red sector on the scale the batteries should be changed. Note that at this stage the instrument may appear to operate satisfactorily at low counting rates but loss will occur at the upper end of the scale as the current drain increases. The useful life of the batteries is well passed and it is therefore advisable to change them to avoid trouble from possible corrosion.

Battery replacement The batteries are carried on the back plate of the instrument. To change them the back plate must be removed by first unscrewing the four instrument screws at the corners. The batteries can then be unplugged and removed by unscrewing the bolts holding down the battery cover.

2.3 Scintillation probe supply potential

The photomultiplier potential can be raised from a minimum of 500 volts to a maximum of 1500 volts which is adequate for most probes. With the back of the instrument removed the potential control is situated near the centre of the printed circuit board. A clockwise rotation increases the potential. The method of adjustment is given in 3.2.

2.4 Mains Unit

A small battery replacement mains unit is available to operate all instruments. The components are mounted on a printed circuit board which bolts to the back plate in the same position as the batteries. Press studs mounted on the board accept the two battery leads. The supply must be 50/60Hz AC 180-250 volts unless otherwise stated.

Note that the mains supply is not switched by the control switch on the panel so the mains unit is always on when plugged into the supply. The design of the unit makes the possibility of shock during servicing most unlikely but the mains plug should be removed from the socket before adjustment is made to this unit. A three pin fused plug should be used with the fuse at the lowest possible rating. The current consumption is approximately 5mA. There is no internal fuse.

2.5 Input requirements

The input requires negative pulses approximately 100mV in magnitude and with a time constant of a few micro-seconds. The input impedance is approximately 3500ohms. Care should be taken not to feed in fast positive pulses of a few volts amplitude for fear of damaging the input transistor. The two input pins are situated at the top right hand corner of the board — the upper pin positive. The instrument may be used remotely from the scintillation probe if the extensible cable is replaced by a low capacity coaxial cable. A total shunt capacity up to 600 pF is acceptable and this allows lengths of cable up to 15 metres to be used.

2.6 Ratemeter calibration

The calibration is set at the time of the instrument's final check but should recalibration become necessary the details are given in section 6.2.

The scaling does not include any correction for instrumental dead time. The dead time is set at 50μs and so gives a loss of counts of 10% at 2000pps and proportionately less at lower counting rates. For normal use of the instrument this correction is seldom important.

2.7 Overload response

The scintillation meters are primarily designed to achieve a high sensitivity for the detection of contamination by electron capture nuclides. If placed in quite weak X or γ ray fields the counting rate may be so high that the probe is overloaded and will cease to function. The meter will not respond and the speaker becomes silent. The operator should familiarise himself with the effect so as not to be caught unawares.

3. SCINTILLATION PROBE

3.1 Mechanical construction

The scintillation probes have been designed to offer a small convenient detector for most γ and X ray monitoring applications.

Each probe contains a lead shield surrounding the sodium iodide crystal. This reduces the background count and gives some collimation for low energy γ and X rays. Figures 1 and 2 show the mechanical construction of the γ ray and X ray probes respectively.

The photomultiplier tube (EMI 9524B) is the one commonly used in portable equipment and has a 20mm diameter cathode plus 11 stages of multiplication. It is surrounded by a μ metal shield to reduce the effects of magnetic field. The dynode chain and preamplifier components are fitted into the base unit which is held in the probe by a circlip. Removing this clip will allow the base, photomultiplier and crystal to slide out as one unit.

3.2 Photomultiplier potential adjustment

Photomultipliers have widely differing characteristics so it is not possible to quote a potential for a given tube. For certain applications the potential may be adjusted to make the probe insensitive to radiation energy below a chosen level. If it is required to take a note of the probe working potential this can be done by uncoupling the probe from the cable and measuring the potential at the plug pin. Use a 20,000ohm/volt meter set on the 2500 or 3000 volt range. This will load the instrument output almost identically to the probe.

An instrument supplied with a probe is adjusted in the following way:—

γ ray probe type 5-41

The probe is attached to the instrument and without a γ source the potential is slowly increased until photomultiplier noise is reached.

This shows up as a sharp rise in counting rate. The control is turned back to just below this level and the potential is noted.

An ^{125}I source giving X rays of 28 keV is brought up to the crystal until the counting rate is above 500cps. The control is turned back until the counting rate has again fallen away sharply. The control is then adjusted to half way between the two positions. The probe is sensitive to radiation energies exceeding 20-30keV.

X ray probe type 5-42

The probe is adjusted similarly to the γ probe using ^{55}Fe as the source. This emits 5.9keV X rays. The range between the region of noise and signal is much less but should be quite separable. The photomultiplier tube for this probe is selected for low noise.

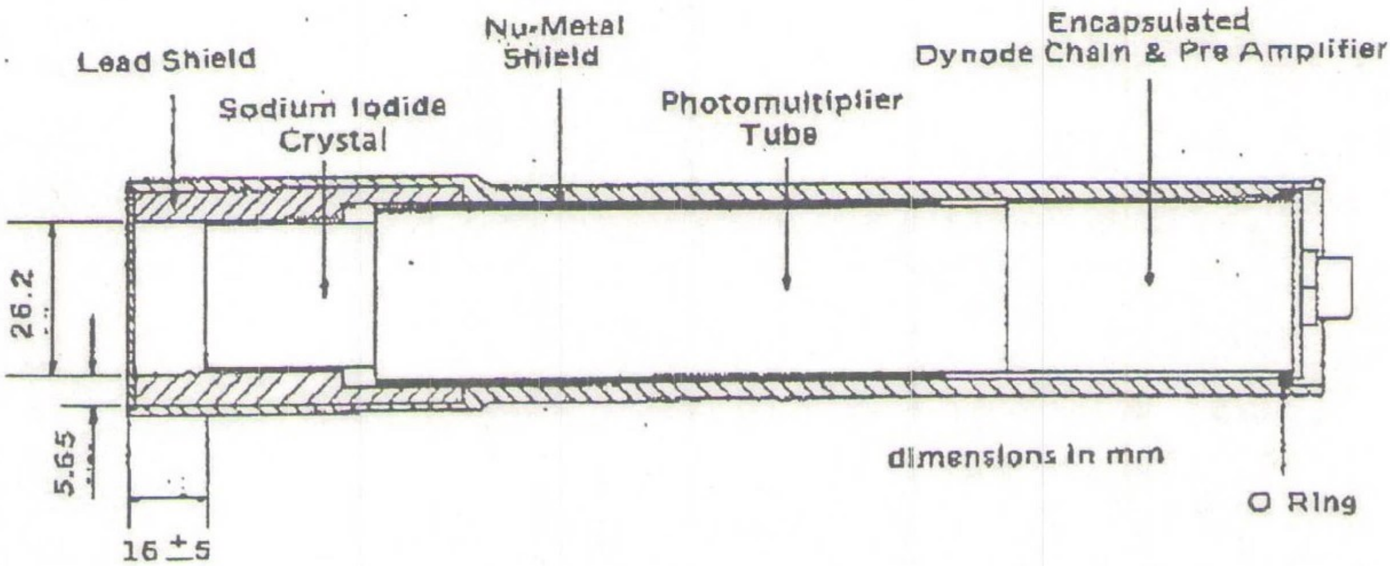


Figure 1

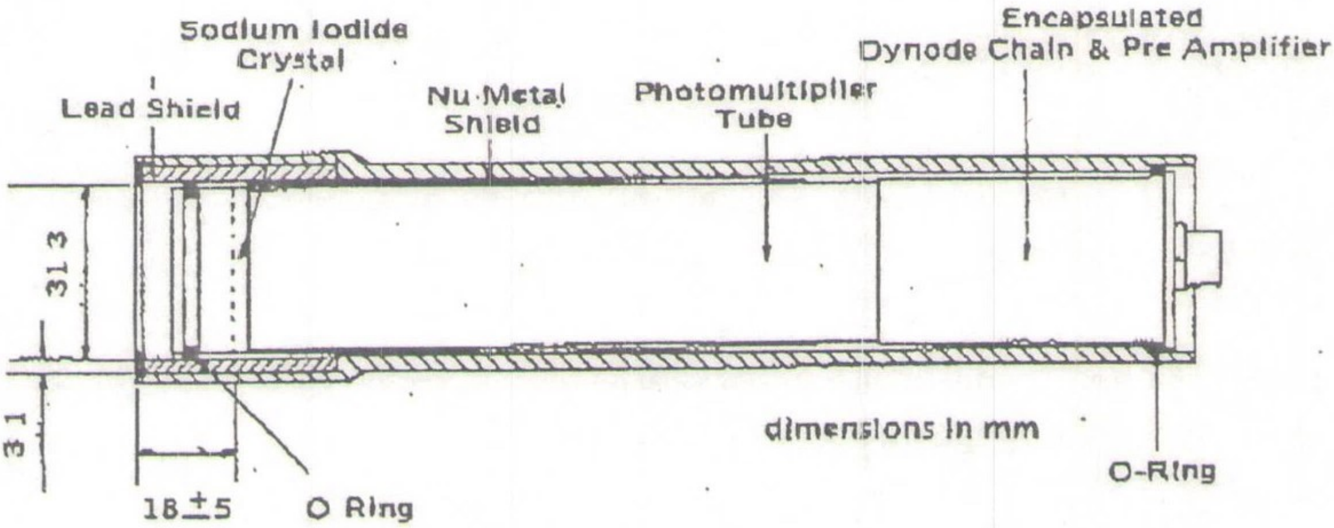


Figure 2

4. SCINTILLATION PROBE SENSITIVITY TO RADIATION AND CONTAMINATION

Table 1 shows the approximate response of the probes to a number of important nuclides. The graphs (figures 3 to 6) give the approximate response of the types 5-41 and 5-42 scintillation probes to X and γ radiation. These are calculated using published data on the detection efficiency of NaI to radiation.

Nuclide	γ type 5-41		X ray type 5-42	
	0.1 μCi at 20 mm	10^{-3} $\mu Ci/cm^2$	0.1 μCi at 20 mm	10^{-3} $\mu Ci/cm^2$
^{51}Cr	12	1	20	1
^{55}Fe	0	0	48	2
^{57}Co	200	13	190	15
^{67}Ga	160	—	100	—
^{75}Se	270		80	
^{99m}Tc	170	—	75	
^{109}Cd	100	—	290	14
^{125}I	190	5	360	21
^{131}I	130	—	65	—
^{60}Co	160	—	30	—
^{137}Cs + ^{137}Ba X ray	90		40	—
^{241}Am	70	—	90	--

Table 1

NOTES:

1. 20mm is approximately the nearest distance of approach to the crystal surface from the end of the probe.
2. The figures do not include background.
3. **Thyroid Monitoring**.
   Phantoms have been used to determine the sensitivity of the 5-42 probe to ^{125}I in the thyroid. With the probe against either lobe it is estimated that a burden of 0.1 μCi will give a count rate of between 25 and 35 cps.

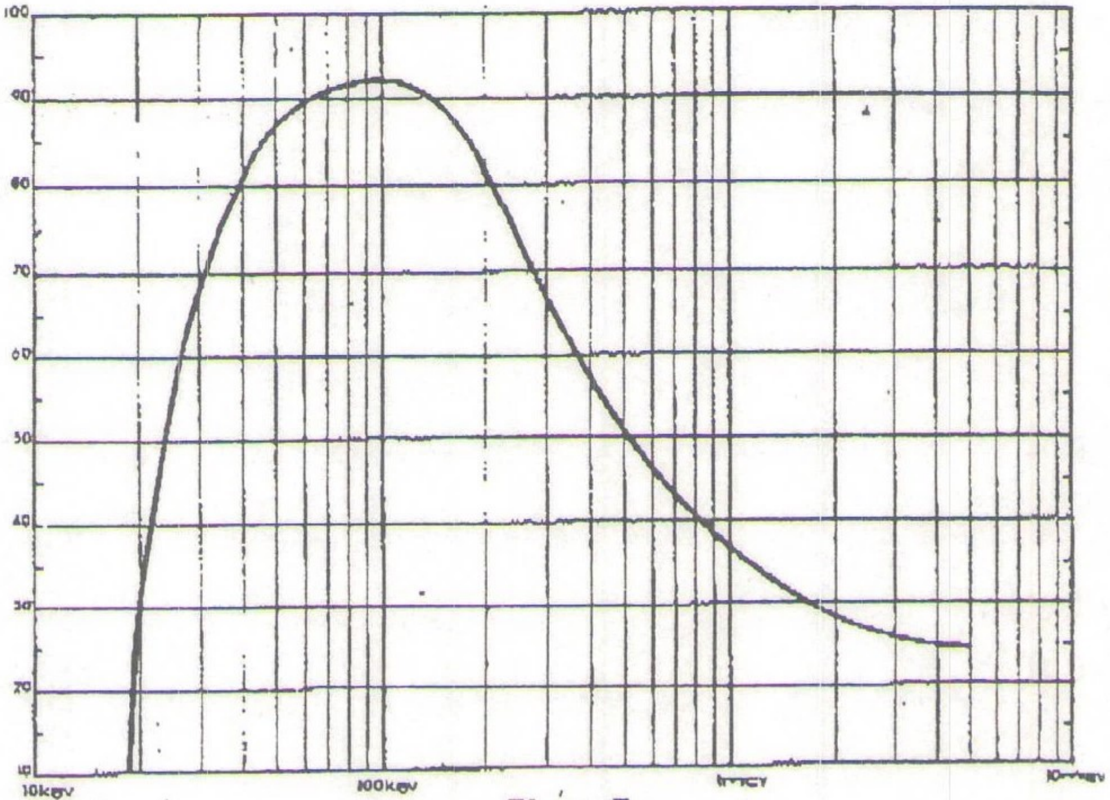


Figure 3

Type 5-41 probe – Photon detection efficiency versus Energy. The low energy cut off is calculated assuming 117mg/cm^2 Al in the can sealing the crystal and 183mg/cm^2 Al in the probe end cap giving a total of 300mg/cm^2.

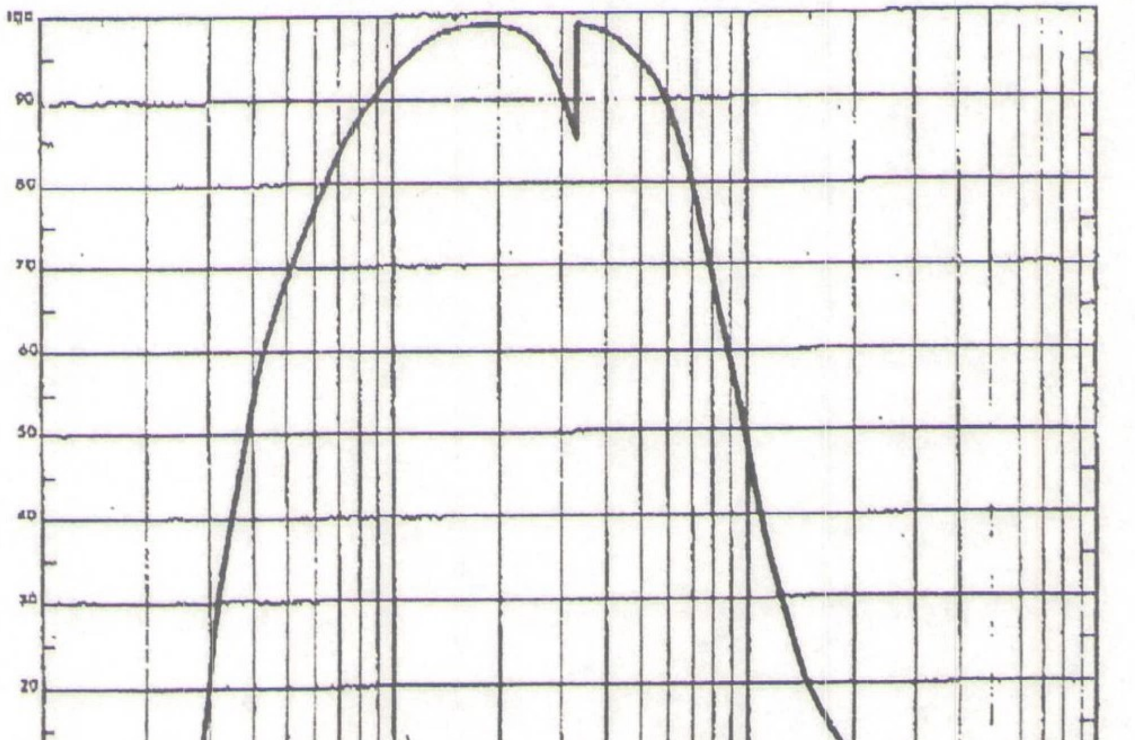


Figure 4

Type 5-42 probe – Photon detection efficiency versus Energy. The low energy cut off is mostly due to the beryllium window but crystal surface effects may also contribute. For this reason the position of the cut off has been set from experimental results. When comparing this probe with the 5-41 note the shifted energy scale. Also note that the 22mm diameter crystal has a collection area 1.3 times greater than the 5-41. Thickness of crystal 1mm. The dip at 33keV is due to the iodine absorption edge.

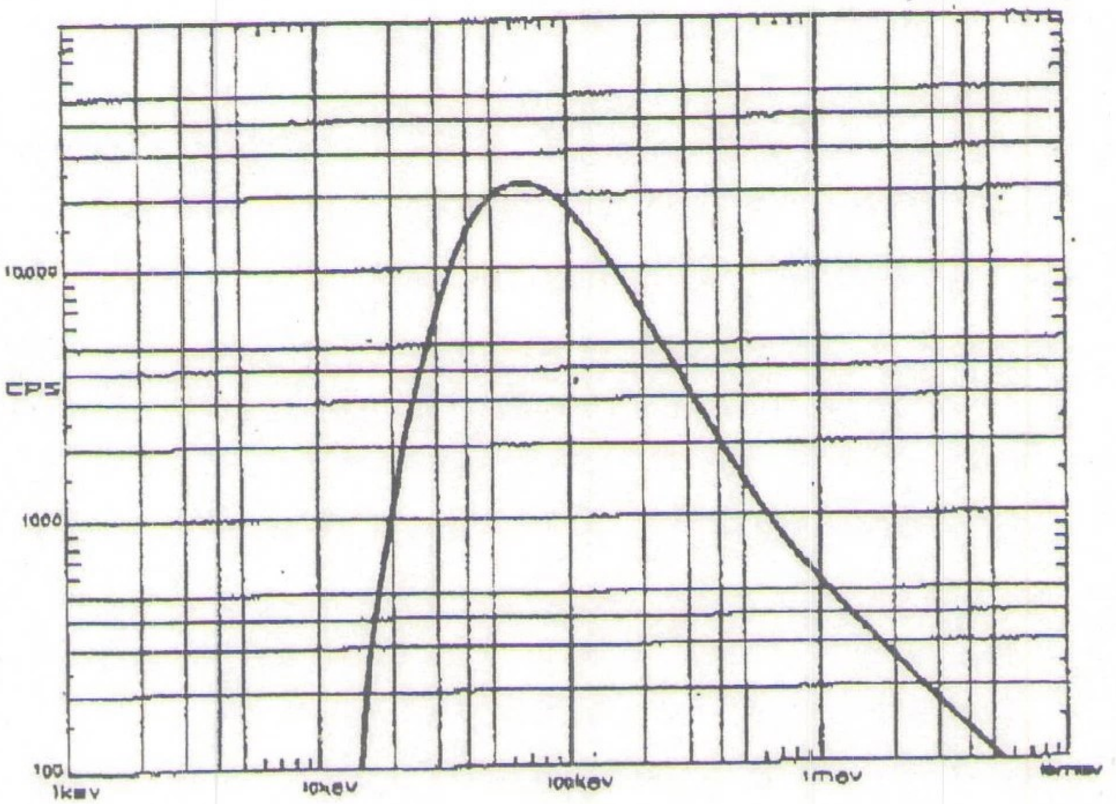


Figure 5
Calculated response of type 5-41γ probe to 1mRoentgen/hour exposure rate.

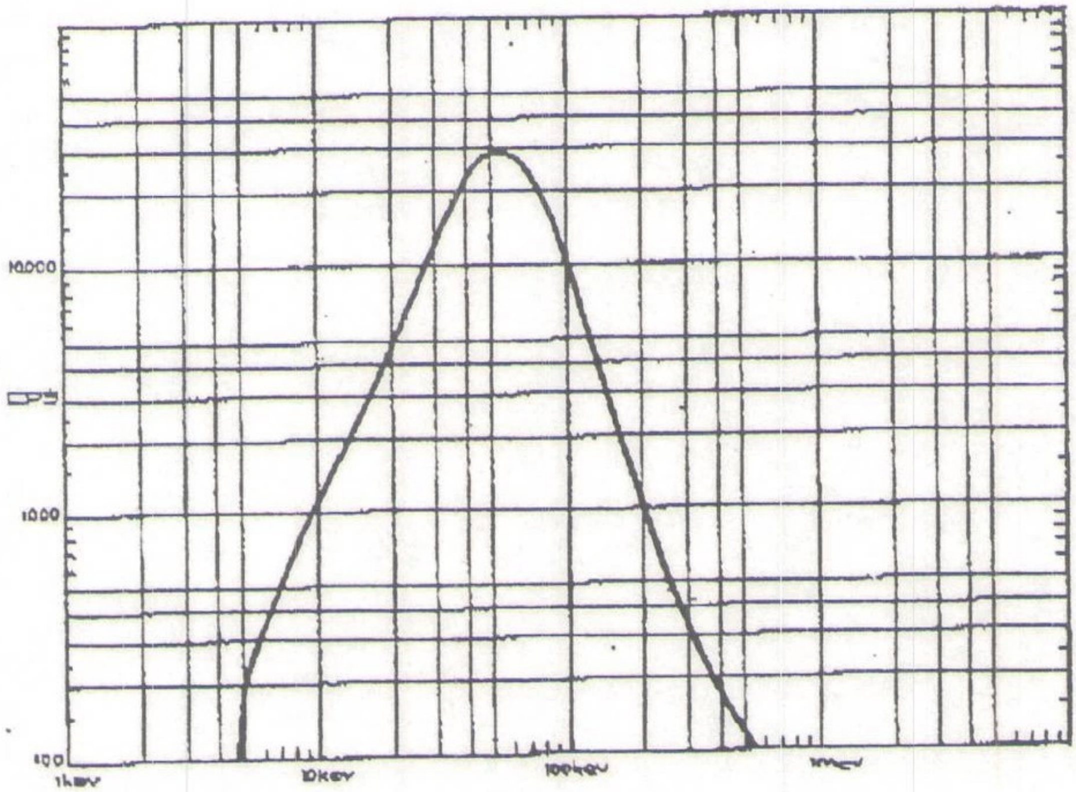


Figure 6
Calculated response of type 5-42 X ray probe to 1mRoentgen/hour exposure rate.

5. MAINTENANCE

These instructions are written to help owners keep their instruments in working order. By following them simple faults may be located and often repaired.

5.1 The scintillation probe

The probe contains items which could be damaged by a sharp knock. The glass photo-electron multiplier tube, protected by the probe case against crushing, is not sufficiently sprung to withstand dropping onto a hard surface. The electrode structure may be damaged or the glass shattered in a severe accident. The X ray probe can be damaged by a knock on the beryllium window. This may cause a light leak or fracture the crystal.

If an instrument fails switch off, uncouple the probe and switch on again. With an *insulated* wire short intermittently the pin and body of the plug. If the response to this test is a burst of pulses with small sparks then the instrument is most likely working and one must suspect the probe. The probe may be dismantled by first removing the circlip at the cable end. For this a special tool (Anderton International Ltd. pliers type HB2) is required. The complete unit of preamplifier, photomultiplier and crystal can be gently withdrawn but in the case of the X ray probe the crystal holder will need to be eased down the tube for the short distance of the lead shield owing to the light tight ring seal. See the mechanical construction in Figures 1 and 2. Remove the circlip stop and apply gentle pressure to the crystal *holder*, not to the beryllium window. The component parts of the crystal, photomultiplier and μ metal shield are held together by a special PVC tape. This will have to be removed to inspect or replace the photomultiplier or crystal.

It is unlikely that the sealed preamplifier and dynode chain can be damaged except by the application of an excessive potential. If a component failure is suspected the whole probe should be returned to the manufacturers for repair. See section 6.3

5.2 The circuit

The circuit diagram is given at the end of the manual. A description of its operation is made easier by considering the circuit divided into five units.

(a) Battery input stabilising circuit. The line voltage of the instrument is 9.5 ± 0.5 volts and is set by the Zener diode Z. J_8 is the comparator coupled to J_7 and the series control J_6.

(b) Oscillator. Transistor J_4 coupled to the transformer T_1 form the oscillator circuit. L_2 supplies the necessary feedback to maintain oscillation. The amplitude of the oscillation is limited by the diode D_7 whose potential is set by R_{17}. The emf from the tertiary winding L_3 is full wave rectified using a voltage doubler circuit.

(c) Input amplifier. J_1 is a straight forward amplifier with a gain of 10 determined by feedback. It reverses the phase of the input pulse and supplies a positive signal to the blocking trigger circuit composed of J_2, L_4, and L_5. This generates a high current negative pulse for operating the diode pump circuit.

(d) Diode pump circuit. There are two separate pump circuits with characteristics determined to give a smooth response over the three decades of count rate. The pump circuit containing the diodes D_3 and D_5 is mainly responsible for the lower part of the scale and diodes D_4 and D_6 for the upper part of the scale. The two outputs are linearly combined at the junction of resistors R_{14} and R_{15}. Time constants of 5 seconds and 1 second determined by C_6 and C_7 have been chosen for the two circuits. This gives a variable sampling time to match the count rate over the range.

(e) Audio amplifier. J_3 is connected as a common emitter amplifier and is introduced mainly to isolate the speaker from the pump circuit. The capacity-resistance combination at the base of J_3 cuts the pulse size to the speaker at high counting rates to reduce current drain.

6. INSTRUMENT FAULTS

The components are mounted on a printed circuit board attached to the meter and switch. Access to components can be gained by removing the front panel from the box.

First check that wires have not come adrift. Make sure that the battery press studs are making contact and that on 'bat chk' the meter reads above the red sector.

6.1 Further tests

Referring to the test carried out in section 5.1., if there is no burst of pulses on intermittently shorting out the input the response may be either one or two occasional clicks or no response whatsoever.

If the response is a few clicks suspect a failure in the polarising supply. Verify this by shorting the positive end of the rectifier D_2 to earth using a short piece of insulated wire or an insulated screwdriver. The sparks should be quite visible and audible.

If there is no response to the test in 5.1., it suggests a failure of the pulse amplifier circuit or the battery stabilising circuit. If there is a good spark on shorting the high potential supply then the pulse amplifier is suspect. If there is no spark suspect the battery stabilising circuit.

The tests given are designed to assist in localising the fault. Some electrical test equipment will be necessary to investigate the faults further together with a working knowledge of electrical faults. A circuit diagram and component list are given at the end of the manual.

6.2. Meter calibration

The calibration of the instrument depends on the Zener diode operating potential and the components in the pump circuits. All these quantities are fixed but the replacement of any of these components may change the calibration. In the circuit the meter is shunted by a variable resistance R_{16} so that the effective sensitivity can be varied. This resistance is situated on the printed circuit board at the bottom of the left hand corner.

To recalibrate inject square pulses of a few volts via a small condenser of about 10pF into the cable input. The pulse repetition frequency is set to say 500pps and the resistance varied until the meter reads correctly. The other frequencies should line up exactly but in practice a small error not exceeding 10% may occur.

6.3 Service

With normal care and attention these instruments should give many years of service. If any fault occurs to the instrument (excluding the photomultiplier and tube crystal) within two years that is due in our opinion to a manufacturing error then it will be repaired free of charge. The company will not be responsible for damage occurring in transit whether or not properly packed but emphasis cannot be made strongly enough on the need to ensure adequate packing before returning for service. A note explaining what you believe to be wrong is often helpful.

COMPONENT LIST TYPE 5.40 SCINTILLATION METER

Resistances ±10% carbon film unless otherwise stated.

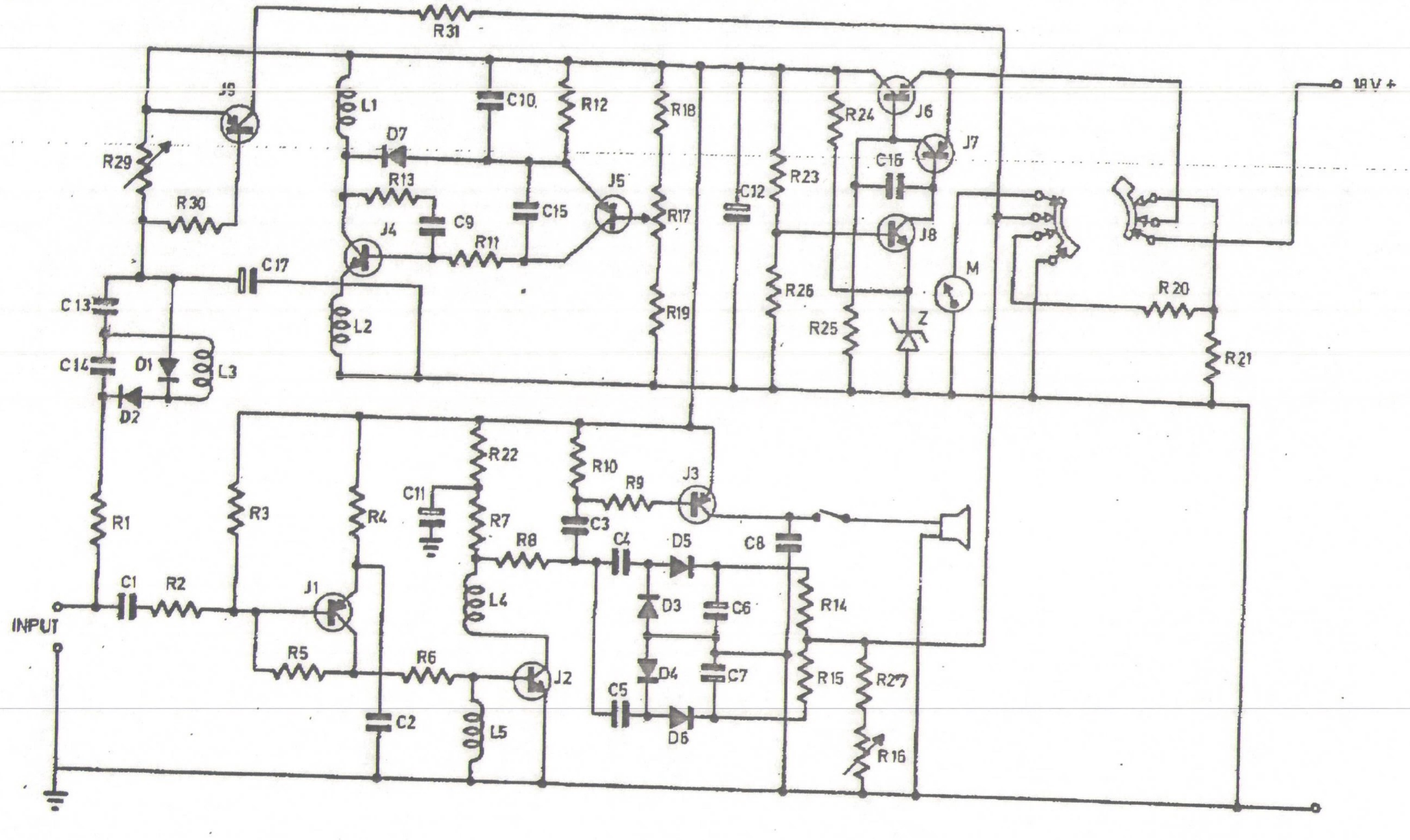
R_1	100K	
R_2	3K3	
R_3	100K	
R_4	22K	
R_5	47K	
R_6	4K7	
R_7	820R	
R_8	10R	
R_9	10K	
R_{10}	470K	
R_{11}	470R	
R_{12}	47K	5% metal film
R_{13}	4K7	
R_{14}	120K	2% metal film
R_{15}	120K	2% metal film
R_{16}	4K7 pot	
R_{17}	100K pot	
R_{18}	47K	
R_{19}	3K3	
R_{20}	220K	5%
R_{21}	1K2	
R_{22}	10R	
R_{23}	330K	2% metal film
R_{24}	100K	
R_{25}	100K	
R_{26}	680K	2% metal film
R_{27}	1K5	
R_{29}	47K pot	
R_{30}	1K	
R_{31}	47K	

COMPONENT LIST continued

C_1	1000pF ceramic 4000 volt	C_{10}	0.068μF metallised foil
C_2	0.1μF ceramic	C_{11}	220μF electrolytic
C_3	4700pF ceramic	C_{12}	150μF electrolytic
C_4	1μF ±5% metallised foil	C_{13}	0.01μF ceramic 1000V
C_5	0.022μF ±2% metallised foil	C_{14}	0.01μF ceramic 1000V
C_6	47μF tantalum	C_{15}	0.068μF metallised foil
C_7	10μF tantalum	C_{16}	1000pF ceramic
C_8	0.1μF ceramic	C_{17}	2.2μF tantalum
C_9	220pF ceramic		

L_1, L_2, L_3	EHT transformer T_1
L_4, L_5	Winding 1, pulse transformer T_2

$J_1, J_3, J_5, J_6, J_7, J_9$	BCY72/BC558B
J_2, J_4, J_8	BC108B/BC548B
Z	BZY88/C6V2
D_1, D_2	IJK30
$D_3 - D_7$	ITT44



MINI - INSTRUMENTS Ltd. CIRCUIT DIAGRAM for Type 5.40

(a) Battery input stabilising circuit. The line voltage of the instrument is 9.5 ± 0.5 volts and is set by the Zener diode Z. J_8 is the comparator coupled to J_7 and the series control J_6.

(b) Oscillator. Transistor J_4 coupled to the Transformer T_1 form the oscillator circuit. L_2 supplies the necessary feedback to maintain oscillation. The amplitude of the oscillation is limited by the diode D_7 whose potential is set by R_{17}. The emf from the tertiary winding L_3 is full wave rectified using a voltage doubler circuit.

(c) Input amplifier. J_1 is a straight forward amplifier with a gain of 10. determined by feedback. It reverses the phase of the input pulse and supplies a positive signal to the blocking trigger circuit composed of J_2, L_4, and L_5. This generates a high current negative pulse for operating the diode pump circuit.

(d) Diode pump circuit. There are two separate pump circuits with characteristics determined to give a smooth response over the three decades of count rate. The pump circuit containing the diodes D_3 and D_5 is mainly responsible for the lower part of the scale and diodes D_4 and D_6 for the upper part of the scale. The two outputs are linearly combined at the junction of resistors R_{14} and R_{15}. Time constants of 5 seconds and 1 second determined by C_6 and C_7 have been chosen for the two circuits. This gives a variable sampling time to match the count rate over the range.

(e) Audio amplifier. J_3 is connected as a common emitter amplifier and is introduced mainly to isolate the speaker from the pump circuit. The capacity-resistance combination at the base of J_3 cuts the pulse size to the speaker at high counting rates to reduce current drain.

(f) Overload circuit. Excess current drawn through the probe when in a radiation flux exceeding the scale limit causes J_9 to conduct and the collector current maintains the deflection. The potentiometer R_{29} sets the limit when this occurs.

The company believes it has taken all reasonable precautions to ensure that the correct use of these instruments does not endanger the health and safety of any person but it is essential that persons using these instruments should be trained to interpret the results sensibly and be aware of their limitations.

To help the operator some of these limitations are described below—

(a) Make sure that the batteries are in good order. Do not perform the battery check too hastily or it will not give a true indication of battery charge.

(b) Make sure that the instrument is working by noting if it is responding to background. It is also sensible to check the instrument with a radioactive source to see if it is giving the expected reading and audible signal.

(c) The probe determines the characteristics of the instrument. Make sure you are using the probe for a radiation it was designed to measure.

(d) Some X-ray machines and particle accelerators produce radiation in short pulses. If the intensity of the radiation in these pulses is sufficient to cause a response at a rate exceeding an order of magnitude less than the pulse repetition frequency then nonlinearity of response will occur. In the limit the instrument indicated pulse repetition frequency and not the radiation intensity.

(e) The probe and/or instrument may fail to read at radiation intensities above full scale. The instrument contains an overload circuit to maintain full meter reading but this will not operate unless it is correctly adjusted for the particular probe. Operators should familiarise themselves with this effect. A reading beyond full scale should be interpreted as essentially dangerous and action should be taken immediately.

(f) All probes are fragile. If you drop the probe it may not work again.

(g) The instrument is not tropicalised or ruggedised and will not work if dropped into a pond or run over by a tank!

900 RATEMETER

Radiation Monitor
Models R, G & D

Instruction Manual
April 2008

1. GENERAL DESCRIPTION

1.1 BASIC MONITOR

The monitor is designed for use in teaching, research, hospital, industrial laboratories and other areas where radiation levels need to be measured down to the accepted levels of safety.

The monitor is powered by easily available primary cells or may be mains operated from a small power unit. In addition rechargeable cells can be used which are recharged by using the same power unit.

The probe is connected to the monitor by a coiled extensible cable. It may be used remotely or attached to the case by a clip. A meter registers the intensity on a semi-logarithmic scale thus making range changing unnecessary. An internal speaker, which may be switched off, gives an audible indication of intensity.

The monitor has a warning alarm adjustable to trip at any selected level on the scale. It can be made inoperative during normal use but will respond on overload.

1.2 PROBE ATTACHMENTS

The monitor is available with three different probes, each identified as a separate model. The probes cannot be exchanged as the meter is uniquely scaled for the probe.

(a) **Model R** This model is scaled 0.5 to 5000μSv h^{-1}. The G-M tube is compensated to give a useful response from 45keV to 1.25MeV and above. The tube has a response nearly independent of orientation but the most reliable measurements are made with the incidence of radiation normal to the axis of the tube.

(b) **Model G** This model is scaled 0.05 to 75μSv h^{-1}. The G-M tube is compensated to give a useful response from 55keV to 1.25MeV with the radiation normal to the axis of the tube.

(c) **Model D** Is scaled 0.1 to 1000μSv h^{-1}. The G-M tube is partially compensated to give a response from 30keV to 1.25MeV. The detector is directional, particularly at low energies, and must therefore only be used where the radiation is incident on the front face of the detector.

The probe may be used further from the instrument than allowed by the extensible cable. Up to 15 metres of low capacity co-axial cable is acceptable.

2. OPERATING INSTRUCTIONS

2.1 CONTROLS

There are two external controls:

(a) A four position rotary switch labelled with symbols OFF, BAT, ON, ON (SPEAKER OFF)

(b) A screwdriver control to set alarm level.

2.2 CONNECTORS

There are two external connectors:

(a) A 2.1 mm coaxial low voltage DC power connector
12- 18 volts d.c. 80mA max – centre contact is –ve.

(b) A detector PET connector.

2.3 BATTERY

The state of the battery is indicated on the meter when the switch is turned to the position marked ‘bat’. In this position the battery is subjected to a current drain in excess of that used in normal operation. In order to ensure that the battery is satisfactory the pointer should be observed for about 15-20 seconds to see if it falls below the green sector. If so, the battery should be changed or if rechargeable, put on charge.

The battery is contained within the rear compartment. A half turn on the screw lets down the flap to reveal the six cells contained in a removable holder. Take out the holder and replace the cells observing the correct polarity. The label on the hinged flap suggests some suitable replacement types. Make sure the monitor is off before connecting the press studs as an accidental reversal may damage the circuit.

Suitable batteries are:

6 x AA Cells

Standard	IECR6, SP7, UM3
Alkaline	IEC LR6, AM3, MN1500
Rechargeable	IEC KR15/51

2.4 MAINS OPERATION

The monitor may be operated from the mains by using a separate power unit. For electrical safety reasons it MUST use a ‘double insulated’ isolating transformer. The unit supplied by Thermo Fisher Scientific is recommended as it conforms to the appropriate specifications. The same unit also provides the charging current when rechargeable cells are fitted.

The unit is plugged into the jack socket on the right-hand side of the case. A green LED shows when in use. When the power unit is plugged in, the internal batteries are disconnected but make sure that the internal charge switch is ‘off’ if the cells are not rechargeable.

Mains units are available for the following supplies:

210 – 250V, 50Hz and 110 – 120V, 60Hz

Output 12 – 10 volts d.c. at 75mA

There is no internal fuse in the monitor. Should a failure occur that overloads the mains power unit a thermal protection device cuts off the mains input. The thermal device is not resettable.

2.5 BATTERY CHARGE

The mains unit can be used to replenish rechargeable cells. When the cells are exhausted, plug in the mains unit and switch the charge switch within the battery compartment over to ‘charge’. The charge rate is 45mA and charging is complete in 16h. Do NOT charge primary cells. When the charge is complete, switch off the charger at the mains.

WARNING:

Ensure that the internal charge switch is only set to the ON position when rechargeable batteries are fitted. Do not attempt to charge primary cells – attempting to do so may result in battery electrolyte leakage.

2.6 SETTING THE ALARM

The alarm level is variable from zero to beyond the limit of the scale. It is set by using a test source to give the desired level and adjusting the front panel control with a small screwdriver. The alarm resets when the radiation level falls below the trip level. If the control is turned fully clockwise the alarm is disabled for all levels on the scale. The alarm is not disabled for overload conditions providing this adjustment is correctly made: see section 5.5. In addition the alarm is not switched out by the ‘speaker off’ position.

3. RESPONSE TO RADIATION

The monitors are calibrated against exposure using a ^{137}Cs source traceable to national standards. Tests are made at four points on the scale plus overload to satisfy UK recommendations and to check compliance with IEC document 395. For practical reasons these tests are carried out on the basis that 1 Sievert equals 100 Roentgens exposure.

You are strongly advised to have the monitor response checked at least yearly. This can be carried out by the company.

3.1 MODEL R

The G-M tube is mounted, together with its compensating shields, in a thin walled aluminium tube. The sensitive length is 20mm.

Figure 1 shows the relative energy response of a sample tube.

Figure 2 shows the polar response at 60keV. The response improves at higher energies.

A paralysis time of 50µs is included in the scaling of the meter. The correction does not exceed 25% at full scale.

Response to other ionising radiation. The monitor detects radiations other than X and γ rays. The response quoted below is defined as scale reading divided by true equivalent dose rate.

Soft β	negligible
Hard β	0.02
Neutrons ($^{241}Am/Be$)	0.03

Response time This is the time taken for the meter to indicate 63% of a sudden tenfold change in radiation level.

Doserate change	Response time
1 - 10	8s
10 - 100	3s
100 – 1000	1.5s

Transport index To assist in the use of this instrument for measurement of packets and containers in transport the transport index (TI) at 1 metre is marked on the scale below the ‘replace battery’ sector.

3.2 MODEL G

The G-M tube is nearly 20 times more sensitive that the type ‘R’ tube and is energy compensated for radiation normal to the axis. In practice, a tilt of +45º makes only a small percentage difference to the reading.

Figure 3 shows the relative energy response of a sample tube.

Owing to the large size of the tube, care should be taken in the interpretation of measurements made in divergent radiation. Point sources should not be brought closer than one metre to the axis to keep errors below 5%.

The scale has been corrected to compensate for a paralysis time of 200µs.

Response to other ionising radiation. The monitor detects radiations other than X and γ rays. The response quoted below is defined as scale reading divided by true equivalent dose rate.

Soft β	negligible
Hard β	0.001
Neutrons (4-5MeV)	<0.01

Response time This is the time taken for the meter to indicate 63% of a sudden tenfold change in radiation level.

Doserate change	Response time
0.1 – 1	12s
1 – 10	2s
10 – 100	0.5s

Internal background. The 900G tube has an internal background count of approximately 0.46 counts s^{-1}. The special 900GL tube has a background of approximately 0.18 counts s^{-1}. These correspond to 0.033µSvh^{-1} and 0.013µSvh^{-1} respectively. This should be taken into account when measuring low background rates.

3.3 MODEL D

The instrument is scaled from 0.1 to 1000μSvh-¹. It uses a γ compensated end window G-M tube where the energy compensation is provided by a combination of copper, tin and plastic filters. The thin window is only partially obscured by the filters, a feature which enables the 900'D' to maintain a useful response down to 17.5keV where the response factor is typically 0.5 relative to ^{137}Cs.

Figure 4 shows the photon energy response of the G-M tube. The response is normalised to 0.662 MeV (^{137}Cs) and has a range of 30 keV to 1.25 MeV +20%/-12%. This response was obtained with the radiation flux incident on the front face of the probe in the axial plane of the G-M tube. This is the normal operating position for making measurements.

The monitor has an internal paralysis time of 75μs giving a counting loss of less than 20% at 1000μSvh-¹. No correction need be applied as the meter scaling includes a correction.

Directional response

The directional (polar) response is summarised below.

E(keV)	Maximum deviation from normal Incidence over first 45°
65	+7% to – 12%
100	+2% to – 6%
161	0% to – 9%
662	0% to – 10%

At lower energies the variations in directional response will be greater. To reduce the error always try to point the probe directly at the source of radiation.

Response to other ionising radiation The monitor detects radiation other than X and γ rays. The response quoted below (**with the cap off**) is defined as the scale reading divided by the true dose equivalent rate.

$^{90}Sr/^{90}Y\beta$	0.8
Neutrons ($^{241}Am/Be$)	0.03

A substantial part of the G-M tube window (superficial density 1.5-2.0mg cm^{-2}) is not covered by the γ compensating filters. The monitor will therefore respond to β radiation of 150keV and above. Care should be taken when interpreting the monitor readings in the presence of poorly shielded β sources. When γ and β radiation are present together the monitor will generally overestimate the doserate. The response shown below (**with the cap off**) is defined as the scale reading (μSvh^{-1}) divided by the skin doserate (μSvh^{-1}).

Nuclide	Distance (cm)	E(max MeV)	Response
$^{90}Sr/^{90}Y$	30	2.20	0.54
^{204}Tl	30	0.76	0.24
^{147}Pm	20	0.22	0.22

End cap over the energy range 30keV to 1.25MeV the protective end cap can remain n place. At 30keV the difference between cap on and cap off response is about 3%. At higher energies the attenuation is negligible. With the cap in place, only those beta particles with an energy above 400keV will be detected.

Response time This is the time taken for the meter to indicate 63% of a sudden tenfold change in radiation level.

Doserate change	Response time
1 - 10	3.5s
10 – 100	2s

4. PRECAUTIONS IN USING RADIATION MONITORS

The company believes it has taken all reasonable precautions to ensure that the correct use of this monitor does not endanger the health and safety of any person but it is essential that persons should be trained to interpret the results sensibly and be aware of the limitations of the monitor.

To help the operator some of these limitations are described below.

(a) Make sure that the battery is in good order. Do not perform the battery check too hastily or it will not give a true indication of battery condition.

(b) Make sure that the monitor is working by noting if it is responding to background. It is sensible to check the monitor with a radioactive source to see if it is giving the expected reading and audible signal. The test source need not be traceable but a consistent source-to-tube geometry should be maintained.

(c) The probe determines the performance of the monitor. Make sure the correct probe is chosen for the radiation you wish to monitor. Remember that the 'R' and 'G' monitors have a sharp cut off below about 50keV and should not be used to measure soft X-rays from low voltage equipment.

(d) Some X-ray machines and particle accelerators produce radiation in short pulses. If the intensity of the radiation in these pulses is sufficient to cause a response at a rate exceeding an order of magnitude less than the pulse repetition frequency then non-linearity of response will occur. At the limit the monitor indicates pulse repetition frequency and not the radiation intensity.

(e) Owing to the nature of the tube construction a pencil beam does not give a true reading. The entire probe must be within a flux of constant intensity.

(f) The monitors are not suitable for the measurement of contamination or β dose rate.

(g) The meter reading of G-M tube monitors is prone to fall back at very high radiation levels. The monitor contains an overload circuit to maintain full meter reading but its operation depends upon correct adjustment of an internal control. Users should occasionally check that full scale is maintained at high radiation levels. Do not try to estimate a reading off scale.

(h) The monitor is not intrinsically safe and must not be used in potentially explosive atmospheres.

(i) All probes are fragile. If you drop the probe it may not work again.

(j) The monitor is not ruggedised and will not work if dropped into a pond or run over by a bus!

5. MAINTENANCE

The instructions that follow are written to help owners make certain repairs themselves. An expertise beyond that necessary to operate the monitor may be required and the company cannot be responsible for damage incurred to monitors or persons while carrying out these instructions. If there is doubt the monitor should be returned to the manufacturer.

If the monitor fails after having checked the battery then access to the components and pre-set controls is obtained by removing the front panel.

The components are mounted on a printed circuit board attached to the meter and switch.

5.1 G-M TUBE REPLACEMENT

The model 'G' probe is a sealed assembly and repair is only possible after returning it to the factory. The G-M tube in the 'R' and 'D' models may be replaced by the user. Both need a special tool to remove the circlip (Anderton type HD2) but long nosed pliers will do. On the model 'R' make a note of how the connections are made to the pins on the tube base as a reversal will damage the tube.

For the model 'D' remove the circlip from the probe housing using a suitable tool. Withdraw the G-M tube/spring assembly and disconnect the anode and cathode leads. The anode clip can be simply pulled off but the cathode lead has to be unwrapped from the spring. When re-connecting the cathode lead use plastic insulating tape to secure it in place. During replacement operations it is a good idea to keep the protective transit cap on the tube.

If the discarded tube is identical to the replacement tube then it is likely that none of the internal controls will require adjustment. However, you may be statutorily required to check the response. In particular you must ensure that the overload control is correctly set. See section 5.5.

5.2 METER ZERO ADJUSTMENT

The mechanical zero is set on the meter barrel and any adjustment must be made with the monitor switched off. The pointer must rest at approximately 1mm below the scale zero. With the monitor switched on the electrical zero control R34 is now adjusted to bring the pointer back to the scale zero. Owing to background radiation it must be adjusted with the G-M tube disconnected. Allow several minutes for the meter to settle before making the adjustment.

5.3 METER CALIBRATION

The calibration potentiometer R31 is situated at the bottom centre of the printed circuit board. To recalibrate inject square pulses of a few volts via a 100pF (2kV) capacitor into the G-M tube input pin (junction of R22/C14). The pulse repetition rate will need to be corrected to allow for paralysis time correction built into the scale. The table below relates the scale with the pulse repetition frequency (PRF).

This correction is shown in the table below:

Model R Scale reading μSv h^{-1}	**PRF**	**Model G/GL Input pulse frequency μSv h^{-1}**	**PRF**
5000	3114	75	1016
2000	1427	50	727
1000	749.7	10	164
100	78.58	1	16.9
10	7.90	0.1	1.7

Model D Scale reading μSv h^{-1}	**PRF**
1000	1925
500	1037
100	221
50	112
10	22

5.4 HV SUPPLY

The detector HV supply can be varied from 300 to 650 volts. The control for adjusting the HV is R18. Anti-clockwise rotation increases the potential. The voltage is best measured using a high resistance meter, at least 20kohm/V, connected between the junction of R22/C11 and 0V. The required operating voltage is 450V for the model ‘G’ and 550V for models ‘R’ and ‘D’.

5.5 OVERLOAD SETTING

An overload circuit ensures that the meter pointer remains over maximum deflection for radiation intensities exceeding many times the maximum scale reading. The adjustment depends on the HV setting and G-M tube and must be done whenever either is changed. The control for setting the overload alarm point is the potentiometer R20.

To adjust the alarm set the function switch to the ‘speaker off’ position and turn the control fully anti-clockwise. Using a strong source send the meter well over the maximum scale mark, adjust the control to sound the alarm. Check that the alarm stops sounding when the source is moved to a position where the reading is equal to the maximum scale mark on the meter. If necessary re-adjust the control until this condition is met. In case of difficulty the company should be consulted.

5.6 CLEANING AND DECONTAMINATION

Use a damp cloth with mild detergent, or proprietary anti-static foam cleaner (Amberclens).

6. SERVICE & GUARANTEE

With normal care and attention this monitor should give many years service. If any fault occurs to the monitor within two years of purchase (one year for the detector) that is due, in our opinion, to a manufacturing defect then it will be repaired or replaced without charge.

If a fault occurs outside the guarantee period the company or its agents will service the monitor. A note explaining what you believe to be wrong is often helpful. If the customer wishes to repair the fault the company will give technical help. However the company does not wish to abrogate its prime responsibility to its customer to third parties and service organisations. If these organisations are employed we would ask for the monitor to be forwarded to us, untampered with, for service. Overseas customers should return instruments by air parcel post, not air freight.

The company will not be responsible for damage or loss occurring in transit to the company whether or not properly packed but emphasis cannot be made strongly.

The address is:

Service Department
Thermo Fisher Scientific
Bath Road
Beenham
READING RG7 5PR
Berkshire
ENGLAND

Telephone:	0118 971 2121	National
	+44 118 971 2121	International
Fax:	+44 118 971 2835	

7. CIRCUIT DESCRIPTION

The circuit diagram is given at the end of the manual. The circuit operation is as follows:

(a) **Battery input stabilising circuit.** The line voltage of the monitor is 5.8 ± 0.2 volts and is set by the reference diode D4. Ic2 is the comparator coupled to the series control TR1.

(b) **HV Converter** Transistor. TR4 coupled to the transformer T1 forms the flyback converter circuit. IC3 forms a gated oscillator to provide the drive for TR3 and TR4. The output voltage is stabilised by negative feedback via a resistive divider to a gate in IC3 which controls the oscillator frequency. Adjustment to the divider and hence the HV level is provided by R18. The waveform across the secondary winding of T1 is half wave rectified to provide the detector voltage. Voltage doubling is used for the scintillation monitors and detectors operating above 600V.

(c) **Input amplifier** TR5 and TR6 from an amplifier with a gain determined by feedback. It reverses the phase of the input pulse and supplies a positive signal to a monostable circuit IC4b which determines the paralysis time. The input requires negative pulses exceeding 100mV into approximately 3000 ohms.

(d) **Ratemeter circuit** Two analogue outputs from IC5 are combined to give a signal nearly proportional to the log of the input pulse rate. This output is applied to an operational amplifier IC6a which drives the meter. The potentiometer R31 sets the meter scale and R34 the meter zero.

(e) **Audio output** The speaker derives its power from IC7 which produces a 300μs pulse when triggered by the monostable (IC4b). This connection is switched at the front panel to suppress a pulse output. A similar but unswitched connection from the comparator sets off the timer to give the alarm.

(f) **Comparator** The comparator IC6b compares the potential on the set alarm control with an output from the meter amplifier IC6a. If the latter is greater the comparator trips and sets off the timer. A little hysteresis is applied to smooth out the random nature of the input.

(g) **Overload circuit** Excess current drawn through the probe when in a radiation flux exceeding many times the scale limit causes the comparator formed by IC3d to trip thus maintaining the deflection of the meter. The potentiometer R20 sets the limit when this occurs.

8. SPECIFICATION

Case size	165mm high, 180mm wide, 110mm deep
Weight	1.0 kg
Material	Coated aluminium
Battery (6 cells)	Normal AA cells IEC type R6 Alkaline cells IEC type LR6 Rechargeable cells IEC KR15/51
Battery life (at 4h/day)	Normal cells 150 hours Alkaline cells 300
HV supply	Approx. 300-650V at 50 μA max
Response time	See section 3
Accuracy	IEC 395 Class 2
Linearity	±10% over first 75% of scale
Meter	Taut band 0.5mA full scale over 65mm
Ambient temperature	-10 to +40 deg. Celsius
Relative humidity	Up to 85% non-condensing
Detector type	Halogen-quenched G-M tube

Model dependent characteristics

	R	G	D
Measurement Range	0.5-5000	0.05-75	0.1-1000μSvh-¹
Energy range	45keV-1.25MeV	55keV-1.25MeV	30keV-1.25MeV
Paralysis time (μS)	55	180	75
Coefficient of variation 10% at:	7	0.5	2.5μSv h-¹
Sensitivity in counts s-¹/μSv h-¹ (^{137}Cs)	0.95	14	2.2

9. COMPONENTS LIST

Resistors

All resistors MFR4 unless otherwise stated.

R1	330R	R25	4K7
R2	27R	R26	39K
R3	390R	R27	22K
R4	47K	R28	See table below
R5	6K8	R29	1M0
R6	82K	R30	1M0
R7	22K	R31	2K0 potentiometer
R8	4M7	R32	7K5
R9	100K	R33	180R
R10	470R	R34	100K potentiometer
R11	330K	R35	180R
R12	68R	R36	82K
R13	180R	R37	10K
R14	10R	R38	10K
R15	400M thick film	R39	24K
R16	220K PR01	R40	10K
R17	1M8	R41	330K
R18	2M0 potentiometer	R42	22K potentiometer
R19	See table below	R43	4M7
R20	220K potentiometer	R44	47K
R21	1M0	R45	47K
R22	1M0 PR01	R46	10K
R23	3K3	R47	120K
R24	10K		

Capacitors

C1	100nF ceramic	C14	1n0F ceramic 2kV
C2	47nF ceramic	C15	4n7F ceramic
C3	470µF electrolytic	C16	1n0F polystyrene
C4	100nF ceramic	C17	See table below
C5	22nF ceramic	C18	See table below
C6	220pF polystyrene	C19	See table below
C7	100nF ceramic	C20	See table below
C8	6n8F ceramic 2kV	C21	100nF ceramic
C9	Not fitted	C22	4n7F ceramic
C10	Not fitted	C23	100nF ceramic
C11	6n8F ceramic 2kV	C24	4n7F ceramic
C12	100nF ceramic	C25	100nF ceramic
C13	100µF electrolytic	C26	2n2F polystyrene

Diodes

D1	IN4001	IC1	LM317
D2	BZX83C9V1	IC2	7611DCPA
D3	IMO5120	IC3	HEF4001
D4	ICL8069	IC4	HEF4013
D5	IN4148	IC5	HEF4066
D6	IN4148	IC6	LM392N
D7	BY584	IC7	TLC555CP
D8	See table below		
D9	See table below		
D10-15	IN4148		

Transistors

TR1	BC328	M1	500 µA taut band moving coil
TR2	BC548B		
TR3	BC558		
TR4	BC639		
TR5	BC548B		
TR6	BC548B		

Model dependent component values

		R	G	D
R19		47K	47K	100K
R28		68K	300K	120K
C17	polystryrene	2n2F	6n8F	6n8F
C18	polystryrene	100nF	330nF	330nF
C19	electrolytic	10µF	22µF	10µF
C20	electrolytic	2µ2F	2µ2F	4µ7F

10. PARTS LIST

900116A	900 Basic PCB Assembly

11. DRAWING

900117	900 Circuit Diagram

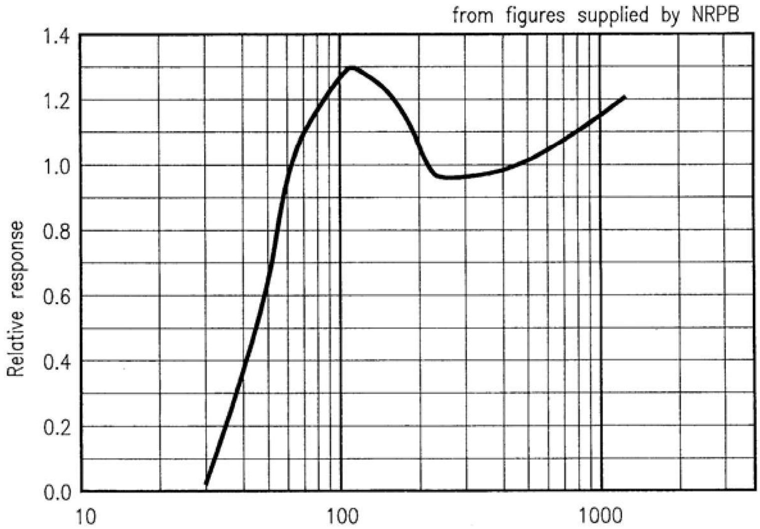


Fig. 1 Photon energy response (air kerma) in keV of type model G dose rate meter normalised to 1.00 at 137Cs.

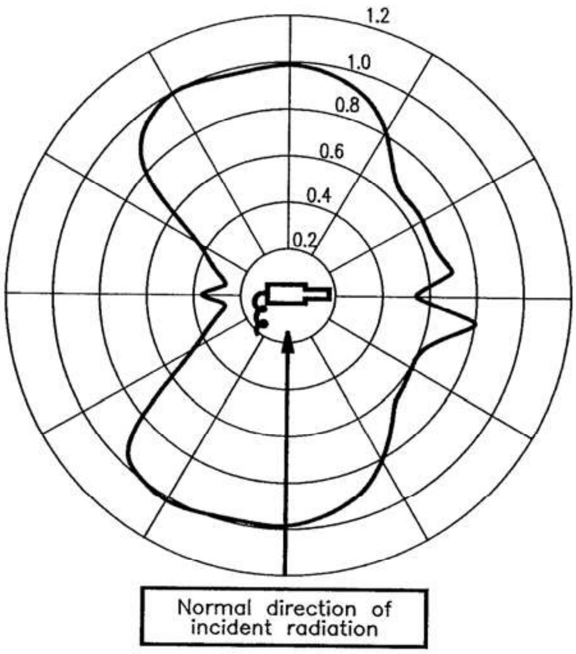


Fig. 2 Polar response of the model R dose rate meter to 60 keV ^{241}Am γ rays with figures supplied by NRPB

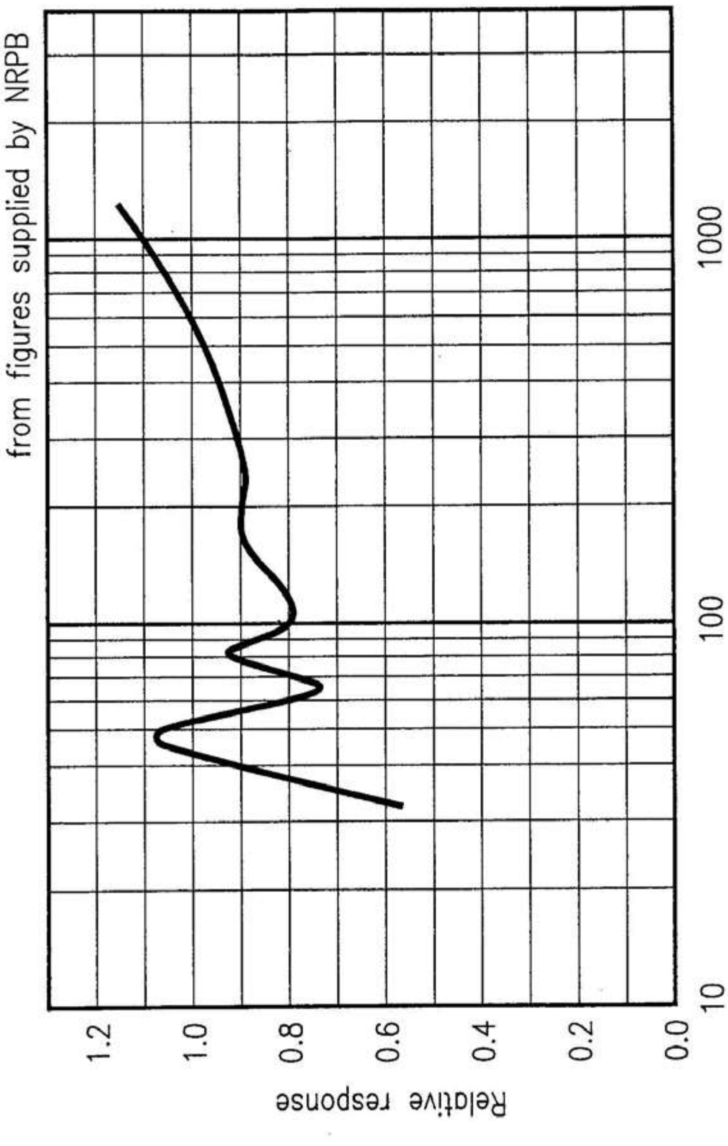


Fig. 3 Photon energy response (air kerma) in keV of type model R dose rate meter normalised to 1.00 at 137Cs.

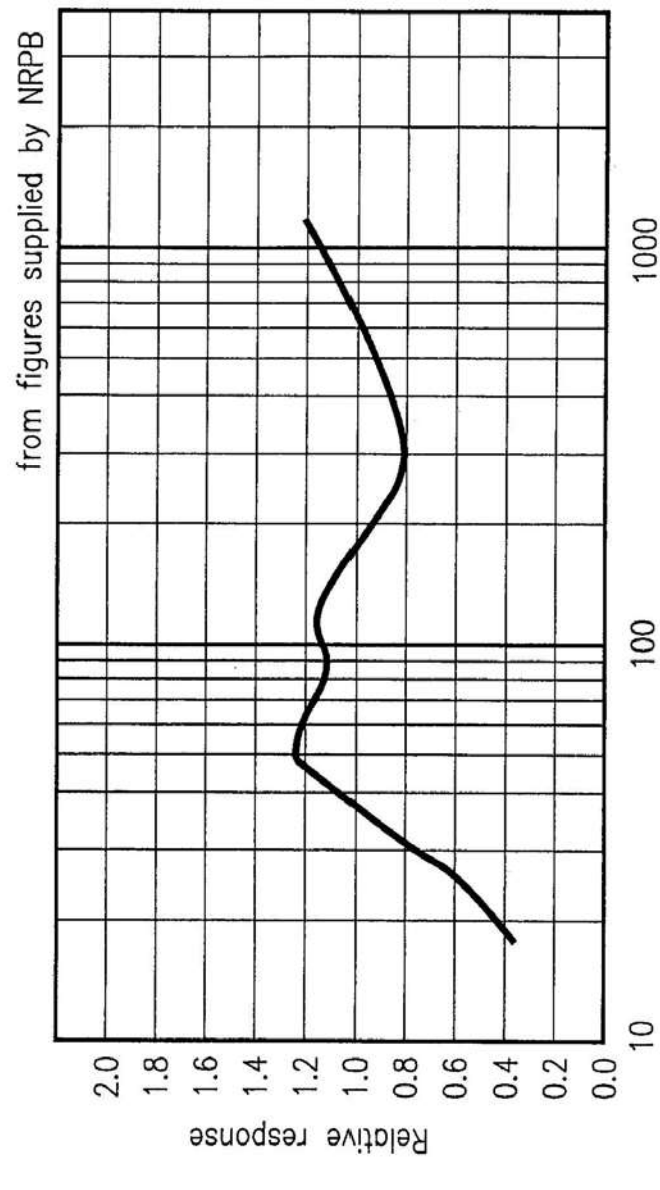
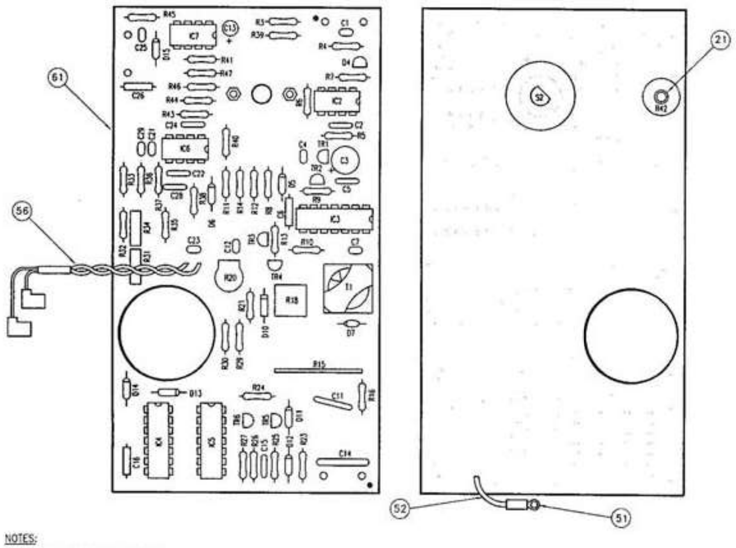


Fig. 4 Photon energy response (air kerma) in keV of type model D dose rate meter normalised to 1.00 at 137Cs.



ITEM	DWG. No.	DESCRIPTION	QTY	NOTES
52	00001065	WIRE 32/0.2mm WHITE	0.03	
53	00001142	CAPACITOR CERAMIC 0.1uF 63V	8	C1,4,7,12,21,23,25,29
54	000065.1	CAPACITOR CERAMIC 22pF 100V	1	C5
55	000331.1	INTEGRATED CIRCUIT ICL7611DCPA	1	IC2
56	000405.2	LEAD METER 900 SERIES	1	
57	000548.1	POTENTIOMETER 2K 3386H-1-202	1	R31
58	000569.1	POTENTIOMETER 2M 3386F-1-205	1	R18
59	000613.1	RESISTOR M/F 68R MFR4 1%	1	R12
60	000640.1	RESISTOR M/F 7K5 MFR4 1%	1	R32
61	MS3247	900 PCB & PINS ONLY	1	
62				
63				

ITEM	DWG. No.	DESCRIPTION	QTY	NOTES
1	00000072	CAPACITOR CERAMIC 1n0F HD16 2KV	1	C14
2	00000075	CAPACITOR CERAMIC 4n7F 63V	4	C15,22,24,28
3	00000076	CAPACITOR CERAMIC 6n8F 2KV	1	C11
4	00000078	CAPACITOR CERAMIC 47nF 100V	1	C2
5	00000091	CAPACITOR ELECTROLYTIC 100uF 6.3V	1	C13
6	00000098	CAPACITOR ELECTROLYTIC 470uF 16V	1	C3
7	00000126	CAPACITOR POLYPROPYLENE 220pF 630V	1	C6
8	00000130	CAPACITOR POLYSTYRENE 1000pF 250V	1	C16
9	00000132	CAPACITOR POLYPROPYLENE 2200pF 250V	1	C26
10	00000201	DIODE 1N4002RL	1	D10
11	00000202	DIODE 1N4148	7	D6,8,11,12,13,14,15
12	00000204	DIODE BY584	1	D7
13	00000213	DIODE 8069 VOLTAGE REF	1	D4
14	00000300	INTEGRATED CIRCUIT CMOS HEF4001BP	1	IC3
15	00000302	INTEGRATED CIRCUIT CMOS HEF4013BP	1	IC4
16	00000305	INTEGRATED CIRCUIT CMOS HEF4066B	1	IC5
17	00000311	INTEGRATED CIRCUIT TIMER TLC555CP	1	IC7
18	00000326	INTEGRATED CIRCUIT LM392N	1	IC6
19	00000380	LABEL POSITIVE STICKER	2	
20	00000512	PINS TRACK	14	
21	00000541	POT SPINDLE CODE 1 058603	1	
22	00000558	POTENTIOMETER 22K PT15NV 17.5	1	R42
23	00000563	POTENTIOMETER 100K 3386H-1-104	1	R34
24	00000566	POTENTIOMETER 220K PT10LV	1	R20
25	00000601	RESISTOR C/F 4M7	2	R8,43
26	00000609	RESISTOR M/F 10R MFR4 1%	1	R14
27	00000618	RESISTOR 180R MFR4 1% 50PPM	3	R13,33,35
28	00000622	RESISTOR M/F 390R MFR4 1%	1	R3
29	00000623	RESISTOR M/F 470R MFR4 1%	1	R10
30	00000635	RESISTOR M/F 3K3 MFR4 1%	1	R23
31	00000637	RESISTOR M/F 4K7 MFR4 1%	1	R25
32	00000640	RESISTOR M/F 6K8 MFR4 1%	1	R5
33	00000643	RESISTOR M/F 10K MFR4 1%	5	R24,37,38,40,46
34	00000648	RESISTOR M/F 22K MFR4 1%	2	R7,27
35	00000649	RESISTOR M/F 24K MFR4 1%	1	R39
36	00000653	RESISTOR M/F 39K MFR4 1%	1	R26
37	00000654	RESISTOR M/F 47K MFR4 1%	3	R4,44,45
38	00000658	RESISTOR M/F 82K MFR4 1%	2	R6,36
39	00000659	RESISTOR M/F 100K MFR4 1%	1	R9
40	00000661	RESISTOR M/F 120K MFR4 1%	1	R47
41	00000663	RESISTOR M/F 220K MFR4 1%	1	R16
42	00000666	RESISTOR M/F 330K MFR4 1%	2	R11,41
43	00000673	RESISTOR M/F 1M MFR4 1%	3	R21,29,30
44	00000686	RESISTOR 400M THICK FILM 1%	1	R15
45	00000870	SWITCH ROTARY 900 SERIES	1	S2
46	00000907	TRANSFORMER 900/1000 SERIES	1	T1
47	00000916	TRANSISTOR BC327	1	TR1
48	00000918	TRANSISTOR BC548B	3	TR2,5,6
49	00000919	TRANSISTOR BC558B	1	TR3
50	00000921	TRANSISTOR BC639	1	TR4
51	00001062	CONNECTOR 4BA/M3.5	1	

NOTES:

1. SAMPLE NUMBER IS SAM9063

ISSUE	1	2	3	4	5	6
DATE	07/90	09/92	01/97	07/00	07/02	08/02
CHANGE NOTE	---	000215	001038	REDRAWN	002326	002325

Thermo
ELECTRON CORPORATION

A2

PROJECTION THIRD ANGLE | DRAWN TO BS 308 | SCALE | UNITS mm

DIMENSIONS APPLY AFTER PLATING

TOLERANCES (EXCEPT WHERE STATED) LINEAR DIMENSIONS | HOLES | ANGLES | SURFACE

APPROVED: m. R. D | MATERIAL

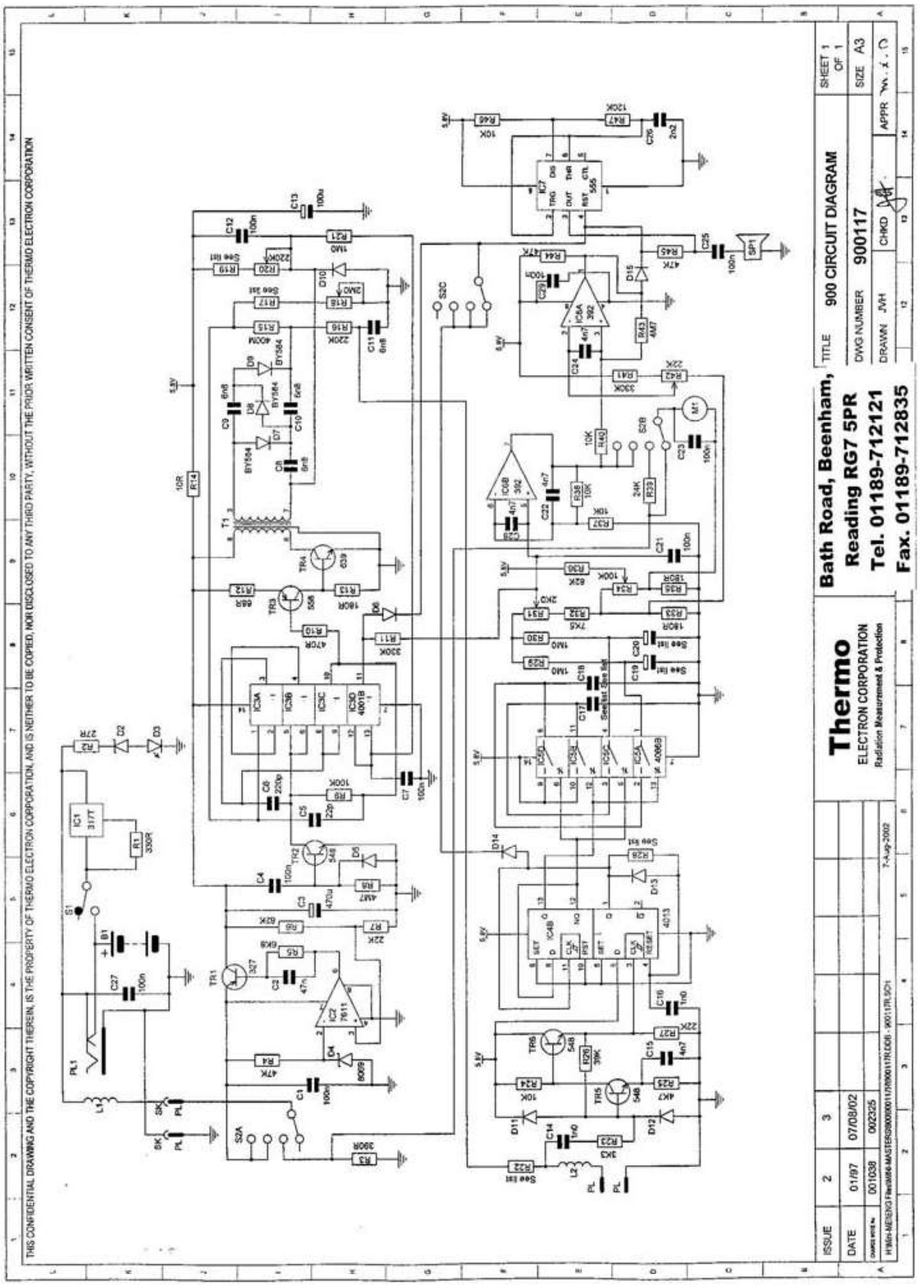
CHECKED | FINISH

DRAWN: TJSH

TITLE Mini-Instruments
900 BASIC PCB ASSEMBLY

PART No. MS3244S

DRAWING No. 900116A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TITLE 900 CIRCUIT DIAGRAM
DWG NUMBER 900117
DRAWN JVH
SHEET 1 OF 1
SIZE A3
Thermo
ELECTRON CORPORATION
Radiation Measurement & Protection
Bath Road, Beenham,
Reading RG7 5PR
Tel. 01189-712121
Fax. 01189-712835
ISSUE 2 3
DATE 01/97 07/08/02
001038 002325

MINI-INSTRUMENTS LIMITED

MINI-MONITOR

MINALARM
TYPE 7-10 ALARM MONITOR

Our instruments are subject to continuous development and minor changes in detail may occur which are not incorporated in this manual.

Issue 2
March, 1992

CONTENTS

1. INTRODUCTION

The 7-10 series of alarm monitors are mains driven instruments designed to give a continuous assessment of radiation intensity in the vicinity of the detector.

An alarm is sounded if the radiation level exceeds a pre-set value set by the operator. Additional relay contacts are provided for an external alarm or lamp. An analogue output is also available for driving a slave meter or chart recorder. There are extensive fail-safe facilities.

The series is available as six models. With the exception of the 7-10C all models use compensated G-M tubes. The models are:

Model	Detector type	Meter scaling
7-10R	MC10	0.5 to 5,000μSv h^{-1} (0.05 – 500mR h^{-1})
7-10RL	MC20	0.5 to 1,000μSv h^{-1} (0.05 – 100mR h^{-1})
7-10D	900D	0.5 to 1,000μSv h^{-1} (0.05 – 100mR h^{-1})
7-10G	MC70	0.05 to 75μSv h^{-1} (0.005 – 7.5mR h^{-1})
7-10GL	MC71	0.05 to 75μSv h^{-1} (0.005 – 7.5mR h^{-1})
7-10C	specified by user	0.5 to 2,000 counts s^{-1}

Models G, R and RL are general purpose gamma alarm monitors. The 7-10D detector has an extended low-energy response and is useful for monitoring X-ray apparatus operating down to 50 kV(p). The 7-10GL is similar to the 7-10G but is modified for environmental monitoring and uses the MC71 tube which has a low intrinsic background count.

The 7-10C is intended for applications where the customer has supplied the detector or another type of Mini-Instruments probe is used.

2. INSTALLATION

2.1 Mains supply and fuses

There is no mains switch so the instrument is ON when connected to the mains supply. The instrument is supplied with a mains cable fitted with a plug appropriate to the local standard. Should it be necessary to use an alternative mains connector the cable is colour coded as follows: green/yellow = earth (ground), blue = neutral, brown = live.

The instrument can be wired for a supply of 200-250V or 100-125V at 50-60Hz alternating current. A label by the input connector indicates the factory voltage setting. Check that this is set correctly for your local supply otherwise refer to section 7.1. **For safe operation this instrument MUST BE EARTHED (GROUNDED).**

The mains fuses are housed in the connector housing and are 20mm size.

For 100-125V operation 100mA anti-surge
For 200-250V operation 50mA anti-surge

2.2 Rechargeable battery

A switch for isolating the internal back-up battery is located on the back panel. Before packing and shipment the switch is placed in the OFF position. When the instrument is first connected to the mains, switch the battery ON to allow the battery to charge. On receipt the battery will be in a discharged condition so it will be necessary to leave the instrument connected to the mains for at least 12 hours to facilitate complete recharging. **To prevent damage to the battery it is advisable to switch the battery OFF when the instrument is not in use.**

2.3 Mounting

The instrument is designed to be bench or wall mounted. There are two slots on the rear panel for fixing with roundhead screws (No 8, shank diameter 4mm) spaced 150mm apart. Drive the screws into the wall leaving a gap of about 7mm between the underside of each screw and the wall. The instrument then hangs correctly with the two rubber feet keeping the lower edge off the wall. Holes are provided in the detector clip for wall mounting. When fixing the cable with cable clips take care not to damage the cable insulation.

If the probe is to be used in the same vicinity as the instrument the bracket can be attached to the side of the case using the holes provided.

The connecting cable for the detector is normally supplied 3m long but can be up to 10m therefore allowing the detector to mounted away from the instrument.

Longer distances of up to 100m can be used in conjunction with a special pre-amplifier developed for this purpose. The pre-amplifier is powered from the detector HV supply and is simply inserted in the cable, preferably within 1m of the probe. Using a longer cable or pre-amplifier will have the effect of increasing the apparent dead-time of the probe. It is therefore essential to have the instrument and probe combination calibrated using the desired cable length.

3. OPERATING INSTRUCTIONS

3.1 Initial test

If the instrument is supplied with a detector all the necessary internal adjustments will have been made during manufacture. If you are using your own detector please refer to section 7.3 for advice on setting the high voltage (HV) and overload controls. First connect up the detector and connect the instrument to the mains supply. On applying the power the alarm sounds and the red light shows. If the detector is connected and set correctly then, within a short period, the alarm ceases and the green light shows, providing the radiation level does not exceed the pre-set trip level and the LATCH is OFF.

The initial delay in resetting the alarm depends on the arrival of the first pulse from the detector. If the alarm does not reset within 5 minutes a fault condition is indicated.

Depressing and releasing the TEST ALARM switch also resets the alarm and if a fault exists the alarm sounds after a short delay.

3.2 Alarm Trip Level Adjustment

The alarm trip adjustment control is located on the rear panel. First loosen the set screw above the slotted shaft then press the SET ALARM switch to display the level on the meter then, using a screwdriver, adjust the control. When the desired trip level has been set retighten the set screw. The alarm trip level may be put just beyond maximum scale reading. This disables the normal alarm facility but does not inhibit the overload alarm function.

3.3 Alarm Latch

With the LATCH switch OFF the alarm resets itself when the radiation level falls below the trip level. There is a small amount of hysteresis applied so the reset occurs at a point 10% to 20% lower than the initial trip setting. This reduces the effect of statistical fluctuations on alarm operation.

With the LATCH switch ON the alarm, once triggered, continues to sound regardless of the subsequent radiation level. The alarm can only be reset by manual operation of the LATCH switch. The TEST ALARM switch does not reset the alarm in this case.

3.4 Test Alarm

This function tests the operation of the instrument by injecting pulses into the input circuitry and activating the alarm. When the TEST ALARM switch is pressed the meter should read in the small green sector below the normal scale. At the same time the audible alarm sounds and the red light shows. When released, the switch resets the alarm if this has been initiated by a reduction in background or failure of the detector assembly. It does not reset the alarm if this is due to radiation exceeding the trip level.

The HV supply to the detector is switched off when the test function is activated.

4. INTERPRETATION OF THE MEASUREMENTS

4.1 7-10R

The MC10 G-M tube used on this model is energy compensated and is effective over a wide solid angle. Figure 1 shows the relative energy response of a typical production tube. The radiation flux is incident in a direction perpendicular to the axis of the tube. The response is normalised at 0.662MeV gamma radiation from ^{137}Cs.

The scale incorporates a correction for loss of counts resulting from the 60μs paralysis time.

4.2 7-10RL

The MC20 G-M tube used on this model is double the sensitivity of the 7-10R and is useful for monitoring radiation in the 1 to 10μSv h^{-1} range. The energy compensation is effective over the range 45keV to 1.2MeV with the radiation flux incident in a direction perpendicular to the axis of the tube. Refer to Figure 2.

A correction for loss of counts resulting from the 200μs paralysis time is incorporated in the scale.

4.3 7-10G

The MC70 G-M tube used on this model is about 8 times more sensitive than the MC20 (7-10RL). The tube is energy compensated for radiation normal to the axis and has the same response as the MC71 tube used with the 7-10GL.

Owing to the large size of this tube care should be taken in the interpretation of measurements made in divergent radiation. Point sources should not be brought closer than 1m from the axis to keep geometric errors to less than 5%.

The G-M tube produces a small intrinsic background equivalent to approximately 0.03μSv h^{-1} which should be subtracted from the scale reading. In practice the correction is usually insignificant and can be ignored. At high intensities the counting loss arising from the 200μs paralysis time is incorporated in the meter scaling.

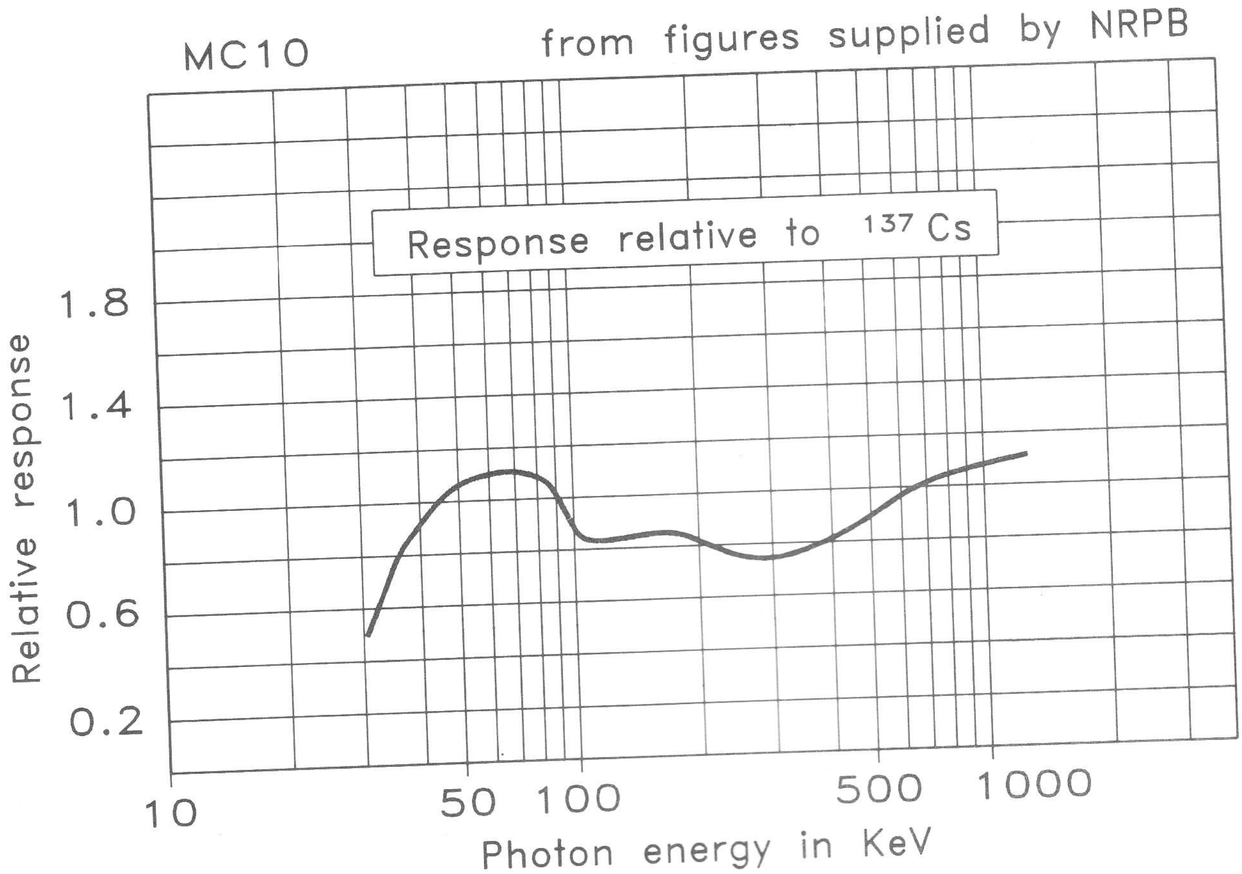

MC10
from figures supplied by NRPB
Response relative to 137 Cs
1.8
1.4
1.0
0.6
0.2
Relative response
10
50 100
500 1000
Photon energy in KeV

FIG 1

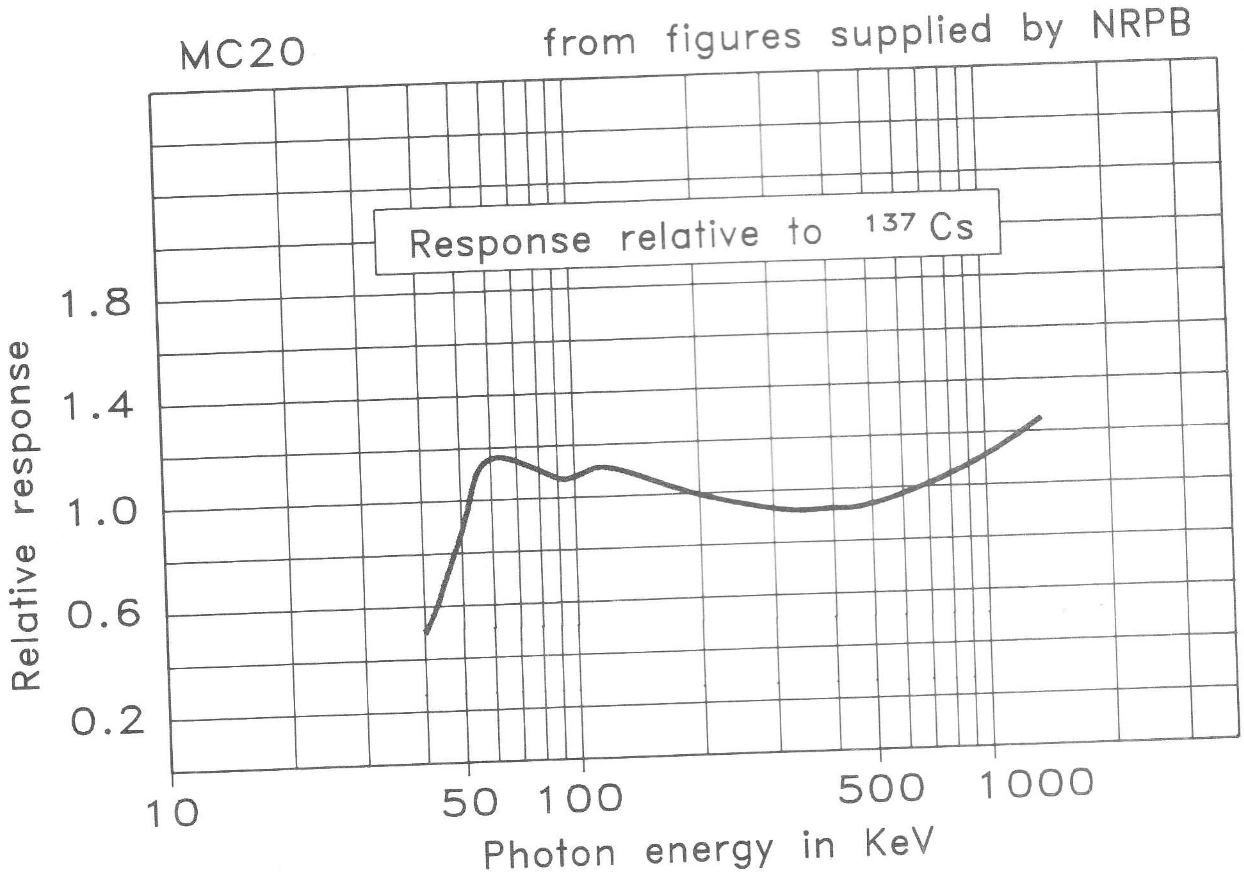

MC20
from figures supplied by NRPB
Response relative to 137 Cs
1.8
1.4
1.0
0.6
0.2
Relative response
10
50 100
500 1000
Photon energy in KeV

FIG 2

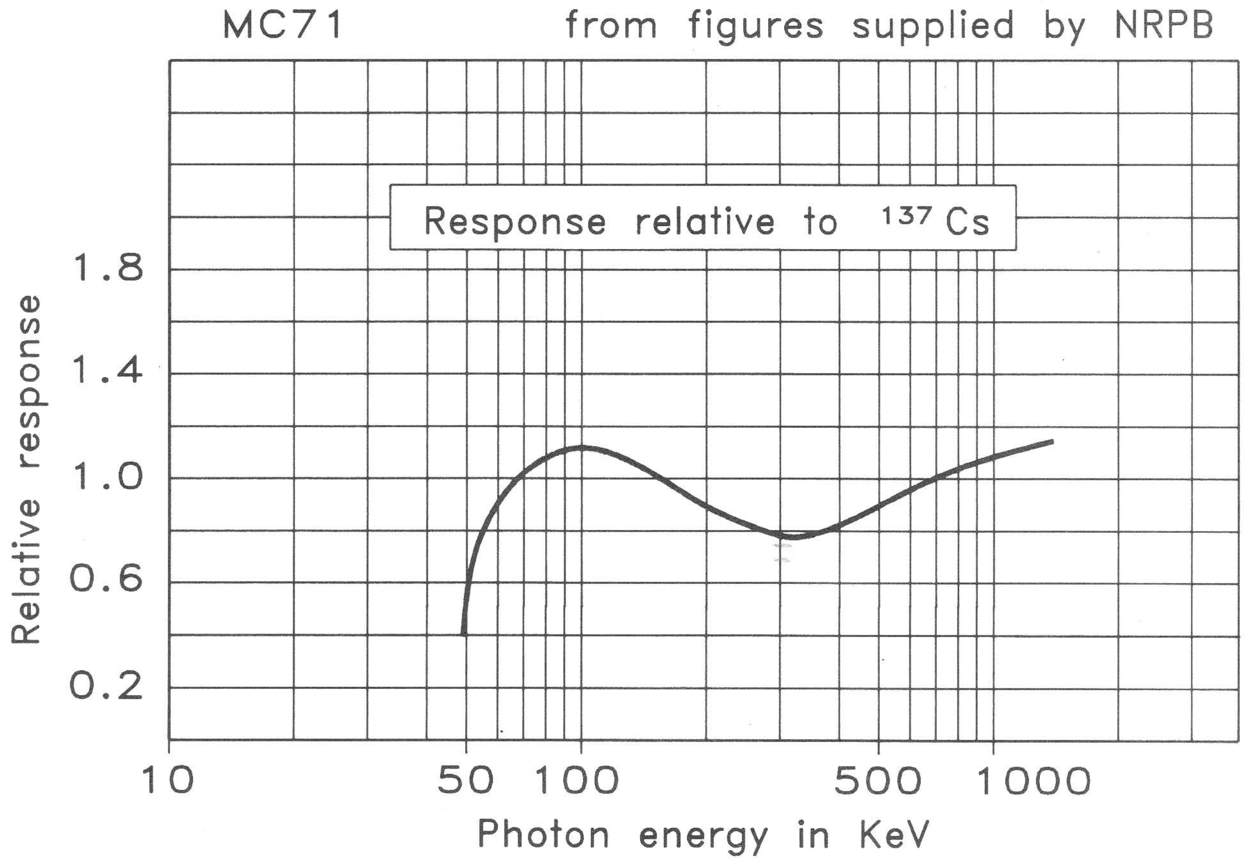

MC71
from figures supplied by NRPB
Response relative to 137 Cs
1.8
1.4
1.0
0.6
0.2
Relative response
10
50
100
500
1000
Photon energy in KeV

FIG 3

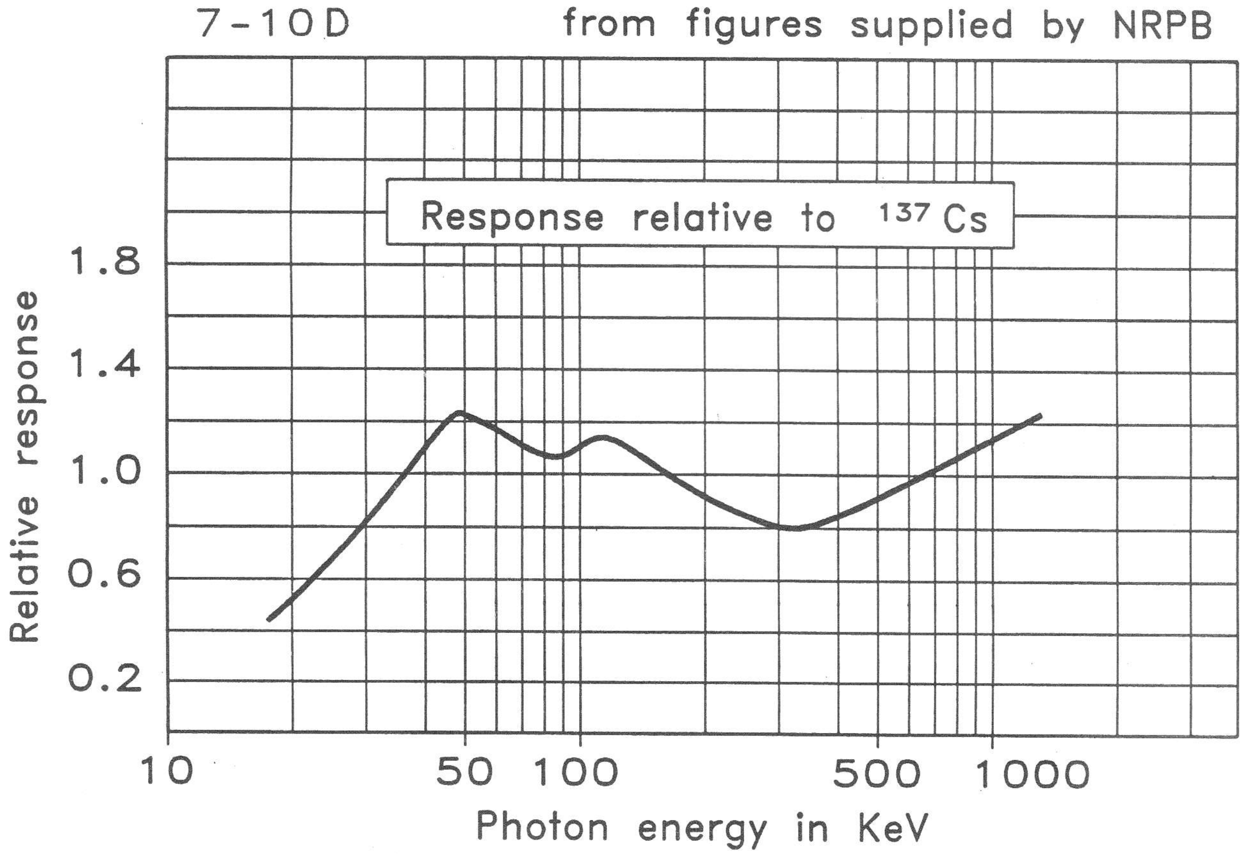

7-10D
from figures supplied by NRPB
Response relative to 137 Cs
1.8
1.4
1.0
0.6
0.2
Relative response
10
50
100
500
1000
Photon energy in KeV

FIG 4

4.4 7-10GL

This model is similar to the 7-10G but incorporates some modifications to fulfil the role of a continuous environmental background monitor.

The MC70 G-M tube is replaced by the MC71. This is a low intrinsic background version and is therefore more appropriate for the measurement of natural background levels. The tube is energy compensated for radiation normal to the axis and figure 3 shows the relative energy response of a typical production tube.

The ratemeter time constant has been increased from 10 to 100 seconds. This allows the alarm to be set close to the natural background level without a high incidence of false alarms. The following calculated figures show the predicted false alarm frequency at different alarm level settings. The figures are derived assuming a *constant* background of 0.1μSv h^{-1}.

Tube sensitivity	16 counts s^{-1} for 1μSv h^{-1} (^{137}Cs)
Sample size n	100 x 16 x 0.1/0.693 = 231 counts
% standard deviation	$\sqrt{n}$/ (n/100) = 6.6%
Set alarm at:	Probability of false alarm
3 x SD. = 0.120 μSv h^{-1}	one in 5 hours
4 x SD. = 0.126 μSv h^{-1}	one in 43 hours
5 x SD. = 0.133 μSv h^{-1}	one in 22 days
6 x SD. = 0.140 μSv h^{-1}	one in 340 days

It can be seen that an alarm level set about 1.5 times the background is unlikely to trip but small changes in the background can quickly erode this margin.

4.5 7-10D

The 7-10D detector is a partially compensated G-M tube type ZP1490. This extends the useful low-energy photon response down to 30keV. At this energy the response is approximately 0.75 relative to 662keV (^{137}Cs). At 17.4keV this figure falls to 0.5. Figure 4 shows the relative energy response with the radiation flux incident on the front face of the tube i.e. aligned with the radial axis of the tube. The response is normalised at 0.662MeV gamma radiation from ^{137}Cs.

It should be noted that the compensation is only effective over a relatively narrow angle so that care must be taken when siting the detector.

4.6 7-10C

The instrument scale is marked from 0.5 to 2000 counts s^{-1} so that you may connect your own detector. There is an internal paralysis time of 60μs which is incorporated in the meter scale. If the detector has a **longer dead time** then this should be used to calculate the true count rate in the normal way.

True count rate = Scale reading/1-Scale reading x dead time.

5. PRECAUTIONS IN USING THE MINALARM MONITOR

The company believes it has taken all reasonable precautions to ensure that the use of these instruments does not endanger the health and safety of any person. It is essential that persons using these instruments should be trained to interpret the results sensibly and be aware of their limitations.

To assist the operator some instrument limitations and suggestions for safe use are listed below.

a) It is important to ascertain that the instrument installed is suitable for the kind of radiation you intend to measure. **Energy compensated G-M tubes in the models 7-10R, RL, G and GL are not suitable where there is a high proportion of X or gamma energy below 50keV.** This applies to X-ray crystallographic machines and other apparatus with inherently low filtration. They are also unsuitable for monitoring alpha and beta radiation.

b) If possible, check the operation of the instrument regularly by using a small radioactive check source placed at a reproducible distance from the detector to see if it gives the expected reading. Occasionally check the fail-safe facilities for correct operation. Also, regardless of regulatory requirements, it is advisable to have the instrument calibrated on an annual basis.

c) Some X-ray machines and particle accelerators produce radiation in short pulses. If the intensity of these pulses is sufficient to cause a response at a rate exceeding an order of magnitude less than the repetition frequency then non-linearity of response will occur. In the limit the instrument indicates pulse repetition frequency, not the radiation intensity.

d) The use of the two front panel lamps is to provide a fail-safe indication. When the instrument is operating one or other lamp will show. If no lamps are showing the cause should be investigated immediately.

e) The instruments are not intended to be used at radiation levels in excess of the maximum scale reading. However, an overload circuit is incorporated to respond to accidental high levels of radiation thereby setting off the alarm.

f) Radiation detectors are fragile and if you drop the probe it may not work again.

g) The instrument is not fully sealed and must not be situated outdoors, exposed to high humidity or subjected to severe environmental conditions. It is not intrinsically safe and must not be used in potentially explosive atmospheres.

6. EXTERNAL FACILITIES

6.1 Meter output

If, in addition to the meter on the instrument, a second external meter or recorder is required an output is provided on the DIN socket. A signal of 1 volt for maximum scale reading is available at a maximum current of 1mA.

The pin connections, counting clockwise, on the socket are as follows:

meter positive	pin 1
ground or negative	pin 2

6.2 Alarm connections

A single pole double throw relay contact is provided to operate an external warning device. The normally closed contact signals the alarm condition thereby providing a fail-safe mechanism in the event of total power loss.

An external warning device must be powered by an independent supply if a full fail-safe facility is required. If remote alarm operation using the instrument power supply is acceptable an internal link can be used to apply approximately 12V to the relay common contact. The maximum current that can be drawn from this source is 15mA.

The output socket is only suitable for low voltage operation and **UNDER NO CIRCUMSTANCES MUST THIS BE CONNECTED TO THE MAINS SUPPLY.** The maximum rating is *24V d.c. at 1A.* The pin connections counting clockwise from the front socket are as follows:

made on alarm (NC)	pin 3
common contact	pin 4
made while safe (NO)	pin 5

The outer case is connected to ground.

7. MAINTENANCE

WARNING: LETHAL MAINS VOLTAGE IS PRESENT ON THE MAIN PRINTED CIRCUIT BOARD. To reduce the hazard of electrical shock it is recommended that the instrument be operated via an isolating transformer.

7.1 Mains supply adjustment

If it is necessary to alter the voltage setting first disconnect the mains supply and then carefully remove the front panel. At the mains entry to the printed circuit board near the transformer, there are two pairs of holes which take wire links so that the transformer primary windings can be connected in series or parallel. If the voltage is altered the fuses must be changed and the label on the outside of the case marked accordingly.

7.2 G-M tube replacement

The G-M tube is very fragile and a sharp knock may crack the internal seals causing it to fail. It can be replaced as follows:

a) **7-10R** The G-M tube is held in an anodised aluminium holder. When the circlip is removed the complete assembly can be withdrawn through the holder. It is now a simple manoeuvre to replace the tube but take care to connect the leads the right way round. The centre lead must be connected to the anode pin.

b) **7-10D** The procedure is similar to that employed with the 7-10R. When re-assembling the filters ensure that the correct order is maintained i.e. copper first followed by the tin and finally the plastic.

c) **7-10RL/G/GL** These are sealed units and field repair is not feasible. Uncouple from the cable and replace with a new assembly. Retain the old tube and return it to the company as repair is sometimes possible.

You are strongly advised to have the instrument re-calibrated if the probe is replaced. In the UK re-calibration would be required to ensure compliance with the Ionising Radiation Regulations.

d) **7-10C** If another type of probe is fitted e.g. a scintillation probe, then it will be necessary to adjust the HV when a replacement is made. If in doubt please consult the company.

7.3 Detector Voltage Supply

The detector supply is adjustable over the normal range of 400-1200 volts by a multi-turn potentiometer. First disconnect the mains supply cable. Gain access to the main printed circuit board (PCB) by carefully removing the front panel. The potentiometer (R209) is situated on the small HV printed circuit board which plugs into the main PCB.

The high voltage supply is available on the two pins at the bottom left hand corner of the main PCB. **If the instrument has been on during the previous few minutes sufficent charge may remain to give a small shock so allow about 10 seconds for the voltage to discharge to a safe level.** The outer pin is positive. Connect a high resistance voltmeter (at least 20,000 ohms/volt or 60Mohms) with the scale switched to 3,000 volts. Connect the mains supply. The alarm will almost certainly sound so try pressing the "test alarm" button. If this does not reset the alarm then the overload trip has operated owing to meter loading and you will have to carry out the adjustment with the noise or set the audible alarm switch to the OFF position. Set the voltage to the required value less about 15 volts to allow for meter loading. Remember that any change in tube voltage may need an adjustment to the overload control (see section 7.6). Typical operating voltages are:

MC10/20/900D	550 volts	MC70/71	425 volts

For the 7-10C it will be necessary to set the HV to the value recommended for the probe or, alternatively, plot a plateau by taking a series of readings against a number of HV settings. The HV should then be set approx. ⅓ to ½ along the plateau.

See section 7.6 on overload trip adjustment.

7.4 Meter Calibration

Before calibration the meter zero should be checked. With the instrument disconnected from the mains first check and, if necessary, adjust the mechanical meter zero to bring the pointer over the zero mark on the scale. The adjustment is on the rear of the meter barrel.

With the instrument operational but with the detector disconnected check the electrical zero setting. The zero control (R37) is located on the main PCB. Allow adequate time for the meter to settle before making the final adjustment. The low level trip will operate after a while but the audible alarm can be muted by means of the switch S2.

The meter calibration control (R41) is situated on the main PCB. To recalibrate inject square pulses of a few volts via a 100pF, 2kV capacitor into the detector input. The pulse repetition frequency is set to one of the upper values in the table below and the potentiometer varied until the meter reads correctly. The other scale values should line up correctly but a small error not exceeding 10% (usually much less) may occur in practice.

The scaling of the monitors takes into account the paralysis of the detector and circuit. Model C, scaled in counts s^{-1}, incorporates a 60μs paralysis time correction. The following table relates the scale reading with pulse repetition frequency (PRF).

Model R		Model RL		Model G/GL		Model 900D		Model C	
μSv h^{-1}	PRF	μSv h^{-1}	PRF	μSv h^{-1}	PRF	μSv h^{-1}	PRF	cps	PRF
5000	3418	1000	1241	75	874	1000	2052	2000	1786
1000	817	500	708	50	619	500	1093	1000	943
500	419	100	160	20	267	100	231	500	485
200	170	50	81	10	137	50	116	200	198
100	86	10	17	1	14.1	10	23	100	99
10	8.6	1	1.65	0.1	1.41	1	2.3	10	10

7.5 Low Level Trip

If the pulse rate falls below a certain level or stops completely due to any one or more of a number of possible causes the alarm is sounded. Included in this list is a failure of the G-M tube, the cable, the HV supply and the ratemeter circuit. It is desirable that the alarm does not sound when there is a fall in the instantaneous background counting rate due to statistical fluctuations. There is a time delay T (set internally) for which the probability of not receiving a count and therefore setting off the alarm needlessly is sufficiently small for this risk to be acceptable. The value of T for each model is:

7-10R: 330s   7-10G/GL: 120s   7-10RL/900D: 250s   7-10C: 120s

Other values of T can be obtained by replacing components R59 and C22. The maximum practical value of R59 and C22 is 10M and 100μF respectively giving T = 1000s. **If a low sensitivity detector is used it is recommended that the circuit is disabled by linking pins 12/13 to ground.**

Should failure occur in the G-M tube or associated circuits there will be delay of up to T seconds before the alarm is sounded. It must be left with the competent person responsible for radiation safety to assess whether or not the delay after a failure is an acceptable risk.

7.6 Overload Trip Adjustment

It is in the nature of G-M tube pulse counting instruments that very high radiation levels may cause a signal blockage which would be recorded by the meter as a low or zero reading. Although this failure does not occur until the radiation level is perhaps 100 times full scale a circuit is provided to operate soon after full scale deflection to ensure that the meter remains off scale for all conceivable radiation intensities.

The overload trip adjustment is a single-turn potentiometer (R24) located on the main printed circuit board. The control is set at the factory and is unlikely to need re-adjustment. It is, however, important that the HV potential is not changed as the two controls are interdependent for any one type of G-M tube.

The operation of the overload trip facility can be checked by subjecting the detector to a rapid increase in radiation intensity from a low radiation intensity to an estimated level of two or three times full scale reading. The meter will be seen to kick violently off scale before the ratemeter circuit has responded. To make any necessary adjustment the control should first be turned to minimum and gradually increased until the above effect occurs. Over-sensitive adjustment is indicated by the meter kicking erratically for a radiation level less than full scale. The overload circuit always trips the alarm irrespective of the setting of the alarm trip control.

7.7 Audible Alarm Muting

The audible alarm may be silenced by selecting the OFF position with the PCB mounted slide switch S2. It is located next to the fuse on the top corner of the main PCB. **Note: this also mutes the audible overload signal.**

7.8 Panel Lamp Replacement

The warning lamps used are large area LEDs contained in dual in-line packages. Each "lamp" uses two red and green bars mounted side-by-side. To replace an LED remove the main PCB from the front panel and disconnect the display PCB. The defective item can now be unsoldered from the PCB and replaced. Reassemble in reverse order.

7.9 Internal Fuse

A 20mm fuse rated at 500mA (anti-surge) is mounted on the printed circuit board. The fuse protects the battery against a short circuit. If for any reason the fuse fails a fault should be sought in the circuits associated with the positive supply rail.

7.10 Battery Charging Voltage

This will not normally require adjustment unless the regulator (IC1) or any of the associated components are replaced. To set the voltage disconnect the battery. Connect a DVM between the two battery feed wires and adjust control R3 until the DVM reads 13.65 +/-5mV. **Note: This setting is critical. Under voltage will result in inadequate charging whilst over voltage could lead to battery failure.** Carefully re-connect the battery leads noting the polarity.

7.11 Battery Replacement

It is recommended that the rechargeable battery is replaced every 2 years. To change the battery disconnect the instrument from the mains and set the battery switch in the OFF position. Remove the rear panel. Take off the battery connections and securing clamp. Fit the new battery and re-assemble in reverse order. After replacement connect the instrument to the mains supply to allow the new battery fully to charge. See section 2.

8. SERVICE AND GUARANTEE

With normal care and attention these instruments should give many years of service. If any fault occurs to the instrument within two years (one year for G-M tubes and photomultipliers) of purchase that is due, in our opinion. to a manufacturing error then it will be repaired free of charge.

If a fault occurs outside the guarantee period the company or its agents will service the equipment. A note explaining what you believe to be wrong is often helpful. If the customer wishes to repair the fault the company will give technical help. However, the company does not wish to abrogate its prime responsibility to its customer to third parties and service organisations. If these organisations are employed they should be instructed to return the equipment to us for service and repair.

The company will not be responsible for damage occurring in transit whether or not properly packed; but emphasis cannot be made strongly enough on the need to ensure adequate packing before returning.

The address is:

Service Department
Mini-Instruments Limited
8 Station Industrial Estate
Burnham-on-Crouch
Essex CMO 8RN
UK

Tel: (0621) 783282
Fax: (0621) 783132

DUE TO THE HIGH COSTS INVOLVED OVERSEAS CUSTOMERS SHOULD RETURN INSTRUMENTS BY PARCEL POST NOT AIR FREIGHT.

9. COMPONENTS LIST

All resistors 0.5W 1% metal film unless stated otherwise

R_1	470R
R_2	680R
R_3	2KO
R_4	4K7
R_5	3R9 2.5W wirewound
R_6	22K
R_7	91k
R_8	12K
R_9	10K
R_{10}	3K3
R_{11}	270R 1W 1% metal film
R_{12}	270R 1W 1% metal film
R_{13}	270R 1W 1% metal film
R_{14}	270R 1W 1% metal film
R_{15}	Not fitted
R_{16}	3K9
R_{17}	22K
R_{18}	100K $^1/_2$W 2% metal film
R_{19}	39K
R_{20}	15K
R_{21}	430K
R_{22}	120K
R_{23}	4K7
R_{24}	220K potentiometer
R_{25}	4K7
R_{26}	1MO
R_{27}	See table below
R_{28}	not fitted
R_{29}	not fitted
R_{30}	10K
R_{31}	6K8
R_{32}	1MO
R_{33}	1MO
R_{34}	330K
R_{35}	10K
R_{36}	8K2
R_{37}	20k Potentiometer
R_{38}	100R
R_{39}	15K
R_{40}	1K1
R_{41}	2KO Potentiometer
R_{42}	1KO
R_{43}	820R
R_{44}	7K5
R_{45}	1KO Potentiometer
R_{46}	39R
R_{47}	1KO
R_{48}	1K5
R_{49}	10K
R_{50}	680K
R_{51}	100K
R_{52}	4K7
R_{53}	10K
R_{54}	See table below
R_{55}	47K
R_{56}	47K
R_{57}	1M0
R_{58}	3K3
R_{59}	See table below
R_{60}	22R

C_1	1000µF 25V Electrolytic
C_2	10µF 50V Electrolytic
C_3	470µF 10V Electrolytic
C_4	100µF 6.3V Electrolytic
C_5	1nOF 2kV Ceramic
C_6	220pF Ceramic
C_7	220nF Ceramic
C_8	100nF Ceramic
C_9	100nF Polyester
C_{10}	47nF Ceramic
C_{11}	1nOF Polystyrene
C_{12}	10µF 50V Electrolytic
C_{13}	10µF 50V Electrolytic
C_{14}	See table below
C_{15}	See table below
C_{16}	See table below
C_{17}	See table below
C_{18}	100nF Ceramic
C_{19}	68nF Polyester
C_{20}	4n7F Ceramic
C_{21}	10nF Polyester
C_{22}	47µF Electrolytic
C_{23}	10nF Polyester

COMPONENTS LIST (cont)

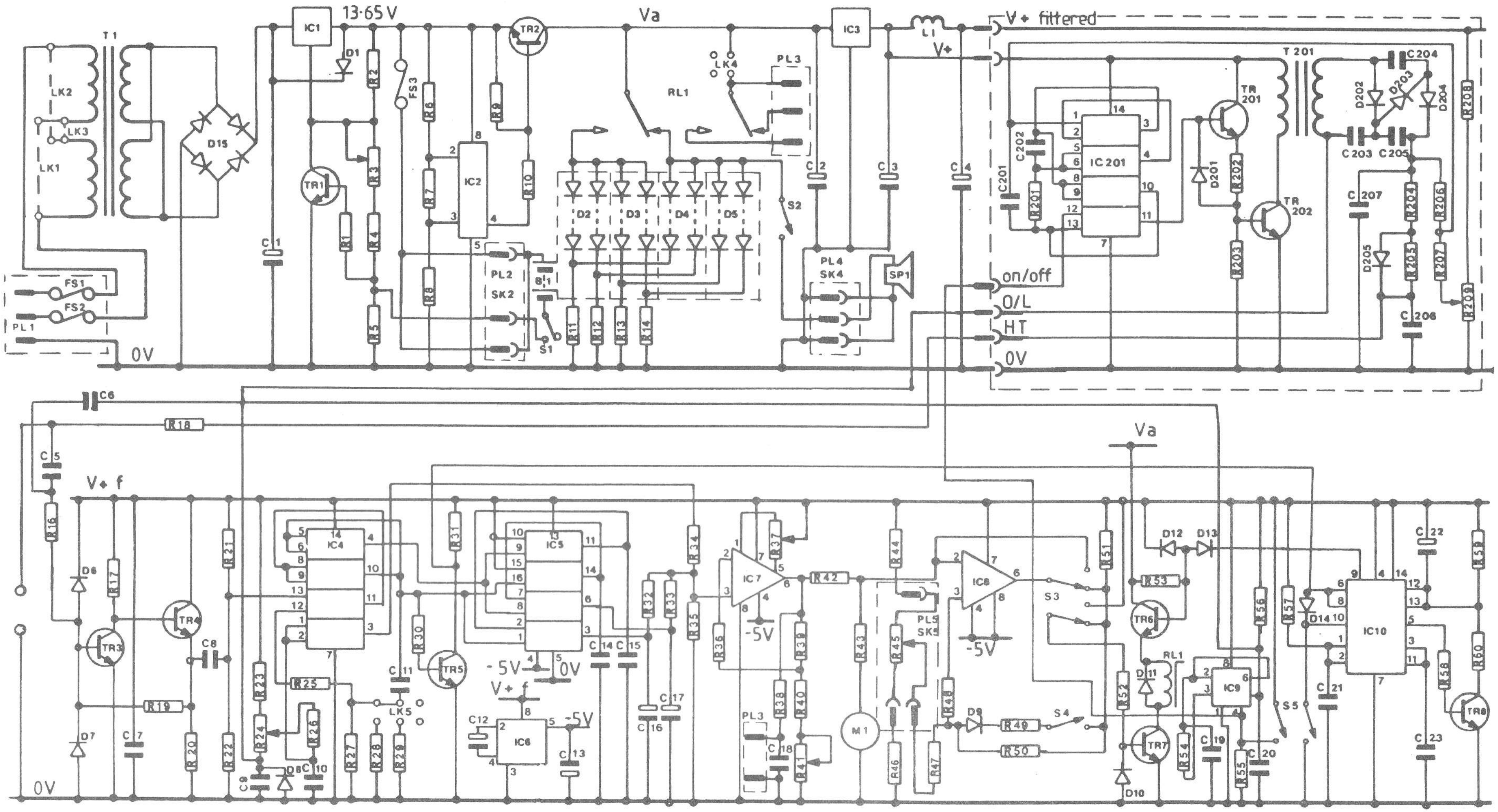
D_1	1N4001	$TR_{1,3-6}$	BC548B
D_2	green LED bar	TR_2	BC328
D_3	green LED bar	TR_7	BC639
D_4	red LED bar	TR_8	BC338
D_5	red LED bar		
D_6	1M4148	IC_1	LM317T
D_7	1M4148	IC_2	ICL8212CPA
D_8	1N4001	IC_3	78L05
D_9	1N4148	IC_4	HEF4001B
D_{10}	1N4148	IC_5	DG308ACJ
D_{11}	1N4001	IC_6	ICL7660
D_{12}	1N4148	IC_7	ICL7611
D_{13}	1N4148	IC_8	ICL7611
D_{14}	1N4148	IC_9	TLC555
D_{15}	W005 bridge rectifier	IC_{10}	TLC556CN
T_1	115-240V pri: 2 x 15V sec, 6VA	T_2	HV transformer

MODEL DEPENDENT COMPONENT VALUES

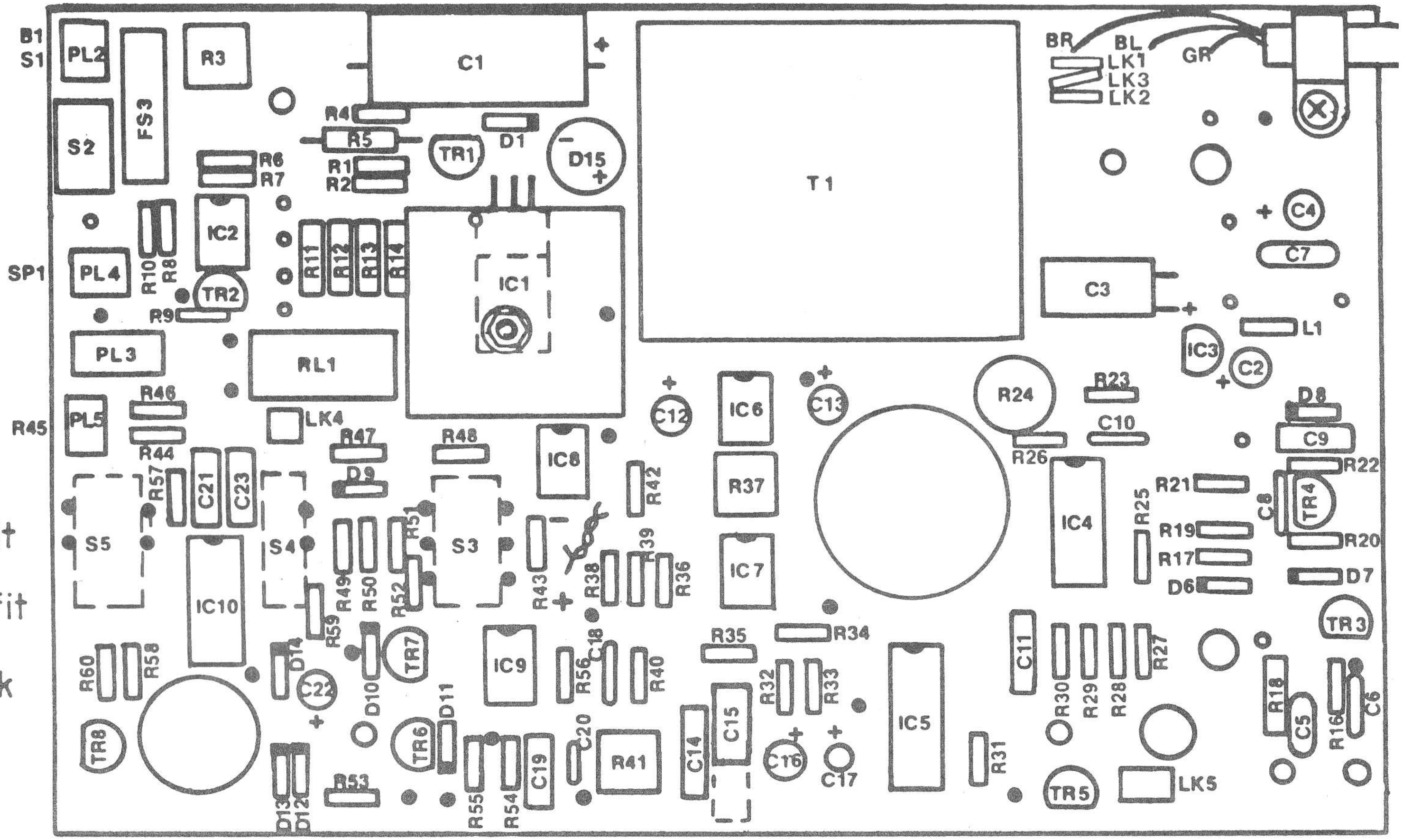
	G	GL	R	RL	C (G-M)	C (P-M)	D
R_{27}	330K	330K	100K	330K	100K	100K	100K
R_{54}	47K	47K	22K	68K	39K	39K	47K
R_{59}	2M2	2M2	5M6	3M3	5M6	2M2	3M3
C_{14}	2n2F	2n2F	1n0F	2n2F	2n2F	2n2F	1n2F
C_{15}	100nF	100nF	68nF	150nF	100nF	100nF	68nF
C_{16}	22μF	100μF	10μF	10μF	4μ7F	4μ7F	10μF
C_{17}	2μ2F	2μ2F	2μ2F	4μ7F	1μ0F	1μ0F	2μ2F

HV PCB

R_{201}	100K	C_{201}	22pF
R_{202}	47R	C_{202}	220pF
R_{203}	390R	C_{203}	10nF 1kV
R_{204}	150K	C_{204}	10nF 1kV
R_{205}	10M	C_{205}	10nF 1kV
R_{206}	400M	C_{206}	6n8F 2kV
R_{207}	820K	C_{207}	6n8F 2kV
R_{208}	24K	D_{201}	1N4148
R_{209}	Potentiometer 20K	D_{202-5}	BY584
IC_{201}	HEF4001B	T_{201}	HV transformer
TR_{201}	BC548B		
TR_{202}	BC639		



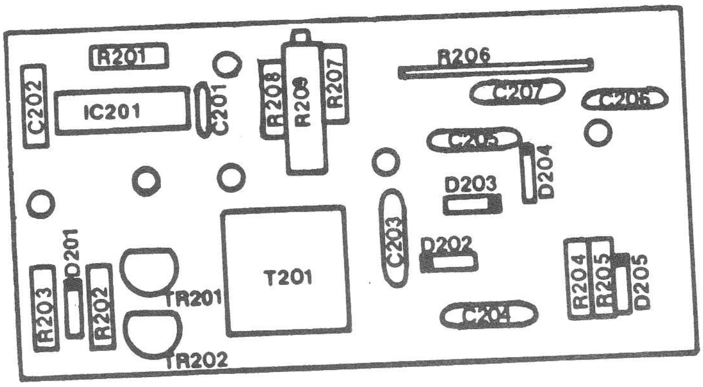
7—10 CIRCUIT DIAGRAM



NOTES

1. For 240V models fit LK3, but for 120V models fit LKs 1&2
2. S3-5 fitted to track side

7–10 P.C.B. ASSEMBLY DRAWING



7–10 H.V. BOARD ASSEMBLY DRAWING

NRPB-R326

Guidance on the Choice, Use and Maintenance of Hand-held Radiation Monitoring Equipment

P H Burgess

Abstract

This report is designed to assist users to choose appropriate radiation monitoring equipment. It covers a wide range of radiation sources and both dose rate and contamination monitoring. It also includes guidance on surveying techniques, instrument maintenance and ways of determining the nature of potentially complicated radiation fields.

The Health and Safety Executive supported the preparation of this report.

Chilton
Didcot
Oxon OX11 0RQ

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This NRPB report reflects understanding and evaluation of the current scientific evidence as presented and referenced in this document.

5.1 General maintenance

The most important item of general maintenance is looking after the battery box. Changing batteries can damage the battery connectors. Check that the connectors still have enough bite to produce good electrical contact even when the instrument is held at unusual angles. Check that the level of wear is acceptable and that corrosion is not producing poor contract. On instruments that use PP3 style batteries check that the wires from the battery connector are undamaged.

One unexpected aspect is that battery lengths vary considerably within one type. The specification for the common AA cell allows a total variation in length of 2 mm. This means that a change in manufacturer can lead to a change in length. Fitting a shorter battery will produce unreliable contact. Fitting a larger battery will produce a good contact but will often permanently distort the flat spring connectors, leading to poor function when one of the original, shorter, batteries is fitted.

Maintenance otherwise is generally a matter of keeping nuts and bolts reasonably tight and checking for obvious physical damage which would indicate the instrument has been dropped perhaps. If such damage is found then it may well be worth performing a radiation function check.

5.2 Instruments with probes on cables

One of the most vulnerable components is the cable connecting probe and ratemeter, particularly if it is fitted with connectors. Connecting and disconnecting cables will ultimately lead to the connectors coming loose on the cable, perhaps breaking either the centre wire or the braiding or both. Users may be careless about unscrewing collars and may turn the whole connector body. This can twist the connector on the cable leading to rapid failure. Users may also swing the probe by the connector. The connectors and cables are rarely designed for this. Particularly vulnerable in such circumstances are right-angle connectors, where dangling the probe on the cable rapidly leads to failure. Unfortunately most cables with connectors are really rather feeble for industrial use. Cables which are fed through a gland into the probe are generally much more reliable.

Other cable damage includes cuts where the cable has been dragged over a sharp edge or squashed areas where the cable has been trapped by the lid when the instrument was placed in its carrying case.

It is important that cables are inspected regularly.

5.3 Detector windows

Many contamination probes and instruments have thin windows. These are always vulnerable to damage. The effect is obvious in Geiger Müller (GM) tubes, where damage to the window produces instant catastrophic failure. Damage to alpha and beta scintillation probes will produce a light leak, leading to a high erratic background or, in some old alpha monitors, to a fail to danger. In this case there is no obvious background but the instrument simply does not respond to radiation. In sealed proportional counters damage produces a loss of function, effectively caused by an increase in energy threshold as oxygen leaks in and counting gas escapes. In refillable ones damage means excessive refilling of the detector with counting gas. For sodium iodide detectors the windows are generally tougher, but damage can lead to light leaks and, more insidiously, a slow deterioration in the scintillator as moisture gets in. Sodium iodide is hygroscopic. The clear crystal rapidly turns to a yellow powder in the presence of moisture. This leads to a general loss of sensitivity, particularly at low energies.

Any instrument with a thin window should be inspected regularly. For conventional alpha and beta scintillation probes many users are prepared to correct pinhole light defects using typists' correcting fluid. This requires skill and a degree of judgement. The process must be confined to a very small fraction of the detector area, certainly no more than 0.5%, and should only be undertaken if both the RPA and the qualified person (see Section 6) are prepared to accept the slight drop in performance.

5.4 Ionisation chamber instruments

Most of these instruments use desiccators to keep the electrometer amplifier dry. These desiccators will require regular drying, particularly if the instrument is used in cold, damp conditions. On many instruments the inside is quite well sealed from the outside world. If the desiccant seems to need frequent drying then it may be that one of the rubber seals has failed, allowing water into the electrometer.

5.5 Gas refillable proportional counters

These are the most maintenance intensive monitors. The counters require regular (daily, four hourly) flushing with fresh gas to remove the oxygen that diffuses in through the thin window. This can be done directly, from a small cylinder, or the instrument may have a built-in reservoir which requires only occasional refilling. In either case it is important that the detector is flushed regularly. If the instrument is abandoned for any length of time then it may well take several flushings to restore its performance. Such instruments are best suited to regular use and are not suitable for emergency kits, for example, where use is intermittent.

6 Legislative requirements for testing

The Ionising Radiations Regulations 1999[1] require that equipment shall:

(a) be properly maintained so that it remains fit for the purpose for which it was intended,

(b) be adequately tested and examined at appropriate intervals. This testing process should take place at least once every year.

The RPA has a role in this process in advising the employer on appropriate means of checking that the instruments are serviceable, including the nature and frequency of routine checks and on their testing and examination.

Periodic examination and testing is to ensure that the monitoring equipment is not damaged, operates as expected and remains suitable for the expected duration of use until it is next thoroughly examined and tested.

In this context an instrument that operates as expected is one with a radiation response which agrees substantially with the expected value derived from type test data and which also agrees with any previous data derived from its test before use and any periodic test data. The Ionising Radiations Metrology Forum has produced guidance on this matter which has been published by the National Physical Laboratory in Good Practice Guide 14 (GPG14)[2].

This process of thorough examination and testing should take place at least every 12 months, although it is recognised that there may be practical difficulties in achieving this in some circumstances. It is the employer’s duty to ensure that any significant faults are repaired and that the instrument is re-tested after repair where the nature of the repair could affect the performance of the instrument.

Testing should be performed under the supervision of a qualified person, defined as a person who has a good knowledge and understanding of current testing standards and any relevant technical guidance, such as GPG14[2]. The qualified person can be an employee of the employer using the instrument or of an instrument manufacturer, supplier or specialist test house. The employer does not have to appoint the qualified person formally in writing but it is important that both employer and qualified person understand their responsibilities.

The RPA should advise on the type, energy and intensity of the radiations which the instruments can be expected to encounter and this advice must be communicated to the qualified person. The qualified person should also ensure that their clients know exactly what sort of examination and calibrations that they have contracted for and also any relevant limitations.

7 Examination and testing process

7.1 Type tests

Any equipment should normally have been subjected to a type test before it is first put into use. This is a demanding and thorough test of its radiation, environmental, electrical and mechanical characteristics which is performed on one or a small number of production standard instruments to make sure that they are functioning acceptably well when compared with the design specification and also to provide data for all subsequent tests. These tests are generally performed on behalf of or by the manufacturer using guidance from the IEC[3]. A useful summary is also available in IPEM Report 69[4].

7.2 Tests before first use

These tests are designed to confirm that the instrument in question has a similar performance to the type test instrument. These are described fully in GPG14[2] but fall broadly into four categories, as follows.

(a) A check on the instrument's linearity over its intended range of use – for an energy compensated GM detector this would comprise exposing the instrument in the calibration orientation to known ambient dose equivalent rates of ^{137}Cs or ^{60}Co gamma radiation over the operating range which could reasonably be anticipated, given its intended use.

(b) Overload performance – this is to confirm that the instrument's performance at very high levels is correct. In many situations the range of dose rates, for example, which the instrument could reasonably encounter exceeds the maximum useful range of the instrument. This could happen if an interlock was to fail or a source fail to retract into its housing. It is important that thought is given to deciding the maximum dose rate which the instrument could encounter as an instrument failure in such circumstances could lead to high doses, direct injury or death. The RPA should advise the employer on this maximum value so that the information can be passed on to the qualified person. A sense of proportion is required and should take into account the relevant working practices. For example, in a gamma irradiation plant used for the sterilisation of medical products, it could be defined as the dose rate in a maze entrance just before a person can see that the sources are exposed. As a minimum, gamma dose rate instruments should be exposed to 10 mSv h^{-1}.

(c) Energy response – an instrument should be checked at, or below, the minimum energy of use for the appropriate radiation type. For example, for conventional energy compensated GM detectors, which have a lower useful x, gamma energy of 50 keV, a check using ^{241}Am gamma radiation (60 keV) is appropriate as a manufacturing defect which leads to a poor response at 50 keV will be obvious when checked at 60 keV and there is no convenient source of 50 keV radiation. For many beta contamination monitors a check using a ^{14}C contamination plaque (E_{max} = 0.16 MeV) is reasonable.

(d) Uniformity of response – this falls into two broad groups. For dose rate monitoring equipment this generally comprises irradiation of the instrument at ±90º to the calibration orientation in the horizontal plane. Often ^{241}Am gamma radiation (60 keV) is used. For contamination monitoring the corresponding test is to measure the response of the monitor to a small area source at a range of positions over the nominal sensitive area of the probe.

9 Instrument selection

1. Determine the radiation types, energies and intensities which the instrument will be expected to measure.

2. Determine the quantity or quantities which the instrument will be expected to measure. For example, for the measurement of gamma dose rate the usual quantity is ambient dose equivalent rate. For surface contamination the desired endpoint is Bq cm^{-2}, but the normal instrument indication is in counts per second.

3. Is there a possibility of any interfering radiations, such as high levels of gamma dose rate when the main aim is to measure alpha surface contamination? If so, these will have to be quantified so that instrument specifications can be checked to ensure that the instruments should work and also so that appropriate tests before use can be selected.

4. Is the instrument to be used in a tough environment? Is it likely to be knocked and dropped? Does it need to be waterproof or at least well sealed? Are there any limitations such as use in an explosive atmosphere? What temperature range is expected?

5. What will the end user expect from the instrument? What sort of weight will be acceptable? Will the instrument have to be carried up ladders? Does it require a light so the reading can be seen in poor light? Which geometry is best? Sometimes, for gamma dose rate monitoring, users prefer a display on the opposite face of the instrument to the detector. Then the instrument can be held at arm's length and the display read conveniently. For more restricted areas a display on the top and a detector on the front face of the instrument allows the user to hold the instrument close to the body and look down on it.

   There is a very broad choice between analogue and digital displays, with users expressing strong preferences. Establish these, but also remember that digital displays are increasing in quality rapidly and many users previously committed to conventional analogue meters are now quite happy with liquid crystal digital displays.

6. Is there a preference for battery type or types? Are certain types unacceptable? What minimum battery life is required? Remember that a longer battery life generally means a heavier, bulkier battery and a heavier, bulkier instrument.

7. Some instruments offer data logging capability. Would this be an advantage for the application under consideration? Such a facility will generally add a small cost to the instrument but could add a large preparation cost, if bar codes or micro cans have to be placed around the site, and also a large cost for the software to make good use of the data.

8. Are smart instruments a good idea, ie instruments where a ratemeter can be plugged into any of a series of probes without adjustment being required? Or would it make more sense to have permanent probe and ratemeter combinations, which generally allow a cheaper ratemeter?

9. How clever should the instrument be? For a contamination monitor is there any advantage in having a set of calibration factors stored for a range of nuclides or would a simple counts per second display be less prone to misinterpretation?

10 Records

Records of monitoring should be kept for at least two years. It is important that data for a particular monitoring point can be accessed quickly and easily. There is a variety of means which can be employed, depending on the number of monitoring points to be covered and the complexity of the situation.

The aim should be to cover:

Where

- the location of the monitoring points, described clearly and unambiguously.

When

- when the monitoring took place.

Who

- who performed the measurements.

With what

- which piece of monitoring equipment was used and the date of test of the equipment.

How

- how that piece of equipment was employed – this could be a reference to a written procedure, for example.

How much

- the measured value of the dose rate or contamination level.

  It is important in many situations not to log the result as zero. For beta contamination surveys it is important that the surveyor's best estimate of the count rate is recorded. This can then be compared with the relevant background value and with the appropriate limiting value. Similarly, for alpha surveys, <0.2 count per second is better than zero as is $<X$ μSv h^{-1} for dose rate surveys, where X depends on the instrument sensitivity. This approach will provide a convincing picture of radiation levels in a particular area to the RPA, the employer and any inspecting agency.

In simple situations data can be stored on paper very conveniently. There are two main approaches. One is to record the results from one point on a particular page, the other is to have a page for each phase of monitoring. The first method is useful in identifying trends while the second can be filled in more easily as monitoring takes place. A variation on the first approach would be to graph the results. Using the date as one axis will give a very clear indication of any trend with time.

For more complicated situations a computer database is ideal. It is perfectly practicable to transcribe monitoring results from a hand written sheet into the database but this can be a time consuming, boring process and errors can result. Instruments which log value and position are increasingly available and these have the advantage that the data can be directly downloaded. They also have the advantage of credibility, in that the presence of a value in the database makes it very likely that the measurement was actually made, whereas hand entered data can be made up or copied from previous results.

As in all computer data management it is essential that data are backed up in some way, either electronically or, if derived from hand written sheets, by storing the original sheets.

11 Training for users

Users should be trained to use instruments effectively to generate good quality monitoring data efficiently and safely. Staff maintaining and testing equipment should be trained to discharge their duties efficiently and safely.

Users should be given an understanding of:

Why

- An explanation of why radiation is seen as a hazard.
- The legal obligations of the employer and employees.

What

- The characteristics of the radiation types which are likely to be encountered.

With what

- A description of the types of monitoring equipment provided, which type to use for which monitoring situation and the limitations of each type.

Checking

- Does it have a valid test certificate?
- Does it look as if it is in working order? Is there, for example, obvious damage to cable or connectors?
- Is the battery good enough to last out the work period? For conventional instruments the needle should be well within the acceptable battery condition range and not visibly moving.
- Is the background count rate believable? If it is a scintillation monitor does it respond when held close to a fluorescent or other bright light? A change in count rate, up or down, shows the presence of a light leak. Does the count rate change when the cable between probe and ratemeter is flexed?
- Use of check sources – if these are available, and they can be extremely useful, how should they be employed?
- What to do if the instrument appears faulty. A user should know who to refer to, where to put the instrument and how it should be labelled. There should be no excuse for someone putting the instrument back on the shelf and taking the one next to it.

Where

- Where each monitoring point or area is and how to identify it.

When

- The frequency that monitoring should take place. This could be task based, eg after a filter change or flask movement, or time based, once a day, week, month or quarter.

How

- The process of making the measurement. This should cover:

(a) the reference direction, ie the direction of radiation incidence for which the manufacturer designed the instrument,

(b) how to turn on the instrument including battery checking and range selection,

(c) use of any audio output (clicker or alarm) – the audio output gives an instant indication of the count rate rather than the damped or average value indicated on the display,

(d) for contamination monitoring, the correct distance between probe and surface and how to maintain it safely,

(e) how to take the measurement, in the sense of a length of time to wait and how long to average the indication for – this should also cover the interpretation of logarithmic scales,

(f) where and how to record the data,

(g) how to respond to any unusual values,

Excessively high results point to shielding failure, hot particles or excessive contamination. It is important that such results are reported quickly to someone who can deal with them. Low values could also indicate a missing source, which should also be reported quickly, or a possible instrument failure. For very high levels it is important that the individual moves away quickly and does not assume it is an instrument problem.

(h) the environment causing instrument problems,

High electromagnetic, electrostatic and magnetic fields can cause high count rates or fail to danger. Very bright lights can cause spurious count rates. Taking cold instruments into warm, damp environments can cause condensation, giving spurious high dose rates on ionisation chamber instruments.

(i) failure modes for the instrument,

For scintillation based contamination monitors this could cover light leaks. Probe and ratemeter combinations often suffer from cable damage. Touching the windows of thin end window GM detectors with anything sharp generally results in implosion. Regular battery checks are essential.

(j) maintenance by the user – this could include zero setting, battery changing, cleaning and checking.

How not to

- Things not to do. The classic temptation is to swing probes by the cable. Unfortunately the standard UK Pet-Pet cable is not up to this. Other common faults include putting thin window detectors down on sharp things, such as nail ends and swarf, letting instruments become damp and not drying them and throwing instruments into the backs of cars, not in a proper box.

Personal safety

- The person performing the monitoring should be safe. Generally training should cover conventional safety and radiological safety. Particular emphasis should be given to dose avoidance, particularly in high dose rate plants. This would include the classic time, distance and shielding, with particular emphasis on instrument choice and use. For example, a telescopic monitor can be useful in some circumstances. Very clear limits on permissible dose rates should be established to avoid over-enthusiastic staff investigating high dose rate areas. Avoidance of personal contamination is a priority.

This list may seem intimidating but the training should fit the circumstances. If an individual has to deal with one relatively low activity beta thickness gauge source using one instrument then the training programme would be very short. Training for plants reprocessing irradiated fuel, however, would have to be much more comprehensive.

12 Training for maintenance staff

The maintenance of radiation monitoring equipment is essential for good quality results. Section 5 covered typical maintenance procedures. Manufacturers' manuals are the first source to be consulted. These will usually provide all the information necessary for routine maintenance and, sometimes, for simple repairs and adjustments.

Staff undertaking maintenance should be capable of making repairs and adjustments up to a specified level. Many users will only undertake routine maintenance and will send any instrument requiring repair or adjustment to a repair house or back to the manufacturer. A normal level of manual dexterity will be all that is required. Other users, with more instruments, may wish to perform repairs themselves, in order to avoid the inevitable delays caused by sending instruments away. In this case a much higher level of knowledge will be required. Typical qualifications include City and Guilds, ONC, HNC or higher qualifications in electronics.

Differences from many forms of electronic maintenance include:

(a) the presence of high voltages, up to 2.5 kV, on proportional counters, scintillation detectors and some neutron dose rate monitors,
(b) the need to use radiation sources for setting up and testing,
(c) the need for a very high level of cleanliness when working with ionisation chambers,
(d) the importance of not making modifications to detectors or their mountings.

Using conductive silver based paint instead of graphite inside an ionisation chamber will raise the instrument's low x-ray energy response.

Holding a GM detector in with a spring steel clip instead of a nylon tie will reduce the low energy photon response. Extending the length of cable between probe and ratemeter can change the low energy threshold of scintillation and proportional counters. This is unlike most radiofrequency work where extending a cable with appropriate connectors and cable produces little effect.

Using the wrong thickness or material for ion chamber windows can change the beta response, particularly, dramatically.

The windows on end window GM detectors are particularly vulnerable. Particular care is required when changing detectors.

It is important that instruments from contamination areas are looked at suspiciously. Accessible areas of an instrument can be completely clean but areas which are accessible only during maintenance can become contaminated.

In GM based equipment which operates up to very high dead times, care is vital when changing detectors. Using different anode clips, anode resistors or anode resistor lead lengths can change the response to high dose rates drastically.

Fitting new windows to scintillation detectors requires care to ensure that there are no light leaks.

Rewiring proportional counter detectors is demanding as the wire is only 25 to 50 μm in diameter.

The list above is not exhaustive but it covers the more unusual aspects of repair. Hence staff tend to require both a general knowledge of equipment maintenance and a particular knowledge of radiation monitoring equipment.

13 Acknowledgements

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14 References

1 Ionising Radiation Regulations 1999. London, HMSO SI (1999) No. 3232.

2 NPL. The examination, testing and calibration of portable radiation protection instruments. Teddington, NPL, Measurement Good Practice Guide 14 (1999).

3 IEC. Beta, x and gamma radiation dose equivalent and dose equivalent rate meters for use in radiation protection. Geneva, IEC Publication 846 (1989).

4 IPEM. Recommendations for the presentation of type test data for radiation protection instruments used in hospitals. York, IPEM, Report 69 (1994).

APPENDIX A

Exposure Situations and the Equipment and Techniques for Monitoring Radiation Levels

A1 Industrial radiography using energetic gamma emitters

For normal industrial radiography of welds in steel pipes and ferrous forgings and castings the most common nuclide is ^{192}Ir. There are others but all emit gamma radiation with energies of a few hundred keV up to 1.25 MeV. The main emissions from ^{192}Ir are given below.

Gamma emissions *E* (keV)	Fraction (%)
296	14
308	14
317	40
468	23
589	2
604	4
613	3

The shielding produced by the casting under examination, any exposure collimator and any additional shielding will tend to harden the radiation, removing the lower energy components preferentially.

Multiple scatter from the walls of a shielded enclosure out through a maze entrance will tend to soften the beam, ie reduce its energy. However, a significant component below 60 keV is unlikely.

Suitable instruments

- Conventional energy compensated GM detector.
- Thin window energy compensated GM detectors.
- Ionisation chambers.
- Scintillation based dose rate monitors.

Generally the best

- Conventional energy compensated GM detectors.

Survey procedure

(a) Confirm the instrument has a valid test certificate.

(b) Perform a function check on the instrument, confirming that the battery condition is adequate and is showing no signs of fading, that the background count rate seems believable and that the instrument seems generally in good order.

(c) If a check source is available, confirm that the instrument is giving the correct reading.

(d) For enclosure radiography, where the source is in a shielded room, monitor areas of potential weakness where shielding may have become damaged or may have been removed. The edges of doors and any penetrations through the shielding should be checked carefully. Note that where the roof of the enclosure is relatively thin then the maximum dose rate may be away from the walls of the enclosure. This can be the case where there is a crane rail running above a removable roof, which can generate scatter.

(e) For open shop radiography confirm that dose rates at and outside the barriers are acceptable.

(f) Use any audio output. This gives an instant indication of dose rate, rather than the damped one provided by the display. If the click rate increases, pause for a few seconds to allow the instrument reading to stabilise.

(g) Take an eye average of the indication. Do not record the peaks. Particularly at low count rates the indication can fluctuate by tens of per cent.

(h) Remember that an instrument indication can take up to ten seconds to stabilise. Have patience. The more sensitive the instrument, the lower the level of fluctuation and the less time that the operator has to wait to allow the indication to stabilise.

A2 Industrial radiography using very high energy x-rays (>1 MeV)

Generally the radiation source is a betatron, which produces a very high energy pulsed electron beam which is directed on to a target, generating x-radiation. The advantage of these units is that they can generate a very high energy beam without using a high energy, high activity source such as ^{60}Co. The two important aspects of this type of source are the very high energy, typically about 6 MeV, and the pulsed nature, typically a 200 Hz beam with each pulse being a few microseconds long.

Suitable instruments

- Conventional energy compensated GM detectors.
- Thin window energy compensated GM detectors.
- Ionisation chambers.
- Scintillation based dose rate monitors.

Generally the best

Probably ionisation chamber instruments.

GM detectors have a count rate limitation when used with pulsed sources. For pulsed sources producing narrow (up to tens of microsecond) pulses it is important that the count rate from the detector does not exceed 30% of the pulse repetition frequency, otherwise the instrument will under-read. Hence it is essential to know the sensitivity of the instrument [in counts $s^{-1}/(\mu Sv\ h^{-1})$] and to identify a maximum trustworthy count rate. This leads to the unfortunate circumstances that the higher the sensitivity, the lower the maximum useful indication.

GM detectors will give a completely false reading at high dose rates, for example close to the target in the main beam. At the ultimate the detector will record one pulse per radiation pulse. For a 400 Hz machine this means a maximum count rate of 400 s^{-1}. If a relatively high sensitivity detector is used, for example one giving 5 $s^{-1}/(\mu Sv\ h^{-1})$, then that gives an ultimate indication, at no matter how intense a dose rate, of 80 $\mu Sv\ h^{-1}$.

However, GM based instruments are satisfactory provided the detector sensitivity has been well chosen and provided the maximum believable dose rate has been calculated and the user informed.

Survey procedure

See Section A1.

A3 Industrial radiography using relatively low voltages, and baggage and security x-ray machines

Typically this involves using x-ray sets operating with maximum potentials in the range 50 to 400 kV. The lower potentials are used for quality control of materials such as aluminium, whereas the higher potentials are used for radiographing thin steel fabrications, such as piping.

The radiation characteristics for these sets differ greatly from gamma radiation. Gamma radiation occurs at discreet energies. X-radiation at the output from the x-ray tube has a spectrum which rises from zero at very low energies, peaks in intensity at an energy equivalent to about 30% of the applied kV and then falls to zero at an energy in keV equal to the tube potential in kV.

Hence there is almost always the possibility of a significant low energy component at the output from the x-ray tube. Any form of intact shielding by concrete, lead or steel will preferentially attenuate the low energy end of the spectrum, reducing the dose rate but, at the same time, increasing its average energy. A few mm of steel or lead or a few cm of concrete will remove any component below 50 keV. However, scatter round a door or from a maze will reduce the average energy. Open shop radiography can obviously present the full spectrum at a barrier, particularly if the beam size is larger than the object to be examined.

Suitable instruments

- Conventional energy compensated GM detectors.
- Thin window energy compensated GM detectors.
- Ionisation chambers.
- Scintillation based dose rate monitors.

Generally the best

- Thin window energy compensated GM detectors. Conventional energy compensated GM detectors can be used for the higher kV sets or where shielding has hardened the beam.

Monitoring procedure

For industrial x-radiography equipment follow the suggestions in Section A1.

For baggage x-ray equipment, the highest dose rates occur when a large volume, low atomic number object is passing through the beam. Normally, then, a large polyethylene container filled with water is used as the scattering object and monitoring performed while it is in the beam. The highest dose rates are generally encountered when the vertical fan shaped beam is just buried within the nearer edge of the scattering object.

A4 Flash x-ray sets

Battery powered x-ray sets are popular for security applications such as the radiography of suspect packages. They have very unusual characteristics in that they produce a short but intense pulse of x-radiation at a relatively low potential. The maximum exposure time is typically three seconds. Monitoring of these using conventional ratemeter based equipment is not possible. The only satisfactory method is to use an ionisation chamber instrument with a sensitive dose range. The monitor is placed, the indication zeroed and the x-ray unit triggered. The new indication is then recorded. Dose rates over an hour can be calculated by multiplying the recorded dose by the number of exposures per hour.

A5 Industrial sterilisation units

High dose rate x or gamma radiation is frequently used for the sterilisation of medical supplies and similar applications. The dose rates involved are extremely high, in excess of 100 kGy h^{-1}. Instruments are used in two modes in such plants. One is to confirm that the dose rates on the outside are acceptable, normally less than 7.5 μSv h^{-1}. Instruments used only for such functions are unlikely to encounter extremely high dose rates. Section A1 on industrial radiography using energetic gamma emitters should be consulted for appropriate types. The other application is much more demanding. These are instruments which are to be carried by personnel when entering the irradiation plant. In the vast majority of cases the various controls and interlocks which are designed to ensure that the sources or x-radiation sources are safe will be working correctly. However, there is always an extremely small possibility that there may some form of failure which leaves the source at least partially exposed while allowing access.

It is important that instruments used during entry should behave correctly if they encounter a very high dose rate. This will normally mean going straight to their overload indication. The instruments used for this purpose should have their performance confirmed at the maximum credible dose rate which they could reasonably encounter. This is not the maximum accessible rate if a failure takes place but more the maximum rate which a user could encounter in the entry maze just before he or she can see that the source is exposed or some other failure has taken place. Typically the dose rate will be of the order of 100 Sv h^{-1}.

Suitable instruments

The instrument is used purely as an indicator, not to measure the dose rate. The radiations are also extremely penetrating. For virtually all applications a relatively insensitive conventional energy compensated GM detector instrument will be the most reliable and quickest to react. The instrument should have a logarithmic scale. Range switching or detector autochanging is not acceptable as both may slow down the identification of the presence of very high dose rates.

Testing should confirm that the instrument goes rapidly to overload at the maximum credible dose rate that it could encounter and that it remains off-scale and does not fail to danger. The majority of GM detectors which operate at 400 to 600 V will operate correctly, whereas many which operate at 900 V will fail to danger.

A6 Transport of large gamma emitting sources in shielded containers

Road, rail, ship and air transport large numbers of high activity gamma sources. These sources are generally extremely well shielded. However, on occasion package design has been found to be defective. Monitoring such packages has close parallels with the monitoring performed during industrial radiography using energetic gamma emitters, and generally a conventional energy compensated GM detector of the appropriate sensitivity will be appropriate. If anything, compact size and a high degree of robustness are even more important as monitoring may involve climbing on to vehicles.

A7 Level gauging using gamma emitting sources

These are very popular in industry for the measurement of the level in hoppers, the height of molten steel in a mould and similar applications. The majority of sources used are ^{137}Cs. The source is in a collimated housing on the one side of the volume to be measured with a detector on the other. Section A1 on industrial radiography using energetic gamma emitters gives advice on monitoring instruments and techniques.

A8 Finding lost gamma sources

Occasionally gamma sources are lost or stolen and it becomes necessary to search for them. In such cases the main requirement is a very high sensitivity. Other dosimetric properties such as a good energy response are generally irrelevant. The best instrument for confirming that a source may be present and identifying its general position is a large sodium iodide scintillation detector. Such detectors have a very high sensitivity. For example, a 51 mm diameter, 51 mm deep detector has a sensitivity of approximately 1500 $s^{-1}/(\mu Sv\ h^{-1})$ for ^{137}Cs gamma radiation and a normal background count rate of 50 to 200 s^{-1}. It is easy, using such equipment, to detect sources which produce an increase in count rate of 50% over background, provided the background is reasonably stable. For areas where it is variable, such as in a built up site where building materials will have an influence, then the ability to detect sources will be reduced.

A10 Monitoring of x, gamma dose rates from radiopharmaceuticals

Large numbers of packages are transported containing radiopharmaceuticals. Some are x, gamma emitters, some of which, such as ^{125}I, generate low energy but still reasonably penetrating x-radiation, ie 27 to 35 keV. Many are beta emitters. The beta radiation is always completely attenuated but the associated Bremsstrahlung may be relatively penetrating. As a consequence any radiation dose rate monitor must cover a wide x, gamma energy range. This rules out conventional energy compensated GM detectors for general application as these do not respond correctly to radiation energies less than approximately 50 keV.

Suitable instruments

- Thin window energy compensated GM detectors.
- Ionisation chambers.
- Scintillation based dose rate monitors.

Generally the best

- Thin window energy compensated GM detectors.

A11 Thickness gauging equipment using low energy x-ray tubes or low energy x, gamma sources

Thickness gauging of plastics, paper and cardboard is sometimes performed using low energy photon sources, such as x-ray tubes or nuclides such as ^{55}Fe, which emits 5.9 keV x-radiation. The gauge is generally well shielded but inevitably there is a slot where the material to be gauged passes into and out of the unit.

The monitoring problem is similar to that involved in the measurement of adventitious x-radiation and can be tackled in a similar way, ie detecting first and, if an apparently significant radiation field is encountered, measurement later.

Instruments for searching

There are two suitable types of detector, thin sodium iodide detectors and thin end window GM detectors. The sensitivity and low energy response must be adequate for the limiting dose rate and the expected spectrum.

Instruments for the estimation of dose rate

The same instruments can be used provided the radiation mean energy is known and credible type test data are available. If the source is ^{55}Fe then response data are likely to be available for both instrument types. These can be used to convert the indication from counts per second to $\mu Sv\ h^{-1}$, directional dose equivalent. If the source is a low energy x-ray tube then the process is more complicated. The easiest approach is to determine the half-value layer using thin aluminium or plastic absorbers. The half-value thicknesses are tabulated below, derived from Hubbell and Seltzer[1].

The effective energy of the beam can be interpolated from the values tabulated below. In combination with type test data this value can be used to estimate the response to the leakage radiation which is being monitored.

	Half-value layer (mm)	
Energy (keV)	Aluminium	PMMA (Perspex)
5	–	0.24
10	0.10	2.0
15	0.34	6.6
20	0.8	–
30	2.6	–

Other types of instrument are rarely suitable. The energy compensated GM types do not operate well at very low energies, the ion chamber instruments tend to have a very large averaging area and to be too bulky and the plastic scintillator types do not work well at very low energies.

A12 Crystallography x-ray equipment

Crystallography x-ray equipment generally employs a copper or molybdenum target x-ray tube, operated at relatively low tube potentials, up to about 50 kV. The useful parts of the x-ray spectrum generated are the characteristic x-rays, at approximately 8 keV for a copper target and 17 keV for a molybdenum target. Normally, leakage from x-ray equipment is dominated by the high energy end of the possible spectrum. However, for this type of equipment, and particularly for copper, radiation leaking through shielding defects is dominated by the characteristic radiation.

In many ways the monitoring problem is similar to that involved in the measurement of adventitious x-radiation and can be tackled in a similar way, ie detecting first and, if an apparently significant radiation field is encountered, measurement later.

Instruments for searching

There are two suitable types of detector, sodium iodide detectors and thin end window GM detectors. The sensitivity must be satisfactory for use at the two energies of interest, 8 keV and 17 keV.

Instruments for the estimation of dose rate

The same instruments can be used for the estimation of dose rate, provided their sensitivities are known. There is an additional type of instrument which uses a relatively high pressure GM detector provided with an energy compensation filter which has the advantage that it is calibrated directly in dosimetric units. The disadvantage with this type of unit is that its response is highly directional and its angle should be adjusted to maximise the indication and that value recorded.

It should be noted that this type of equipment produces a very intense x-ray beam. It is important that the main beam is properly shielded and that the person performing the monitoring has no access to the main beam.

A13 Environmental gamma dose rates

Frequently there is a requirement to monitor very low x, gamma dose rates at site boundaries, normally to assess public exposure.

Dose rates of interest normally cover from normal background levels (0.03 $\mu Gy\ h^{-1}$ air kerma) to 1 or 2 $\mu Gy\ h^{-1}$. Suitable instrumentation has been discussed in detail in Technical Guidance Note (Monitoring) M5[2], but the requirements are summarised here.

These are:

(a) an adequate sensitivity,

(b) an acceptable energy response over the range 60 keV to 7 MeV,

(c) a reasonably low inherent signal, ie the signal produced by radioactivity incorporated in the instrument.

Suitable instruments

- Large energy compensated GM detector connector to a scaler-timer.
- Large energy compensated proportional counter detector connected to a scaler-timer.
- High pressure ionisation chamber instruments.
- Large volume plastic scintillator instruments.

Generally the best

- The energy compensated GM detector type. For greater sensitivity but still at a low cost three detectors can be connected in parallel to a single scaler-timer.

A14 Beta thickness gauges

Beta radiation sources are commonly found in paper and board manufacture and in the processing of printed circuit boards. The source is selected according to the material to be measured and its thickness. Beta sources with maximum energies between ^{14}C (0.167 MeV) and ^{90}Sr + ^{90}Y (2.2 MeV) can be encountered. Beta radiation is relatively easy to shield but the associated Bremsstrahlung is more penetrating. Bremsstrahlung is the x-radiation generated by beta particles slowing down. Its maximum energy is that of the maximum energy of the beta source. However, in common with x-ray generation, the mean energy of an x-ray is about 30% of the energy of the electron causing it. In addition, beta radiation has an energy distribution between zero and the maximum energy for the nuclide in question, with the average at about 30% of the maximum. The beta radiation also loses energy as it passes into a material. These factors combine to ensure that the Bremsstrahlung spectrum has a much lower energy than would be expected from the maximum energy generated by the nuclide.

If the Bremsstrahlung has to penetrate relatively high atomic number shielding then the lower energy components will be preferentially attenuated producing a less intense spectrum with a higher mean energy.

The radiation spectrum emerging from these machines is thus rather complicated. From the relatively unshielded areas, for example slots where the material to be measured enters and leaves the machine, there will be a mixture of beta radiation which has been scattered, and thus had its energy reduced, and Bremsstrahlung. For the shielded areas the only radiations present will be the relatively penetrating component of the Bremsstrahlung.

Suitable instruments

- Thin end window GM detector.
- Ionisation chamber.

Generally the best

- Thin end window GM detector, despite the uncertainty caused by energy response variations. An appropriate response factor is generally that for ^{137}Cs gamma dose rate. This will normally lead to an overestimate of the Bremsstrahlung component and a slight underestimate of any beta component.

A15 Neutron dose equivalent monitoring

Neutron dose equivalent rates are encountered in a variety of circumstances. Some of these are unique to the nuclear industry, such as neutron dose rates from nuclear reactors, irradiated fuel and the storage of plutonium.

Outside the nuclear industry neutron sources, often ^{241}Am + ^{7}Be, are used in borehole logging, soil moisture content measurement and tarmac quality assessment. Adventitious neutron dose rates are encountered in high energy accelerators, which are designed to produce x-rays for therapy or industrial radiography, but which, at accelerating potentials above approximately 6 MV, can also produce neutrons.

An important difference between high energy neutrons and x, gamma radiation is the very high dose equivalent per neutron striking the body. This is partly because the energy generated per neutron incident on the body is higher because of the high probability of interaction and the energy released in some of the capture reactions. The other reason is the high radiation weighting factor. From the point of view of monitoring this difference is a disadvantage. It means that far fewer neutrons strike unit area of an instrument per unit dose equivalent. Hence, to generate a useful count rate at normal occupational dose rates an instrument has to be relatively large and the detection efficiency has to be much larger, when compared to most x, gamma detectors.

Unfortunately, the response of the majority of instruments is still very low, typically 0.3 $s^{-1}/(\mu Sv\ h^{-1})$, about 20% of the response of the industry standard energy compensated GM detector for x, gamma radiation.

Suitable instrument types

There is a variety of instrument types available, but the vast majority of radiation protection measurements are performed using some form of thermal (ie very low) energy detector surrounded by a large mass of polyethylene, the moderator. This mass thermalises high energy neutrons by forcing them to undergo multiple collisions until their energy is reduced to the energy that would be predicted by the ambient temperature. The thermal neutron detector can be a BF_3 proportional counter, a ^3He proportional counter or a lithium iodide scintillator doped with europium, within the moderator, which is a cylinder or sphere of polyethylene. Within the moderator there is often a layer of neutron absorbing material, such as boron loaded plastic, which is used to improve the energy response.

The energy response of neutron monitors is much poorer than for x, gamma monitors. Examples are shown in Figure A1 for some common instruments. The extreme over-response at intermediate energies when compared to the high energy (≈1 MeV) and thermal (0.025 eV) responses should be noted. The problem is obviously more difficult than for x, gamma radiation because of the much wider energy range, 0.025 eV to 10 MeV, a range of 4 10^8, compared to the

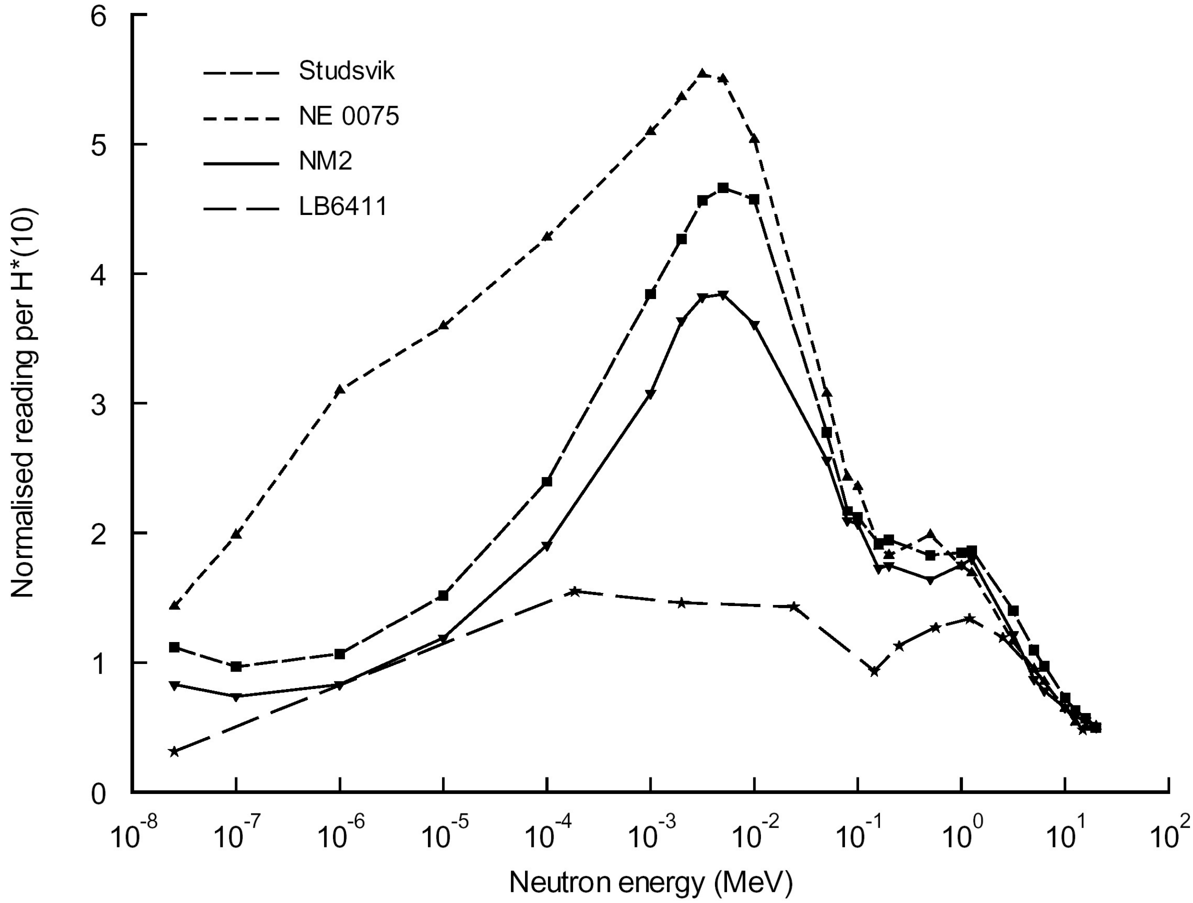


FIGURE A1 Energy response for some commom instruments

5 keV to 3 MeV range usually considered important for x, gamma monitoring, a range of 600. The over-response is also generally unimportant in practical monitoring because the majority of practical spectra are composed of a high energy component and a thermal component, with little in between. There are, as always, exceptions.

The detector is connected to a ratemeter or scaler-timer. This contains a discriminator which rejects the small pulses produced by x and gamma radiation and only accepts the much larger pulses produced by neutron interactions. In essence, the ratemeter is very similar to those found in proportional counter based contamination monitors. The major problem is how to deal with the relatively low count rate expected at normal operational levels approximately 0.3 $s^{-1}/(\mu Sv\ h^{-1})$. At 7.5 $\mu Sv\ h^{-1}$ this corresponds to only 2.3 pulses per second. The count rate from the industry standard ZP1202 GM detector at the same dose equivalent rate from gamma radiation is 12 pulses per second. There are two approaches to this. One is to use a very long time constant ratemeter, which averages over a long period to give a reasonably constant indication. The disadvantage of this is that the user has to wait at least three time constants after moving position before recording the indication. The other solution is to use some variation of the cycling scaler, where the instrument counts for a fixed time and then displays the answer. The time can be selected to provide a suitable statistical precision. For example, for an instrument with a nominal sensitivity of 0.3 $s^{-1}/(\mu Sv\ h^{-1})$, a counting time of 33 seconds at a dose equivalent rate of 7.5 $\mu Sv\ h^{-1}$ will give an average close to 75 counts. This can be displayed as 7.5 to give a direct indication of dose equivalent rate.

Suitable instruments

- Spherical 210 mm diameter moderator, BF_3 proportional counter.
- Spherical 210 mm diameter moderator, ^3He counter.
- Spherical 210 mm diameter moderator, LiI(Eu) scintillator.
- Cylindrical moderator (≈215 mm diameter, ≈250 mm long) moderator, BF_3 proportional counter.

Generally the best

- Where portability dominates, generally the 210 mm diameter moderator BF_3 detector type, provided the radiation spectrum is not thought to contain a large component above 1 MeV.
- Where the spectrum is complicated, the large cylindrical moderator BF_3 detector type.

Survey procedure

This follows the same general procedure as in the monitoring of x, gamma radiation. The main differences are the weight of any of these instruments and the low sensitivity. At low dose equivalent rates, <20 $\mu Sv\ h^{-1}$, a stool or tripod can be useful to support the instrument. At lower dose equivalent rates, the instrument has to have either a very long response time or some form of scaler-timer.

A16 Alpha contamination

Alpha emitting nuclides tend to have relatively high radiotoxicities. The alpha emissions also have a very short range. The first characteristic means that acceptable maximum surface activity levels are very low, with many organisations working to a maximum level of 0.4 Bq cm^{-2}. The second characteristic means that any coating of paint, grease or polish over the contaminated surface will attenuate the alpha radiation considerably and also demands that monitoring is carried out very close to the surface, normally with the probe about 3 mm from the surface. The energy range of alpha disintegrations is relatively narrow, covering 4 to 8 MeV. This should be contrasted with beta radiation, which covers a range from 18 keV maximum energy to in excess of 3 MeV and with photon radiation, which covers the range 5 keV to tens of MeV. This limited energy range means that all alpha emitters tend to be treated as the same, which is regrettable as the range of a ^{238}U alpha particle is less than half that of the more energetic particles.

Direct monitoring is only possible where the alpha activity is directly on the surface. Material such as stainless steel, melamine faced boards and intact paint are normally satisfactory. Surfaces such as plaster, concrete, soil and wood are not.

Suitable instruments

- Zinc sulphide scintillation detectors.
- Dual phosphor probes, comprising a layer of zinc sulphide on a thin plastic scintillator plate.
- Solid state alpha detectors.
- Gas refillable proportional counters.

Generally the best

- There is no clear choice. The instrument characteristics should be considered in the light of the monitoring circumstances.

Survey procedure

Alpha particles have an extremely short range, with a maximum in air of a few cm, even for a perfect source, ie one with an extremely thin layer of alpha emitting activity on the surface, not covered by even the thinnest layer of oil, grease or dirt. Practical monitoring distances have to be less than this, because the particle has to have sufficient energy to penetrate the detector window and also to generate a countable pulse. In practice, the count rate from an alpha source will drop off significantly with increased separation between the source and detector and will normally fall to zero by approximately 15 mm. As a consequence, monitoring is normally carried out with a probe to source spacing of about 3 mm, close enough to allow efficient detection from a clean source and far enough away to avoid contamination of the detector. Even then, the slightest covering of the source will make the alpha contamination undetectable. As an example, one coat of gloss paint will completely shield an alpha source, as will a barely perceptible film of grease or oil. Even a very thin coat of furniture polish will have a considerable effect.

The other significant problem is the generally low maximum level of acceptable surface alpha contamination, typically 0.4 Bq cm^{-2} or less. This low level means that any alpha detected has to be treated as significant. The surveyor must pause at the point where the event was detected and confirm that the average count rate is within the acceptable level. The one positive characteristic of alpha detectors is the very low background count rate, typically less than 0.1 s^{-1} for a 150 cm^2 detector. This means that two counts in adjacent seconds are likely not to be background and are probably due to contamination. A further problem is that even quite trivial levels of contamination on the probe will cause an unacceptably high background.

To summarise, the problems are as follows.

(a) Alpha particles can only be detected with the probe very close to the surface under examination.

(b) Even the slightest covering of grease, oil or paint over the contamination will attenuate the alpha particles to the point of making them undetectable.

(c) The process relies upon the normally very low background count rate from an alpha detector. Any contamination on the probe will be unacceptable in most circumstances.

Guiding a probe 3 mm above a surface demands a steady hand. When the area in question is likely to be clean then it is permissible to support the back of the detector using a finger tip rubbing gently on the surface. The surveyor should wear gloves and the detector must pass over the surface before the finger. Hence the finger should be rubbing on a surface which has been already monitored. The finger should be checked regularly for contamination.

The rate of movement should normally be a few cm s^{-1}, if the surveyor wishes to identify areas of approximately 100 cm^2 contaminated at a level of 0.4 Bq cm^{-2} or less. Alternatively, if an averaging area of 1000 cm^2 is being employed then movement can be faster. At this larger averaging area, a 10 cm × 15 cm detector, a typical size, can be moved quite fast, at up to 30 cm s^{-1}.

There are two basic forms of alpha monitor generally produced. These are the probe and ratemeter combination and the single-handed unit.

The probe and ratemeter type has the advantage that the probe is much lighter than the single-handed unit. This makes it easier to use over a long day. A separate probe also simplifies monitoring of difficult access areas, although the advantage is less than with other forms of monitoring because of the need to keep the probe close to the surface.

The single-handed form has the advantage that the user will have the ratemeter indication in view as he or she moves the detector window over the surface.

Monitoring should be performed mainly using the audio output. The instrument indication is generally only important when recording the maximum count rate from a relatively active area. For noisy areas a lightweight ratemeter is useful as the loudspeaker can be held close to an ear. Alternatively an earpiece can be used. Much alpha monitoring is performed using dual function detectors. It is important that alpha counts make a very different noise from a beta channel count, as a user will wish to distinguish the probably rare alpha event from the several counts per second produced by the beta channel, generated by the gamma background.

A17 Beta contamination monitoring for nuclides with a maximum energy equal to or greater than 0.16 MeV

Beta emitting nuclides in the form of liquid sources are used in large quantities in nuclear medicine and research. They will also be encountered in nuclear power stations as a consequence of activation of the core and in any work with nuclear fuel, either pre- or post-irradiation. Monitoring of people, surfaces and equipment for beta contamination is thus very common. Beta radiation differs from alpha radiation in two ways. One is the very wide spread of maximum energies of common nuclides, from ^{3}H at 18 keV to ^{32}P and ^{90}Y at over 2.2 MeV. The other is that beta emitting nuclides do not emit discrete energies. Each decay has a range of possible energy from essentially zero up to a defined maximum value. Generally the average energy is about 30% of the maximum for the decay. Another aspect which is different from alpha monitoring is that any detector will have a background count rate caused by gamma background and cosmic ray interactions. A typical value is one per second for every 20 or 30 cm^2 of detector. The surveyor thus does not have the luxury of considering any event detected as significant. To set against this, however, is the generally lower radiotoxicity of beta emitters compared to alpha emitters, which leads to generally higher maximum acceptable levels which, in turn, leads to generally higher limiting count rates.

The low energy cut-off suggested (0.16 MeV) is because below that energy the range of the average beta particle is insufficient to cross a typical 3 mm air gap and penetrate a detector window. Monitoring for lower energies generally uses wiping followed by liquid scintillation counting.

Suitable instruments

- Thin end window GM detectors.
- Thin glass or metal walled GM detectors.
- Gas refillable proportional counters.
- Thin window xenon filled sealed proportional counters.
- Thin windowed scintillation detectors.

Generally the best

- There is no clear choice. The instrument characteristics should be considered in the light of the monitoring circumstances. The most important parameter is the maximum energy of the beta emitter.The instrument has to have a useful response at that energy. The most restricted type is the thin glass or metal walled GM which can only be used for energies in excess of 0.5 MeV.

Survey procedure

For soft beta emitters the probe should be held about 3 mm from the surface, which is difficult to achieve for any length of time. When the area in question is likely to be uncontaminated or only very lightly contaminated then it is permissible to support the back of the detector using a fingertip resting gently on the surface. The surveyor should wear gloves and the detector must pass over the surface before the finger. This will identify any significantly contaminated areas before the finger touches them. The finger should be checked regularly for contamination.

For energetic beta emitters, such as ^{32}P or $^{90}Sr + {}^{90}Y$, a gap of 10 mm will not seriously attenuate the radiation. Hence the probe need not be held so close to the surface. Moving the probe away from the surface effectively increases the averaging area. For point contamination the count rate will drop off with increasing distance because of the consequences of the inverse square law. For contamination which is relatively uniform over a wide area no obvious drop off will be observed.

In contrast to alpha monitors, most large area beta probes will have a significant background count rate. At normal environmental levels this is about 1 s^{-1} for every 20 cm^2 of probe area.

When exposed to high energy gamma radiation the response is typically 5 $s^{-1}/(\mu Sv\ h^{-1})$ for every 20 cm^2 of probe area. This sensitivity inevitably limits the ability of the probe to detect contamination when monitoring is taking place in significant gamma radiation fields, by producing a general increase in background count rate. The most obvious example of this is the monitoring of transport packages which contain energetic beta emitters. This beta radiation is likely to be completely shielded. However, Bremsstrahlung x-rays will be produced which can give rise to a measurable dose rate on the outside of the package. For a typical package containing ^{32}P the surface dose rate can reach a few $\mu Sv\ h^{-1}$. This will produce a count rate on a 50 mm diameter pancake GM detector of about 25 s^{-1}. This count rate will also vary as the detector is moved over the surface of the box because the source to detector distance will change, even if only one source is present. As many of these packages contain more than one source then the count rate from the x-rays alone will vary in a complicated way over the bottom of the box. This high and varying count rate will mask contamination by ^{32}P at a level of a few Bq cm^{-2}. Direct monitoring of such packages is thus confined to the detection of relatively high levels of contamination. To avoid this problem the normal solution is to wipe the box and measure the wipe in a lower background area.

A18 X-ray and gamma contamination

Many nuclides produce low energy x-rays, typically by a process of electron capture. The nucleus captures an electron from the K shell, leaving a gap. This is then filled by an electron dropping down from a higher level. In doing so it sometimes produces an x-ray photon with an energy equal to the difference in energy levels. Such nuclides are popular in many research applications as they produce reasonably penetrating radiation, which can also be detected efficiently. An example is ^{125}I which produces a mixture of 27 to 32 keV x-rays and 35 keV gamma photons.

X-ray emitting nuclides can also be found in contamination around nuclear reactors, and are particularly prominent in AGRs. The most prominent nuclide is ^{55}Fe, which emits a 5.9 keV x-ray.

A less familiar application is for the detection of relatively gross levels of contamination by transuranic nuclides such as ^{239}Pu and ^{241}Am. Many transuranics decay by alpha emissions which are very easily shielded. If contamination is suspected but the surface in question is dirty or greasy then a check for relatively high levels of activity, typically from a few Bq cm^{-2} upwards, can be made by looking for x-rays in the 13 to 20 keV range. These are generated by electrons dropping down into the L shell, rather than the K shell. These x-rays are relatively penetrating and will pass through a thin layer of grease or oil almost unattenuated. They will also pass, to a degree, through paint but will be attenuated by the pigment which is usually titanium or, in older paint, lead based.

Most gamma emitters also emit beta radiation and, generally, it is the beta radiation which is used in contamination monitoring. Typical examples are ^{137}Cs and ^{60}Co. However, there are relatively rare examples which do not emit beta radiation or, rather more correctly, where the beta decay stage has already taken place. Most common is ^{99m}Tc, which is used in large quantities in medical imaging. This emits a 140 keV photon.

It is also, obviously, possible to monitor surface contamination by the beta + gamma emitting nuclides using the gamma radiation. This is not done normally for higher energy emitters simply because the gamma radiation is too penetrating. To detect it efficiently demands a large area, high mass detector, which leads automatically to a high response to background gamma and cosmic radiation. As an example, a typical 50 mm diameter, 50 mm thick sodium iodide detector will have a background of 50 s^{-1}. In comparison, a typical 50 mm diameter thin end window pancake GM detector will have a background of 0.5 s^{-1}, a factor of 100 lower. Hence, this section will concentrate on the detection of relatively low energy x, gamma radiation covering the range 5 to 140 keV.

There are two main problems. At the low energy end the window covering the detector has to be relatively thin and have a low atomic number to give a good transmission. At the high energy end the problem is to stop the relatively penetrating radiation. This demands a high mass per unit area, high atomic number detector. There are two popular forms. One is the xenon filled, titanium windowed proportional counter. The other is the aluminium or beryllium windowed sodium iodide scintillation detector.

Suitable instruments

- Xenon filled, titanium windowed proportional counter.
- Aluminium or beryllium windowed sodium iodide detectors.

Generally the best

- There is no clear choice. The instrument characteristics should be considered in the light of the monitoring circumstances. See Appendix C.

Survey procedure

Even low energy (5.9 keV) x-radiation has a much longer range than alpha or low energy beta radiation. Hence the need to hold the detector very close to a surface is reduced. In a similar way to high energy beta radiation, drawing back a few mm from a surface effectively increases the averaging area, reducing the count rate from point source contamination but having little effect on distributed contamination. Monitoring is thus generally similar to dealing with high energy beta radiation. The probe should be scanned over the surface in question while the operator listens to the audio output. If an increase is noted or if a trigger point is exceeded then the operator should move the probe to maximise the count rate, and either record the value and position or clean up the contamination immediately. The main problem is the calculation of the expected response to a particular nuclide. Many have complicated decay schemes, generating a range of energies. There is also a rather poor set of calibration sources in comparison with alpha and beta contamination. Manufacturers can often supply typical response data for a range of nuclides but, in the absence of specific information, frequently the best that can be done easily is to confirm that the instrument should have a significant response to at least a significant proportion of the radiations present. This will give the user the confidence that the instrument will detect significant contamination, although quantifying it will not be easily achieved. Alternatively, it may be possible, if facilities are available, to make a calibration source by spotting known activity solution on to a suitable surface. The response of the instrument can be calculated and noted for future reference.

One other aspect which is generally more of a problem than for alpha and beta radiation is the influence of stock solutions of the nuclide on the bench or in the room. Often these generate a significant background level which makes direct local monitoring difficult. If the solutions cannot be removed or better shielded then it may be necessary to take wipes for monitoring in a lower background area. The same problem is also present when monitoring packages.

A19 References

1 Hubbell J H and Seltzer S M. Tables of x-ray mass attenuation coefficients and mass energy-absorption coefficients 1 keV to 20 MeV for elements $Z = 1$ to 92 and 48 additional substances of dosimetric interest. Washington DC, US Department of Commerce, NISTIR 5632 (1995).

2 HMIP. Routine measurement of gamma ray air kerma rate in the environment. London, HMSO, Technical Guidance Note (Monitoring) M5 (1995).

APPENDIX B
Hints on Establishing Radiation Type and Energy

In many circumstances there is no debate on the dominant radiation types and energies present. Good examples of this are open shop radiography using an ^{192}Ir gamma source and contamination monitoring in a radiopharmacy that uses only ^{125}I. However, in many circumstances, things are more complicated. These have been noted in earlier sections where, for example, the energy of an x-ray beam may be in debate because of scatter or hardening via transmission or where there may be a mixture of radiation types produced by a beta thickness gauge.

B1 X-radiation energy

X-rays tend to be softened by scatter and hardened by transmission. Often a user might wish to employ a steel walled energy compensated GM based detector, because of its low cost and operational convenience, but is concerned because there may be a significant component below 50 keV, to which the energy compensated GM will not respond. What possibilities are there to identify whether such an instrument is acceptable? The simplest one is to compare the indication of the instrument in question with one with better metrological qualities such as an ionisation chamber. If the user makes measurements at each point of interest with the two instruments then an intercomparison of the results will clearly identify any points where the energy compensated steel walled GM produces a significantly lower indication. If there is no such point, then the GM based instrument is acceptable. If there are, then an instrument of better metrological quality will be required, such as an ionisation chamber or a thin window energy compensated GM detector.

An alternative route is to use an ionisation chamber instrument of good quality and a 0.5 mm thick copper filter. If the user goes to each monitoring point and performs a measurement with and without the copper filter then an intercomparison of the results will show points where a conventional steel walled energy compensated GM detector cannot be used. These will be where the indication with the filter between the source and the open window of the ion chamber (slide open or cap off) is less than 50% of the corresponding reading without the copper filter. The rationale behind this is that the energy response of the ion chamber with the filter will be very close to that of a good quality energy compensated steel walled GM detector. If no large differences appear, then the GM unit can be used.

To illustrate this point the transmission of the copper filter is given below.

Energy (keV)	Transmission of a 0.5 mm thick Cu filter
20	$1.5\ 10^{-6}$
30	$1.2\ 10^{-2}$
40	0.14
50	0.35
60	0.53
80	0.75
100	0.85

B2 Estimation of beta energy

It may be useful to have some feel for the energy of a beta radiation field. For example, a user may wish to use a thin end window GM detector to determine the directional dose equivalent rate with reasonable accuracy. The response of such a detector varies by about a factor of two over the normal energy range of interest for beta dose rate measurements. The values below will help to make an estimate of the radiation energy. These were derived using an NPL beta protection level secondary standard to produce the radiation field and a Mini Instruments 900 EP15 thin window pancake GM survey instrument.

Nuclide	E_{max} (MeV)	Transmission of 1 mm polyethylene
^{90}Sr + ^{90}Y	2.27 + 0.54	0.3
^{85}Kr	0.67	0.05
^{147}Pm	0.225	<0.01

It should be noted that polyethylene was chosen for its good transmission of x-radiation. If there is a large x-ray (Bremsstrahlung) component then transmissions will be high. Identifying the relative components is described in the subsequent section.

B3 Identifying the presence of x-radiation in the presence of beta radiation

The process relies upon the fact that the transmission of beta radiation depends mainly on the mass per unit area of the material between source and detector, and only to a small degree on its atomic number. The transmission of low energy x and gamma radiation, however, depends greatly on the atomic number of the filter.

Convenient filters are given below. Again the transmissions were measured using a Mini Instruments 900 EP15. The filter materials have a transmission of about 0.04 for ^{90}Sr + ^{90}Y beta radiation and lower for lower energies. The other filter required is 4 mm PMMA (Perspex). This has a similar beta transmission.

x, gamma energy (keV)	Transmission of		
	0.5 mm Cu	1.8 mm Al	4 mm PMMA
15	0	0.03	0.69
20	0	0.22	0.97
30	0.03	0.63	1
40	0.22	0.81	1
50	0.45	0.88	1
60	0.62	0.95	1

These filters can clearly help to identify whether the field is mainly beta radiation and whether it has a significant x, gamma component, and determine its effective photon energy, at least approximately. This level of information will usually be sufficient to allow a sensible choice of monitoring equipment and a sensible choice of correction factor, if needed at all.

This process will not work where, for example, there are two widely separated gamma energies contributions such as ^{137}Cs (662 keV) and ^{241}Am (60 keV) but will work where there is a mixture of Bremsstrahlung and beta radiation.

Alternatively, an easy qualitative test is to use a detector with a very poor beta response and a very high x, gamma response, such as a sodium iodide detector with a thick plastic end cap. This will clearly indicate the presence of x, gamma radiation even in the presence of a relatively high beta intensity. However, the results will be difficult to interpret quantitatively.

B4 Gaining information on mixed contamination

Sometimes, particularly in older facilities undergoing decommissioning, it is useful to be able to identify, broadly, the contaminants present.

Easy first separations are into alpha, beta and x, gamma emitters. Alpha emitters are relatively easily identified because only they will cause a count rate in a correctly set up alpha probe. Similarly, low energy x, gamma emitters can clearly be identified because they will produce a very much higher count rate on a thin sodium iodide scintillation detector than on any beta scintillation, GM or gas refillable proportioned counter detector.

If the potential beta contaminants are reasonably energetic, with E_{max} from 0.3 MeV upwards, then the alpha contribution to a typical beta detector can be removed simply by making measurements with a 15 mm surface to probe spacing. This will normally reduce the alpha contribution to close to zero while not greatly affecting the beta signal.

B5 Estimating beta contamination energy

Often it will be useful to be able to make a crude estimate of the energy of a beta contaminant. This is reasonably easy to do where there is one dominant nuclide, but care should be taken where there is a complicated mixture. The results below were obtained using paper absorbers, but any other similar material, such as polythylene food bags or cling film will do, provided the mass per unit area can be estimated. The paper used had a thickness of 6 mg cm^{-2}, equivalent to 60 g m^{-2}.

Again a Mini Instruments 900 EP15 was used.

Nuclide	E_{max} (MeV)	Half thickness (mg cm^{-2})	Quarter thickness (mg cm^{-2})	Tenth thickness (mg cm^{-2})
^{90}Sr + ^{90}Y	0.54 + 2.27	24	96	–
^{36}Cl	0.69	23	46	70
^{60}Co	0.31	5	11	25
^{147}Pm	0.225	3	6	10
^{14}C	0.167	–	–	6

B6 Estimating the energy of a gamma source

Sometimes, particularly in NAIR incidents or when decommissioning facilities, it will be convenient to estimate the energy of a gamma source. This can be done using lead filters. Lead is easily available from most builders' merchants in a range of thicknesses and of sufficient purity for this purpose. Any gamma detector can be used provided its response is not violently energy dependent, such as thin sodium iodide scintillation detectors. Thick ones, eg 50 mm x 50 mm, are acceptable, as are any GM detector and ionisation chamber.

This process is not accurate but can be used to differentiate between ^{60}Co, from activation, 1.25 MeV average, and ^{137}Cs, from contamination, 662 keV, for example. It can also be used to identify an ^{241}Am smoke detector from a ^{226}Ra based example, as 1 mm of lead will completely shield an ^{241}Am gamma source but will have only a limited influence on the ^{226}Ra one.

Nuclide	E (MeV)	Half-value thickness (mm Pb)
^{60}Co	1.17 + 1.33	16
^{131}I	0.36–0.72	3
^{137}Cs	0.662	8
^{192}Ir	0.32–0.61	3
^{226}Ra	Various to 2.09	12

APPENDIX C
Summary of Instrument Characteristics

C1 Conventional energy compensated GM detector

Good points

- Compact for a particular sensitivity, compared to ion chambers.
- Electronically simple.
- Low maintenance.
- Tough, when well designed.
- Popular and inexpensive.
- Easy to couple to an audio output.
- Adequate energy and polar response if well designed.
- Will withstand very high dose rates in the case of equipment failure.

Weaknesses

- Responds only to x, gamma radiation above 50 keV. They will under-respond significantly in an unfiltered x-ray beam for potentials less than 150 kV.
- A vigorous over-response, by up to a factor of two for very high energy (>3 MeV) x, gamma radiation
- Pulsed sources – there is a count rate limitation when used with pulsed sources. For pulsed sources producing narrow (up to tens of microsecond) pulses it is important that the count rate from the detector does not exceed 30% of the pulse repetition frequency, otherwise the instrument will under-read. Hence it is essential to know the sensitivity of the instrument [in counts $s^{-1}/(\mu Sv\ h^{-1})$] and to identify a maximum trustworthy count rate. This leads to the unfortunate circumstances that the higher the sensitivity, the lower the maximum useful indication.
- Pulsed sources will give a completely false reading at high dose rates, for example close to the target in the main beam. At the ultimate the detector will record one pulse per radiation pulse. For a 400 Hz machine this means a maximum count rate of 400 s^{-1}. If a relatively high sensitivity detector is used, for example one giving 5 $s^{-1}/(\mu Sv\ h^{-1})$, then that gives an ultimate indication, at no matter how intense a dose rate, of 80 $\mu Sv\ h^{-1}$.

Check for

- Adequate sensitivity. For reasonably quick monitoring a minimum count rate of at least 3 s^{-1} and preferably 5 s^{-1} is required. Higher is better. For 7.5 $\mu Sv\ h^{-1}$ choose a detector giving at least 0.8 $s^{-1}/(\mu Sv\ h^{-1})$. For 2.5 $\mu Sv\ h^{-1}$ choose one giving at least 2 $s^{-1}/(\mu Sv\ h^{-1})$.
- A decent ambient dose equivalent rate response from 50 keV to 1.25 MeV (within ±25% compared to ^{137}Cs gamma radiation).
- A reasonable polar response. When tested at 60 keV the response should be within ±25% of that in the reference direction when tested out to 45° off axis.
- No fall back at high dose rates. There is no technical reason why a GM based instrument should fail to danger below 1 Sv h^{-1}.

C2 Thin window energy compensated GM detectors

Good points

- Compact for a particular sensitivity compared to ion chamber types.
- Electronically simple.
- Low maintenance.
- Very wide energy response for x, gamma radiation, 10 keV upwards.
- Inexpensive.
- Easy to couple to an audio output.
- Detector can be mounted on a probe, which can be steered round complicated objects.

Weaknesses

- Responds effectively only to x, gamma radiation.
- Slightly less robust than conventional energy compensated GM instruments.
- Similar problems as for conventional energy compensated GM instruments at high energies and when dealing with pulsed sources.

Check for

- Adequate sensitivity. Aim for a count rate at the lowest dose rate of interest of at least 3 s^{-1}.
- As for conventional energy compensated GM instruments, except for the wider energy range, 10 keV to1.25 MeV.

C3 Thin end window GM detectors

Good points

- A reasonably high sensitivity to a wide range of x-ray energies.
- Responds to beta radiation.
- Electronically simple.
- Low maintenance.
- Inexpensive (≈£100).
- The detector is normally on a probe, which can be steered round complicated objects.
- A good audio output, which means the user can concentrate on steering the probe and only has to read the display when an elevated count rate is located.

Weaknesses

- X-radiation response is energy dependent typically over a range of about four from the minimum, usually taken as ^{137}Cs gamma radiation (662 keV), to the maximum, at approximately 60 keV, falling slowly for lower energies. For estimating directional dose equivalent rates in mixed beta and x, gamma fields the normal approach is to use the ^{137}Cs gamma response factor, which is generally close to the response for energetic betas (^{90}Sr + ^{90}Y) and not more than twice the response for betas of lower energy. In this way the instrument may slightly under-respond for beta radiation and will generally over-respond for the Bremsstrahlung.
- Very vulnerable to window damage. A typical 1 mg cm^{-2} window can be punctured by a cut-off rye grass stalk, as well as obviously potentially damaging objects such as tweezers and screwdrivers. However, for x-ray measurements, the protective cap can normally be

left in place, provided the energy response is known for the cap on and provided the user is confident that really low energies, ie those below 15 keV, are not likely to be present. Above that energy a typical plastic cap provides very little attenuation.

- Relatively high repair costs. The only solution to a damaged detector is complete replacement, unlike some other contamination monitor types which can be refurbished.

Check for

- X, gamma radiation – polar response. The best shape of detector is one with a window diameter which is large compared to the detector depth. For that shape the response is not violently directional. For long thin detectors at low energies the response is very directional. Hence, to make a sensible measurement of leakage radiation, such a detector has to be in the right place and pointing in the right direction.
- Beta contamination monitoring – sufficient size. The industry standard has a 50 mm diameter end window. Smaller ones make for very labour intensive monitoring and should only be used when monitoring difficult and complicated objects.
- Good grille. The detectors are very vulnerable and should normally be protected by a fine etched mesh grille. Wire grilles are less transparent, particularly to betas arriving at shallow angles. Open mesh grilles generally lead to high damage rates but can be useful when monitoring smooth surfaces at very low levels.
- A good performance at the lowest energy of interest. This low energy defines the maximum window thickness. The performance of the detector drops as the beta energy decreases. Generally such detectors are useable down to 0.17 MeV (^{14}C, ^{35}S) at a limit of 4 Bq cm^{-2}.
- The correct shape. Detectors should have a window diameter greater than the detector depth. Deep detectors lead to higher background count rates, increasing the maximum missable activity. The normal term for a detector with a high diameter to depth ratio is a pancake detector.

C4 Large energy compensated GM detector connector to a scaler-timer for environmental air kerma rate measurements

Normally this employs a ZP1221/01 or similar energy compensated GM detector.

Good points

- Adequate sensitivity, ≈16 s^{-1}/(μGy h^{-1}).
- A reasonably low self dose rate, typically 0.2 pulses per second compared to the 1 to 2 pulses per second produced by cosmic and environmental gamma radiation.
- Electronically simple.
- Low maintenance.
- Extremely light.
- Easy to mount on a tripod.
- Low cost.

Weaknesses

- The response rises sharply above 1 MeV. See Figure C1. This can cause problems in the presence of very high energy gamma radiation, such as the 6 to 7 MeV radiation from ^{16}N.
- The detector is not completely robust but can be protected by foam.

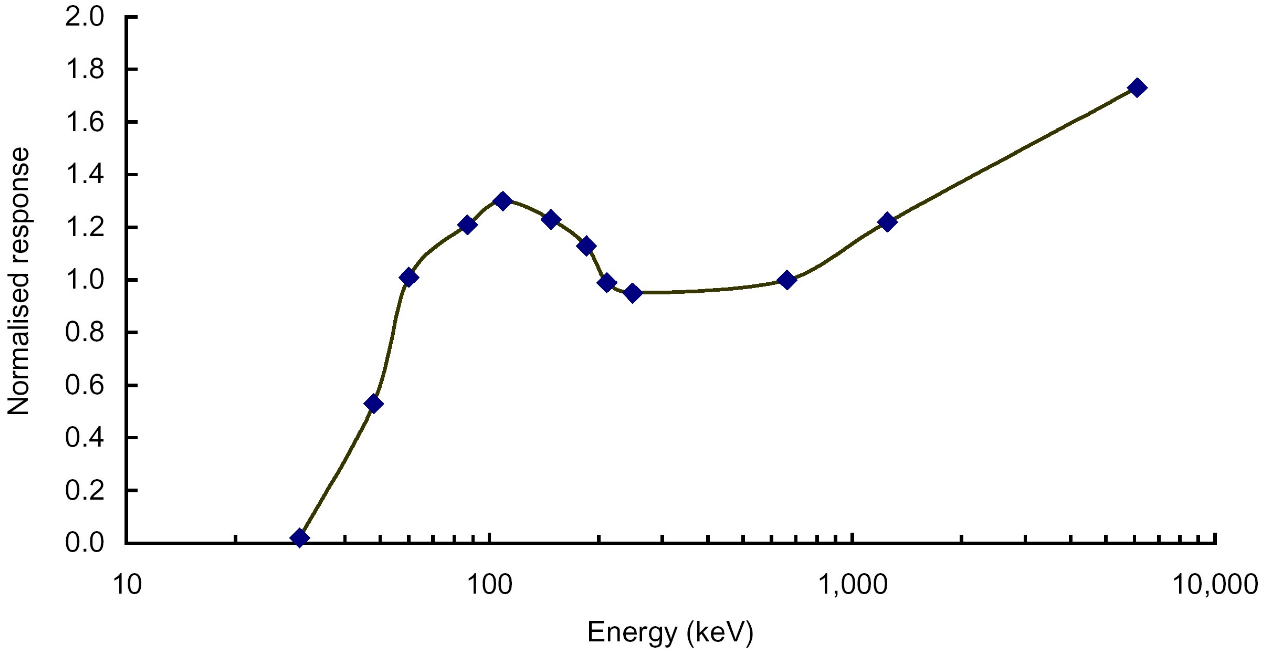


FIGURE C1 X and gamma air kerma response of a ZP1221/01 energy compensated GM detector

Check for

- A creeping increase in background count rate, particularly when the detector is left powered for months.
- A tendency for the count rate to change with temperature, particularly when the detector is continuously powered.
- A gradual fading away after an impact. Dropping the probe can cause cracks in glass or ceramic seals, leading to loss of function over days and weeks.

C5 Thin glass or metal walled GM detectors

These are generally cylindrical with a glass or metal wall with a thickness of approximately 30 mg cm^{-2}, a length of 10 to 20 cm and a diameter of approximately 15 mm.

Good points

- Reasonably robust when compared with thin window detectors.
- Electronically simple.
- Inexpensive to buy.
- Easy to couple to an audio output.
- Light.

Weaknesses

- A relatively high minimum useful beta E_{max}, generally approximately 0.5 MeV.
- A rather undefined monitoring area. An end window detector held close to a beta contaminated surface will, for monitoring purposes, only respond to activity directly below the window as the thick side walls will screen out particles from further away. With a cylindrical geometry, even in a shielded probe, most designs will respond to particles incident at shallow angles and hence from far away.
- Relatively high background count rate per unit contamination sensitivity.

Check for

- Halogen filling. These operate over a wide temperature range and have very long lifetimes. Organic filled detectors, while easier to make and cheaper, are generally less reliable and are shorter lived.

C6 Ionisation chambers

Good points

- Excellent x, gamma ambient dose equivalent energy and polar response generally (slide shut).
- Good beta directional dose equivalent energy and polar response generally (slide open).
- No significant dose rate limitations normally.

Weaknesses

- Bigger and clumsier than energy compensated GM types.
- More expensive.
- Generally more sluggish at low dose rates
- Relatively insensitive and subject to higher background fluctuations than other dose rate monitors.
- Large averaging area for a given sensitivity which may lead to much lower indicated dose rates than end window GM detectors, for example, when monitoring narrow beams.
- Require more maintenance.
- Generally no audio output.
- May change range or function unexpectedly if strong magnetic fields are encountered.

Check for

- Adequate sensitivity – it is important that, at levels at which barriers are to be set etc, the instrument indication is readable. On analogue instruments the minimum level of use should be at least 25% of the lowest dose rate range scale maximum.
- Problems associated with any magnetic fields.
- Low area instruments with an apparently high sensitivity.
- Ion chambers with a 10 cm^2 end window and a 10 $\mu Sv\ h^{-1}$ full-scale most sensitive range are available. However, they are very difficult to use, generally have a very high level of fluctuation at background levels and need careful maintenance.

C7 High pressure ionisation chamber instruments

These use high volume (>5 litres), high pressure (~10 atmospheres) steel walled ion chambers.

Good points

- A good energy response, above approximately 80 keV.
- Adequate sensitivity.

Weaknesses

- The detector is a pressure vessel which cannot be transported by air without special precautions.
- Extremely heavy.

- Bulky detector.
- Very expensive.

C8 Large energy compensated proportional counter detector connected to a scaler-timer

Good points

- Adequate sensitivity.
- Low self dose.
- Good energy response, extending to lower energies than the GM detector types.
- Low maintenance.
- Extremely light.
- Easy to mount on a tripod.

Weaknesses

- Electronically more complicated than GM detector types.

Check for

- Gradual loss in sensitivity with time.

C9 Scintillation based dose rate monitors

These are instruments fitted with plastic scintillators and marked in μSv h^{-1}. These are not sodium iodide based instruments marked in counts per second.

Good points

- Very good x, gamma sensitivity, giving a very fast response and a very steady reading at 2.5 and 7.5 μSv h^{-1}.
- Good x, gamma energy and polar responses.

Weaknesses

- Much more expensive.
- More difficult to set up and maintain.
- Likely to require occasional adjustment throughout their lives.
- Generally no audio output.
- May behave oddly in pulsed fields as the instrument struggles to cope with the relatively high dose rate in the pulse followed by a much longer period at background levels.
- Generally only available as a single-handed unit, not as a probe and ratemeter combination.

Check for

- Low energy performance. Energy responses are often given on logarithmic graphs with sparse markings. When dealing with low energy sources it is important to confirm that the energy and polar response is adequate.

C10 Large plastic scintillator instruments for the detection of lost sources etc

These use large blocks of plastic scintillant. The detection probability is less per unit volume than for sodium iodide because the detector density is less and the atomic number is lower. However, the scintillator is generally much bigger.

Good points

- High sensitivity for large sizes. Typically volumes of 500 cm^3 upwards are used.
- Easy to couple to an audio output.
- Very tough detector.

Weaknesses

- No photopeak, ie full energy peak, but energy information can be derived from the position of the compton edge.
- Lower light output per unit energy deposited so the electronics have to work harder.
- Sensitive to magnetic fields.

Check for

- Adequate sensitivity.

C11 Large sodium or caesium iodide scintillation detector based instruments, for lost source detection

Good points

- High sensitivity, with approaching 70% detection efficiency even for high energy gamma radiation for 51 mm × 51 mm crystals.
- Electronically reasonably simple.
- Easy to couple to an audio output.
- Can be connected to a single channel analyser to reduce background and improve detection efficiency.
- Can be connected to a multi-channel analyser to produce nuclide identification.

Weaknesses

- Expensive.
- Heavy compared to normal radiation protection equipment.
- Fragile, particularly the sodium iodide crystal, less so the caesium iodide type.
- May be corrupted by strong magnetic fields.

Check for

- An adequately low energy threshold. For general monitoring a threshold of 60 keV is useful and easy to set using ^{241}Am gamma radiation.
- Sensitivity – it should be close to values given in standard texts. Low backgrounds or sensitivities indicate detector damage.

C12 Aluminium and beryllium thin windowed thin crystal sodium iodide detectors

These generally comprise a thin sodium iodide crystal, typically 3 mm thick and 20 to 150 mm in diameter, protected by a thin aluminium or beryllium window. Aluminium is used for detectors with a minimum energy of use of approximately 10 keV, while the more expensive and toxic beryllium is used for detectors which have to operate at lower energies.

Good points

- A good detection efficiency over a wide energy range, up to at least 140 keV.
- An extremely high sensitivity typically in the hundreds or thousands of counts s^{-1}/(μSv h^{-1}) for low energy x-ray detection.

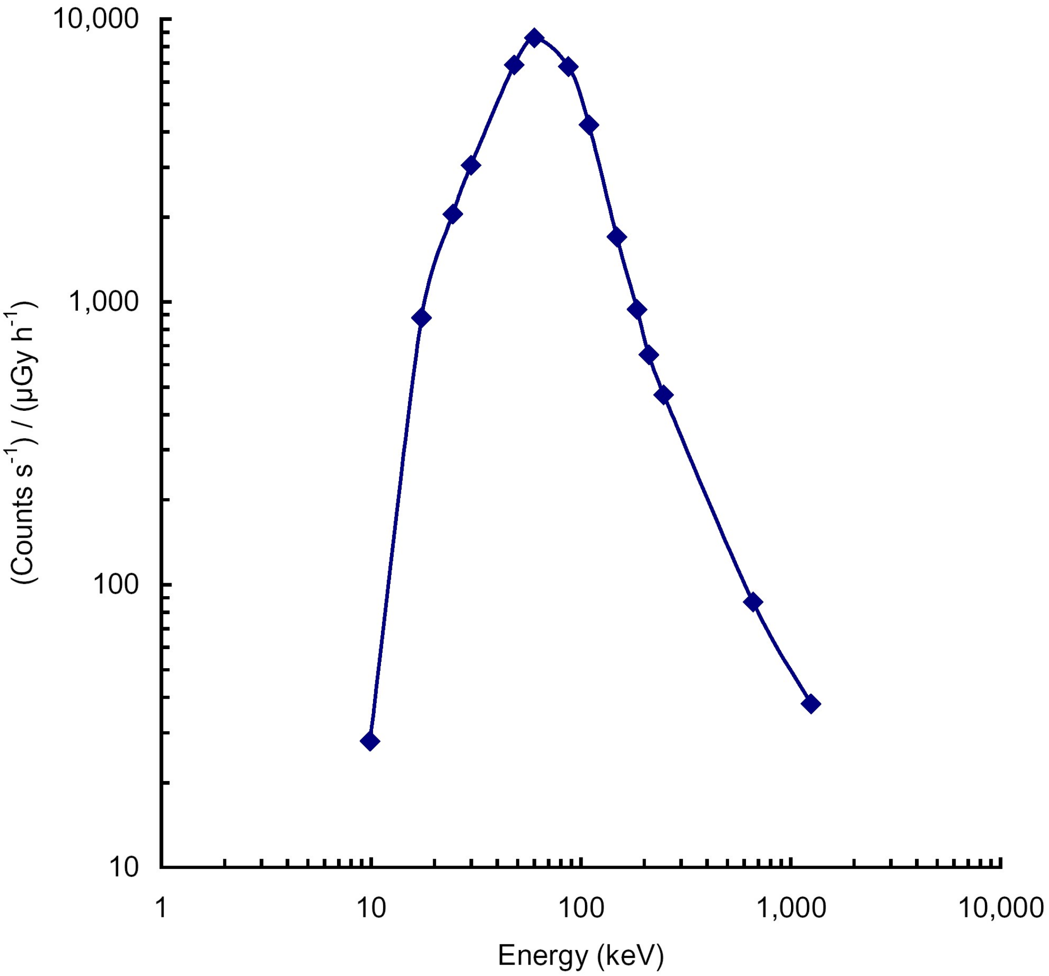


FIGURE C2 Typical response of a thin sodium iodide scintillation detector for x and gamma air kerma rate

- Reasonably tough – the windows are unpressurised and thicker than the xenon filled proportional counters and will not puncture when tapped with a pair of blunt nosed tweezers, for example.
- Can be used very effectively with counting energy windows to reduce background.
- A good audio output. For dose rate monitoring normally the best process is to concentrate on guiding the probe around the object of interest. The very high sensitivity means that even small defects will give a very clear burst of clicks. The surveyor can then pause, move the probe around to maximise the indication and then record the answer.

Weaknesses

- A very rapid change in response with energy when measuring dose rate. See Figure C2.
- The sodium iodide crystal is easily shattered and is also hygroscopic. Sharp knocks will cause the crystal to craze, greatly reducing the light gathering efficiency. Any sort of possible moisture ingress will result in yellowing of the crystal, again reducing the light gathering efficiency. This is expressed as an increase in the counting threshold energy.
- Operating voltage is very variable. In common with other photomultiplier based devices the correct operating voltage can range from 600 to 1200 V.
- Susceptible to strong magnetic fields, although the best examples have a mu-metal shield around the photomultiplier, which helps greatly.
- Background count rate is higher per unit area than proportional counters.
- More expensive than GM units for dose rate monitoring.

Check for

- Confirmation that the energy threshold, ie the minimum energy which the instrument can detect, is low enough. Each probe requires individual setting up. There is also a limited number of test radionuclides which generate low energy radiations which can be used for setting up. This is different from other instrument types, such as GM, ion chamber and plastic scintillator types, where the energy response does not depend on the operating voltage.
- A good polar response. Instruments with the crystal mounted at the very end of the detector always have good polar responses. Some have the crystal within a collimator. This reduces the background, but also gives a very directional response which means that the detector has to be in the right place and pointing in the right direction to give meaningful results.
- Excessive sensitivity when monitoring x-ray dose rate. If significant radiation levels are anticipated, will the instrument go to full-scale deflection? This is a strong possibility for higher voltage electron microscopes, for example.

C13 Zinc sulphide scintillation detectors

Good points

- Very efficient alpha detector.
- Available in reasonably large sizes, up to 20 cm × 30 cm.
- Good beta and gamma rejection.
- Virtually zero background count rate. Every event can be treated as potentially significant.
- Available as both probe and ratemeter and combined units.
- Audio output always available.
- Competitive price.

Weaknesses

- The optimum operating voltage is variable, even within one type of probe.
- Susceptible to damage to the very thin foil covering the scintillator plate which can lead to erratic performance as a result of light getting in to the detector (rugged versions are available but are more expensive).
- Susceptible to strong magnetic fields.

Check for

- Older instruments that fail to danger when there is a light leak.
- Detectors with excessively patched foils. Normally one or two small particles over points where the window has been damaged are acceptable.
- Poor uniformity of response over the area of the detector caused by poor light collection or scintillator deterioration.
- Correct operating potential. When in use for confirming the absence of alpha contamination in a low beta and gamma background the operating voltage should be set close to the point where background becomes noticeable, $>0.1\ s^{-1}$. When used in areas of high gamma background or in the presence of beta contamination the operating voltage should be lower to avoid background counts. This, however, will reduce the sensitivity to alpha activity, particularly for lower energy and dirty sources.

C14 Dual phosphor probes, comprising a layer of zinc sulphide on a thin plastic scintillator plate

These offer dual monitoring of alpha and medium to high energy beta contamination.

Good points

- Dual function.
- Available in reasonably large sizes.
- Virtually zero alpha background count rate in normal gamma backgrounds.
- Audio output available with a different sound used to indicate alpha and beta pulses.
- Window easy to replace.

Weaknesses

- More susceptible to influence from beta and gamma radiation.
- More complicated, with a more demanding setting up procedure.
- Variable operating voltage between examples.
- Beta detection efficiency is poorer than both gas filled detectors and most beta only scintillation detectors.
- Susceptible to window damage (rugged versions are becoming available).
- While beta radiation should rarely cause an alpha count, a good proportion of the alpha radiation will cause a count in the beta channel. The dirtier the source, in the sense of the thickness of grime or grease covering the activity, the larger the proportion that enters the beta channel.
- Susceptible to magnetic fields.

Check for

- Light leaks.
- Detectors with excessively patched foils.
- Poor uniformity of detection, particularly in the corners of the probe.

C15 Solid state alpha detectors

These use large area silicon diodes as the sensitive element.

Good points

- Compact, as no photomultiplier tube is required, unlike scintillation detectors.
- No gas filling is required, unlike thin window proportional counters.
- Lightweight.

Weaknesses

- No amplification in the detector itself which makes them particularly sensitive to interference from radiofrequency fields and magnetic fields.
- Light sensitive.
- Expensive detector.

Check for

- Magnetic fields and radiofrequency fields which may corrupt monitoring results.

C16 Gas refillable proportional counters

These use a large area, often 10 cm × 15 cm, thin windowed gas filled proportional counter. The hand-held ones generally use butane lighter fuel as a counting gas. The detector requires regular refreshing, either from an external tin or from a built in reservoir.

Good points

- Large size.
- Good uniformity of response.
- Good alpha and beta detection efficiency over a wide range, covering beta emitters with maximum energies from ^{14}C (0.167 MeV) upwards.
- Relatively compact (no photomultiplier tube).
- Easy window repair.
- Detector can be rewired.

Weaknesses

- Needs regular gas refilling and refreshing.

C17 Thin window xenon filled sealed proportional counters

These are generally 10 cm × 10 cm or larger xenon filled proportional counters with titanium windows about 5 mg cm^{-2} thick.

Good points

- Can be obtained in large sizes.
- Also sensitive to low energy x, gamma emitters such as ^{125}I and ^{55}Fe.
- Can be re-windowed, although the cost is a large fraction of a new detector.
- Tougher than the thin end window GM detectors although still vulnerable to sharp points such as tweezers, nails, wire and swarf.

Weaknesses

- Expensive compared to GM detectors.
- Requires a better stabilised higher voltage supply, typically 1.6 to 2 kV.

On rare occasions can fade away slowly as a consequence of an undetectable leak.

Check for

- An acceptable performance at the minimum energy of interest. Generally they are suitable down to 0.17 MeV, in spite of the generally thicker window when compared to GM detectors.
- A good fine etched mesh grille. Detector repair costs are high, generally around £500. It makes sense to have a grille offering a high level of protection provided the response is still adequate.

C18 Thin windowed scintillation detectors

These use either a thin layer of an organic scintillator deposited on a clear plastic plate or a thin plate made from a plastic scintillator. The former variety has a generally better low energy performance. The scintillator is protected by a thin aluminised melinex window with a mass per unit area of around 1 mg cm^{-2}. Window areas range from 20 to 600 cm^{2} and come in a variety of shapes, round, square or rectangular. The scinitillator is viewed by a photomultiplier which turns the light generated by the scintillator into an electric current. This can be mounted with its axis normal to the plane of the scintillator or at any angle down to the point where the axis is parallel to the plane of the scintillator. Each shape and photomultiplier tube arrangement has its merits.

Good points

- Generally very good response over a wide energy range.
- Large variety of sizes, shapes and geometries.
- A much lower response to x, gamma radiation below 300 keV than similar sized GM or proportional counters.
- Audio output always available.
- Window repairs are easy.

Weaknesses

- The operating voltage is variable, even within one type of probe.
- Susceptible to window damage, although repair is easy and cheap. This can lead to an erratic performance as a result of light getting into the detector. Rugged versions are available but are much more expensive.
- Susceptible to strong magnetic fields.

Check for

- Detectors with excessively patched foils. Normally one or two small particles over window damage are acceptable.
- Poor uniformity of response over the area of the detector caused by poor light collection or scintillator deterioration.
- Correct operating potential. Normally this should be set just below the point at which the background starts to climb. This will maximise the response to low energy and dirty sources.

C19 Spherical 210 mm diameter moderator, BF_3 proportional counter

Good points

- Lighter than most cylindrical moderators.
- Good gamma rejection.

Weaknesses

- Poor energy response compared to larger moderators, with a rapid fall-off at the high energy end, where many common sources, such as $^{241}Am + {^7}Be$, are encountered.
- BF_3 is poisonous.

Check for

- Suitable time constants. Switched time constants and/or an audio output help locate areas of high dose equivalent rate.

C20 Spherical 210 mm diameter moderator, ^3He counter

Good points

- Lighter than most cylindrical moderators.
- Non-poisonous gas.
- Lower operating voltage.

Weaknesses

- Poor energy response compared to larger moderators, with a rapid fall-off at the high energy end where many common sources are encountered.
- Poorer gamma rejection than the BF_3 detector variety. These may start to respond to gamma radiation from about 20 mSv h^{-1} upwards.

Check for

- As above.

C21 Spherical 210 mm diameter moderator, LiI(Eu) scintillator

Good points

- Lighter than most cylindrical moderators.
- Lower operating voltage.

Weaknesses

- As above, plus a much larger range of operating voltages between individual instruments.

Check for

- As above.

C22 Cylindrical moderator (≈215 mm diameter, ≈250 mm long) moderator, BF_3 proportional counter

Good points

- The best energy response of commonly available types.
- Good gamma rejection.

Weaknesses

- Unpleasantly heavy, to the point at which they may be too heavy to be carried by one person without breaching manual handling regulations.
- BF_3 is poisonous.

Check for

- As above. Many of these instruments have pulse output sockets which can be connected to external scaler-timers. This allows very long integration times to give good precision at low (site perimeter) dose equivalent rates.

Public Health England

Basic Concepts of **Radiation**

What is Radiation?

This leaflet answers key questions about radiation: what is radiation, how does radiation affect people and how are we exposed to radiation? Radiation refers to the transfer of energy from one place to another.

There are two types of radiation:

- **non-ionising radiation,** such as visible light, signals from mobile phones and radio waves
- **ionising radiation,** such as radiation emissions from uranium ore and high frequency waves in the electromagnetic spectrum (eg X-rays)

Each type of ionising radiation is capable of disrupting stable atoms and causing them to have an imbalance of charge (ionisation). This can cause chemical changes in living matter which may cause harm to people's health, depending on the radiation dose received.

What is Ionising Radiation?

Unstable atoms in a material are said to 'decay' giving out ionising radiation in the process. The property of a material to decay and emit ionising radiation is called **radioactivity** and the material is said to be **radioactive**. As the unstable atoms in a radioactive material decay the atoms change to another form. The time taken for half the unstable atoms in a material to decay and change is known as the half-life. Each radioactive material has its own half-life. These vary from less than a few seconds to more than thousands of years.

There are three main types of ionising radiation: alpha (α), beta (β) and gamma (γ). Alpha and beta radiations are particles, while gamma radiation is a wave similar to X-rays. These forms of radiation differ in their ability to penetrate into the body or other materials and also in their ability to cause harm to people.

Alpha particles As they are relatively big, heavy and slow, alpha particles are not able to penetrate very far through materials. They are stopped by a few centimetres of air or a sheet of paper and even by the dead layer of skin on the outside of our bodies. As they usually cannot penetrate into the body, alpha particles do not pose a significant hazard from outside the body. However, radioactive materials emitting alpha particles can get into the body by inhalation, ingestion or through open wounds. They can then damage tissue and have a greater potential to cause cancer than beta particles and gamma rays.

Beta particles These are relatively light, small and fast, so they may travel several metres in air and can penetrate through exposed skin. Consequently, beta particles can present a hazard from inside or outside the body. They can be stopped by thin sheets of aluminium or perspex.

Gamma rays These rays have no weight and can penetrate through the body, depositing some of their energy on the way and so causing harm. Gamma rays are therefore a hazard both inside and outside the body. They can be stopped or exposure can be reduced by the use of thick, heavy shielding.

How Radiation Affects People

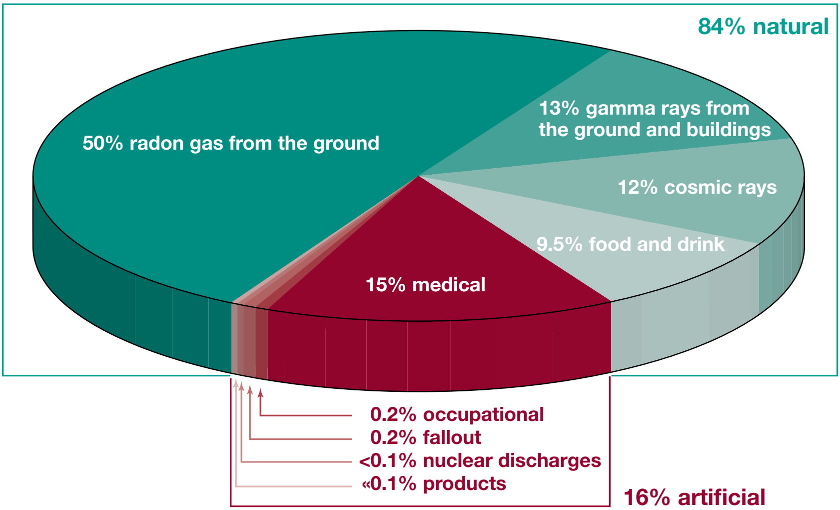
The term 'radiation dose' is used to describe the amount of energy absorbed by a material from ionising radiation passing through it. The most common measure of radiation dose to people is called effective dose, measured in units called sieverts. Effective dose takes account of the different sensitivities of organs in the body and the effects of different types of radiation. A sievert is a large dose of radiation and in most cases radiation dose will be given in microsieverts (μSv, one-millionth of a sievert) or millisieverts (mSv, one-thousanth of a sievert).

At low levels radiation causes no immediate perceptible damage to people. However, any exposure to radiation is considered to be capable of increasing the lifetime risk of cancer and of passing on hereditary illnesses to children. Individuals exposed to very high doses of radiation may receive burns to the skin, damage to the gastrointestinal, cardiovascular or nervous systems, and exceedingly high doses can cause death.

Radiation Exposures

People have always been exposed to low levels of radiation from natural sources. On average, people in the UK receive an annual dose of 2.7 mSv. Natural sources make up 84% of this dose, with the remainder coming from a variety of artificial sources.

Average annual radiation exposure of a person in the UK (2.7 mSv overall)



Natural radiation sources include gamma rays from the natural radioactivity in the Earth and in building materials, the small amounts of natural radioactivity in food and drink, and cosmic rays which bombard the Earth from space. However, by far the greatest contribution comes from breathing radon gas which is given off by natural radioactive materials in the Earth. Inhalation of radon leads to alpha-particle irradiation of the lungs and has been shown to cause lung cancer.

Artificial (man-made) sources are dominated by medical exposures. All other artificial sources contribute in total less than 0.5% of the average annual exposure.

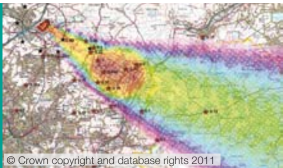
For further information visit our website at www.gov.uk/phe.

PHE publications gateway number: 2013-235

Public Health England

Nuclear Emergencies

Information for the Public



Introduction

The Radiation (Emergency Preparedness and Public Information) Regulations 2001 (REPPIR) establish a framework for the protection of the public through emergency preparedness for accidents with the potential to affect members of the public. The Regulations require the provision of information to the public in advance in situations where a radiation emergency might arise and during any kind of radiation emergency.

This booklet is intended to support the operators of nuclear sites* in the provision of information to the public by providing background information on radiation and health. It should be noted that further detailed information is provided by the site operator to residents who live within the detailed emergency planning zone (DEPZ) around sites. It is recommended that the contents of this booklet are read together with other local guidance provided by the site operator.

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* Nuclear sites can be fixed nuclear plants used (or formerly used) for power generation and research, berths cleared for use by nuclear powered warships, defence nuclear sites or facilities used to store nuclear material or radioactive waste.

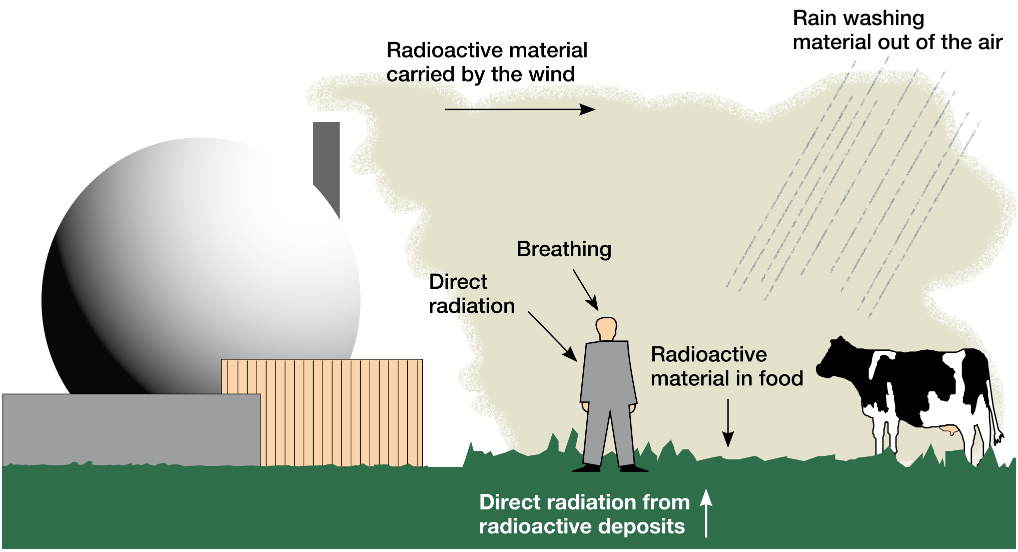
Accident Consequences

Nuclear sites are designed, built and operated so that the chance of an accident and any release is very low. Accidents have occurred however, notably at Windscale (UK) in 1957, Three Mile Island (US) in 1979, Chernobyl (Ukraine) in 1986 and Fukushima (Japan) in 2011. In the last two cases, radioactivity was released from the site. Legislation requires operators of nuclear sites to have plans to deal with accidents.

Weather conditions at the time of release are an important factor determining the affected areas as the radioactive material is carried down wind, spreading out and depositing on the ground and other surfaces as it goes.

People may be exposed to radioactivity released during an accident in the following ways:

- by breathing in radioactive materials (inhalation)
- by direct radiation exposure from radioactive materials carried in the air and deposited on surfaces
- by eating and drinking food and water contaminated with radioactive materials (ingestion)









Countermeasures

In the unlikely event of an accident at a nuclear site which results in a release of radioactive material, the following actions could be taken to reduce radiation doses.

Sheltering Staying indoors with doors and windows closed. This provides protection from breathing in radioactive material in the air. It also gives protection from direct radiation from radioactive material on the ground.

Evacuation Evacuation reduces exposure by taking people away from the affected area.

Stable iodine tablets Faults at operating nuclear reactors can release radioactive forms of iodine, which can lead to radiation doses to the thyroid gland. It has been shown that taking stable iodine speeds the removal of radioactive iodine from the body, resulting in a reduced radiation dose. In the UK, potassium iodate tablets are available for this purpose.

Food Radioactive material deposited on soil or grass can find its way into food through crops and animals. It might be necessary to ban milk or other foods containing radioactive material following an accident.

Food advice compared with other countermeasures Where food is contaminated it can lead to an intake of radioactivity over a longer period of time, leading to a build-up of dose. This dose can be reduced by banning the sale of contaminated food. The limits on radioactivity in food are deliberately low to reduce radiation dose to minimal levels. This may result in a wide area being subject to food controls.

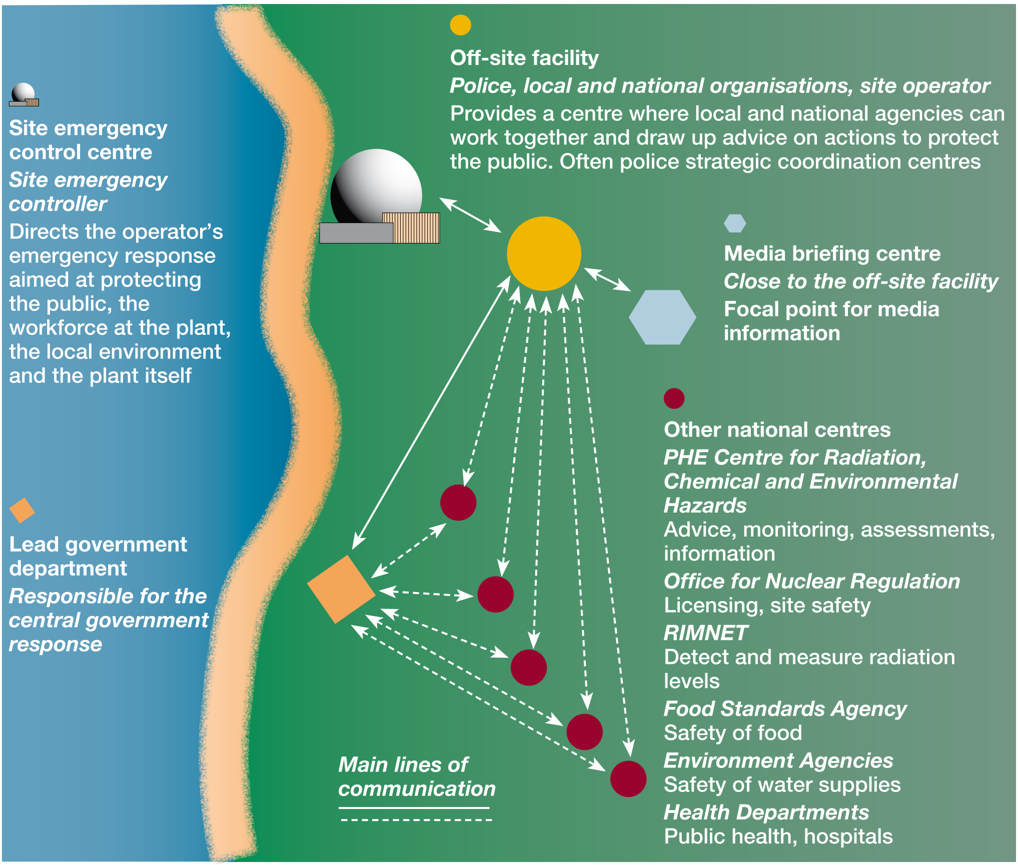
If you are in doubt about what countermeasure action to take, follow the instructions provided by the emergency services.

If you live close to a nuclear site, you should refer to the specific local information provided to you.

Emergency Plans

To ensure that there is adequate protection against accidents, legislation requires the operator of a site to conduct a detailed safety assessment of the plant and processes. This assessment assists in identifying circumstances in which an accident may occur. Based on the results of the assessment, working procedures may be changed or additional engineering controls introduced to make the possibility of an accident even more unlikely.

From the assessment, the most serious reasonably foreseeable accident is identified. Each site is required to have emergency plans to deal with the on- and off-site consequences of such an accident. Emergency plans must be sufficiently flexible to deal with any reasonably foreseeable accident and extendable in the event of a more serious, but less likely accident. The plans contain details of arrangements to protect the public and are available to the public through local authority websites and public libraries.



Detection and Monitoring

Radioactive material in the environment can be measured in various ways. Many organisations can make such measurements: operators of nuclear sites, Public Health England (CRCE), government departments, local authorities, universities and local medical physics departments.




Following an accident, a wide range of food supplies and drinking water would be checked to see if they contained more radioactive materials than the allowed levels.





Fixed radiation monitors around nuclear sites would detect and measure abnormal radiation levels.By international agreement the UK should receive warning of nuclear accidents abroad. As a back-up, automatic instruments throughout the country form the radioactive incident monitoring network (RIMNET), which would detect and measure abnormal radiation levels.

Detailed and sensitive measurements of radioactive materials in people can be made to assess doses and to check that countermeasures were effective.

Monitoring of the general public living in the vicinity of a nuclear site would be conducted to provide reassurance to the public in the event of an accident. Initial monitoring would be followed-up, if necessary, to assess long-term doses to individuals.




Website Links and Further Reading

Additional and more detailed information is publicly available on the internet. Links to some websites of interest and valid at the time of publication are given below.

Department of Energy & Climate Change – www.gov.uk/decc

Environment Agency – www.environment-agency.gov.uk/nuclear

Food Standards Agency – www.food.gov.uk/

HM Government – www.gov.uk/preparing-for-and-responding-to-energy-emergencies#civil-nuclear

International Atomic Energy Agency – www.iaea.org/Publications/Factsheets/English/ines.pdf

Meteorological Office – www.metoffice.gov.uk/publicsector/emergencies

Ministry of Defence – www.gov.uk/mod

Nuclear Emergency Planning Liaison Group – www.gov.uk/government/publications/nuclear-emergency-planning-consolidated-guidance

Office for Nuclear Regulation – www.hse.gov.uk/nuclear/index.htm

Scottish Environment Protection Agency – www.sepa.org.uk/radioactive_substances/what_we_do/emergency_response_planning.aspx

Scottish resilience – www.scotland.gov.uk/Publications/2007/06/12094636/6

UK nuclear sites

- EDF Energy – www.edfenergy.com
- Magnox – magnoxsites.co.uk
- Sellafield Ltd – www.sellafieldsites.com/

UK resilience – www.gov.uk/government/policies/improving-the-uks-ability-to-absorb-respond-to-and-recover-from-emergencies

About Public Health England

Public Health England's mission is to protect and improve the nation's health and to address inequalities through working with national and local government, the NHS, industry and the voluntary and community sector. PHE is an operationally autonomous executive agency of the Department of Health.

Public Health England
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London SE1 8UG
www.gov.uk/phe
@PHE_uk

PHE has a large network of staff based throughout the UK, including a central office based in London and three major centres at Chilton, Colindale and Porton.

For further information and to find your local PHE office visit the website at

www.gov.uk/government/publications/phe-centre-addresses-and-phone-numbers

PHE Centre for Radiation, Chemical and Environmental Hazards

CRCE provides advice and services, and carries out research, to protect the public from hazards resulting from exposure to chemicals and poisons, radiation both ionising and non-ionising, and ultrasound and infrasound. CRCE also leads for PHE on public health effects of climate change and extreme environmental events such as flooding. In a radiation emergency, senior CRCE representatives would provide radiological advice to government and to the local emergency centres dealing with the incident.

PHE CRCE Emergency Role

- radiological protection advice and information
- radiological assessment
- environmental radiation monitoring
- personal monitoring

CRCE is based at Chilton, Oxfordshire. There are also specialist radiation centres at Leeds and Glasgow.

Contact PHE CRCE

Chilton Chilton, Didcot, Oxfordshire OX11 0RQ, T: +44 (0)1235 83160
Leeds Oak Park Lane, Cookridge, Leeds LS16 6RW, T: +44 (0)113 267 9041
Glasgow 155 Hardgate Road, Glasgow G51 4LS, T: +44 (0)141 440 2201

 PHE publications gateway number: 2013-235

UK Recovery Handbook for Radiation Incidents: Inhabited Areas

A Nisbet, J Brown, H Rochford, T Cabianca and A Jones

VERSION 3

UK Recovery Handbooks for Radiation Incidents 2009 Handbook for Inhabited Areas

Version 3

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ABSTRACT

The handbook for assisting in the management of contaminated inhabited areas following a radiological incident has been developed as a result of a series of UK and European initiatives that started in the early 1990s. It is aimed at national and local authorities, central government departments and agencies, radiation protection experts, emergency services, industry and others who may be affected.

The handbook includes management options for application in the early and medium to longer term phases of an incident. Sources of contamination considered in the handbook include nuclear accidents and radiological dispersion devices. The handbook is divided into several sections which provide supporting scientific and technical information; an analysis of the factors influencing recovery; compendia of comprehensive, state-of-the-art datasheets for more than 50 management options; and guidance on planning in advance. A decision-aiding framework comprising colour coded selection tables for each of the main surfaces found in an inhabited area, look-up tables to assist in the elimination of options and several worked examples are also included.

The handbook can be used as a preparatory tool, under non-crisis conditions, to engage stakeholders and to develop local and regional plans. The handbook can also be applied as part of the decision-aiding process to develop a recovery strategy following an incident. In addition, the handbook is useful for training purposes and during emergency exercises. The handbook for inhabited areas complements the other two handbooks for food production systems and drinking water.

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Table 1.1 Predominant emissions and half-life for each radionuclide considered in the Inhabited Areas Handbook

Radionuclide		Alpha (MeV)	Beta (MeV)	Gamma (KeV)	Dominant radiation type	Radioactive half-life
Symbol	Name					
^{60}Co	Cobalt-60	–	1.48 (0.1%) 0.31 (99%+)	1173 (100%) 1332 (100%)	Gamma	5.27 y
^{75}Se	Selenium-75	–	–	265 (60%) 136 (57%)	Gamma	119.8 d
^{90}Sr + ^{90}Y	Strontium-90 + Yttrium-90	–	0.546 2.27	–	Beta	29.12 y
^{95}Zr	Zirconium-95	–	0.89 (2%) 0.396	724 (49%) 756 (49%)	Gamma	63.98 d
^{99}Mo + ^{99m}Tc	Molybdenum-99 + Technetium-99m	–	1.23	740 (12%) 81 (7%)	Gamma	66 h
^{103}Ru	Ruthenium-103	–	0.70 (3%) 0.21	497 (88%) 610 (6%)	Gamma	39.28 d
^{106}Ru + ^{106}Rh	Ruthenium-106 + Rhodium-106	–	3.54	512 (21 %) 622 (11%)	Gamma	368.2 d
^{132}Te	Tellurium-132	–	0.22	53 (17%) 230 (90%)	Gamma	78.2d
^{131}I	Iodine-131	–	0.606	364 (82%) 637 (6.8%)	Gamma	8.04 d
^{134}Cs	Caesium-134	–	0.662	796 (99%) 605 (98%)	Gamma	2.062 y
^{136}Cs	Caesium-136	–	0.341 0.657	819 (100 %) 1048 (80%)	Gamma	13.1 d
^{137}Cs + ^{137m}Ba	Caesium-137 + Barium-137m		1.176 (7%) 0.514	662 (85%)	Gamma	30 y
^{140}Ba	Barium-140	–	1.02	438 (5%) 537 (34%)	Gamma	12.74 d
^{144}Ce	Cerium-144	–	0.318 0.238	133.5 (100%)	Gamma	284.3 d
^{169}Yb	Ytterbium-169	–	–	63(45%) 198 (35%)	Gamma	32.01 d
^{192}Ir	Iridium-192	–	0.67	317 (81%) 468 (49%)	Gamma	74.02 d
^{226}Ra	Radium-226	4.78 (95%) 4.60 (6%)	3.3	186 (4%) 260 (0.007%)	Alpha	1.6 10^3 y
^{235}U	Uranium-235	4.40 (57%) 4.37 (18%)	0.3	185 (54%) 143 (11%)	Alpha/ Gamma*	7.04 10^8 y
^{238}Pu	Plutonium-238	5.50 (72%) 5.46 (28%)	–	99 (0.008%) 150 (0.001%)	Alpha	87.74 y
^{239}Pu	Plutonium-239	5.16 (88%) 5.11 (11%)	–	52 (0.02%) 129 (0.005%)	Alpha	2.4 10^4 y
^{241}Am	Americium-241	5.49 (85%) 5.44 (13%)	–	60 (36%) 101 (0.04%)	Alpha/ Gamma*	432.2 y

Notes:

*: For these radionuclides inhalation doses from resuspended material are mainly due to the alpha radiation emitted, but if the contamination is fixed to surfaces and not available for resuspension, only external exposure to gamma radiation contributes to the dose

Figure A1 Range of beta particles in air as a function of beta energy

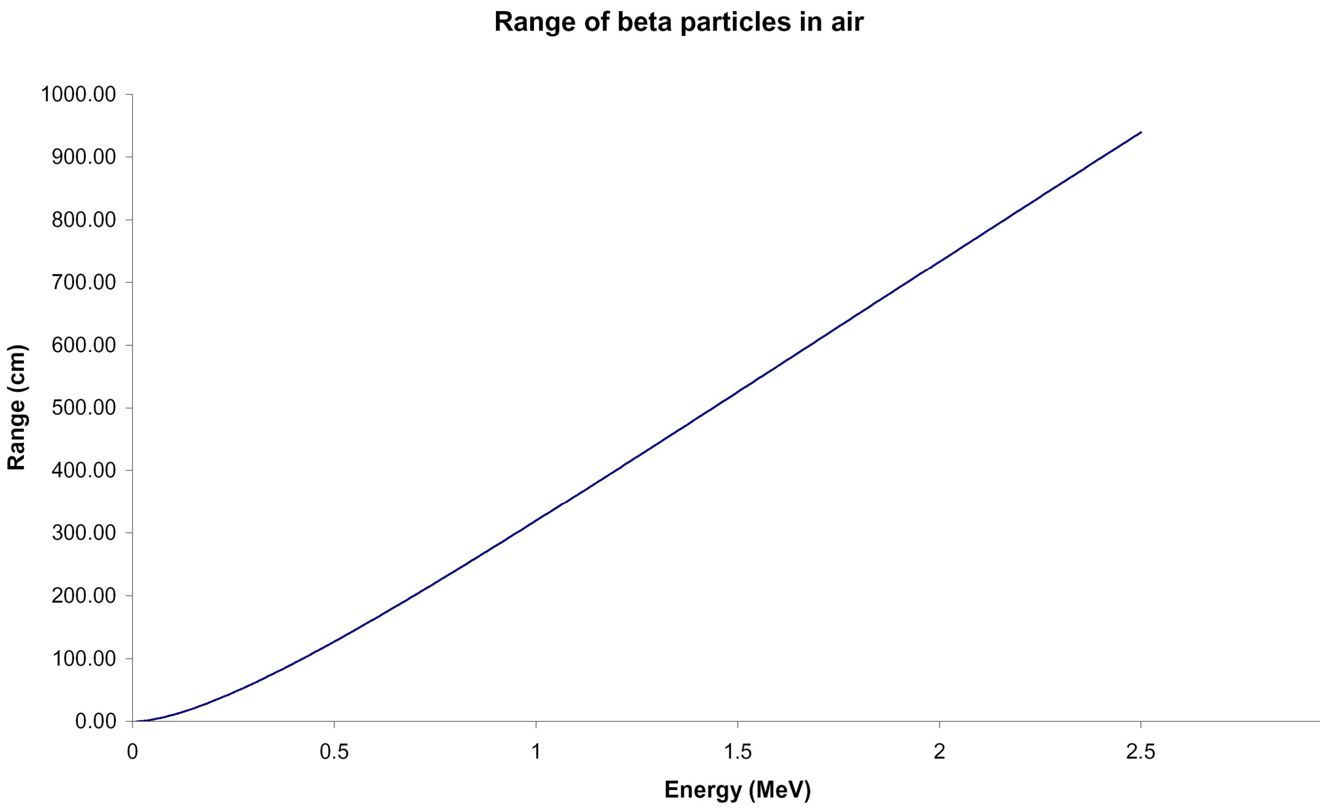
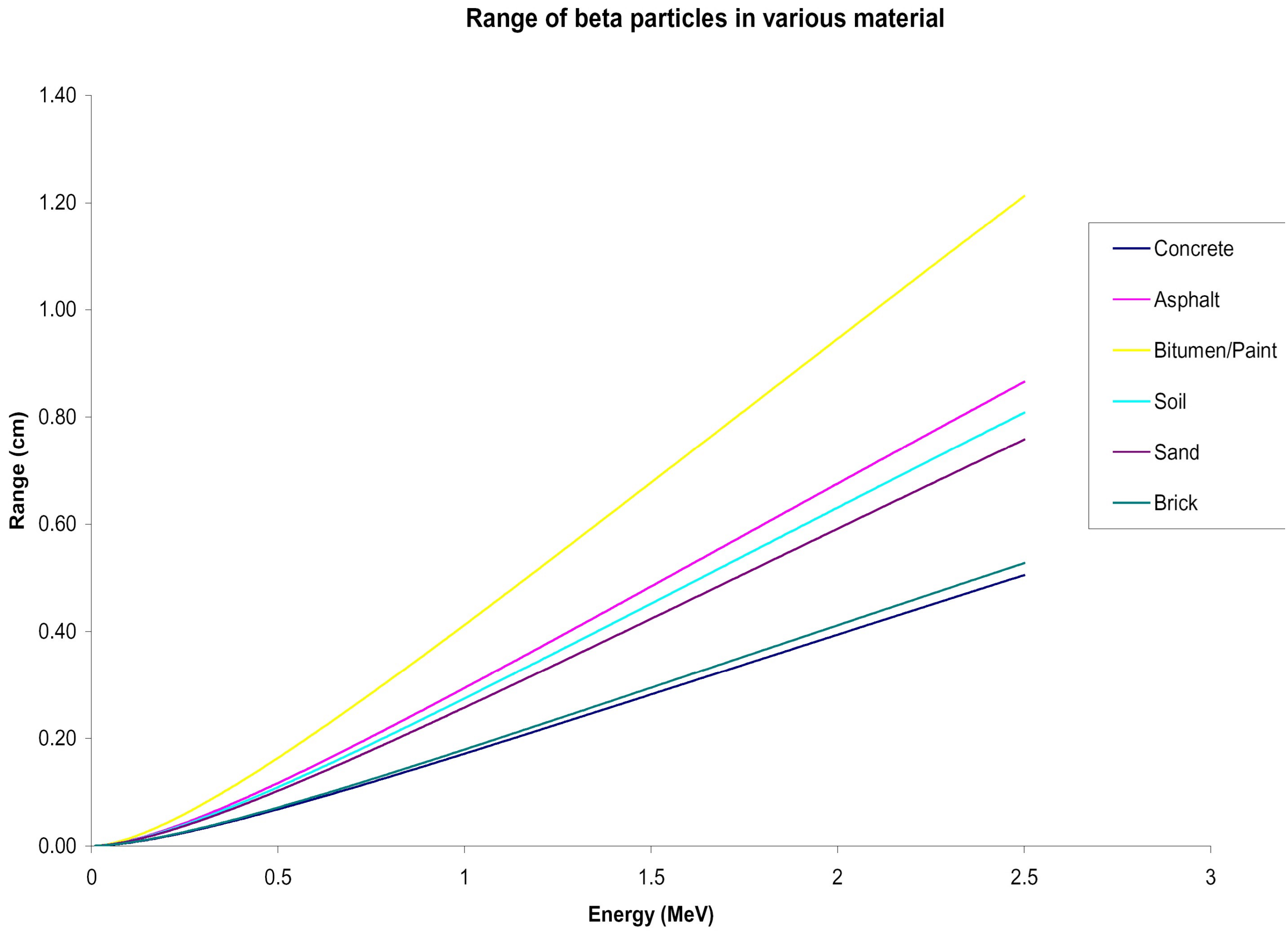


Figure A3 Range of beta particles in materials likely to be used for shielding in inhabited areas as a function of maximum beta energy



A4 GAMMA EMITTING RADIONUCLIDES

Gamma rays are attenuated by the material they pass through but they do not have a defined range.

The attenuation of a narrow beam of gamma or X-rays is given by:

$$I = I_0 e^{-\mu t}$$

where I is the fluence rate after passing through a thickness t (cm), I_0 is the initial fluence rate and μ is the linear attenuation coefficient of the attenuating medium (cm^{-1}). In the case of broad or uncollimated beams, build-up can occur due to scattered photons still reaching the target which causes the attenuation to be less rapid than indicated in the above equation.

Materials with high atomic number and high density, such as lead, provide the best shields for gamma and X-rays, although these are unlikely to be practicable for shielding within contaminated inhabited areas.

The greater the density of a material the smaller the thickness needed to decrease the gamma ray intensity to a specified extent. This means that the mass of materials needed to decrease the intensity of the radiation by a certain amount is very nearly the same irrespective of the material. Two quantities are normally used to specify the thickness: the half value thickness and the tenth value thickness which are the thicknesses of a material required to reduce the gamma ray intensity by a factor of two or by a factor of ten, expressed by:

$$\text{Half value thickness (cm)} = \frac{0.693}{\mu}$$

$$\text{Tenth value thickness (cm)} = \frac{2.3}{\mu}$$

Where μ is the linear attenuation coefficient in the shielding material for the gamma energy of concern (cm^{-1}).

Table A6 gives linear attenuation coefficients in air as a function of gamma energy. Linear attenuation coefficients for other materials can be estimated using the assumption that the linear attenuation coefficient is approximately proportional to the density of the material. This assumption holds for gamma energies in the range of about 0.05 – 5.0 MeV for most of the materials that are considered as shielding materials in Section A3. For materials, such as lead, that have a high atomic number, this approach would not be appropriate. However, linear attenuation coefficients are readily available for lead and are given in Table A7 for a range of gamma energies (Kaplan, 1979).

For other shielding materials of relevance for use in recovery options in inhabited areas, the linear attenuation coefficient for the material of interest can be estimated in the following way:

$$\mu_{material} = \mu_{air} \frac{\rho_{material}}{\rho_{air}}$$

where μ is the linear attenuation coefficient in material (cm^{-1}), μ_{air} is the linear attenuation coefficient in air (cm^{-1}) $\rho_{material}$ is the density of material (kg m^{-3}) and ρ_{air} is the density of air (1.293 kg m^{-3}).

For example, if the radionuclide in the contamination has a gamma energy of 1MeV and the material to be used is soil (1500 kg m^{-3}) the linear attenuation coefficient for soil can be calculated to be

$$\mu_{soil} = 8.23 \cdot 10^{-5}\ \text{cm}^{-1}\ \frac{1500\ \text{kg m}^{-3}}{1.293\ \text{kg m}^{-3}} = 0.095\ \text{cm}^{-1}$$

Assuming a thickness of soil of 10 cm is used, the intensity of gamma irradiation with soil shielding is 0.39 I_0 where I_0 is the intensity of gamma irradiation with no shielding. This means that 10 cm of soil reduce the intensity of the gamma irradiation from the radionuclide to about 40% of that with no shielding in place.

The half value thickness for the radionuclide can be estimated to be about 7 cm of soil, i.e. a thickness of 7 cm reduces the intensity by a half. The tenth value thickness for the radionuclide can be estimated to be about 24 cm, i.e. a thickness of 24 cm reduces the intensity to a tenth.

Table A6 Linear attenuation coefficients for gamma rays in air

Gamma energy, (MeV)	Linear attenuation coefficient (cm^{-1}) *
0.1	$1.99\ 10^{-4}$
0.2	$1.60\ 10^{-4}$
0.3	$1.38\ 10^{-4}$
0.5	$1.13\ 10^{-4}$
0.6	$1.04\ 10^{-4}$
0.8	$9.15\ 10^{-5}$
1.0	$8.23\ 10^{-5}$
2.0	$5.75\ 10^{-5}$
3.0	$4.63\ 10^{-5}$
5.0	$3.56\ 10^{-5}$
10.0	$2.64\ 10^{-5}$

Note:

* The attenuation coefficients are calculated assuming that air consists of 78% nitrogen, 21% oxygen and 1% argon and has a density of 1.293 kg m^{-3}.

Table A7 Linear attenuation coefficients for lead

Gamma energy, (MeV)	Linear attenuation coefficient,(cm^{-1}) *
0.1	60
0.2	10
0.3	3.8
0.5	1.6
0.6	1.3
0.8	0.95
1.0	0.77
2.0	0.51
3.0	0.46
5.0	0.49
10.0	0.57

Note:

* Calculated assuming a density of lead of $1.134\ 10^4$ kg m^{-3}

A5 REFERENCES

Andersson KG, Fogh CL, Byrne MA, Roed J, Goddard AJH and Hotchkiss SAM (2002). Radiation dose implications of airborne contaminant deposition to humans. *Health Physics,* 82(2), 226-232.

Delacroix D, Guerre JP, Leblanc P and Hickman C (2002). Radionuclide and radiation protection data handbook 2002. *Rad Prot Dosim*, **98** (1), 1-168.

Gopala K, Rudraswamy B, Venkataramaiah P and Sanjeeviah H (1986). Thick-target bremsstrahlung spectra generated by the beta particles of ^{90}Sr-^{90}Y and ^{99}Tc. *Physical Review A*, 5126-5129.

ICRP (1983). Radionuclide transformations, energy and intensity of emissions. ICRP Publication 38. *Ann ICRP*, **11-13**.

ICRP (1992). The biological basis for dose limitation in the skin. ICRP Publication 59, ISBN 0 08 041143 6, International Commission on Radiological Protection, Pergamon Press, Oxford.

Kaplan I (1979). Nuclear Physics. Addison-Wesley Publishing Company, USA.

Longworth G (1998). The Radiochemical Manual, AEA Technology plc, Harwell, UK.

Research Establishment Risø (1970). Project Crested Ice. Risø Report 213, Research Establishment Risø, ISBN 87 550 0006 1.

Table B1 Effective external gamma dose rates after an instantaneous deposit of 1 Bq m^{-2} on the ground (HPA-PRD, 2005)

	Dose rate ($Sv\ h^{-1}$)[a]											
Radionuclide	0	6 hours	12 hours	1 day	2 days	7 days	30 days	1 year	2 years	5 years	10 years	50 years
^{60}Co	$5.6\ 10^{-12}$	$5.6\ 10^{-12}$	$5.6\ 10^{-12}$	$5.6\ 10^{-12}$	$5.6\ 10^{-12}$	$5.6\ 10^{-12}$	$5.5\ 10^{-12}$	$4.4\ 10^{-12}$	$3.5\ 10^{-12}$	$1.8\ 10^{-12}$	$6.9\ 10^{-13}$	$9.9\ 10^{-16}$
^{75}Se	$8.9\ 10^{-13}$	$8.9\ 10^{-13}$	$8.9\ 10^{-13}$	$8.8\ 10^{-13}$	$8.8\ 10^{-13}$	$8.5\ 10^{-13}$	$7.4\ 10^{-13}$	$9.5\ 10^{-14}$	$1.0\ 10^{-14}$	$1.3\ 10^{-17}$	$7.4\ 10^{-22}$	$2.3\ 10^{-26}$
$^{95}Zr^{b}$	$1.7\ 10^{-12}$	$1.7\ 10^{-12}$	$1.7\ 10^{-12}$	$1.7\ 10^{-12}$	$1.8\ 10^{-12}$	$1.8\ 10^{-12}$	$1.9\ 10^{-12}$	$9.4\ 10^{-14}$	$1.6\ 10^{-15}$	$4.6\ 10^{-20}$	$1.6\ 10^{-23}$	0
^{95}Nb	$1.8\ 10^{-12}$	$1.8\ 10^{-12}$	$1.8\ 10^{-12}$	$1.7\ 10^{-12}$	$1.7\ 10^{-12}$	$1.6\ 10^{-12}$	$9.7\ 10^{-13}$	$1.2\ 10^{-15}$	$8.7\ 10^{-19}$	$7.5\ 10^{-23}$	$1.3\ 10^{-26}$	0
$^{99}Mo^{b}$	$3.5\ 10^{-13}$	$3.3\ 10^{-13}$	$3.1\ 10^{-13}$	$2.7\ 10^{-13}$	$2.1\ 10^{-13}$	$5.9\ 10^{-14}$	$1.8\ 10^{-16}$	0	0	0	0	0
$^{103}Ru^{b}$	$1.1\ 10^{-12}$	$1.1\ 10^{-12}$	$1.1\ 10^{-12}$	$1.1\ 10^{-12}$	$1.1\ 10^{-12}$	$9.8\ 10^{-13}$	$6.5\ 10^{-13}$	$1.6\ 10^{-15}$	$2.3\ 10^{-18}$	$2.9\ 10^{-22}$	$6.6\ 10^{-26}$	0
$^{106}Ru^{b}$	$4.8\ 10^{-13}$	$4.8\ 10^{-13}$	$4.8\ 10^{-13}$	$4.8\ 10^{-13}$	$4.8\ 10^{-13}$	$4.7\ 10^{-13}$	$4.5\ 10^{-13}$	$2.2\ 10^{-13}$	$9.7\ 10^{-14}$	$9.4\ 10^{-15}$	$2.2\ 10^{-16}$	$2.8\ 10^{-24}$
$^{132}Te^{b}$	$5.0\ 10^{-13}$	$4.7\ 10^{-12}$	$5.2\ 10^{-12}$	$4.8\ 10^{-12}$	$3.9\ 10^{-12}$	$1.3\ 10^{-12}$	$9.9\ 10^{-15}$	0	0	0	0	0
$^{131}I^{b}$	$8.9\ 10^{-13}$	$8.8\ 10^{-13}$	$8.6\ 10^{-13}$	$8.2\ 10^{-13}$	$7.5\ 10^{-13}$	$4.9\ 10^{-13}$	$6.7\ 10^{-14}$	$1.5\ 10^{-22}$	$1.1\ 10^{-25}$	0	0	0
^{134}Cs	$3.6\ 10^{-12}$	$3.6\ 10^{-12}$	$3.6\ 10^{-12}$	$3.6\ 10^{-12}$	$3.6\ 10^{-12}$	$3.6\ 10^{-12}$	$3.5\ 10^{-12}$	$2.3\ 10^{-12}$	$1.5\ 10^{-12}$	$4.1\ 10^{-13}$	$5.5\ 10^{-14}$	$2.3\ 10^{-20}$
^{136}Cs	$5.0\ 10^{-12}$	$4.9\ 10^{-12}$	$4.8\ 10^{-12}$	$4.7\ 10^{-12}$	$4.5\ 10^{-12}$	$3.4\ 10^{-12}$	$1.0\ 10^{-12}$	$1.1\ 10^{-19}$	$8.0\ 10^{-23}$	0	0	0
$^{137}Cs^{b}$	$1.4\ 10^{-12}$	$1.4\ 10^{-12}$	$1.4\ 10^{-12}$	$1.4\ 10^{-12}$	$1.4\ 10^{-12}$	$1.4\ 10^{-12}$	$1.4\ 10^{-12}$	$1.2\ 10^{-12}$	$1.1\ 10^{-12}$	$7.5\ 10^{-13}$	$4.8\ 10^{-13}$	$4.4\ 10^{-14}$
$^{140}Ba^{b}$	$4.2\ 10^{-13}$	$9.2\ 10^{-13}$	$1.4\ 10^{-12}$	$2.1\ 10^{-12}$	$3.1\ 10^{-12}$	$4.0\ 10^{-12}$	$1.2\ 10^{-12}$	$7.1\ 10^{-20}$	$5.3\ 10^{-23}$	0	0	0
$^{144}Ce^{b}$	$1.1\ 10^{-13}$	$1.1\ 10^{-13}$	$1.1\ 10^{-13}$	$1.1\ 10^{-13}$	$1.1\ 10^{-13}$	$1.1\ 10^{-13}$	$1.00\ 10^{-13}$	$3.9\ 10^{-14}$	$1.4\ 10^{-14}$	$6.9\ 10^{-16}$	$5.3\ 10^{-18}$	$1.9\ 10^{-25}$
^{169}Yb	$6.0\ 10^{-13}$	$6.0\ 10^{-13}$	$6.0\ 10^{-13}$	$5.9\ 10^{-13}$	$5.8\ 10^{-13}$	$5.2\ 10^{-13}$	$3.1\ 10^{-13}$	$1.9\ 10^{-16}$	$7.8\ 10^{-20}$	$1.1\ 10^{-22}$	$1.5\ 10^{-26}$	0
^{192}Ir	$1.9\ 10^{-12}$	$1.9\ 10^{-12}$	$1.9\ 10^{-12}$	$1.9\ 10^{-12}$	$1.9\ 10^{-12}$	$1.8\ 10^{-12}$	$1.4\ 10^{-12}$	$5.6\ 10^{-14}$	$1.7\ 10^{-15}$	$6.3\ 10^{-20}$	$2.2\ 10^{-23}$	0
$^{226}Ra^{b}$	$1.5\ 10^{-14}$	$1.7\ 10^{-13}$	$3.3\ 10^{-13}$	$6.4\ 10^{-13}$	$1.2\ 10^{-12}$	$2.8\ 10^{-12}$	$3.9\ 10^{-12}$	$3.5\ 10^{-12}$	$3.2\ 10^{-12}$	$2.4\ 10^{-12}$	$1.8\ 10^{-12}$	$4.6\ 10^{-13}$
$^{235}U^{b}$	$3.4\ 10^{-13}$	$3.5\ 10^{-13}$	$3.5\ 10^{-13}$	$3.5\ 10^{-13}$	$3.6\ 10^{-13}$	$3.6\ 10^{-13}$	$3.6\ 10^{-13}$	$3.2\ 10^{-13}$	$2.8\ 10^{-13}$	$2.1\ 10^{-13}$	$1.4\ 10^{-13}$	$2.4\ 10^{-14}$
^{238}Pu	$2.1\ 10^{-16}$	$2.1\ 10^{-16}$	$2.1\ 10^{-16}$	$2.1\ 10^{-16}$	$2.1\ 10^{-16}$	$2.1\ 10^{-16}$	$2.1\ 10^{-16}$	$1.7\ 10^{-16}$	$1.3\ 10^{-16}$	$6.7\ 10^{-17}$	$2.4\ 10^{-17}$	$7.2\ 10^{-19}$
^{239}Pu	$1.8\ 10^{-16}$	$1.8\ 10^{-16}$	$1.8\ 10^{-16}$	$1.8\ 10^{-16}$	$1.8\ 10^{-16}$	$1.8\ 10^{-16}$	$1.7\ 10^{-16}$	$1.5\ 10^{-16}$	$1.2\ 10^{-16}$	$8.0\ 10^{-17}$	$4.6\ 10^{-17}$	$7.2\ 10^{-18}$
^{241}Am	$3.7\ 10^{-14}$	$3.7\ 10^{-14}$	$3.7\ 10^{-14}$	$3.7\ 10^{-14}$	$3.7\ 10^{-14}$	$3.6\ 10^{-14}$	$3.6\ 10^{-14}$	$3.1\ 10^{-14}$	$3.0\ 10^{-14}$	$1.7\ 10^{-14}$	$9.3\ 10^{-15}$	$8.9\ 10^{-16}$

a) Generic soil of 1.5 g cm^{-3} assumed in calculation, with composition by weight O 0.6, Si 0.25, C 0.07, H 0.04, Al 0.03 Fe 0.01.

b) The doses from the ingrowth of daughter radionuclides are included with the parent, i.e. ^{95}Zr includes ^{95m}Nb, ^{95}Nb; ^{99}Mo includes ^{99m}Tc, ^{99}Tc; ^{103}Ru includes ^{103m}Rh; ^{106}Ru includes ^{106}Rh; ^{132}Te includes ^{132}I; ^{131}I includes ^{131m}Xe; ^{135}I includes ^{135m}Xe, ^{135}Xe; ^{137}Cs includes ^{137m}Ba; ^{140}Ba includes ^{140}La; ^{144}Ce includes ^{144}Pr; ^{226}Ra includes ^{214}Pb, ^{214}Bi, ^{214}Po, ^{210}Pb, ^{210}Bi, ^{210}Po; ^{235}U includes ^{231}Th.

Table B2 Integrated effective external gamma dose after an instantaneous deposit of 1 Bq m^{-2} on the ground (HPA-RPD, 2005)

Radionuclide	Dose (Sv)[a]										
	0	6 hours	12 hours	1 day	2 days	7 days	30 days	1 year	2 years	5 years	10 years	50 years
^{60}Co	0	$3.4\ 10^{-11}$	$6.8\ 10^{-11}$	$1.4\ 10^{-10}$	$2.7\ 10^{-10}$	$9.5\ 10^{-10}$	$4.0\ 10^{-9}$	$4.4\ 10^{-8}$	$7.8\ 10^{-8}$	$1.5\ 10^{-7}$	$2.0\ 10^{-7}$	$2.3\ 10^{-7}$
^{75}Se	0	$5.3\ 10^{-12}$	$1.1\ 10^{-11}$	$2.1\ 10^{-11}$	$4.2\ 10^{-11}$	$1.5\ 10^{-10}$	$5.8\ 10^{-10}$	$3.1\ 10^{-9}$	$4.4\ 10^{-9}$	$3.5\ 10^{-9}$	$3.5\ 10^{-9}$	$3.5\ 10^{-9}$
$^{95}Zr^{b}$	0	$1.0\ 10^{-11}$	$2.1\ 10^{-11}$	$4.1\ 10^{-11}$	$8.3\ 10^{-11}$	$3.0\ 10^{-10}$	$1.3\ 10^{-9}$	$7.3\ 10^{-9}$	$7.5\ 10^{-9}$	$7.5\ 10^{-9}$	$7.5\ 10^{-9}$	$7.5\ 10^{-9}$
^{95}Nb	0	$1.1\ 10^{-11}$	$2.1\ 10^{-11}$	$4.2\ 10^{-11}$	$8.4\ 10^{-11}$	$2.8\ 10^{-10}$	$9.6\ 10^{-10}$	$2.1\ 10^{-9}$	$2.1\ 10^{-9}$	$2.1\ 10^{-9}$	$2.1\ 10^{-9}$	$2.1\ 10^{-9}$
$^{99}Mo^{b}$	0	$2.0\ 10^{-12}$	$3.9\ 10^{-12}$	$7.3\ 10^{-12}$	$1.3\ 10^{-11}$	$2.7\ 10^{-11}$	$3.3\ 10^{-11}$	$3.3\ 10^{-11}$	$3.3\ 10^{-11}$	$3.3\ 10^{-11}$	$3.3\ 10^{-11}$	$3.3\ 10^{-11}$
$^{103}Ru^{b}$	0	$6.7\ 10^{-12}$	$1.3\ 10^{-11}$	$2.7\ 10^{-11}$	$5.3\ 10^{-11}$	$1.8\ 10^{-10}$	$6.2\ 10^{-10}$	$1.5\ 10^{-9}$	$1.5\ 10^{-9}$	$1.5\ 10^{-9}$	$1.5\ 10^{-9}$	$1.5\ 10^{-9}$
$^{106}Ru^{b}$	0	$2.9\ 10^{-12}$	$5.8\ 10^{-12}$	$1.2\ 10^{-11}$	$2.3\ 10^{-11}$	$8.0\ 10^{-11}$	$3.4\ 10^{-10}$	$2.9\ 10^{-9}$	$4.2\ 10^{-9}$	$5.2\ 10^{-9}$	$5.3\ 10^{-9}$	$5.3\ 10^{-9}$
$^{132}Te^{b}$	0	$1.9\ 10^{-11}$	$5.0\ 10^{-11}$	$1.1\ 10^{-10}$	$2.1\ 10^{-10}$	$5.0\ 10^{-10}$	$6.5\ 10^{-10}$	$6.\ 10^{-10}$	$6.5\ 10^{-10}$	$6.5\ 10^{-10}$	$6.5\ 10^{-10}$	$6.5\ 10^{-10}$
$^{131}I^{b}$	0	$5.3\ 10^{-12}$	$1.1\ 10^{-11}$	$2.1\ 10^{-11}$	$3.9\ 10^{-11}$	$1.1\ 10^{-10}$	$2.3\ 10^{-10}$	$2.5\ 10^{-10}$	$2.5\ 10^{-10}$	$2.5\ 10^{-10}$	$2.5\ 10^{-10}$	$2.5\ 10^{-10}$
^{134}Cs	0	$2.2\ 10^{-11}$	$4.3\ 10^{-11}$	$8.7\ 10^{-11}$	$1.7\ 10^{-10}$	$6.1\ 10^{-10}$	$2.6\ 10^{-9}$	$2.6\ 10^{-8}$	$4.2\ 10^{-8}$	$6.4\ 10^{-8}$	$7.1\ 10^{-8}$	$7.2\ 10^{-8}$
^{136}Cs	0	$2.9\ 10^{-11}$	$5.9\ 10^{-11}$	$1.2\ 10^{-10}$	$2.3\ 10^{-10}$	$7.0\ 10^{-10}$	$1.8\ 10^{-9}$	$2.2\ 10^{-9}$	$2.2\ 10^{-9}$	$2.2\ 10^{-9}$	$2.2\ 10^{-9}$	$2.2\ 10^{-9}$
$^{137}Cs^{b}$	0	$8.4\ 10^{-12}$	$1.7\ 10^{-11}$	$3.3\ 10^{-11}$	$6.7\ 10^{-11}$	$2.3\ 10^{-10}$	$9.9\ 10^{-10}$	$1.1\ 10^{-8}$	$2.1\ 10^{-8}$	$4.5\ 10^{-8}$	$7.1\ 10^{-8}$	$1.3\ 10^{-7}$
$^{140}Ba^{b}$	0	$4.1\ 10^{-12}$	$1.1\ 10^{-11}$	$3.2\ 10^{-11}$	$9.5\ 10^{-11}$	$5.6\ 10^{-10}$	$1.9\ 10^{-9}$	$2.5\ 10^{-9}$	$2.5\ 10^{-9}$	$2.5\ 10^{-9}$	$2.5\ 10^{-9}$	$2.5\ 10^{-9}$
$^{144}Ce^{b}$	0	$6.5\ 10^{-13}$	$1.3\ 10^{-12}$	$2.6\ 10^{-12}$	$5.2\ 10^{-12}$	$1.8\ 10^{-11}$	$7.5\ 10^{-11}$	$6.0\ 10^{-10}$	$8.1\ 10^{-10}$	$9.2\ 10^{-10}$	$9.3\ 10^{-10}$	$9.3\ 10^{-10}$
^{169}Yb	0	$3.6\ 10^{-12}$	$7.2\ 10^{-12}$	$1.4\ 10^{-11}$	$2.8\ 10^{-11}$	$9.4\ 10^{-11}$	$3.2\ 10^{-10}$	$6.6\ 10^{-10}$	$6.6\ 10^{-10}$	$6.6\ 10^{-10}$	$6.6\ 10^{-10}$	$6.6\ 10^{-10}$
^{192}Ir	0	$1.2\ 10^{-11}$	$2.3\ 10^{-11}$	$4.6\ 10^{-11}$	$9.2\ 10^{-11}$	$3.1\ 10^{-10}$	$1.2\ 10^{-9}$	$4.6\ 10^{-9}$	$4.8\ 10^{-9}$	$4.8\ 10^{-9}$	$4.8\ 10^{-9}$	$4.8\ 10^{-9}$
$^{226}Ra^{b}$	0	$5.1\ 10^{-13}$	$2.0\ 10^{-12}$	$7.8\ 10^{-12}$	$3.0\ 10^{-11}$	$2.8\ 10^{-10}$	$2.3\ 10^{-9}$	$3.2\ 10^{-8}$	$6.1\ 10^{-8}$	$1.3\ 10^{-7}$	$2.2\ 10^{-7}$	$5.4\ 10^{-7}$
$^{235}U^{b}$	0	$2.1\ 10^{-12}$	$4.1\ 10^{-12}$	$8.3\ 10^{-12}$	$1.7\ 10^{-11}$	$6.0\ 10^{-11}$	$2.6\ 10^{-10}$	$3.0\ 10^{-9}$	$5.6\ 10^{-9}$	$1.2\ 10^{-8}$	$1.9\ 10^{-8}$	$4.1\ 10^{-8}$
^{238}Pu	0	$1.3\ 10^{-15}$	$2.6\ 10^{-15}$	$5.1\ 10^{-15}$	$1.0\ 10^{-14}$	$3.6\ 10^{-14}$	$1.5\ 10^{-13}$	$1.7\ 10^{-12}$	$3.0\ 10^{-12}$	$5.5\ 10^{-12}$	$7.3\ 10^{-12}$	$8.8\ 10^{-12}$
^{239}Pu	0	$1.1\ 10^{-15}$	$2.1\ 10^{-15}$	$4.2\ 10^{-15}$	$8.4\ 10^{-15}$	$2.9\ 10^{-14}$	$1.3\ 10^{-13}$	$1.4\ 10^{-12}$	$2.6\ 10^{-12}$	$5.2\ 10^{-12}$	$7.8\ 10^{-12}$	$1.4\ 10^{-11}$
^{241}Am	0	$2.2\ 10^{-13}$	$4.4\ 10^{-13}$	$8.8\ 10^{-13}$	$1.8\ 10^{-12}$	$6.1\ 10^{-12}$	$2.6\ 10^{-11}$	$2.9\ 10^{-10}$	$5.4\ 10^{-10}$	$1.1\ 10^{-9}$	$1.6\ 10^{-9}$	$2.7\ 10^{-9}$

a) Generic soil of 1.5 g cm^{-3} assumed in calculation, with composition by weight O 0.6, Si 0.25, C 0.07, H 0.04, Al 0.03 Fe 0.01.

b) The doses from the ingrowth of daughter radionuclides are included with the parent, i.e. ^{95}Zr includes ^{95m}Nb, ^{95}Nb; ^{99}Mo includes ^{99m}Tc, ^{99}Tc; ^{103}Ru includes ^{103m}Rh; ^{106}Ru includes ^{106}Rh; ^{132}Te includes ^{132}I; ^{131}I includes ^{131m}Xe; ^{135}I includes ^{135m}Xe, ^{135}Xe; ^{137}Cs includes ^{137m}Ba; ^{140}Ba includes ^{140}La; ^{144}Ce includes ^{144}Pr; ^{226}Ra includes ^{214}Pb, ^{214}Bi, ^{214}Po, ^{210}Pb, ^{210}Bi, ^{210}Po; ^{235}U includes ^{231}Th.

B2 LOCATION AND OCCUPANCY FACTORS TO ESTIMATE DOSES TO PEOPLE INDOORS FROM DEPOSITION OUTDOORS

People typically tend to stay indoors for about 80% to 95% of the time (Jenkins et al, 1992; Andersson, 1996; Long et al, 2001; Kousa et al, 2002). During this time, they are shielded against radiation from outdoor contamination. The extent of this shielding depends on the characteristics of the specific buildings. The values in Table B1 and Table B2 therefore need to be modified using a location factor, which takes into account the shielding provided by the building in question.

Table B3 shows typical location factors for areas with buildings with different characteristics, ranging from thin wooden walls to thick brick and concrete walls (Andersson, 2005). The location factors are given for ^{137}Cs (representative of medium-high energy gamma emitters) shortly after deposition. These location factors can be used as default values for all the radionuclides considered in the Handbook. It should be noted, however, that the shielding offered by medium and high shielding buildings could be about twice as large for gamma-emitting radionuclides with energies around 300 keV compared to those with energies around 3 MeV (Meckbach et al, 1988b). The location factor changes with time, since the natural removal and migration processes of contamination on different surfaces are different. However, for areas with relatively large unpaved ground areas, such as a garden, changes to the location factors over a period of 10 years are expected to be limited (within about 50 %) and can be ignored for the purposes of estimating doses. For urban centres with little or no unpaved ground, long-term doses estimated using time-invariable location factors in Table B3 are likely to be conservative. The presence of airborne contaminants inside buildings leads to deposition on interior surfaces of the building. These deposits will give rise to a dose contribution to persons staying in the buildings. The location factors given in Table B3 take into account that some of the dose received come from contamination that was deposited indoors and that this dose is not affected substantially by the shielding offered by building walls.

Table B3 Location factors for ^{137}Cs (662 keV) for buildings with different shielding properties

Area type	Location factor estimate
Low shielding building	0.62
Medium shielding building	0.14
High shielding building	0.03

Using the values given in Table B2 and Table B3, a simple estimate of external gamma dose from material deposited outdoors can be made using the :

$$\mathrm{D}_{\mathrm{ext.,\,gamma}} = Dep \times Ext_{outdoors}\left(F_{outdoors} + LF \times F_{indoors}\right)$$

where $D_{ext,\ gamma}$ is the external gamma dose (Sv), Dep is the deposition on ground (Bq m^{-2}) $Ext_{outdoors}$ is the external gamma dose outdoors per unit deposition (Sv m^{2} Bq^{-1}), $F_{outdoors}$ and $F_{indoors}$ are the fractions of time spent outdoors and indoors respectively and LF is the location factor.

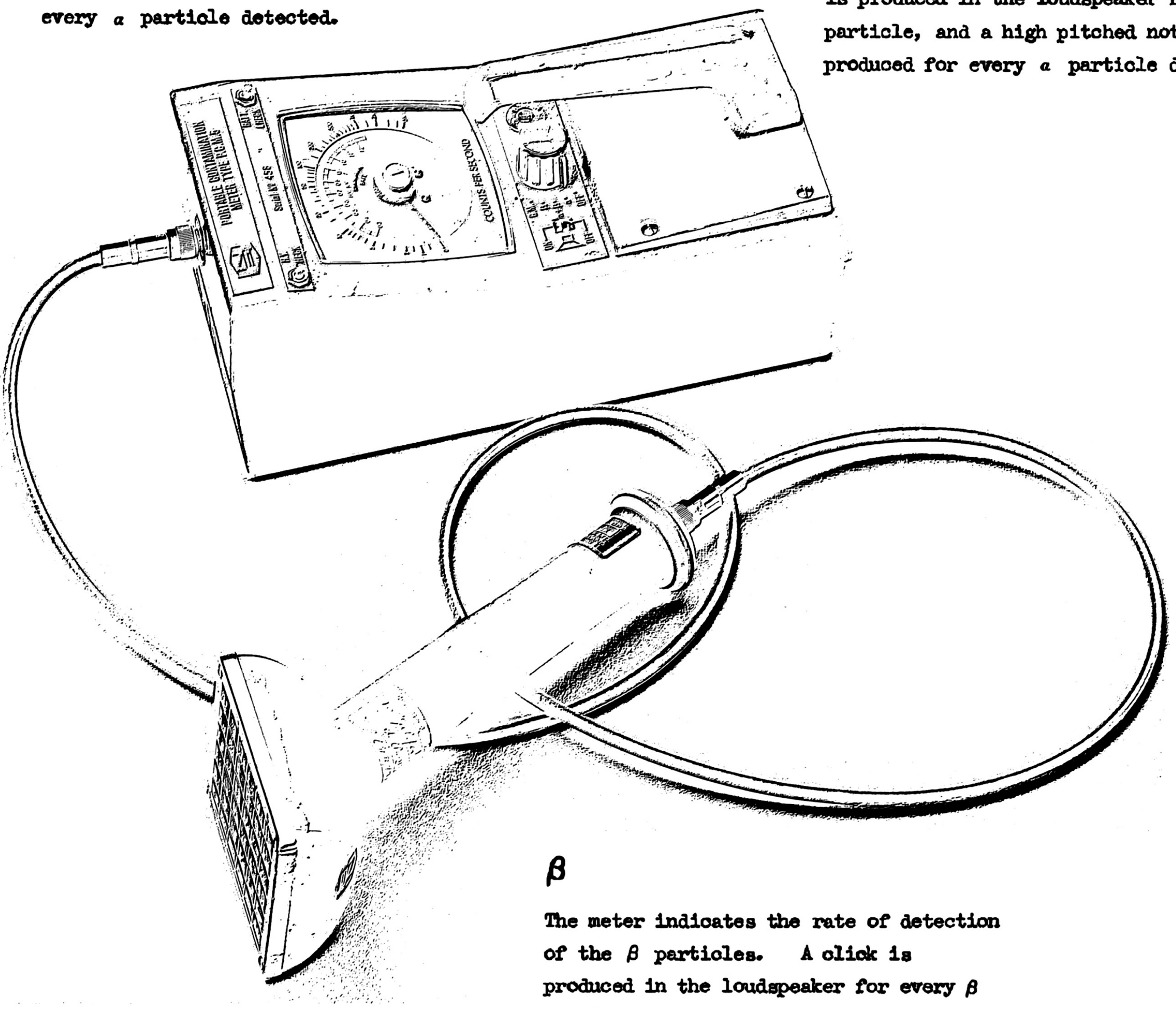
PORTABLE CONTAMINATION MONITOR TYPE PCM

α

The meter indicates the rate of detection of α particles only. A high pitched note is produced in the loudspeaker for every α particle detected.

$\alpha + \beta$

The meter indicates the rate of detection of both α and β particles. A click is produced in the loudspeaker for every β particle, and a high pitched note is produced for every α particle detected.



β

The meter indicates the rate of detection of the β particles. A click is produced in the loudspeaker for every β particle detected.

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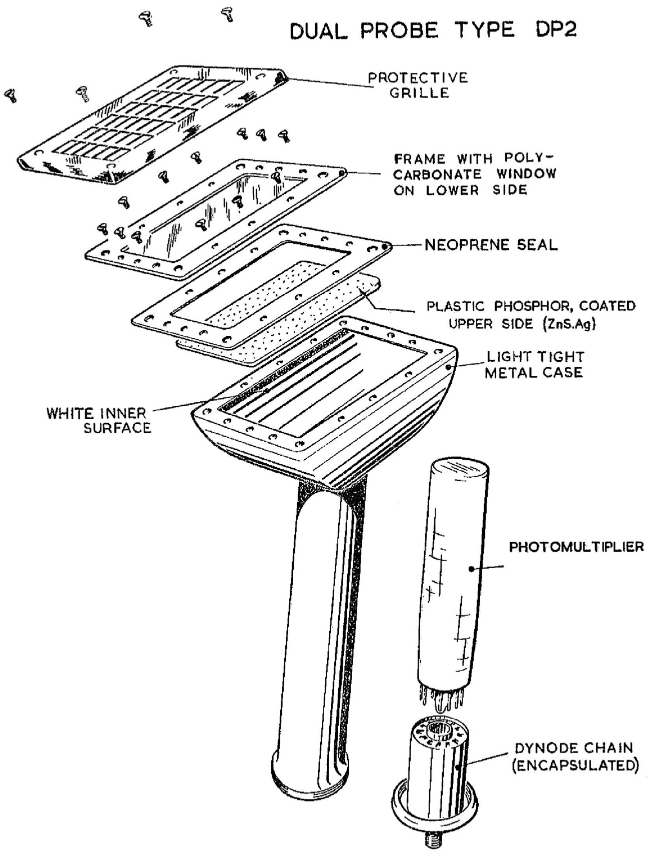
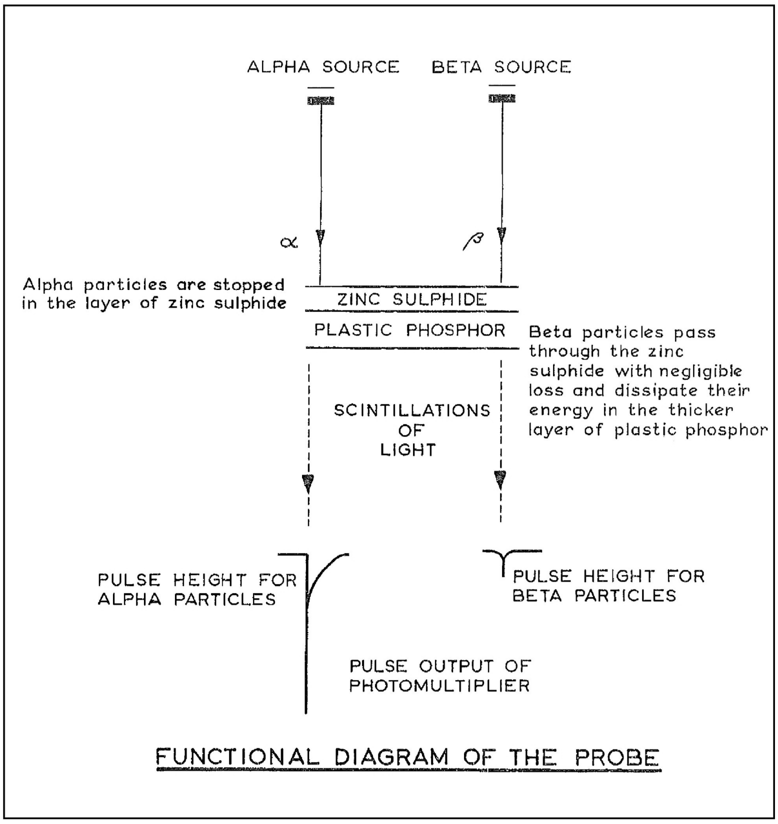
TELEPHONE: 031-443 4060. CABLES: 'NUCLEAR EDINBURGH'. TELEX: 72333





DUAL PROBE TYPE DP2

The probe is designed to provide simultaneous monitoring of alpha and beta contamination. Light scintillations due to α and β particles are produced in the dual phosphor. These scintillations excite the cathode of a photo-multiplier which gives pulse outputs corresponding to the radiation particles reaching the probe. An aluminized window is fitted to the probe to exclude ambient light.

Referring to Fig. 2, the probe is shown as receiving both α and β radiation. The alpha particles are stopped in the zinc sulphide layer, and light scintillations are produced within the layer. These scintillations pass through the plastic phosphor layer which is transparent.

The beta particles pass through the zinc sulphide layer with little loss of energy and produce light scintillations in the plastic phosphor layer. The amount of light a Pu^{239} alpha particle produces is approximately twelve times that of a Sr^{90} - Y^{90} beta particle.

In subsequent circuits, use is made of the different amplitudes of the pulses due to alpha and beta particles to display and count them separately if required.

The alpha efficiency is not less than 20% and the beta efficiency is not less than 30% for thin Pu^{239} and Sr^{90} radioactive sources respectively.

$\alpha + \beta$

The meter indicates the rate of detection of both α and β particles. A click is produced in the loudspeaker for every β particle, and a high pitched note is produced for every α particle detected.

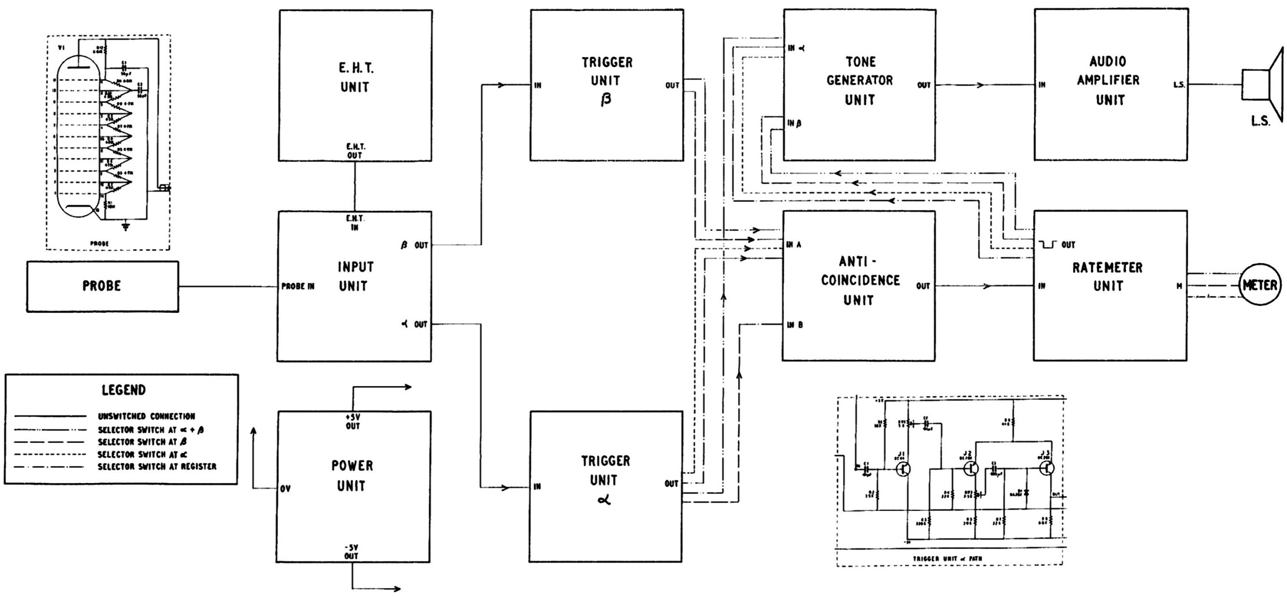
α

The meter indicates the rate of detection of α particles only. A high pitched note is produced in the loudspeaker for every α particle detected.

β

The meter indicates the rate of detection of the β particles. A click is produced in the loudspeaker for every β particle detected.

Two identical Trigger Units are used, one in the α path and the other in the β path. The function of the Trigger Unit is to provide a negative-going 50µS pulse at its output when a pulse, greater than a predetermined level, is present at its input.



BLOCK SCHEMATIC DIAGRAM

TONE GENERATOR UNIT

The function of the Tone Generator Unit is to provide a burst of oscillations at approximately 2kc/s for every pulse received at the IN α terminal and a negative-going square pulse (producing a click in the loudspeaker) for every pulse received at the IN β terminal. When the control switch on the front panel is switched to the $\alpha + \beta$ position, the unit produces one burst of oscillation for every α pulse and a negative-going square pulse for every α or β pulse.

Efficiency

This may be checked by placing alpha and beta sources of known strength in turn on the centre of the probe windows, making sure that the source is not masked by the grille, and taking readings on the ratemeter.

The respective counts per second should be greater than:-

0.0030 x (alpha source disintegrations per minute) (20% efficiency)

0.01 x (beta source counts per minute) (30% efficiency)

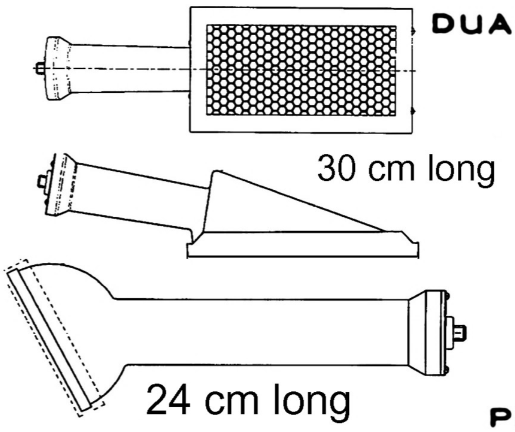
The sources usually used are:-

Alpha:- Pu^{239} (RCC P.1.R.C.2)

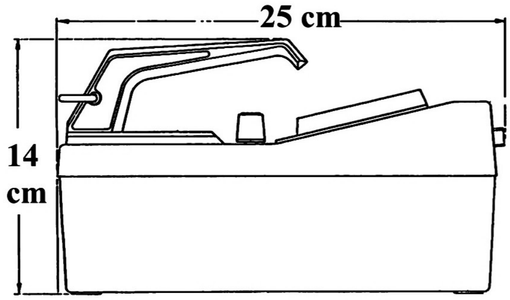
Beta:- Sr^{90} (RCC S.1.R.C.1.)

ACCURATE SETTING (all types of probe).

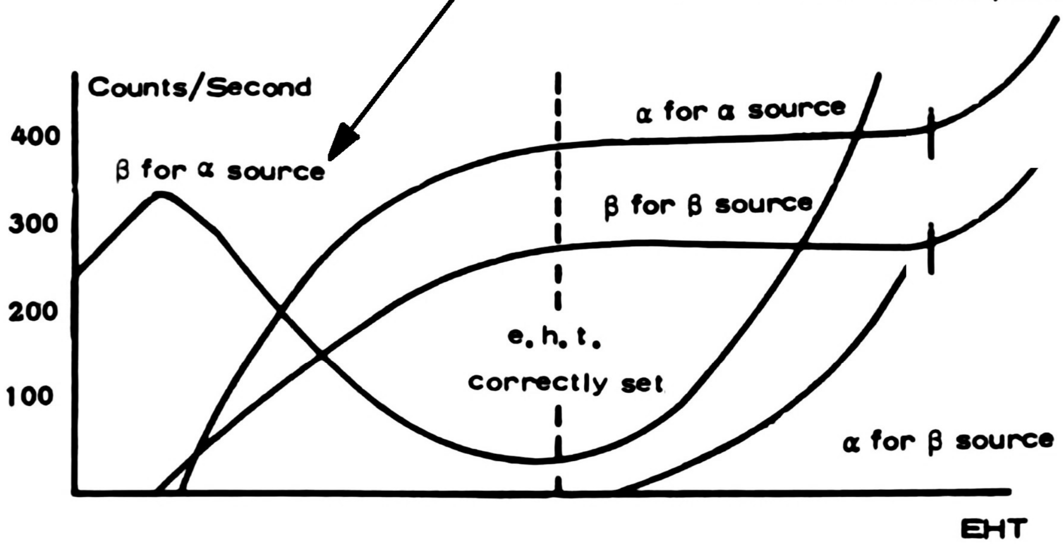
Place the probe face in contact with a suitable radioactive source; e.g. Am^{241} alpha source, in the case of an alpha probe.



DUAL PHOSPHOR PROBES



Plot a graph of counts against e.h.t. voltage but use an alpha source with the function switch set to the beta position.



Probe	Sensitive Area (cm²)	Counts/s for D.W.L. * of $10^{-5}\mu$ Ci/cm² α 10^{-4} μCi/cm² β	Counts/s for 1 mR/h	Approx. Window Thickness (mg/cm²)	Remarks
Alpha Sensitive (ZnS phosphor)					
AP2	49	3 (Am^{241})		1.1	1" dia.
AP3	100	6 (Am^{241})		1.1	PM tube
Beta Sensitive					
BP4	18	10 (C^{14}) 20 (Sr^{90} + Y^{90})	170 (Ra)	1.8	Anthracene Phosphor
BP5	49	40 (Sr^{90} + Y^{90})	120 (Co^{60})	7	Plastic Phosphor

* Derived Working Level

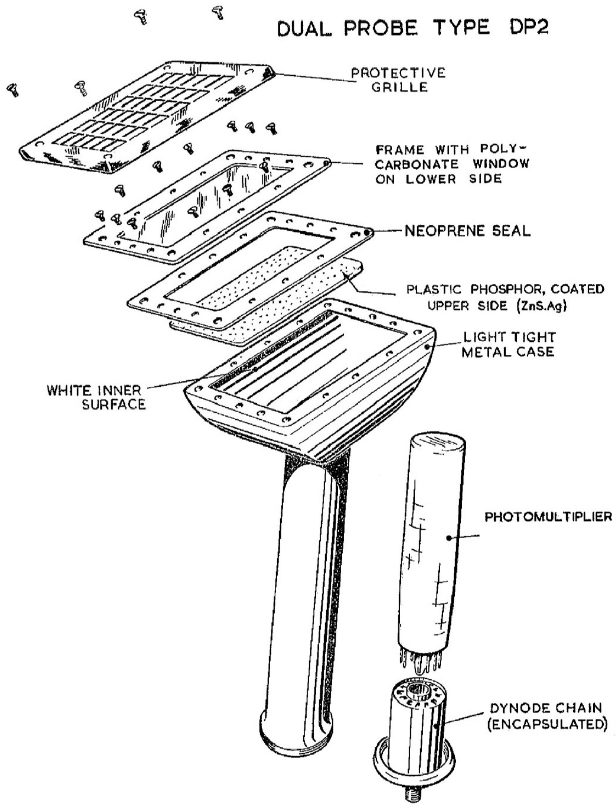
INTRODUCTION

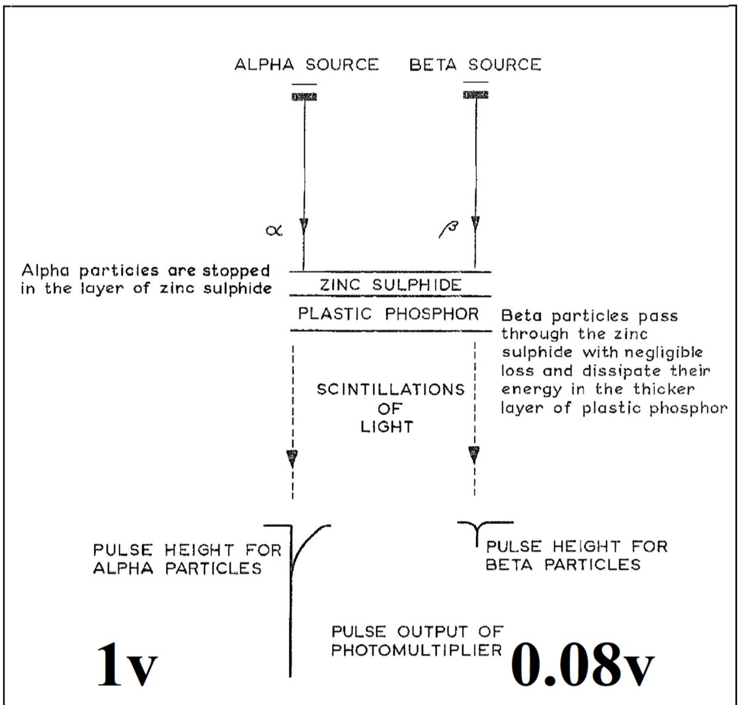
The instrument is particularly suited for use with the Dual Probe Type DP2 for the detection of alpha and beta contamination either separately or simultaneously.

The detection of alpha and beta particles is indicated by two distinctive audio signals in the loudspeaker.

DUAL PROBE TYPE DP2

The probe is designed to provide simultaneous monitoring of alpha and beta contamination. Light scintillations due to α and β particles are produced in the dual phosphor.



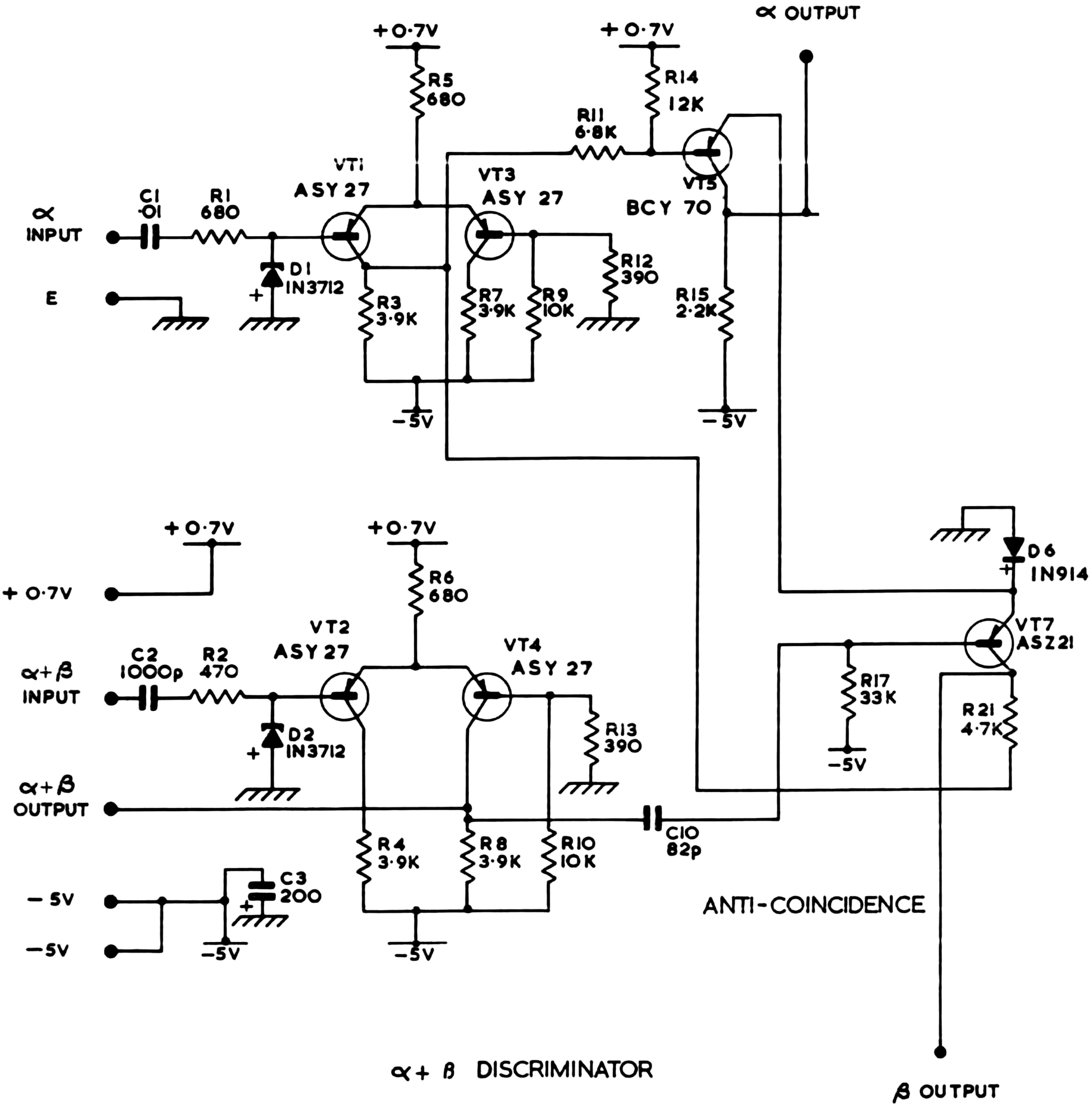


FUNCTIONAL DIAGRAM OF THE PROBE

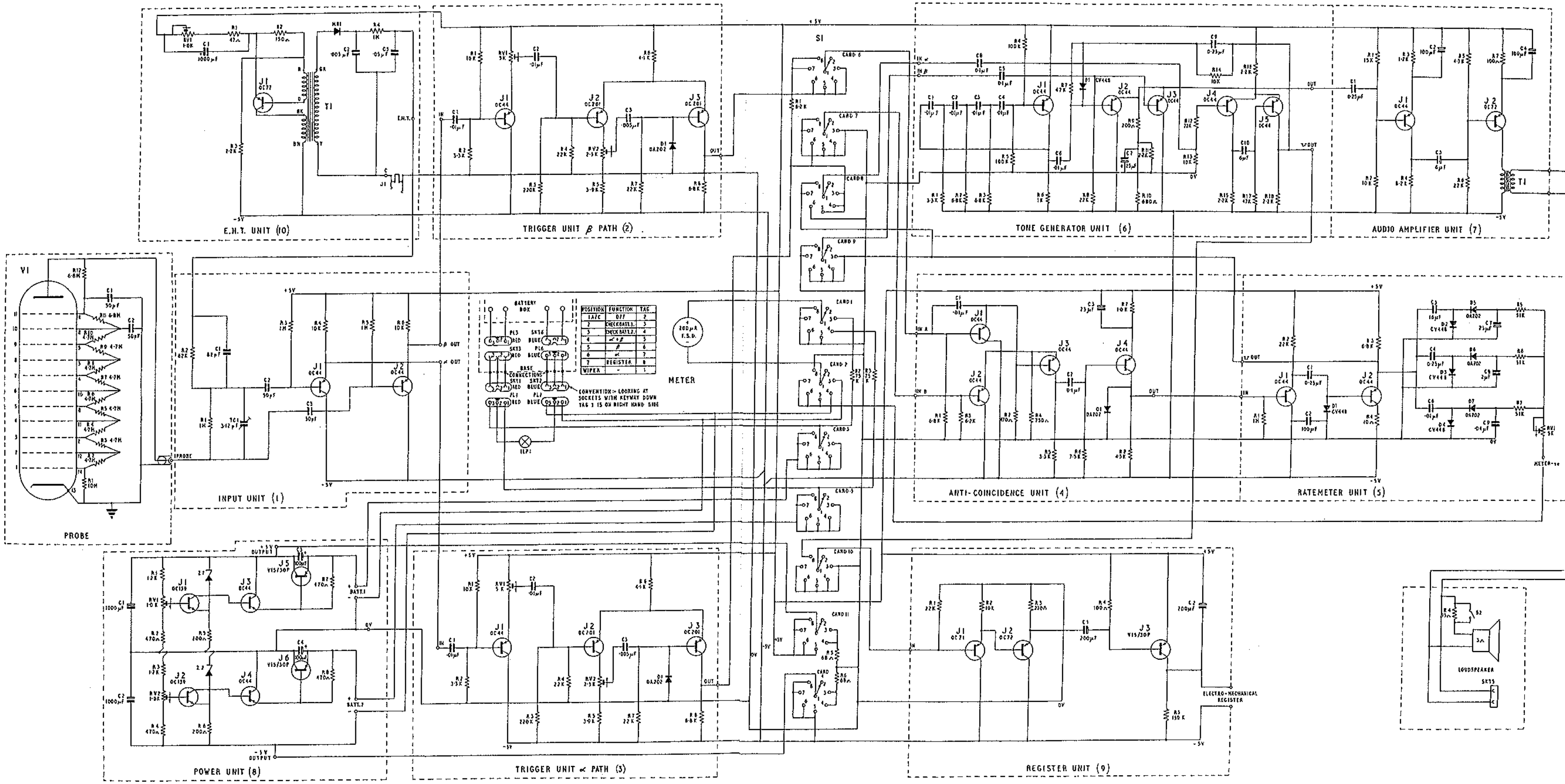
The alpha particles are stopped in the zinc sulphide layer, and light scintillations are produced within the layer. These scintillations pass through the plastic phosphor layer which is transparent.

The beta particles pass through the zinc sulphide layer with little loss of energy and produce light scintillations in the plastic phosphor layer. The amount of light a Pu^{239} alpha particle produces is approximately twelve times that of a $Sr^{90} - Y^{90}$ beta particle.

The alpha efficiency is not less than 20% and the beta efficiency is not less than 30% for thin Pu^{239} and Sr^{90} radioactive sources respectively.



α + β DISCRIMINATOR



TL.1175

PCM1 - CIRCUIT DIAGRAM

FIG.6

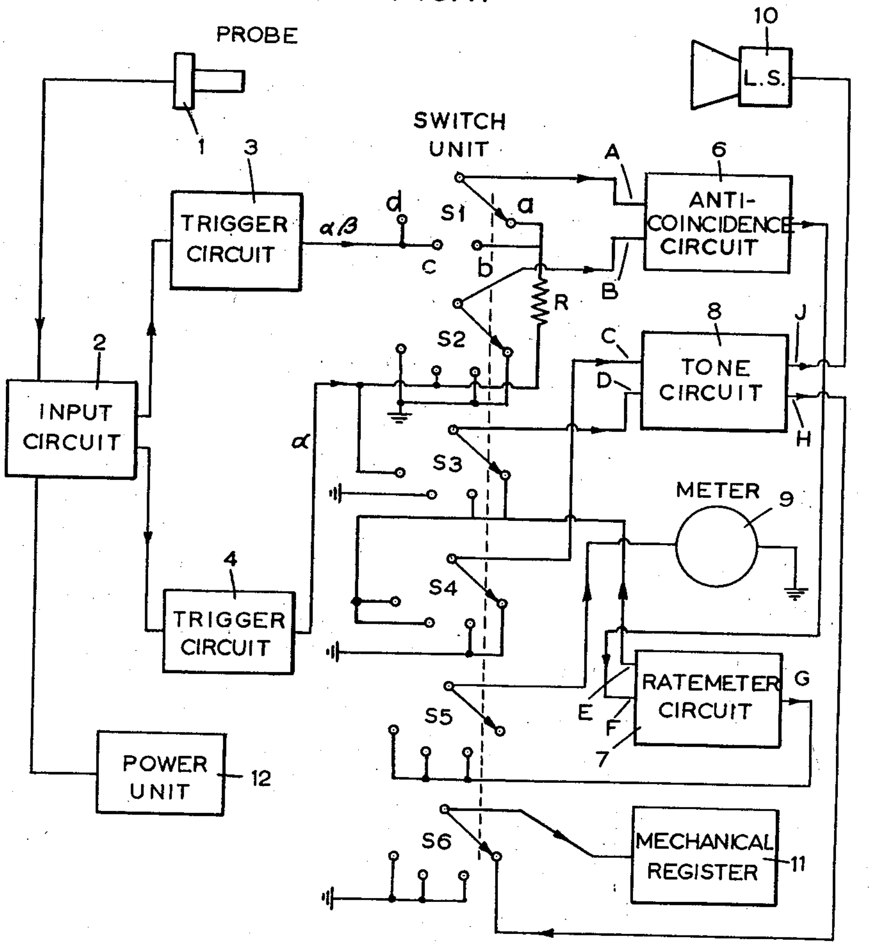
N

March 24, 1964 J. R. BROWN ETAL 3,126,482

RADIO-ACTIVITY CONTAMINATION MONITOR WITH DISCRIMINATION MEANS FOR ALPHA AND BETA RADIATION

Filed Oct. 3, 1960 3 Sheets-Sheet 1

FIG. 1.



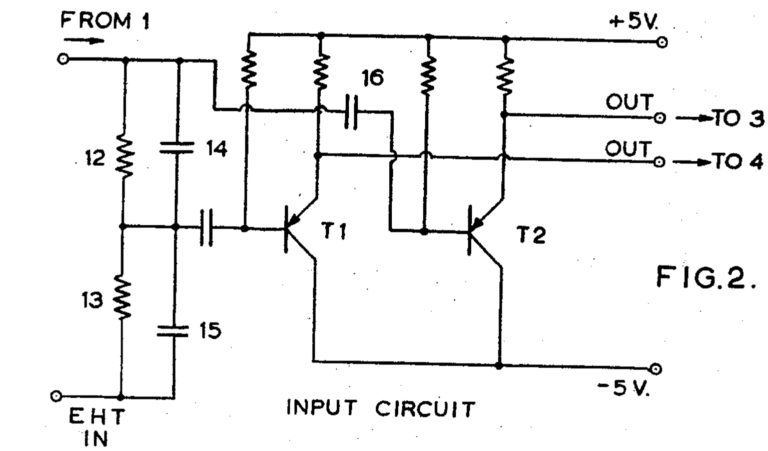


FIG.2.

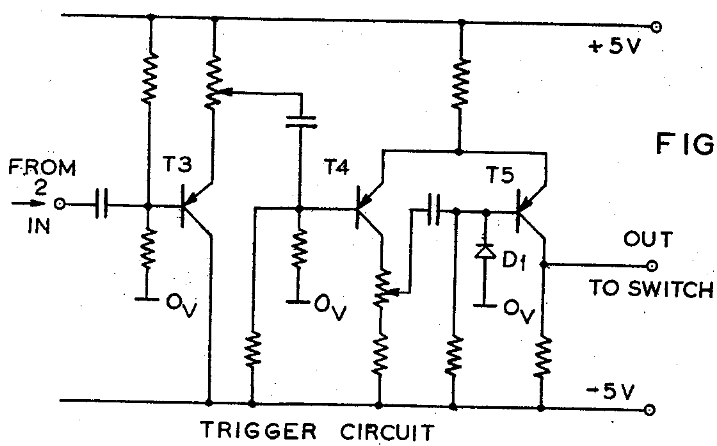


FIG.3.

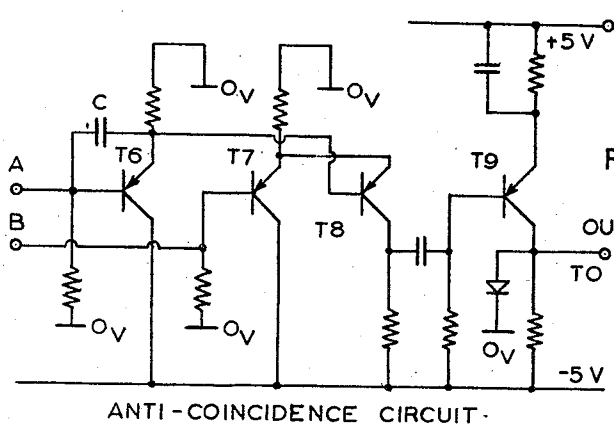


FIG.4.

FIG. 5.

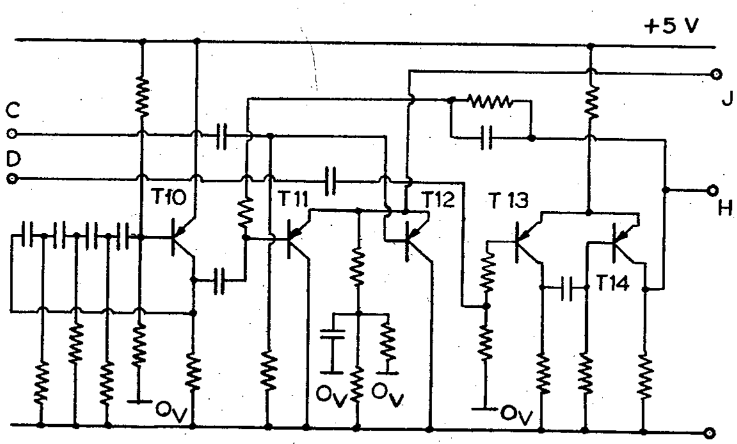
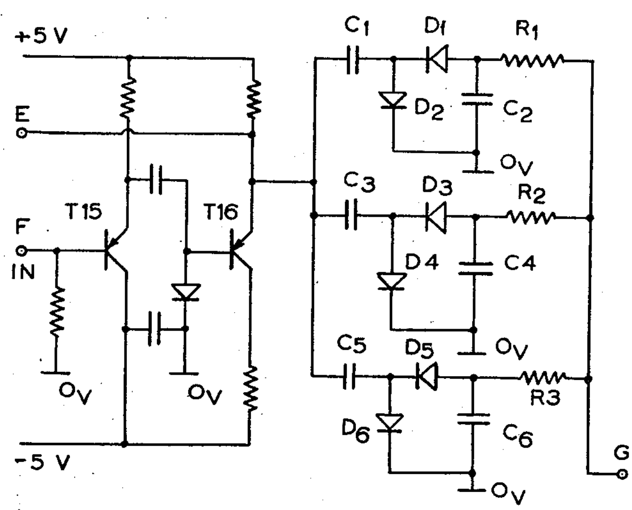

+5 V
C
D
J
H
T10
T11
T12
T13
T14
0V
-5 V
TONE GENERATOR

FIG. 6.


+5 V
E
F
IN
T15
T16
0V
-5 V
C1
D1
R1
D2
C2
C3
D3
R2
D4
C4
C5
D5
R3
D6
C6
G

United States Patent Office

3,126,482

Patented Mar. 24, 1964

3,126,482

RADIO-ACTIVITY CONTAMINATION MONITOR WITH DISCRIMINATION MEANS FOR ALPHA AND BETA RADIATION

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Filed Oct. 3, 1960, Ser. No. 59,889
Claims priority, application Great Britain Oct. 6, 1959
2 Claims. (Cl. 250—83.3)

This invention relates to radio activity contamination monitors.

The object of the present invention is to provide a radio activity contamination monitor which is capable of providing an indication of the presence and quantity of radio active particles of different forms emanating from selected contaminated areas for example benches and clothing.

According to the present invention there is provided a radio activity contamination monitor adapted to respond to α and β radiations and means for producing audibly distinguishable signals in response respectively to said α and β radiations.

According to one aspect of the present invention there is provided a radio activity monitor comprising a detector for producing electrical impulses of different amplitudes in response to atomic radiations of different masses, means for separating electrical impulses produced by radiation of one mass from electrical impulses produced by radiation of a different mass to obtain separate indications of the density of radiation in said different masses.

In order that the present invention may be clearly understood and readily carried into effect one example of an embodiment of the invention will be described with reference to the accompanying drawings of which:

FIGURE 1 illustrates mainly in block form the embodiment about to be described.

FIGURE 2 illustrates the input circuit of the embodiment shown in FIGURE 1,

FIGURE 3 illustrates a trigger circuit suitable for use in the embodiment shown in FIGURE 1,

FIGURE 4 illustrates the anti-coincidence circuit suitable for use in the embodiment shown in FIGURE 1,

FIGURE 5 illustrates a tone generator circuit suitable for use in the embodiment shown in FIGURE 1 and

FIGURE 6 illustrates a rate meter circuit suitable for use in the embodiment shown in FIGURE 1.

Referring to FIGURE 1, the detecting probe for α and β radiations is represented by reference **1**. This probe is preferably of the dual phosphor scintillation counter type and produces output pulses corresponding to individual α and β particles which enter the sensitive region of the probe. In the present example of the invention the probe comprises a layer of zinc sulphide disposed in front of a thicker layer of plastic phosphor so that α particles having a much greater specific ionisation than the β particles are arrested in the zinc sulphide layer to produce light scintillations which are transmitted by the transparent plastic phosphor to be detected by the photo cathode of a photo multiplier. The β particles with low specific ionisation pass through the zinc sulphide layer without substantial loss of energy and are arrested in the plastic phosphor where the loss of energy causes further light scintillations which are also detected by the photo cathode of the photo multiplier mentioned above.

In the present embodiment of the invention, use is made of the fact that with the type of probe described above the electrical pulses corresponding to α particles are of substantially greater magnitude than pulses corresponding to β particles. As will be appreciated hereafter, by transmitting signals derived from the probe along one channel without substantial attenuation and transmitting the same signals along another channel with a predetermined degree of attenuation, trigger circuits receiving the signals from each channel can be arranged to be triggered in the one case by pulses corresponding to α and β particles and in the other case only by α particles. Subtraction between the outputs of the said trigger circuits enables pulses corresponding to α particles and β particles to be presented in separate channels.

Signal pulses derived from the probe **1** are applied to the input terminal of an input circuit **2** which is arranged to feed signals representing α and β particles to two trigger circuits **3** and **4**, the signal applied to **4** being attenuated in the ratio 12:1 as compared with the signal applied to **3**. The output signals derived from **3** and **4** are applied to a switch unit which comprises six switches S1, S2, S3, S4, S5 and S6. Each of these switches has four fixed contacts and a further single contact movable to engage with one or other respectively of the four fixed contacts, the movable contacts being ganged together as indicated. The four movable contacts of S1 denoted in FIGURE 1 by references *a*, *b*, *c* and the positions of the other switches S2 to S6 corresponding to these contacts will also subsequently be referred to by these references. Thus the output from **3** is connected to contacts *c* and *d* of S1 whereas the output of **4** is connected to the contact *d* of S3, *c* of S2 and via a resistor R to contacts *a* and *b* of S1. Fixed contacts *a*, *b* and *d* of S2 are all earthed as is the fixed contact *c* of S3, the contacts *a* and *b* of S4 and the contacts *b*, *c* and *d* of S6.

Associated with the switch unit is an anti-coincidence circuit **6**, which provides the aforementioned subtraction between the signals derived from **3** and **4**, a rate meter circuit **7**, a tone circuit **8** which produces in a loudspeaker **10** different sounds representing α and β particles, an electrical meter **9** and a mechanical register **11**. The circuits of blocks **2**, **3**, **4**, **6**, **7** and **8** are described in greater detail hereafter with reference to FIGURES 2, 3, 4, 5 and 6.

The movable contact S1 is connected to the input terminal A of the anti-coincidence circuit **6** and the movable contact of the switch S2 is connected to the input terminal B. The output terminal of **6** is connected to the terminal F of the rate meter circuit **7**. Movable contacts of S3 and S4 are connected to the input terminals D and C of the tone generator circuit **8** one output terminal of which is connected direct to the loudspeaker **10** and the other output terminal being connected to the fixed contact *a* of S6. The movable contacts of S5 and S6 are connected respectively to the meter **9** and the mechanical register **11**. In addition to the above connections the terminal E of the rate meter circuit is connected to the fixed contacts *a*, *b* of S3 and *c* and *d* of S4, the output terminal G of the rate meter circuit being connected to the fixed contacts *b*, *c* and *d* of S5.

Before operation of the arrangement of FIGURE 1 is described in detail the circuits connected with certain of the blocks shown in FIGURE 1 will be further described. Thus the input circuit **2** is shown in FIGURE 2 and comprises a potentiometer consisting of resistors **12** and **13** and capacitors **14** and **15**, across which the input pulses derived from the probe **1** are applied. These pulsese are also applied via a coupling capacitor **16** to the base of a transistor T2. The junction of **12** and **13** which is common to the junction of **14** and **15**, is connected via a further coupling capacitor **17** to the base of a further transistor T1. The transistors T1 and T2 are connected to operate as emitter followers but by virtue of the step down effect of the potentiometer comprising **13** and **14**, the signal amplitude of pulses applied to the base of T1 is attenuated relative to that of pulses applied to the base of T2. The outputs of T1 and T2 which, as shown, are derived from the emitters thereof, are applied to output terminals which are connected respectively to the identical trigger circuits 3 and 4 shown in FIGURE 1.

The trigger circuits 3 and 4 are adjusted to have triggering thresholds which are so chosen in relation to the attenuation produced by the potentiometer of the input circuit 2, that 3 is triggered in response to pulses representing α particles and β particles but owing to the said attenuation the circuit 4 is only triggered by the higher amplitude pulses, namely those corresponding to α particles.

Referring to FIGURE 3, the trigger circuits 3 and 4 each comprise three transistors T3, T4 and T5 of which the transistor T3 forms a biased emitter follower valve driving a conventional two state device formed by the transistors T4 and T5, to produce a square wave at the collector electrode of T5. The signal applied to the base of T4 is derived from a movable contact at a potentiometer P1 which forms the emitter resistor for the transistor T3 so that the two state device may be triggered at a signal level which depends on the setting of this movable contact. The base of T5 is connected via a diode D1 to a point of zero reference potential to limit the amplitude of output pulses by holding the effective input signal to the base of T5 below a predetermined level. The bias at the transistor T3 for each of the trigger circuits 3 and 4 is adjusted by P1 to be substantially equal so that as aforementioned the circuit A is triggered by pulses corresponding to α and β particles whereas the circuit 4 is triggered only by pulses corresponding to α particles.

The anti-coincidence circuit represented by block 6 in FIGURE 1 is illustrated in FIGURE 4. In FIGURE 4, the input terminal A is connected to the base electrode of a transistor T6 and the input terminal B is connected to the base electrode of a transistor T7, both transistors being connected to operate as emitter followers. The emitter electrode of T6 is thus connected to the base electrode of a further transistor T8, the emitter electrode of which is connected to the emitter electrode of T7. The collector electrode T8 is capacitively coupled to the base electrode of a further transistor T9 which operates as an emitter follower, the emitter electrode being connected to the output terminal which is directly connected to the input terminal F of the rate meter circuit 7 of FIGURE 1. By virtue of the connections between the base and emitter electrodes of T8 and the emitter electrodes of emitter followers T6 and T7 it is arranged that the output signal derived from the collector electrode of T8 represents the difference between signals applied at the input terminals A and B. Again a diode is connected from the emitter electrode of T9 to a point of zero reference potential in order that the output pulses derived from T9 are limited and clearly defined.

By virtue of the fact that the input circuit 2 produces different degrees of attenuation in the signals which are applied to trigger circuits 3 and 4 and since the pulses representing α particles are not truly rectangular but have sloping leading edges, there is a relative time delay between the triggering of circuits 3 and 4 corresponding to the same pulse derived from 1 and consequently the same time delay is endowed in the signals appearing at A and B corresponding to α particles. In order that this delay may be compensated for and output pulses may be derived from the anti-coincidence circuit representing β particles when pulses representing α and β particles are applied to A and pulses representing α particles only are applied to B, a capacitor C is connected between the emitter electrode and the base electrode of the transistor T6.

The tone generator circuit 8 in FIGURE 1 is shown detail in FIGURE 5. Referring to FIGURE 5, the transistor T10 with the associated circuit components forms an oscillator, the frequency of which is so chosen in the audio range that short bursts of oscillations give the sensation of squeaks when applied to the loudspeaker 10. The input terminal D of the circuit is connected to an intermediate point at a potentiometer connected to the base of a transistor T13 which has an emitter connection common with the adjacent transistor T14. Transistors T13 and T14 form a monostable circuit in which T14 is normally conducting and the circuit connections are such that when T14 is conducting a further transistor T11 is biased into its normal conducting state. Oscillations generated in T10 are applied via T11 to the output electrode which is connected to the loudspeaker. The emitter electrode of T11 is connected in common with the emitter electrode of a further transistor T12 the base of which is coupled to the input terminal C of the circuit. Thus on application of negative pulses to the input terminal D the monostable circuit comprising T13 and T14 is switched to its unstable state and oscillations are transmitted from T10 to the output terminal J for the duration of the period in which the monostable circuit remains in its unstable state. Furthermore, on application of a negative pulse to the input terminal C the transistor T12 produces a corresponding pulse at the output terminal J. Thus negative input pulses at C give rise to clicks in the loudspeaker and negative input pulses at D give rise to squeaks in the loudspeaker.

The rate meter circuit 7 is illustrated in detail in FIGURE 6. In FIGURE 6 the two transistors T15 and T16 comprise emitter follower amplifiers connected in series, input signals being applied to the input terminal F. The circuit has two output terminals, namely E and G, of which E is connected directly to the emitter T16 and G is connected via a parallel arrangement of three diode pump circuits to the emitter of 16. The said diode pump circuits comprise pairs of diodes D1 and D2, D3 and D4 and D5 and D6 respectively, pairs of capacitors C1 and C2, C3 and C4 and C5 and C6 respectively and load resistors R1, R2 and R3. The purpose of the parallel diode pump circuits is to provide a D.C. output signal of substantial logarithmic form so that the meter 9 may be calibrated according to a logarithmic scale of representation and thereby avoid the necessity to provide a range change switch. This is permissible since reading accuracy of the meter scale is required to be relatively high for low count rates of α and β particles but can be relatively low for high count rates. The capacitors C1 and C3 and C5 may be termed feed capacitors and in the present example $C1>C3>C5$ and C2, C4 and C6 may be termed reservoir capacitors and are such that $C2>C4>C6$. The load resistors R1, R2 and R3 are all substantially equal. Considering the diode pump circuit comprising D1, D2 and R1, on application of negative pulses from the emitter of T16, the feed capacitor determines the charge per pulse applied to C1 and the reservoir capacitor C2 which tends to charge up in a stepwise fashion via D1. At the same time, C2 tends to discharge via R1 and the meter 9 when the meter is connected at the point G to form a part to earth. The current flowing via R1 and the meter is therefore proportional to the rate of application of pulses from T16. The operation of all three diode pump circuits is the same, but since $C2>C4>C6$, the rate of fall of voltage across C2 is less than that for C4, which in turn is less than that for C6. Therefore for relatively low count rates the discharge current from C2 predominates the discharge currents from C4 and C6 being relatively insignificant whereas for relatively higher count rates the discharge given from C4 becomes of greater significance and for even higher count rates, the discharge current from C6 is of greater significance. The values of the capacitors in the diode circuits are so chosen to give a logarithmic scale of count rate representation of the meter **9**.

Referring now to FIGURE 1, when the switch unit comprising **S1**, **S2** . . . **S6** is set to the position indicated in the drawing negative pulses corresponding to α particles detected by the probe **1** are derived from the trigger circuit **4** and applied via resistor R and the movable contact of **S1** to the terminal A of **6**. The pulses which are derived from the output terminal of the anti-coincidence circuit therefore correspond to α particles and are applied to the terminal F of the rate meter circuit and after being amplified therein by transistors **T15** and **T16** these pulses are applied via the terminal E the movable contact of **S3**, **8**, and the movable contact of **S6** to the input terminal of the mechanical register **11**. The mechanical register comprises the electro-mechanical device of known form capable of counting up to say a maximum of 10 pulses per second and of registering the number counted. This facility enables the count rate for α particles to be recorded assuming that the rate is not more than 10 particles per second.

In the position of the movable contacts of the switch in which the movable contacts engage fixed contacts *b*, again pulses corresponding to α particles are applied via the resistor R, the terminal A of the anti-concidence circuit **6**, the rate meter circuit **7** and the movable contact of **S3** to the tone generator circuit to give rise to squeaks in the loudspeaker **10**. Furthermore, the output derived from the terminal G is applied via **S5** to the meter **9** which therefore gives an indication of the count rate for α particles sensed by **1**. Since the movable contact **S4** is earthed in the positions mentioned so far no clicks are produced at the loudspeaker with the switch in either of these positions.

When the switch is set so that the movable contacts engage with the fixed contacts *c*, pulses corresponding to α particles and β particles detected by the probe **1** are applied via the trigger circuit **3** and the movable contact **3** of **S1** to the input terminal A of **6** and pulses corresponding to α particles only detected by the probe **1** are applied via the movable contact of **S2** to the input terminal B of **6**. Consequently subtraction occurs in **6** as described above and pulses appearing at the output terminal E of **7** are applied via the movable contact of **S4** to the input terminal C of **8**. In this case these pulses correspond to β particles and give rise to clicks in the loudspeaker **10**. Terminal D in this case is earthed so that no squeaks are produced. Furthermore, the output derived from the terminal G of the rate meter circuit is applied via the switch **S5** to the meter **9** which therefore gives an indication of the count rate for β particles.

When the movable contacts of the switch are set to engage with the fixed contacts *d*, the input terminal A of the anti-coincidence circuit receives pulses corresponding to α and β particles derived from the probe **1** but the input terminal B of the anti-coincidence circuit is earthed. Output pulses derived from **6** therefore represent α particles and β particles and a corresponding indication is produced at the meter **9**. However, it will be noted that the output signal derived at the terminal E of the rate meter circuit is now applied via the movable contact of **S4** to the input terminal C of the tone generator circuit and therefore gives rise to clicks in

the loudspeaker corresponding to α and β particles and since the output signal derived from **4** is applied directly via the movable contact of **S3** to the input terminal D of **8**, squeaks are produced in the loudspeaker corresponding to α particles.

To summarise and referring to the switch positions as *a*, *b*, *c* and *d* as appropriate, position *a* gives mechanical registration in **11** of α particles and produces squeaks corresponding to α particles, position *b* gives squeaks corresponding to α particles and a meter indication at **9**, position *c* gives clicks corresponding to β particles and the meter indication at **9**, and finally, position *d* gives clicks corresponding to α and β particles, squeaks corresponding to α particles and a meter indication at **9** corresponding to α and β particles. It will be appreciated, however, that a click appearing at the front edge of a squeak is lost to the ear so that those sounds which are actually heard with the switch in position *d* are such that squeaks correspond to α particles and clicks corresponds to β particles.

What we claim is:

1. A radio-activity monitor comprising a radiation sensitive detector for producing pulses in one amplitude range in response to alpha radiations and for producing pulses in another amplitude range in response to beta radiations, means for producing a pulse in a first channel in response to pulses in both said amplitude ranges and for producing a pulse in a second channel in response only to impulses in said one amplitude range, anti-coincidence circuit having first and second input terminals and an output terminal, said anti-coincidence circuit being arranged to produce output pulses only in response to input pulses applied to the first input terminal when no simultaneous pulse is applied to said second input terminal, a tone circuit having first and second input terminals and an output terminal and arranged to a produce a pulse in response to a pulse applied to its first input terminal, and to produce a burst of audio frequency oscillation in response to a pulse applied to its second input terminal, a sound transducer connected to the output terminal of said tone circuit, a switch having one condition in which said first and second channels are connected respectively to said first and second input channels of said anti-coincidence circuit and the output terminal of said anti-coincidence circuit is connected to one input terminal of said tone circuit, no signal being applied to the other input terminal of said tone circuit in said first condition of said switch, and said switch having a second condition in which said first and second channels are connected respectively to the first and second input terminals of said tone circuit.

2. A radio-activity monitor according to claim 1, said switch having a third condition in which said second channel is connected to one terminal of said tone circuit, no signal being applied to the other terminal of said tone circuit.

References Cited in the file of this patent

UNITED STATES PATENTS

2,716,523	Driver	Aug. 30, 1955
2,727,154	Goldsworthy	Dec. 13, 1955
2,822,479	Goldsworthy	Feb. 4, 1958
2,910,592	Armistead	Oct. 27, 1959
2,963,588	Wilson	Dec. 6, 1960

Alpha Probe Data

Alpha efficiency is expressed as a percentage of the 2π flux of a certified reference source.

Order Code	Radiation Window			Efficiency	Background		Weight	
	Area (cm²)	Shape	Isotope (MeV)	(% surface emission)	s^{-1}	cmp	(kg)	(lb)
A50L	62	rect.	230Th (4.682)	>50%			0.6	1.3
AC-3-7, AC-3-8	59	rect.					0.6	1.4
AP2/4A	50	square	241Am (5.486)	35%	<0.1		0.75	1.7
AP2R/4A	50	square	241Am (5.486)	25%	<0.1		0.75	1.7
AP4/4A	20	disc	241Am (5.486)	35%	<0.1		0.60	1.35
AP5AD	100	rect.	241Am (5.486)	35%	<0.1		0.50	1.1
AP5RA	100	rect.	241Am (5.486)	23%	<0.1		0.50	1.1
AP6A	600	rect.	241Am (5.486)	30%	<0.1		1.55	3.5
HP-380 A	100	rect.	239Pu (5.1 MeV)	42%	<0.1	<1.0	0.59	1.37

A50L

This 50 cm² ZnS scintillation probe offers excellent alpha responses, a low mechanical profile and a conveniently angled grip. Easily-repaired windows are provided with protective covers for storage. Uniformity is within ±10% over the whole phosphor surface.

The A50L is used for general purpose alpha monitoring. This probe can be matched with Thermo's portable survey meters, such as the **ASP-2**, **E-600**, **RM-25**, or **Electra/Delta** series. See also **AC-3**.

- Light weight, low profile, angled grip
- Large radiation window, hex-mesh grills, protective storage covers
- Connector, MHV
- Uniformity within ±10% over the whole phosphor surface
- 50 cm² active area

AC-3-7 and AC-3-8

Alpha probe with a ZnS phosphor used for survey and frisking in a lightweight cast aluminum body. The radiation window is 0.50 mg/cm² thick, made of aluminized mylar. The **AC-3-8** is fitted with a mesh grille. This probe can be matched with Thermo's portable survey meters, such as the **ASP-2**, **E-600**, **RM-25**, or Electra/Delta series.

- Operating voltage: 1,000 V nominal
- Dead time: 12 µs nominal
- Alpha efficiency (4π): 14% ^{239}Pu
- Operating temp: -30 ºC to 60 ºC (-22 ºF to 140 ºF)
- Connector, CJ-1
- Size: 29.2 x 7.0 x 8.3 cm (11.5” x 2.75” x 3.25”)
- 50 cm² window area

AP2 Family

This ergonomically shaped probe with 50 cm² window is suitable for general purpose alpha contamination monitoring with excellent gamma rejection. The AP2R/4A is a version fitted with a rugged 3 mm mesh grill.

General purpose alpha probes containing a ZnS phosphor and PMT in a light alloy housing. The radiation window is conveniently angled for self monitoring of clothing. AP2R/4A is fitted with a rugged 3 mm mesh grille. This probe can be matched with Thermo's portable survey meters, such as the **Electra/Delta** series, **ASP-2**, **E-600**, **RM-25**.

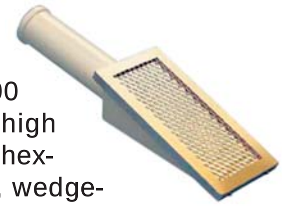
- Excellent gamma rejection
- **AP2/4A** and **AP2R/4A** use a PET connector; **AP2/4B** and **AP2R/4B** use a MHV connector
- ^{241}Am Calibration source, RRS21A
- Endura Phosphor version also available
- 50 cm² window

AP4 Family

A ZnS based alpha probe with circular window, used with wall-mounted friskers, the **710C** Lead Castle and in glove-box areas. The circular radiation window is matched to 2 inch alpha wipes. This probe can be matched with Thermo's portable survey meters, such as the **Electra/Delta** series, **ASP-2**, **E-600**, **RM-25**.

- Circular window matched to 5 cm (2”) alpha wipes
- **AP4/4A** fits **710C** Lead Castle for counting applications
- **AP4/4A** use a PET connector
- 20 cm² window

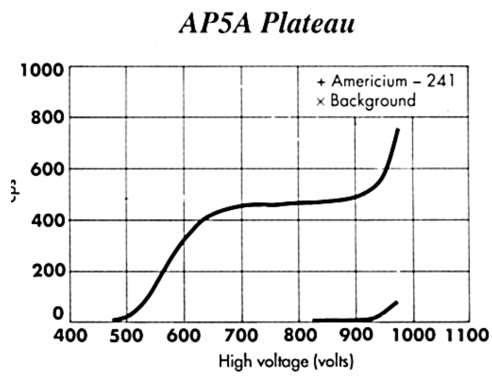
AP5 Family



This hand-held ZnS probe with 100 cm² window, high transmission hex-grill and slim, wedge-shaped profile is popular for monitoring workplaces, benches, personnel and tools. The AP5RA version has a ruggedized hex-grill. Note: the thin radiation windows are field-replaceable.

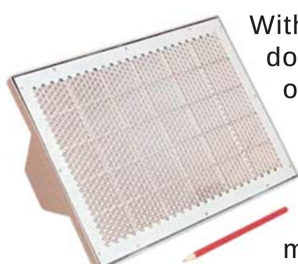
This probe can be matched with Thermo's portable survey meters, such as the **Electra/Delta** series, **ASP-2**, **E-600**, **RM-25**.
See also **HP-380A**

- High transmission rectangular hex-grille
- Slim, light weight, wedge shaped profile
- **AP5RA** version has a ruggedized hex-grille
- Field-replaceable radiation windows
- **AP5AD** and **AP5RA** use a PET connector



- **AP5BD** uses a MHV connector
- Calibration source, RRS 51A
- Endura Phosphor versions also available (**AP5AD/E** or **AP5BD/E**). The Endura is a more resilient detector material which does not require a separate aluminized (Mylar) window.
- 100 cm² window

AP6 Family



With a 600 cm² window but weighing only 1.5 kg (3.3 lb), the AP6A ZnS scintillation probe provides fast monitoring of large surfaces, walls and floors. It has a higher efficiency than air proportional counters and is more practical than gas-flow counters (no counting gas required).

This probe can be matched with Thermo's portable survey meters, such as the **Electra/Delta** series, **ASP-2**, **E-600**, **RM-25**.

- 600 cm² window
- Weight, only 1.55 kg (3.5 lb)
- **AP6A** uses a PET connector; **AP6B** uses an MHV connector
- ^{241}Am Calibration Source, RRH 11B

FLP3A, FLM3A, Delta-5

This highly mobile, lightweight monitor includes a ruggedized 600 cm² scintillation probe and a DELTA5 ratemeter. The FLM3 range is ideal for rapid, sensitive floor monitoring. It includes background subtract and alarm settings for extra sensitivity, and integrate mode for confirmatory counting in marginal situations. Steel roller balls suitable for smooth floors are fitted as standard. The AEO119A Wheel Kit, for rough surfaces and outdoor use, offers a smooth ride with castor action and ground clearance adjustable up to 5 cm (2").

Alpha and beta efficiencies are expressed as a percentage of the 2π flux of a certified reference source. Gamma efficiency is measured in a ^{137}Cs field.

FLP3A utilizes the same 600 cm² detector used in the AP6 above. Mounted in a wheeled assembly to enable effective alpha floor monitoring. The **FLM3A** is the **FLP3A** combined with a **Delta-5** ratemeter as seen in picture.

- Ranges: 0.1–60,000 cps or 1–1,000,000

HP-380A

These hand probes are general purpose survey and frisking probes with excellent sensitivity to alpha with minimum interference from gamma backgrounds. The probe design is constructed from lightweight aluminum which promotes ruggedness and ergonomic handling. This probe can be matched with Thermo's portable survey meters, such as the **ASP-2**, **E-600**, **RM-25** or Electra/Delta series.
See also the **AP-5** family.

- Operating voltage: 600 V nominal
- Window thickness: 3 layers of 0.29 mg/cm² (0.87 mg/cm²)
- Alpha efficiency (4π): 21% ^{239}Pu
- Operating temp: -40 ºC to 60 ºC (-40 ºF to 140 ºF)
- Connector, MHV, also available with Thermo Smart connector as the **SHP380A**
- Size: 28.6 x 7 x 8.3 cm (11.25" x 2.75" x 3.25")
- 100 cm² surface area

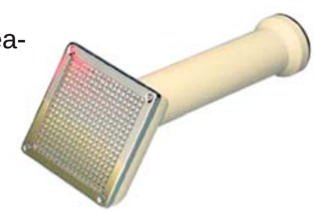
Alpha-Beta Probe Data

Order Code	Window Area (cm^2)	Window Shape	Efficiencies (% surface emission) Alpha ^{241}Am	Beta ^{99}Tc	Beta ^{6}Co	Beta ^{36}Cl	Beta ^{90}Sr/^{90}Y	Background s^{-1}	Background cpm	^{137}Cs (γ) Response s^{-1} (per µSv/h)	^{137}Cs (γ) Response cpm (per 100 µR/h)	Weight (kg)	Weight (lb)
DP2/4A	50	square	35%			29%	34%	<4	<240	25	1500	0.75	1.7
DP2R/4A	50	square	25%		7%	21%	24%	<4	<240	25	1500	0.75	1.7
DP6AD	100	rect.	33%	—	18%	38%	41%	<10	<600	50	3000	0.5	1.1
DP6CD	100	rect.	30%	—	14%	30%	31%	<10	<600	50	3000	0.5	1.1
DP6DD	100	rect.	39%	—	20%	38%	40%	<10	<600	40	2400	0.5	1.1
DP8A	600	rect.	28%	—	12%	31%	36%	<30	<1800	180	10,800	1.55	3.5
HP-380AB	100	rect.	36%	18%			44%	<10	<600	50	3000	0.59	1.37

DP2 Family

A well-established general purpose dual phosphor (ZnS/ BC400) probe which responds to alpha, medium and high energy beta and gamma. Compact, reasonably robust and ergonomic, users include nuclear sites, survey, environmental and government radiation laboratories, emergency services and the petrochemical industry. The DP2R/4A version has a rugged 3 mm mesh grill for longer life of the thin aluminized window.

This probe can be matched with Thermo's portable survey meters, such as the **Electra/Delta** series, **ASP-2**, **E-600**, or **RM-25**.



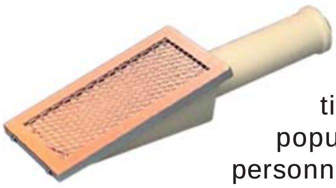
- Compact, reasonably robust, ergonomic
- Rugged 3 mm mesh grille version, **DP2R/4A**
- **DP2/4A**, **DP2R/4A** use a PET connector; **DP2/4B**, **DP2R/4B** use an MHV connector; **IDP2/4B**, **IDP2R/4B** are the intelligent version for use only with the **Selectra**
- ^{241}Am alpha calibration source: RRS 21A
- ^{36}Cl beta calibration source: RRS 24A

HP-380AB

These hand probes are dual phosphor (ZnS/NE102) general purpose survey and frisking probes with excellent sensitivity to alpha and beta with minimum interference from gamma backgrounds. The probe design is constructed from lightweight aluminum which promotes ruggedness and ergonomic handling. This probe can be matched with Thermo's portable survey meters, such as the **ASP-2**, **E-600**, **RM-25** or Electra/Delta series. See also DP-6 Family.

- Operating voltage: 600 V nominal
- Window thickness: 3 layers of 0.29 mg/cm² (0.87 mg/cm²)
- Efficiency (4π): Alpha: 18% ^{239}Pu
- Operating temp: -40 ºC to 60 ºC (-40 ºF to 140 ºF)
- Connector: MHV, also available with Thermo Smart connector as the **SHP 380 AB**
- Size: 28.6 x 7 x 8.3 cm (11.25” x 2.75” x 3.25”)

DP6 Family



These large, 100 cm^2, dual phosphor (ZnS/BC400) scintillation probes are popular for monitoring personnel, tools and work areas for alpha and beta with efficient discrimination. The lightweight, slim, wedge profile, durable hex grill and field replaceable windows provide practical advantages: high availability and faster surveys. The R version is fitted with a more rugged hex grill which reduces the efficiency figures by a factor of 0.65.

- **PET DP6AD** — Al. alloy die-cast housing fitted with a PET connector
- **MHV DP6BD** — Al. alloy die-cast housing, MHV connector
- **MHV DP6DD** - An enhanced design with a more uniform beta energy response and slightly lower background response than others. The radiation window consists of two layers of 0.3 mg/cm² polycarbonate and the grill is supported by an extra frame reinforcement bar.
- **MHV DP6CD** - Al. alloy die-cast housing, MHV connector. The signal gain control is adjusted to simulate GM detectors requiring +900 volts. This allows user sites to upgrade their probes without setup penalties and without needing to replace their ratemeter.

DP6CD versions are customized to user's preferred ratemeter. Further details on request.

This probe can be matched with Thermo's portable survey meters, such as the **Electra/Delta** series, **ASP-2**, **E-600**, or **RM-25**. See also **HP-380AB**.

- Light weight, slim, wedge profile
- Durable hex grille and field replaceable windows provide high reliability
- **DP6R** range: fitted with extra-rugged hex grille
- **DP6AD**, **DP6RA** uses a PET connector
- **DP6BD**, **DP6RB** uses an MHV connector
- **IDP6B** is the intelligent version used only with the **Selectra**

The **DP6CD** and **DP6RC** probes feature signal gain adjustment to permit operation with ratemeters whose HV supply is fixed at 900 V. Users can upgrade from a GM probe to these probes without having to replace their ratemeter, for example the **Surveyor 2000.**

The **DP6DD** is a premium performer with extra-reinforced window frame, a thinner 0.5 µm phosphor and thinner coating of ZnS to better measure lower energy beta emitters.

- Connector: MHV
- Calibration sources ^{241}Am alpha, code RRS ^{51}A, ^{36}Cl beta, code RRS 54A, ^{90}Sr/^{90}Y beta, code RRS 55A

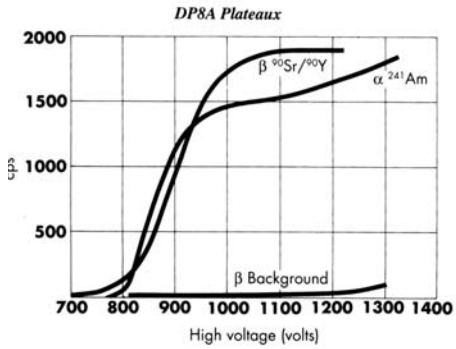
DP8 Family

The largest dual phosphor probe currently available. Its 600 cm² window offers large savings in time when monitoring areas such as walls, floors and flat objects. It weighs only 1.5 kg (3.3 lb).

This probe can be matched with Thermo's portable survey meters, such as the **Electra/Delta** series, **ASP-2**, **E-600**, or **RM-25**.

- High sensitivity to distributed contamination
- Durable, light weight, only 1.5 kg (3.3 lb)
- **DP8A** uses a PET connector; **DP8B** uses an MHV connector

- ^{241}Am alpha calibration source, RRH 11B
- ^{36}Cl beta calibration source, RRH 143.



Beta Scintillation Probe Data

Order Code	Window Area (cm²)	Window Shape	Efficiency (% Surface emission) Beta ^{14}C	^{60}Co	^{36}Cl	^{90}Sr/^{90}Y	Background s^{-1}	Background cpm	^{137}Cs (γ) Response s^{-1} (per µSv/h)	^{137}Cs (γ) Response cpm (per 100 µR/h)	Weight (kg)	Weight (lb)
BP1/4A	1.36	disc	—			58%	<1.0		30	1800		
BP4/4A	20	disc	24%	36%	44%	46%	<4	<240	25	1500		
BP4/4B	20	disc	15%	25%	32%	34%	<4	<240	25	1500		
BP4/4C	20	disc	11%	21%	25%	27%	<4	<240	25	1500		
BP7/4A	50	square	18%	27%	39%	41%	<4	<240	12	720	0.75	1.7
BP13A	80	annular	—	9%	15%	16%	<7	<480	60	4200	0.875	2
BP17A	600	rect.	—	19%	36%	42%	<30	<1800	250	15,000	1.55	3.5
BP19AD	100	rect.	14%	32%	49%	51%	<10	<600	50	3000	0.5	1.1
BP19DD	100	rect.	21%	34%	48%	51%	<8	<480	40	2400	0.5	1.1
HP-380B	100	rect.	28%			52%	<10	<600	50	3000	0.59	1.37

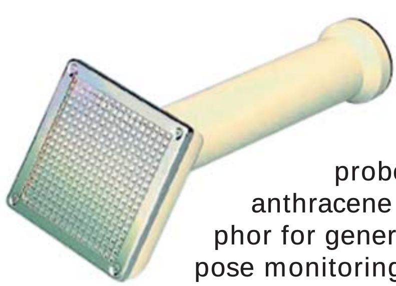
BP4 Family

A scintillation beta probe with high sensitivity to low, medium and high-energy beta radiation. The BP4 Family has the highest efficiency to ^{14}C. Extra window protection is obtained by increasing the window/grill spacing. This probe can be matched with Thermo's portable survey meters, such as the **Electra/Delta** series, **ASP-2**, **E-600**, or **RM-25**.

- Circular radiation window suits 5 cm (2”) filter paper wipes
- Matched to **710C** Lead Castle for counting beta

- Choice of spacings, window-grille: **BP4/4A**, 3 mm (0.12”); **BP4/4B**, 6 mm (0.24”); **BP4/4C**, 9 mm (0.35”)
- **BP4A** uses a PET connector; **BP4B** uses an MHV connector; **IBP4B** is the intelligent version used only with the **Selectra**
- Beta calibration sources: ^{14}C beta RRS 12A, ^{36}Cl beta RRS 14A.

BP7 Family

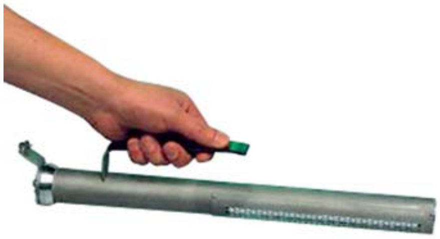


Large area scintillation probe with an anthracene phosphor for general purpose monitoring of low, medium and high-energy beta, with a 50 cm² window angled at 45 degrees to the probe axis. The low response to gammas can be an important consideration in high background applications. The BP20A is a version fitted with an NE 102A equivalent plastic phosphor.

This probe can be matched with Thermo's portable survey meters, such as the **Electra/Delta** series, **ASP-2**, **E-600**, or **RM-25**.

- Premium beta over gamma response suits high background applications
- 45° angled radiation window
- **BP7A** uses a PET connector; **BP7** uses an MHV connector; **IBP17B** is the intelligent version used only with the **Selectra**
- Calibration sources: ^{14}C beta RRS 22A, ^{36}Cl beta RRS 24A.

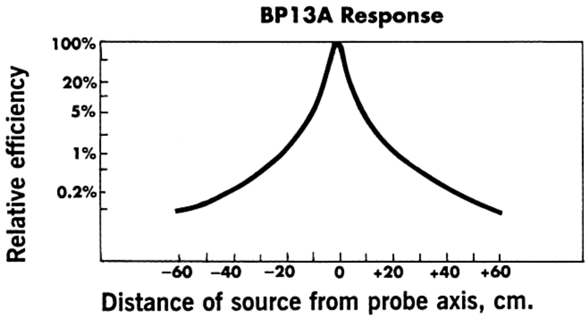
The BP13A is a robust, side-window scintillation probe with a cylindrical plastic phosphor and strong convex grille, for low/medium and high-energy beta for on-plant survey work where hot particles may pose a hazard.



The plastic scintillator is curved to monitor particles trapped at floor/wall angles effectively and the window is very thin. The response is sustained at a considerable distances from the probe so that hot spots or ‘fleas’ are detectable without risk of contact to the user. The “Co efficiency is greater than many side-window GM probes.

Robust, side-window This probe can be matched with Thermo's portable survey meters, such as the **Electra/Delta** series, **ASP-2**, **E-600**, or **RM-25**.

- Wide-angle response—see graph
- Higher sensitivity than side-window GM probes
- Extra effective for edges, corners and returns
- **BP13A** uses a PET connector; **BP13B** uses an MHV connector; **IB13B** is the intelligent version used only with the **Selectra**
- Calibration source, ^{36}Cl beta RRS 64A



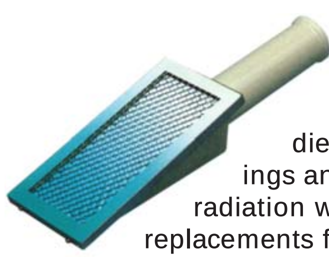
BP17 Family

A very large lightweight probe with good beta efficiency at ^{60}Co energies, the 600 cm² radiation window enables fast and thorough beta monitoring of large, flat surfaces.

This probe can be matched with Thermo's portable survey meters, such as the **Electra/Delta** series, **ASP-2**, **E-600**, or **RM-25**.

- Good efficiency to ^{60}Co beta and higher beta energies
- Very sensitive to large area, low-level emission
- Weight only 1.5 kg (3.3 lb)
- **BP17A** uses a PET connector; **BP17B** uses an MHV connector
- Calibration source, ^{36}Cl beta RRH 14B

BP19 Family



These slim-profile probes with light alloy diecast housings and 100 cm² radiation windows are replacements for the **BP6**, weighing less, and mechanically stronger, with a new design of light seal. The **BP18AD** has a greater low energy beta efficiency and less response to background than the **DP6**. The **BP19AD** is a premium type with improved background and low energy beta efficiency specifications.

These large scintillation probes with a BC400 plastic phosphor in a light alloy diecast housing are ideal for general purpose and large area monitoring for low, medium and high-energy beta. The **BP19DD** is a thin window version offering better ^{14}C beta efficiency. This probe can be matched with Thermo's portable survey meters, such as the **Electra/Delta** series, **ASP-2**, **E-600**, or **RM-25**. See also **HP-380B**.

- Slim profile, low weight
- Connector: PET. MHV available
- **BP19** Calibration sources: ^{14}C beta RRS 52A; ^{36}Cl beta RRS 54A
- Endura Phosphor **BP19 BD/E** version also available

HP-380B

These hand probes are general purpose survey and frisking probes with excellent sensitivity to beta with minimum interference from gamma backgrounds. The probe design is constructed from lightweight aluminum which promotes ruggedness and ergonomic handling. This probe can be matched with Thermo's portable survey meters, such as the **ASP-2**, **E-600**, **RM-25**, or Electra/Delta series.

See also **DP-6** Family.

- Detector Type: NE 102 plastic scintillator
- Operating Voltage: 600 V nominal
- Window Thickness: 3 layers of 0.29 mg/cm² (0.87 mg/cm²)
- Operating Temp: -40 ºC to 60 ºC (-40 ºF to 140 ºF)
- Connector: MHV, also available with Thermo Smart connector
- Size: 28.6 L x 7 W x 8.3 H cm (11.25” x 2.75” x 3.25” H)

FLP3B and FLM3B

FLP3B utilizes the same 600 cm^2 detector used in the **BP17**. Mounted in a wheeled assembly to enable effective alpha floor monitoring. The **FLM3B** is the **FLP3B** combined with a **Delta-5** ratemeter as seen in picture. A Separate data sheet is available for the **FLM-3** Series.

Gamma Scintillation Probes/Data

Gamma Scintillation Probe Data					
Model	**Application**	**Sensing Element**	**Element Size** (Dia. x thick)	**Sensitivity (cpm/mR/h)**	**Energy Range**
LEG-1	^{125}I Measurements	NaI(T1)	1” x 0.04”	60	15–200 keV
PG-2	^{239}Pu, 241 Am, X-ray	NaI(T1)	2” x 2 mm	60,000	10–200 keV
SPA-3	High sensitivity gamma	NaI(T1)	2” x 2”	1,200,000	60 keV–2 MeV
SPA-6	Medium sensitivity gamma	Plastic	50 mm x 60 mm	600,000	40 keV–1.3 MeV
SPA-8	Moderate sensitivity gamma	NaI(T1)	1” x 1”	300,000	40 keV–1.3 MeV
SPA-9	Medium sensitivity gamma	NaI(T1)	2” x 0.05”	400,000	40 keV–1.3 MeV

LEG-1

This is a gamma scintillation probe for detection of low-energy gamma and x-rays, optimized for ^{125}I, housed in a lightweight aluminum body. This probe can be matched with Thermo's portable survey meters, such as the **ASP-2**, **E-600**, **RM-25** or Electra/Delta series.

- Detector type: 1" dia x 0.04" thick NaI
- Window: 75.4 mg/cm^2 aluminum window
- Sensitive area: 5.1cm^2 (0.79 $inch^2$)
- Operating voltage: 1,000 V nominal
- Dead time: 8 µs nominal
- Background sensitivity: 60 cpm/mR/h (^{137}Cs)
- Energy Response/Photon: 95% ^{125}I
- Operating temp: -30 ºC to 60 ºC (-22 ºF to 140 ºF)
- Connector: CJ-1
- Size: 4.2 dia. x 20.1 cm (1.65” dia. x 7.9”)
- Weight: 340 g (12 oz)
- Consider as an alternate to the **G1LE**

PG-2

This is a large-area rugged scintillation detector with an aluminum body and a thin window for application in the detection of low energy gamma or x-ray radiation. This probe can be matched with Thermo's portable survey meters, such as the **ASP-2**, **E-600**, **RM-25** or Electra/Delta series.

- Detector type: 2" dia x 2mm thick NaI
- Window: 0.001” thick (6.9 mg/cm^2) aluminum
- Operating Voltage: 1,000 V nominal
- Dead time: 12 µs nominal
- Efficiency: ² 18% ^{239}Pu, ² 18% ^{241}Am
- Operating Temp: -30 ºC to 60 ºC (-22 ºF to 140 ºF)
- Connector: CJ-1
- Size: 6.8 dia. x 22.9 cm (2.69” dia. x 9”)
- Weight: 1.1 kg (2.5 lb)
- Consider as an alternate to the **G2LE**

SPA-3

A scintillation probe that is a rugged, aluminum bodied, waterproof gamma detector designed for high sensitivity of pulse-height applications. This probe can be matched with Thermo's portable survey meters, such as the **ASP-2**, **E-600**, **RM-25** or Electra/Delta series.

- Detector type: 2" dia x 2" thick NaI
- Operating Voltage: 1,000 V nominal
- Dead time: 14 µs nominal
- Operating Temp: -30 ºC to 60 ºC (-22 ºF to 140 ºF)
- Connector: CJ-1
- Size: 6.7 dia. x 28.3 cm (2.63” dia. x 11.13”)
- Weight: 1.5 kg (3.4 lb)
- Consider as an alternate to the **G2**

SPA-6

This scintillation probe is a rugged, aluminum bodied, (2" x 2.4" plastic scintillator) gamma detector designed for medium sensitivity applications. This probe can be matched with Thermo's portable survey meters, such as the **ASP-2**, **E-600**, **RM-25** or Electra/Delta series.

- Detector type: 2" dia x 2.4" thick plastic scintillator
- Operating Voltage: 1,000 V nominal
- Dead time: 12 µs nominal
- Operating Temp: -30 ºC to 60 ºC (-22 ºF to 140 ºF)
- Connector: MHV
- Size: 6.6 dia. x 25.1 cm (2.6” dia. x 9.9”)
- Weight: 0.8 kg (1.75 lb)

SPA-8

This scintillation probe is a rugged, aluminum bodied gamma detector designed for low sensitivity applications. This probe can be matched with Thermo's portable survey meters, such as the **ASP-2**, **E-600**, **RM-25** or Electra/Delta series.

- Detector type: 1" dia x 1" thick NaI
- Operating Voltage: 600 V nominal
- Dead time: 36 µs nominal
- Operating Temp: -30 ºC to 60 ºC (-22 ºF to 140 ºF)
- Connector: MHV
- Size: 4.7 dia. x 21.1 cm (1.85" dia. x 8.31")
- Weight: 0.4 kg (0.9 lb)
- Consider as an alternate to the **G1**

SPA-9

This scintillation probe is an aluminum bodied gamma detector designed for detection of low to medium energy gammas. This probe can be matched with Thermo's portable survey meters, such as the **ASP-2**, **E-600**, **RM-25** or Electra/Delta series.

- Detector type: 2" dia x 0.5" thick NaI
- Operating Voltage: 1,000 V nominal
- Dead time: 18 µs nominal
- Operating Temp: -30 ºC to 60 ºC (-22 ºF to 140 ºF)
- Connector: MHV
- Size: 6.6 dia. x 20.1 cm (2.6" dia. x 7.9")
- Weight: 0.7 kg (1.5 lb)

Sodium Iodide Scintillation Probes

G1, G1LE, G2, G2LE and G3

Scintillation probes fitted with 2.5 cm (1"), 5 cm (2") or 7.6 cm (3") diameter Sodium Iodide detectors to provide a range of gamma sensitivity that can be used for energy discrimination with single channel analyzers.

G1: Compact, lightweight and useful for detecting small background changes.

G1LE: For enhanced detection of low energy emitters such as ^{125}I. The G2LE is a 2" version also optimized for ^{125}I detection.

G2: Rugged, with greater sensitivity than the G1, and also useful for detecting sub-surface gamma emissions during cleanup or decommissioning. Response: 1,200 kcpm per mR/h due to ^{137}Cs.

G2LE: A 5 cm (2") thin crystal version, optimized for ^{125}I detection.

G3: Rugged with twice the sensitivity of the G2. Response: 4,000 kcpm per mR/h (^{137}Cs).

Consider LEG-2 and PG-2 as possible alternates. Best used with **ASP2E, E-600** and **Electra.**

G5 "FIDLER" Family

The 5" diameter (127 mm) NaI(Tl) crystal is optimized for detection of 10-100 keV gammas eg. from degraded Pu or Pu-Am, and excellent for ^{125}I. The ruggedized version for field use includes a secondary scratch-resistant kapton window. Sensitivity can be further improved by using an instrument with a single channel analyzer such as the **Electra, E-600**, ASP2E or Delta 5.

The ruggedized version for field use includes a secondary scratch-resistant kapton window.

Sensitivity can be further improved by use of a hand held rate meter that features a single channel analyzer.

- Connector: MHV
- **G5-Al**: Aluminum window
- **G5-Be**: Beryllium window for better low energy response
- **G5-BeR**: Ruggedized version
- **G5-BELB**: Low background version

G5 Accessories

•

Military vertical handle, **G5VHX**

•

ruggedized horizontal handle **G5HHR**

•

Horizontal handle, standard **G5**, **G5HH**

•

Vertical G5 handle, **G5VH**

Optional handles

GP13 Family

A very sensitive probe for low energy gamma or beta radiation with a 100 cm² window and CsI phosphor, the GP13A is also ideal for contamination monitoring in medical applications. Used with a two channel ratemeter, DELTA5 or ELECTRA, or with the wall-mounted CM11D, it can discriminate between ^{125}I and higher energy medical isotopes; ^{99m}Tc, ^{14}C, ^{32}P etc.

This probe can be matched with Thermo's portable survey meters, such as the **Electra/Delta** series, **ASP-2**, **E-600**, or **RM-25**.

- **GP13A** uses a PET connector; **GP13B** uses an MHV connector; **IGP13B** is the intelligent version for use only with the **Selectra**.

3. SPECIFICATION

Table 3.1a and b provides an overall summary of the specifications for the probes detailed in this manual.

The following details are not covered in Table 3.1a and b.

Radiation Detected:	AP & IAP Probes - Alpha Particles BP & IBP Probes - Beta Particles DP & IDP Probes - Alpha and Beta Particles
Phosphor:	AP & IAP Probes - ZnS(Ag) on Perspex BP & IBP Probes - Anthracene on Perspex for BP4, BP6, BP7 - BC404 for BP5 - BC400 for BP13, BP19 DP & IDP Probes - ZnS(Ag) on BC400
Window Material:	BP13: 14 μm aluminium, 3.8 mg.cm^{-2} BP19DD, BP19RD, DP6DD, DP6RD: 3 layers of polycarbonate, total 0.9 mg.cm^{-2} All others: 2 layers of polycarbonate, total 1.2 mg.cm^{-2} (3.5 μm, aluminised on both sides) Endura /E versions: equivalent to the above
Area:	See Probe Area in Table 3.1 a and b
Operating Voltage:	Between 500 V and 1350 V
Resistance of Dynode Chain:	69.2 MΩ
Connector:	Non 'I' probe BP4A, B & C: PET Non 'I' probes with suffix A: PET Non 'I' probes with suffix B, DD or RD: MHV 'I' probes with suffix A - 7 way FISCHER plug on flying lead 'I' probes with suffix B - 7 way FISCHER plug on probe

DIMENSIONS

PROBE TYPE		OVERALL LENGTH	MAX. WIDTH	HANDLE DIA.	WEIGHT
AP4/4 BP4/4A	IAP4 IBP4A	224 mm	74 mm	37 mm	600 g
BP4/4B	IBP4B	232 mm	74 mm	37 mm	600 g
BP4/4C	IBP4C	235 mm	74 mm	37 mm	600 g
AP2/4 AP2R/4 BP5/4 BP7/4 DP2/4 DP2R/4	IAP2 IAP2R IBP5 IBP7 IDP2 IDP2R	244 mm	91 mm	37 mm	750 g
BP13	IBP13	424 mm	89 mm	38 mm	875 g
AP3/4 AP3R/4 BP6/4 BP6R/4 DP3/4 DP3R/4	IAP3 IAP3R IBP6 IBP6R IDP3 IDP3R	252 mm	123 mm	32 mm	750 g
AP5 DP6	IAP5 IDP6	296 mm	93 mm	40 mm	500 g
AP5AD DP6AD	BP19AD	296 mm	93 mm	38 mm	650 g

All probes are recommended for use with:

Portable Ratemeter type SELECTRA (‘I’ Series Probes ONLY)
Portable Ratemeter type ELECTRA
Portable Ratemeter type DELTA3 and DELTA5
Ratemeter types RM5/1 and RM6
Portable Contamination Monitor type PCM5/1
Contamination Monitor CM9

TABLE 3.1a - PROBE SPECIFICATIONS

PROBE TYPE	PROBE AREA	-------PROBE EFFICIENCIES[1]------- ALPHA ^{241}Am	BETA $^{90}Sr/^{90}Y$	BETA ^{36}Cl	BETA ^{60}Co	BETA ^{14}C	BACKGROUND RESPONSE[2]	GAMMA RESPONSE[3]	GRILLE TRANSMISSION
AP4/4 & IAP4	19.6cm^2	34%	—	—	—	—	<0.1 cps	—	80%
BP4/4A & IBP4A	19.6cm^2	—	46%	44%	36%	24%	<4 cps	25 cps	80%
BP4/4B & IBP4B	19.6cm^2	—	34%	32%	25%	15%	<4 cps	25 cps	80%
BP4/4C & IBP4C	19.6cm^2	—	27%	25%	21%	11%	<4 cps	25 cps	80%
AP2/4 & IAP2	49cm^2	35%	—	—	—	—	<0.1 cps	—	80%
AP2R/4 & IAP2R	49cm^2	25%	—	—	—	—	<0.1 cps	—	65%
BP5/4 & IBP5	49cm^2	—	42%	42%	—	—	<4 cps	25 cps	80%
BP7/4 & IBP7	49cm^2	—	41%	39%	28%	18%	<4 cps	12 cps	65%
DP2/4 & IDP2	49cm^2	35%	34%	29%	9%	—	<4 cps(β), <0.1 cps(α)	25 cps	80%
DP2R/4 & IDP2R	49cm^2	25%	24%	21%	7%	—	<4 cps(β), <0.1 cps(α)	25 cps	65%
BP13 & IBP13	80cm^2	—	16%	15%	10%	—	~ 7 cps	60 cps	80%

1 Efficiency is given as the percentage detection of alpha or beta particles emitting in 2π steradians from a uniformly distributed surface (which has an active area equal to the sensitive area of the probe) with the surface of the probes grille 4 mm away from the source surface. The efficiency for the measurement of activity will be half the efficiency for the measurement of surface emission for sources of zero self absorption and backscatter. The efficiencies quoted are typical type test efficiencies and there will be a spread of efficiencies from probe to probe of the same type. This could be up to ±10%, i.e. a probe with published efficiency to specific nuclide if say 35% could have a mid point plateau efficiency of anything between 31.5% and 38.5%.

2 Response to an ambient background, taken as a dose equivalent field of 0.1 µSv/h (10 µR/h).

3 Response to an ambient dose equivalent field of 1 µSv/h due to ^{137}Cs.

TABLE 3.1b - PROBE SPECIFICATIONS

PROBE TYPE	PROBE AREA	ALPHA ^{241}Am	BETA $^{90}Sr/^{90}Y$	BETA ^{36}Cl	BETA ^{60}Co	BETA ^{14}C	BACKGROUND RESPONSE[2]	GAMMA RESPONSE[3]	GRILLE TRANSMISSION
		-------PROBE EFFICIENCIES[1]-------							
AP3/4 & IAP3	$100 cm^2$	35%	—	—	—	—	<0.1 cps	—	78%
AP3R/4 & IAP3R	$100 cm^2$	25%	—	—	—	—	<0.1 cps	—	63%
BP6/4 & IBP6	$100 cm^2$	—	46%	44%	32%	17%	<10 cps	25 cps	78%
BP6R/4 & IBP6R	$100 cm^2$	—	36%	35%	26%	14%	<10 cps	25 cps	63%
DP3/4 & IDP3	$100 cm^2$	35%	35%	31%	9%	—	<10 cps (β), <0.1 cps(α)	50 cps	78%
DP3R/4 & IDP3R	$100 cm^2$	25%	24%	21%	7%	—	<10 cps (β), <0.1 cps(α)	50 cps	63%
AP5 & IAP5 & /E	$100 cm^2$	35%	—	—	—	—	<0.1 cps	—	80%
AP5R & IAP5R	$100 cm^2$	22%	—	—	—	—	<0.1 cps	—	48%
BP19 & IBP19	$100 cm^2$	—	51%	48%	32%	14%	<10 cps	50 cps	80%
BP19/E & IBP19/E	$100\ cm^2$	—	52%	49%	33%	16%	< 10 cps	50 cps	80%
BP19R & IBP19R	$100 cm^2$	—	40%	35%	21%	9%	<10 cps	50 cps	48%
BP19DD & IBP19DD	$100 cm^2$	—	51%	48%	34%	21%	<10 cps	40 cps	80%
BP19RD & IBP19RD	$100 cm^2$	—	42%	36%	24%	15%	<10 cps	40 cps	48%
DP6 & IDP6	$100 cm^2$	33%	41%	38%	18%	—	<10cps(β), <0.1 cps(α)	50 cps	80%
DP6/E & IDP6/E	$100 cm^2$	33%	38%	35%	—	—	<10cps(β), <0.1 cps(α)	50 cps	80%
DP6R & IDP6R	$100 cm^2$	27%	34%	30%	12%	—	<10cps(β), <0.1 cps(α)	50 cps	48%
DP6DD, IDP6DD	$100 cm^2$	39%	41%	39%	20%	—	<10cps(β), <0.1 cps(α)	40 cps	80%
DP6RD, IDP6RD	$100 cm^2$	28%	36%	31%	13%	—	<10cps(β), <0.1 cps(α)	40 cps	48%

1 Efficiency is given as the percentage detection of alpha or beta particles emitting in 2π steradians from a uniformly distributed surface (which has an active area equal to the sensitive area of the probe) with the surface of the probes grille 4 mm away from the source surface. The efficiency for the measurement of activity will be half the efficiency for the measurement of surface emission for sources of zero self absorption and backscatter. The efficiencies quoted are typical type test efficiencies and there will be a spread of efficiencies from probe to probe of the same type. This could be up to ±10%, i.e. a probe with published efficiency to specific nuclide if say 35% could have a mid point plateau efficiency of anything between 31.5% and 38.5%.

2 Response to an ambient background, taken as a dose equivalent field of 0.1 μSv/h (10 μR/h).

3 Response to an ambient dose equivalent field of 1 μSv/h due to ^{137}Cs.

4. OPERATION

To facilitate calibration and periodic checking the following Radioactive Reference Source Types are recommended.

AP4	RRS11A (^{241}Am)
BP4	RRS12A (^{14}C) RRS14A (^{36}Cl)
AP2	RRS21A (^{241}Am)
BP5	RRS24A (^{36}Cl) RRS25A (^{90}Sr/^{90}Y)
BP7	RRS22A (^{14}C) RRS24A (^{36}Cl)
DP2	RRS21A (^{241}Am) RRS24A (^{36}Cl) RRS25A (^{90}Sr/^{90}Y)
BP13	RRS63A (^{60}Co) RRS64A (^{36}Cl)
AP3	RRS31A (^{241}Am)
AP5	RRS51A (^{241}Am)
BP6	RRS32A (^{14}C) RRS34A (^{36}Cl)
DP3	RRS31A (^{241}Am) RRS34A (^{36}Cl) RRS35A (^{90}Sr/^{90}Y)
DP6	RRS51A (^{241}Am) RRS53A (^{60}Co) RRS54A (^{36}Cl) RRS55A (^{90}Sr/^{90}Y)
BP19	RRS52A (^{14}C) RRS53A (^{60}Co) RRS54A (^{36}Cl) RRS55A (^{90}Sr/^{90}Y)

4.1 SETTING THE OPTIMUM HIGH VOLTAGE

This procedure **must** be performed whenever repair involves replacing the probe photomultiplier (PM) tube. It should also be performed periodically as a routine calibration.

The relevant probe must be connected to the measuring instrument by means of a suitable coaxial cable, i.e. cable assemblies:

CA 3152C	2 m ‘straight' coaxial cable PET to PET
CA 3190A *	0.3 m extendible 'curly' coaxial cable MHV to MHV
CA 3191A *	0.3 m extendible 'curly' coaxial cable MHV to PET
CA 3201A *	0.3 m extendible 'curly' coaxial cable PET to PET

* EC EMC compliance not guaranteed for these cables.

Generally, the equipment associated with this probe, RM5/1, RM6, CM9 and PCM5/1 have a single connector and fixed discriminator levels. In the case of the ***SELECTRA***, ***ELECTRA***, DELTA 3 and DELTA5, the unit has a variable upper level discriminator (ULD) but the lower level discriminator (LLD) is fixed; the ULD should be set to 1.5 V.

If other ratemeters are used which have accessible discriminator control, discriminator levels should be set to the following:

LLD: equivalent to an input pulse height of 100 mV or a charge sensitivity of 17 pC for β particles

ULD: equivalent to an input pulse height of 1.5 V or a charge sensitivity of 250 pC for α particles

4.1.1 AP, IAP, BP and IBP Probes

This section details the set up procedure required for the alpha only or beta only probes listed below:

Alpha Probes:	AP2, AP3, AP5
Beta Probes:	BP4, BP5, BP6, BP7, BP13, BP19

With the lid and shutter of the relevant Radioactive Reference Source (RRS as defined above) open, place the probe in position with the probe window directly above the source surface.

Switch the measuring instrument ON. Increase the high voltage slowly until counts are first observed in the relevant channel. Plot a count rate against high voltage curve not exceeding 1350 V. From this curve, determine the voltage range at which the rate of change of countrate with change in voltage is a minimum, i.e. a 'plateau' region. The centre of this plateau region is the optimum operating voltage of the probe.

NOTE: *This operating voltage is specific to the discriminator setting of the measuring instrument and the cable being used.*

It is generally more advantageous to operate at little below the centre of the plateau especially where there is likely to be a high background due to gamma or neutron radiation. This is particularly true of alpha probes. In the case of alpha probes if it is necessary, due to economic reasons, to operate a probe at a fixed efficiency an efficiency should be chosen such that all probes of the same type will operate at the lower end of the plateau, i.e. for say the AP5 operate at an efficiency of 30% rather than 32%. This will avoid the possibility of higher than expected sensitivity to gamma and neutrons. It is however recommended that wherever possible probes are operated on their plateau otherwise there will be a higher susceptibility to drift due to temperature electronic instability etc.

The operating voltage should be recorded along with the ratemeter type and serial number, the discriminator setting, the cable type and the probe type number and serial number to avoid unnecessary repetition of the setting up procedure.

The background countrate at the operating voltage determined above should be within the limits specified in Table 3.1 a & b.

4.1.2 DP and IDP Probes

This section details the set up procedure required for Dual Probes used for the simultaneous measurement of alpha and beta particles listed below:

Dual Probes: DP2, DP3, DP6.

There are two methods by which the optimum α and β separation can be achieved; both of which are described below.

Alpha Counts in the Beta Channel:

Use the relevant ^{241}Am Radioactive Reference Source (RRS*1A as defined above) and with the lid and shutter open, place the probe in position with the probe window directly above the source surface.

Switch the measuring instrument ON. Increase the high voltage slowly until counts are first observed in the *beta* channel. Plot a count rate against high voltage curve up to a maximum of 1350 V. The count rate should increase, then decrease, then increase again with increasing high voltage (HV) applied. Adjust the HV to the centre of the dip of the curve.

Beta Counts in the Alpha Channel:

Alternatively, place the probe in the relevant ^{90}Sr/^{90}Y Radioactive Reference Source (RRS*5A as defined above). Observing the count rate in the alpha channel, increase the High Voltage slowly until counts are first observed. Set the *maximum* HV such that less than 1 count per second is observed in the alpha channel.

NOTE: *The point at which the beta-in-alpha take-off occurs will depend upon the beta energy. ^{90}Sr/^{90}Y is taken as a worst case, being a high energy beta. Take-off for lower energy betas such as from ^{36}Cl or ^{60}Co would occur at a slightly higher HV setting.*

The operating voltage should be recorded along with the ratemeter type and serial number, the discriminator setting, the cable type and the probe type number and serial number to avoid unnecessary repetition of the setting up procedure.

NOTE: *This operating voltage is specific to the discriminator setting of the measuring instrument and the cable being used.*

The background countrate at the operating voltage determined above should be within the limits specified in Table 3.1 a & b.

4.2 CALIBRATION

When the source countrate is measured at the optimum HV setting, as determined in 5.1 above, the probe efficiency for the measurement of surface emission is given by:

$$2\pi \text{ Efficiency} = \frac{\text{Detected Source Countrate - Background Countrate}}{\text{Source Emission Rate}\left(s^{-1}\right)} \text{ x } 100\%$$

The efficiency for the measurement of activity will be half the efficiency for measurement of surface emission for sources of zero self absorption and zero backscatter.

4.3 GENERAL USE

Since alpha particles have a range in air of typically only 4 cm and this is effectively reduced by the window of the probe, the probe should be placed as near to the surface to be measured as possible and no further away than 2 cm. It should be noted that the window of the probe is extremely fragile and direct contact with any surfaces must be avoided.

Beta particles have a relatively large range in air compared with alphas but, to maintain efficiency, the probe should also be placed as near to the surface to be measured as possible.

When using the probe to detect low levels of alpha or beta contamination over large areas, the probe should be moved slowly over these areas. Each area should be "seen" by the probe for at least a second.

EXAMPLE

Probe: DP6 (or IDP6)

The expected countrate for 0.37 Bq.cm^{-2} (10^{-5} μCi.cm^{-2}) of alpha contamination will be:

$$0.37 \text{ x Probe Area}\left(cm^{-2}\right) \text{ x } \frac{\left(\text{Probe Efficiency for Surface Emission}\right)}{2}$$

= 18.5 x Probe Efficiency

i.e. typically 6.1 s^{-1} for ^{241}Am.

The expected countrate for 3.7 Bq.cm^{-2} (10^{-4} μCi.cm^{-2}) of beta contamination will be:

$$3.7 \text{ x Probe Area} \left(\text{cm}^{-2}\right) \text{ x } \frac{\left(\text{Probe Efficiency for Surface Emission}\right)}{2}$$

= 185 x Probe Efficiency

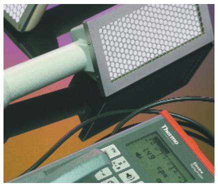
i.e. typically 76.1 s^{-1} for ^{90}Sr/^{90}Y.

Product Specifications

Easy-to-use, rugged and reliable, this versatile family of meters has a variant to suit just about every rate or survey application. The Electra range consists of the Electra, plus three variations (Selectra, Plus and GM) which can be specified in any combination, from the base Electra model up to the flagship SelectraGMPlus.

Electra / Selectra

Survey Meters



- Autoranging digital and bargraph displays
- Rugged metal body and long battery life
- Wide range of GM and scintillation probes
- Easy probe swapping with Selectra models and "I" probes
- 500 point datalogging with Plus models

Electra

The Electra is a digital, microprocessor based, rate meter which is compatible with most GM and scintillation survey probes, and can be calibrated with an external probe for direct readout of dose rate or count rate, in a range of units. Readings are displayed both numerically and on a bargraph, which autoranges across seven decades. Intelligent software discriminates between true rate changes and insignificant fluctuations. Digitally controlled HV and preset parameters provide outstanding consistency between instruments: the setup does not drift and instruments with identical setups are directly interchangeable.

The Electra is sturdy, well balanced, comfortable over long periods of use and operable when wearing double protective gloves. It is built in a metal extrusion with tough, replaceable, plastic end caps and is powered by long life dry cells or rechargeable batteries. Internal configuration switches let a supervisor choose which parameters are available to users.

Selectra

The Selectra models feature automatic probe setup when used with our "I" style probes. These probes contain chips which store operating parameters, and connect to the meter via a 7-way Fischer connector (the Electra models having PET or MHV). Selectra benefits include tamperproof setup, simpler probe exchange, and less equipment to carry around.

Product Specifications

GM
GM models have a low weight, compact, front extension, housing an energy compensated GM probe whose position is shown by two white crosses. Contact dose rate measurements can be taken without disconnecting the external probe. The GM models' memory includes an exact setup for the internal probe and adjustable setup for the external probe. A single key press switches from one probe to the other. "G" is displayed on screen when the internal GM probe is active. GM models are designed for ease of decontamination, with simple replacement of heavily contaminated parts.

Plus
Datalogging is made easy with the Plus models. Up to 500 detailed results can be stored on-board in non-volatile memory, from all measuring modes. Result data includes rate, integrate time, date stamp, operating mode, stored background and unique location identities, and results can be reviewed on the instrument. Location identity is a breeze with the built-in iButton™ reader, or optional barcode reader, with alphanumeric location names of up to 16 characters stored with each reading.

The supplied PlusLink software handles communication between the Plus models and external PCs, running under Windows™. Datalog download is easily achieved, for further analysis with common applications such as Microsoft™ Access or Excel. Plus model setup and automatic plateau plotting are also provided in PlusLink, along with other useful facilities.

Technical Specifications - all models
Count rate ranges:
 Settable, 0.1 cps to 100 kcps, or 1 cpm to 1000 kcpm
Response factors:
 dpm: 0.001 to 1.000 cpm/dpm
 Bq: 0.001 to 1.000 cps/Bq
 Bq/cm²: 0.01 to 999 cps per Bq/cm²
 R/h: 0.01 to 999 cps per mR/h
 Gy/h: 0.001 to 99.9 cps per µGy/h
 Sv/h: 0.001 to 99.9 cps per µSv/h
Integrate mode preset time:
 1 to 10 s in 1 s steps, 15 to 30 s in 5 s steps, and 40 to 5,000 s in 10 s steps
Display:
 3 decade bargraph, 6 decade span, autoranging. 4 character digital display. Symbols for: units, sound, battery, alarm, mode, inhibit, channel, setup, overload and operational parameters
Backlight:
 A momentary press of the backlight key gives 30 s illumination
Sounder:
 Distinct tones for alpha and beta pulses, alarm, change of range and overload
Dead time:
 Presettable correction, 0 to 250 µs
Connectors:
 Probe: PET or MHV (Electra models)
 Fischer (Selectra models)
 Headphone/earpiece:
 3.5 mm stereo jack socket
 Charger: 2.5 mm power jack socket
High Voltage supply:
 400 to 1400 V in 5 V steps.
 Max. load 66 MOhms, current 40 µA at 900 V
Overload setting:
 0.25 to 40 µA excess HV current, adjustable in 0.25 µA steps
Alarm thresholds:
 Presettable alpha and beta settings with dual probes
 0.1 to 50,000 cps, 1 to 300,000 cpm,
 0.1 to 50,000 Bq/cm², 0.1 to 50,000 Bq,
 1 to 300,000 dpm, 0.01 µSv/h to 5 Sv/h,
 1 µR/h to 500 R/h, 0.01 µGy/h to 5 Gy/h, Off
Lower signal threshold:
 1.7×10^{-11} C fixed (100 mV internal)
Upper signal threshold:
 2.6×10^{-11} C to 5.1×10^{-10} C (150 mV to 3 V internal in 50 mV steps)
Batteries:
 Three 1.5 V, C sized dry cells (IEC LR14) or three rechargeables (IEC KRH 27/50)
Battery life:
 90 h typical, with dry cells and power saver feature (auto switch-off)
Operating temperature:
 -20 to +50 °C (-4 to +122 °F)
Humidity:
 up to 95%, non-condensing
EMC:
 CE approved
Dimensions:
 135 H x 110 W x 250 D mm
 (5.3" H x 4.3" W x 9.8" D) including handle. GM models are 300 mm (11.9") D
Weight:
 1.22 kg (2.7 lb) excluding batteries, except GM models which are 1.42 kg (3.2 lb)

Further Specifications - GM
Gamma Range:
 0.1 to 20,000 µSv/h
Instrinsic error:
 ±10% (IEC60846 requirement, 15%)
Energy response:
 -15% to +30%, 60 keV to 1.25 MeV relative to 662 keV ^{137}Cs
 Overreads slightly above 1.25 MeV
Response times:
 1 s sampling with 10 s rolling average for rates > 2 cps. Less than 2 s to respond to > 2.6 sigma changes.
 (IEC60846 requirement, < 10 s)
Warm up:
 20 s, including completion of self-checks
Overload:
 Overload alarm and > Full Scale Deflection maintained for 20 mSv/h to 2000 mSv/h
 Complete recovery after only 30 s
Pulsed radiation:
 Not designed for pulsed radiation fields
Coefficient of variation:
 Well within IEC 60846 above 2.5 µSv/h
Alarms:
 One for dose rate, presettable to any on-range value. Settings stored in non-volatile memory
Temperature:
 -10 to +40 °C (14 to 114 °F), within ±6%
Temperature shock:
 Has no greater effect than slow changes
Humidity:
 No significant change, up to 95%, RH at 35 °C

Further Specifications - Plus
Preset precision:
 0.1% to 20% in 0.1% steps (at 2 sigma confidence level)
Sampler mode:
 Up to 500 cycles comprising Integrate, followed by Pause
Peak hold mode:
 Display is updated only if latest value exceeds all previous since selecting mode
Additional connectors:
 RS-232 serial link: 5-way DIN
 iButton receptor
Data Log:
 Up to 500 unique locations, up to 500 total readings

Accessories
Optional accessories include external probes, iButtons, barcode reader, reference sources, probe holders, belt holsters, cables, batteries and chargers. Consult your supplier for details.

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Thermo
ELECTRON CORPORATION

Product Specifications

Mini 600 Series, Type 6-80

Environmental Radiation Meter

The 6-80 is widely used by nuclear research establishments, nuclear power utilities and public health authorities as a reliable, convenient, and inexpensive means of measuring environmental gamma doserate.

Environmental Radiation Meter Type 6-80

The 6-80 series has the following features:

- Uses a high sensitivity compensated GM tube type MC7I.
- Clear 6 digit liquid crystal scaler display.
- A logarithmically scaled analogue ratemeter covering four decades without range switching.
- Preset counting times from 10 seconds to 1000 seconds in seven steps plus manual timing using the start and stop buttons.
- Battery operation gives up to 400 hours life from four readily available cells.
- A comprehensive manual containing energy response data, calibration curves and other useful information.
- Tough, splashproof polycarbonate case.

The 600 Series Scaler/Ratemeters
Environmental Radiation Meter Type 6-80

The Type 6-80 is a portable counting system for the determination of environmental gamma radiation levels. It is therefore suitable for use in normal and emergency monitoring programmes including those concerned with the pre-commissioning, operational, decommissioning and post-operational phases of nuclear installations.

The radiation intensity is obtained directly from the analogue meter. An integrated count from the digital readout enables the user to calculate a more accurate value after referring to calibration data.

The 6-80 is supplied with the compensated GM tube type MC71. The MC71 has a sensitivity of approximately 18.5 counts s-1 µGyh-1. Special materials are also used in the construction of this tube to reduce the inherent background. A measurement over a period of 1000 seconds will give a result having a 1SD statistical accuracy of ±3% for a background of 60 nGyh-1.

The gamma response of the GM tube has been modified by filters and has a response from 55kev to 1.25MeV with a deviation from linearity not exceeding ±25% for radiation normal to the axis. It is strongly recommended that each instrument is calibrated by an approved laboratory, using sources traceable to national standards before delivery to the customer.

The instrument, MC71 detector, 1 meter of cable and a tripod stand for mounting the detector assembly can be obtained as a complete kit packed in a convenient carrying case.

The Type 6-80 Specification

Radiation detected:	Gamma only
Detector:	Halogen quenched, energy compensated G-M tube. Typical sensitivity to: ^{226}Ra 18.5 counts s-1 µGy h^{-1} ^{137}Ca 15.7 counts a-1 µGy h^{-1} Inherent background typically 0.25 count s^{-1}
High voltage:	300-600 volts, internally adjustable.
Ratemeter display:	70mm meter logarithmically scaled 0.05 µGyh^{-1} to 75 µGyh^{-1}
Scaler display:	Liquid crystal 5 digit readout and overflow indication
Batteries:	4 x IEC R14 (“C” size) or similar.
Battery life:	Approximately 400 hours at 4 hours/day.
Timing:	Crystal controlled having the following selectable intervals: 10, 30, 60, 100, 300, 600, 1000 seconds and unlimited.
Recorder output:	0-0.5 volt at 1mA is available for driving a recorder, slave meter or data logger.
Size:	240 x 120 x 100mm (9.5” x 4.5” x 4”) Makrolon plastic weatherproof case and carrying strap.
Weight:	1.2 kg (2.5 lbs)

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Franklin, MA 02038 USA +1 (508) 428-3535 fax

www.thermo.com/rmp

Thermo SCIENTIFIC

Product Specifications

The Mini-monitor serves as a portable or bench top style radiation counter available with a variety of different probes to accommodate most of your radiation detection needs.

The 900 Series

Mini Monitor

- Several Configurations available
- Battery or Line Powered
- Very Affordable

The 900 Series of radiation counters are well established in teaching, research, hospital and industrial laboratories. Their reliability and convenient design are particularly attractive for industrial hygiene applications or where budgets are tight.

These instruments feature a large logarithmically scaled meter with an open scale at the lower end to show background levels of radiation while displaying high levels without switching. A built-in speaker provides audible feedback of the radiation intensity while the user is performing the measurement. An alarm can be set to trip at any level on the scale.

To support its versatile use and portability, the Mini-900's are packaged in a durable, lightweight aluminum case. Operation may be conducted on either battery power or by mains operation using a separate power unit. Included is an internal constant current charger for rechargeable batteries.

Each unit comes with a comprehensive manual containing tables and curves of response to different radiations and other useful information. These monitors conforms to the requirements of the International Technical Commission publication 325.

Specifications

Weight:	1 kg. (2.2 lbs)
Size:	180 x 110 x 165 mm (7” x 4.5” x 6.5”)
Batteries:	6 type AA cells, alkaline (IEC LR6) or rechargeable (IEC KR 15/51)
Battery life:	Approximately 300 hours at 4 hours/day.
Paralysis time:	Scale corrected to give true reading.
Meter integration time:	1 to 4 seconds set to match counting rate.
Radiation detector:	Halogen quenched G-M tube.
Radiation detected:	Gamma and X-rays only.
G-M tube supply:	300-700 Volts preset for tube type.
Overload protection:	No meter ‘fallback’ with intensities at least 100 times full scale reading.
Main power:	12-18 V dc from mains unit.

Available Configurations

Type R:	Monitoring High Level Dose Rates A monitor scaled over the range 0.5 to 5000 μSv h^{-1} (0.05 to 500 mR/h). The G-M tube is compensated to give a useful response from 45 keV to 1.5 MeV and above. It is not recommended for monitoring X-radiation from apparatus operating below 75 kVp.
Type G:	Monitoring for Low Environmental Dose Rates Highly sensitive performance. The monitor is scaled over the range 0.05 to 75 μSv h^{-1} (0.005 to 7.5 mR/h). The useful energy range is 55 keV to 1.5 MeV and above. This instrument is not suitable for monitoring X-radiation.
Type D:	A monitor using a partially compensated G-M tube to obtain an extended low energy response. The instruments is scaled over the range of 0.5 to 1000 μSvh^{-1} (0.05 to 100 mR/h). The useful energy range is from 30 keV to 1.5 MeV but response is maintained down to at least 17 keV. It is suitable for measuring radiation from X-ray apparatus operating at or above 45 kVp.
Type X:	This instrument is scaled 0.5 to 2000 counts per second and uses an end window G-M tube without energy compensation. It is sensitive to radiation down to 10keV and is therefore useful for locating X-ray leakage from a variety of systems including high voltage equipment where X-rays are generated adventitiously. It is not intended for measurement but as a relative check device.

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Thermo SCIENTIFIC

FHT 1377 PackEye

Radiation Detection Backpack

- High sensitivity plastic scintillation detector for fast response - true gamma doserate (50 keV to 3 MeV)
- Natural Background Rejection (NBR) indicates artificial sources - no false alarm upon NORM and natural background changes
- High neutron detection sensitivity
- User friendly, simple LED status indication
- Unchallenged light weight of 6 kg
- Low power consumption - operation time 60-70 h

NBR

Natural Background Rejection Technology for Enhanced Sensitivity

The FHT 1377 PackEye system was developed by Thermo Fisher Scientific for the rapid detection and location of gamma emitting radioactive sources. It provides survey teams with a tool for effectively addressing the problems of orphaned sources, radiological contamination, and maliciously introduced sources.

FHT 1377 PackEye

By virtue of the proprietary NBR-technology (**N**atural **B**ackground **R**ejection) extremely low contributions of artificial gamma radiation are quickly detected, despite much larger fluctuations of the natural gamma background radiation. Thus alarm levels in the order of 1 µR/h for SNM or heavily shielded industrial sources (dirty bombs) are achieved.

The NBR measurement method has been developed by Thermo Fisher Scientific, Erlangen (Germany) for extremely fast discrimination between natural and artificial gamma radiation. Worldwide, more than 2000 devices based on this technology are in use.

Unlike conventional spectroscopic based gamma identification systems, the systems using NBR do not require the presence and resolution of gamma spectral lines. Because of this flexibility, NBR can also definitively distinguish artificial high energy beta sources and heavily shielded gamma ray sources from fluctuating natural background sources. NBR has a rapid response time. Artificial gamma radiation sources are identified in seconds by operators with basic training levels. Presence of artificial gamma radiation is simply indicated by a red flashing light and an audible alarm.

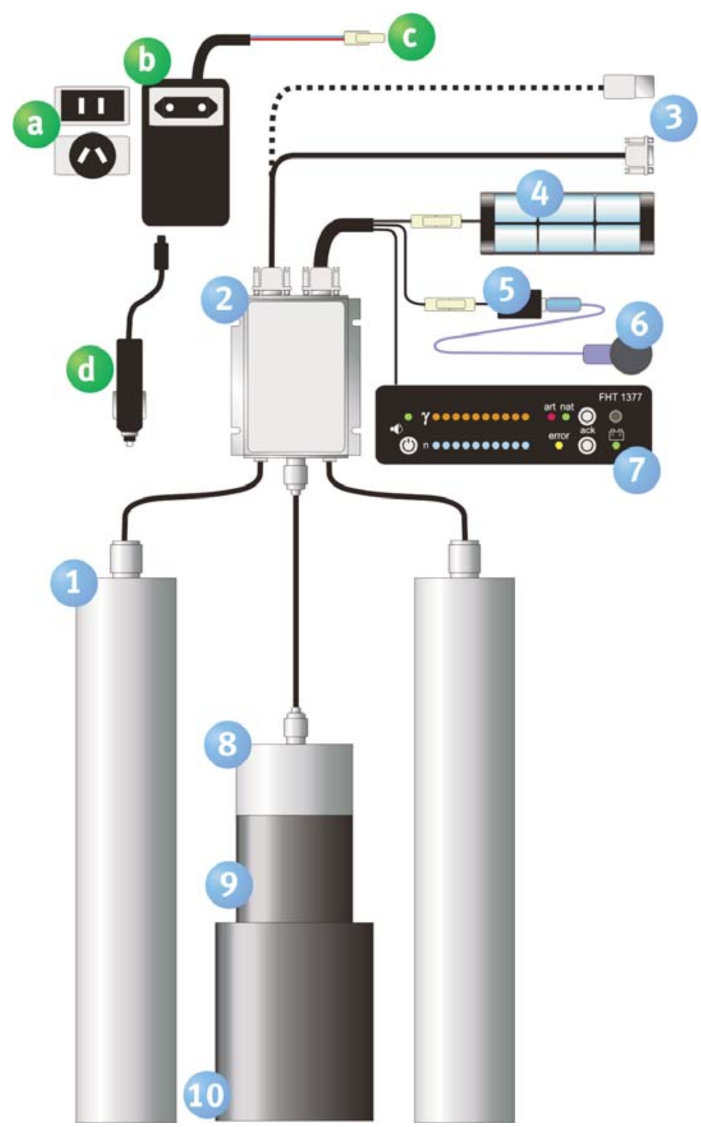
In addition to the detection of artificial gamma radiation (percentage alarm) a sigma based net count rate gamma alarm is active as well. Within a preset count rate range this alarm level is constantly and automatically updated according to the present background level.

System components

The detection of neutron sources is performed with the help of 2 ea. He-3 tubes (2.5 bar, 770 ccm active volume ea.). The sliding evaluation window with 100 ms update cycles allows the setting of a very low net alarm threshold level. A neutron source with an activity of 20,000 n/s can typically be detected in a distance of 3 m (10 ft), i.e. the neutron detection limit corresponds to the requirement for installed gate monitors!

1. Two He-3 counting tubes
2. Intelligent amplifier FHT 681
3. Connection cables to PC or notebook (serial RS232 or USB)
4. Battery pack
5. Earphone socket
6. Optional single earphone
7. Indication unit
8. Voltage devider
9. Photomultiplier
10. NBR detector

- a Set of international power socket plugs for charger
- b Battery charger with interchangeable plugs
- c Connector to battery pack
- d Car adapter as alternative power supply for the battery charger



Discrimination between artificial and natural radiation

In case of absence of detectable artificial gamma radiation, the green "nat" LED (E) is flashing slowly. The red "art" LED (D) light is blinking once artificial radiation is present. The presence of artificial radiation always triggers an alarm.

Excess of high energy radiation

If both LED lights (D + E) are on, the presence of an excess of high energy gamma radiation is indicated. Such an unusual background energy distribution results in a slightly reduced NBR-sensitivity to SNM or shielded industrial sources and can be caused by large amounts of K-40, an AmBe source or N-16 radiation

Alarm indication

Once an alarm had been triggered the location of the source can be traced by using the acoustical and / or LED bar indication. For stealth operation or in a noisy environment a standard earphone can be used. Optionally data display , alarm indication and data storage can be performed with the help of a PDA with bluetooth communication.

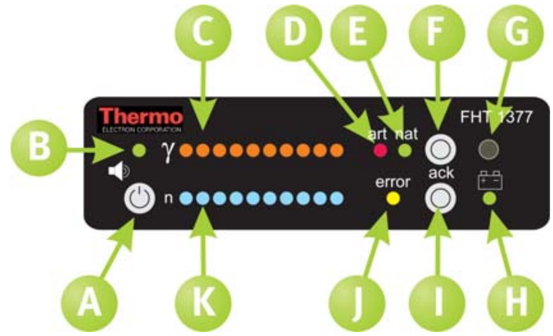
RadEye PRD - Personal Radiation Detector

For very low gamma energies the shielding effect of the user's body might hamper the detection of a source located in front of the user. It is therefore strongly recommended to wear an additional RadEye PRD at the belt. This pocket-sized instrument is an ideal complementary instrument for the precise localization of a source initially detected by the larger size FHT 1377.

RadEye PRD calibrated in R/h
4250671

RadEye PRD calibrated in Sv/h
425067120

Holster for RadEye PRD
425067046



Indicator unit display

- A Push button on
- B LED chirper Mode Indication
- C LED gamma radiation level bar
- D LED artificial radiation
- E LED natural radiation
- F Push button acknowledgement gamma radiation alarm
- G Sounder
- H LED battery status
- I Push button acknowledgement neutron radiation alarm
- J LED system error
- K LED neutron radiation level bar

Indicator unit

Stealth Operation:
The indicator unit can be hidden inside the backpack. The display of data as well as alarm indication is achieved through the optional PDA.

- 1 PDA
- 2 Radiation Detection Backpack
- 3 RadEye PRD
- 4 Indicator unit
- 5 Hidden radioactive material

Upon request, other backpack brands and models can be provided - weight and size will change accordingly.

Interceptor™

For advanced isotope identification Thermo Fisher Scientific's new Interceptor™ is available. The Interceptor™ offers immediate gamma isotope analysis.

INT Gid

Please ask for detailed datasheets!

FHT 1377 PackEye # **4255051**

Scope of supply: 1 ea. light weight backpack containing radiation detection equipment[1], 1 ea. indicator unit mounted at the backpack's belt and 1 ea. accessory aluminium case[2].

[1] Comprising: *1 ea. NBR-Detector, 2 ea. He-3 tubes (2.5 bar), 1 ea. preamplifier and controller type FHT 681.*

[2] Containing: *1ea. user manual, 1 ea. USB connection cable with Driver Software, 1 ea. RS 232 serial connection cable, 1 ea. rain cover for backpack, 1 ea. earphone, 2 ea. rechargeable battery packs (one in exchange) for 60-70 h operation time each (378 g ea.), 1 ea. charger for 120/240 V AC and 12 V DC, 1 ea. package of black bands to secure the cables and belts of the backpack.*

Accessories

PackEye Case # **4255085**

Scope of supply: 1 ea. transport case for one PackEye (not included). The case allows the inside operation of a PackEye to be used as stationary detector. The PackEye can be powered externally by a case-adapter. It is recommended to use the optional PackEye PDA for data display as the indicator unit is hidden inside the case.

Tripod Stand # **4255086**

Scope of supply: 1 ea. easily adjustable tripod stand with mounting plate for the PackEye case (not included).

Case with PackEye inside

PackEye PDA # **425505091**

Scope of supply: 1 ea. Windows Mobile PDA including preinstalled software for data display and logging for retrospective analysis, 1 ea. plug-and-play Bluetooth adapter for the PackEye. The PDA has a built-in GPS system and class 2 Bluetooth capability.

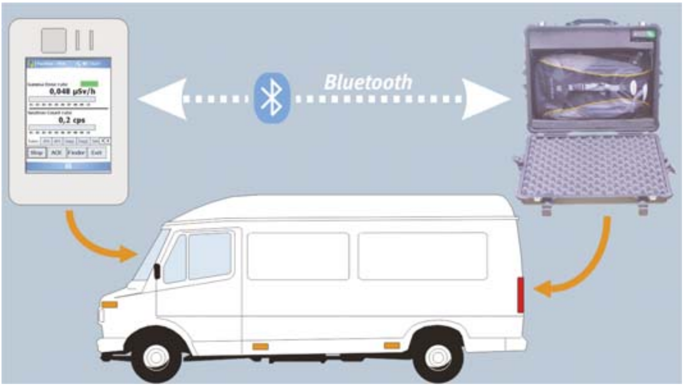
Case-Adapter DC/DC # **4255087**

Power adapter with special plug for the connection to a PackEye case. Input 12-24 V DC, output 7.5 V DC

Case-Adapter AC/DC # **4255088**

Power adapter with special plug for the connection to a PackEye case. Input 100-240 V AC, output 7.5 V DC

Application Example



Gamma Test-Adapter Kit - # **4254949:**

(100 g natural Lu_2O_3); Immediate indication of artificial gamma alarm (NBR).

Technical Specification

Gamma detector	NBR-detector FHZ 672 E (advanced version)
Gamma energy range / sensitivity	50 keV to 3 MeV / > 30 cps / µR/h [3000 cps / µSv/h] at 662 keV
Artificial gamma alarm	Typically better than 20 % of natural background
Neutron detectors	2 ea. He-3 tubes (2.5 bar), active length 15"ea., dia. 2"
Update	100 ms
Power supply	Rechargeable NiMH - power pack (7.2 V) - operation time 60-70 h
Total weight	approx. 6 kg (approx. 13 lbs)

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Thermo SCIENTIFIC

Product Specifications

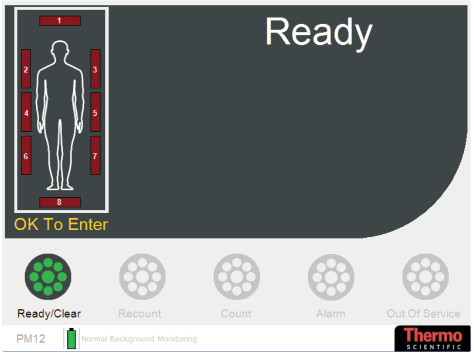
The PM12 gamma portal monitor breaks new ground in personnel monitoring. It provides a major improvement in sensitivity over similar instruments, thus leading to faster monitoring

PM12

Personnel Gamma Portal Monitor

- Reduced time to count (Quickscan)
- PC controlled, with embedded Windows XP operating system
- All results logged to internal database
- Achieves measurements of 370 Bq (10 nCi) of ^{60}Co
- Five modes of operation: walk through, one step, two step, three step or stand and turn
- Two types of high level alarm, as well as an optimized ^{60}Co alarm
- Ability to check for changing background during the measurement
- Optional large touch-screen color LCD display - no keyboard required
- Automated calibration and checking routines
- Easy upload and download via USB
- Viewpoint compatibility

The PM12 utilizes eight identical large gamma-sensitive plastic scintillation detectors to monitor personnel passing through the portal. Traffic flow can be either direction. Three detector assemblies are located in each side of the portal, with additional detectors to monitor the head and feet. The PM12 maintains the simple operation of its predecessor the PM7. In its basic form no keypads or complicated displays are necessary. The only user control is an alarm acknowledge switch, which is used to silence the audible alarm after contamination has been detected. The operational status of the portal is clearly indicated by a set of vertical system indicator lights located on both sides of the portal frame.



The System Indicator Lights are as follows:

- Contaminated: A red light indicating the presence of contamination
- Ready: A green light indicating that the PM12 is ready to use and is measuring background

  Count: A yellow light indicating that the portal is monitoring a user for contamination
- Re-count: A white light indicating that the user left the monitoring position before the count interval was complete
- Out of service: A blue light indicating that the personnel monitor is undertaking internal checks or has a failed component

Along with these indicators, a human silhouette, located on the right hand side of the portal frame, indicates which of the eight detector zones are “contaminated” thus aiding in localizing the contamination on an individual. The monitor will utilize double detector and triple detector sum-zones for monitoring of low level distributed activity. Voice commands may be utilized to help with the positioning of the user.

The PM12 may operate in either minimum count time or maximum sensitivity mode. The user enters the desired alarm level in terms of activity located in the centre of the monitor, or activity located adjacent to a detector (or both) and the personnel monitor determines the appropriate alarm level and minimum necessary count time to achieve these levels. The typical MDA for activity on the surface of the body is 200 Bq (6 nCi) of ^{60}Co.

An optional touch screen LCD is provided which will provide additional instructions to the users, and display monitoring results. The LCD is used for the calibration and configuration of the portal, and also may be used for retrieving measurement and calibration data from the portal's database. The portal may also be calibrated using a laptop PC connected to the portal's Ethernet port. The software provided by Thermo Fisher Scientific is highly intuitive and provides detailed high voltage scanning, calibration and report generation.

Products available

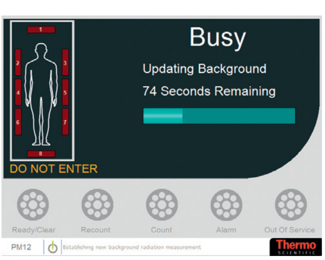
PM12A-05L	LCD and 0.5 inch of lead shielding	**PM12B-05L**	No LCD and 0.5 inch of lead shielding
PM12A-10L	LCD and 1 inch of lead shielding	**PM12B-10L**	No LCD and 1 inch of lead shielding

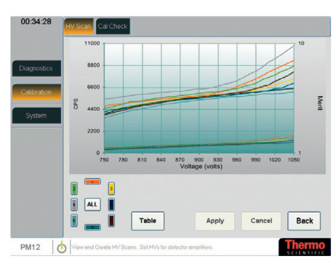
General

- The monitor has 8 identically sized detectors
- The outer dimensions of the monitor are 603 x 940 x 2190 mm (23.7 x 37 x 86.2 in). The LCD protrudes a further 290 mm (11.4 in)
- The internal passage width is 710 mm (28 in) in centre of portal
- The monitor is available both with and without an LCD display
- There are two thicknesses of shielding: 12.7 mm (0.5 in) and 25.4 mm (1 in)
- The mass of the monitor is either 820 kg (1800 lbs) or 1000 kg (2200 lbs), depending on the shielding used

Features

- The monitor may be used in five modes: walk-through, one step, two step, three step, stand and turn. The two step mode is the most sensitive for contamination on the body. The three-step mode is a combination of one step and two step
- The software allows both an activity alarm and a high activity alarm
- An alarm may be set on each individual detector, as well as double detector sum zones and triple detector sum zones, and gross sum (8 detector) zone.
- Quickscan may be used, which significantly reduces the counting time, without compromising the statistical probabilities of detection or false alarm.
- A low energy check may be used if a user is contaminated with contamination from medical radionuclides
- An additional ^{60}Co alarm will monitor for the presence of ^{60}Co, with greater sensitivity than the standard alarm
- A changing background indication will indicate significant changes in background radiation
- A changing conditions alarm will indicate if there is a significant change in the count rate during the monitoring period, which would invalidate the measurement
- Rapid recovery from background changes with a dynamic background counting time
- All background, measurement, source checking, event log, voltage scanning is stored to an SQL database within the monitor
- Set-up and configuration and diagnostic information is accessed via a touchscreen LCD, or an optional external PC
- User screens and voice prompts in a wide range of user-selectable languages
- When used with user identification, may be used to monitor lung burden trends on individuals over a period of time
- Dongle security, with three security levels
- Battery and sensor diagnostics
- Calibration integrity checking
- Video camera, barcode reader and EPD reader options





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Product Specifications

Thermo Scientific's newest RadEye instrument for surface contamination measurements

The perfect solution for

- **Civil Defence**
- **Fire Brigades**
- **Hospitals**
- **Nuclear Industry**
- **Pharmaceutical Industry**

RadEye AB100

Alpha Beta Contamination Monitor

Features of RadEye AB100

- Light Weight (900 g), excellent grip with or without gloves
- Rugged and compact design, thick rubber protection cover
- Low cost of ownership with > 1,000 h operation time using 2 C batteries – rechargeable NiMH-cells can be used
- Menu-driven user interface resulting in low training cost and immediate familiarity
- Huge internal data memory for both scaler type and continuous data recording
- Bright backlit LCD display – plain text messages - different languages can be selected
- Easy adaptation to different tasks by supervisor configuration, calibration, selection of measuring units
- Versatile operation modes:
  - Scaler / Timer with preset count and preset time for sample measurements
  - Continuous ratemeter mode for frisker operation
  - Alpha, Beta and Alpha + Beta modes
  - Gross or net counting
- Audible indication: single pulse for alpha, chirper mode for beta - proportional to count rate
- Earphone output for operation in a loud environment
- One hot and four advanced buttons - easy to use, no PC required

The RadEye AB100 is a modern contamination meter for surface contamination measurements with excellent alpha/beta discrimination. The user can select the proper calibration factor within a list of isotopes (e.g. Bq, Bq/cm², dpm).

The instrument is part of the growing RadEye family of high-end stand-alone meters, which are designed to meet the most demanding user expectations.

Large graphic display with clear prefix and bar-graph

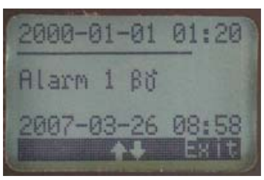
Simultaneous measurement of alpha-, beta-, and gamma radiation

Alpha alarm is indicated

Scaler Mode

Menu Operation

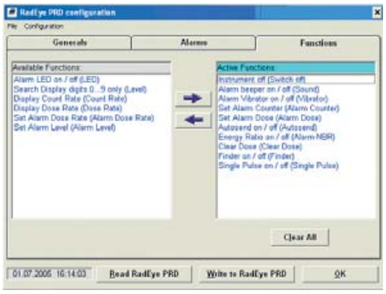
All factory-set parameters can be easily modified on the RadEye or using optional software. These menu operations can also be partially or fully blocked to simplify the instrument and to avoid any faulty operation. Navigation is made easy by a clear and intuitive user concept. Separate alarm levels for alpha, beta, gamma respectively alpha mode can be set.



RadEye Software

All settings and the data analysis can be done by an optional Windows™ -based PC-software and an accompanying reader device. At the end of the scaler measurement the data are recorded with date and time (up to 1,200 data sets).

Changes in configuration, occurring alarms and errors are saved in the RadEye memory. These saved events can be read out via the option "logbook". It is shown as a table and can be saved to the PC hard disc or printed. The logbook has a maximum of 250 data sets. Several events at the same time are saved as one record. On the display every event is shown in one line for a clear view.



RadEye AB100 configuration

Efficiency (per surface emission)	Am-241: Co-60 : Sr/Y-90:	36 % (α) 23 % (β) 49 % (β)
Gamma response (Cs-137)	approx. 40 s^{-1}/(μSv/h)	0.4 s^{-1}/(μR/h)
Window thickness/Active area	Thickness: 0.87 mg/cm² aluminized plastic film Sensitive area of 69 x 145 mm [2.71" x 5.71"]; Open area of approx. 85 %	
Dimensions / Weight	355 mm x 100 mm x 180 mm [14" x 4" x 7.1"] / approx. 0.9 kg [2 lb]	

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Product Specifications

RadEye B20 / B20-ER

Multi-Purpose Survey Meter

Thermo Scientific's newest RadEye instrument for contamination and dose rate measurements

The perfect solution for

- **Civil Defence**
- **Fire Brigades**
- **Hospitals**
- **Nuclear Industry**
- **Pharmaceutical Industry**

Features of RadEye B20 and RadEye B20-ER

- Light Weight (300 g), excellent grip with and without gloves
- Rugged and compact design, thick rubber protective cover
- Low cost of ownership with > 500 h operation time with 2 AAA batteries – rechargeable NiMH-cells can be used
- Menu-driven user interface results in low training cost and immediate familiarity
- Huge internal data memory for both scaler results and continuous data recording
- Bright backlit LCD display – plain text messages - different languages can be selected
- Easy adaptation to different tasks by supervisor configuration, calibration, selection of measuring units
- Versatile operation modes:
  - Scaler / Timer with preset count and preset time for sample measurements
  - Continuous ratemeter mode for frisker operation
  - Dose rate mode
- Audible indication: single pulse or chirper mode proportional to count rate
- Earphone output for operation in loud environment

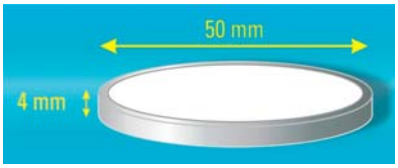
Order number: 4250685

The RadEye B20 is a modern compact multi-purpose contamination meter for alpha, beta, gamma and X-ray radiation. By virtue of an optional gamma energy filter, gamma dose rate measurements from 17 – 1300 keV can be performed. For emergency response purposes alpha and beta contamination can be discriminated using another optional filter.

The instrument is part of the growing RadEye family of high-end stand-alone meters, which are designed to exceed the most demanding user expectations.

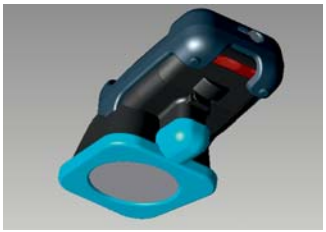
Accessories

High precision, low energy test adapter for performance verification ***Order number: 425068571***



- 9 g natural Lutetium-Oxide with 50 Bq/g (1.4 nCi/g): non radioactive in respect to StrSchV and NRC 49 CFR 173.403(y)
- Lu-176: half life 37,000 Million years
  - No error prone half life correction by the user
  - Check sources with short half-live are no longer required
- Extremely uniform activity content and surface emission rate
- Identical surface emission rate for each check source

Energy Filters



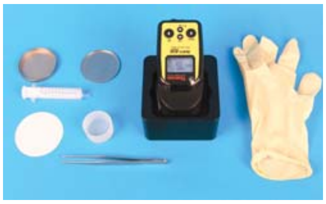
- Removable energy filter for X-ray & gamma dose rate measurements in Sv/h or Rem/h from 17 keV. ***Order number: 425068582***
- Removable alpha-rejection filter for quick estimation of alpha contamination in emergency response situations. ***Order number: 425068581***

Car Adapter Interface ***Order number: 425067065***

- AAA NiMH cells can be charged in the instrument
- Continuous monitoring in the car / fire truck with illuminated display
- RS 232 / USB / Bluetooth communication options

First Responder Laboratory Kit

Without RadEye: ***Order number: 425069011***



Pelican Case containing:

- Sample changer for use with the RadEye B20
- Sample planchets with different lip heights
- Disposable gloves, spatula
- 50 mm paper filters

Space for:

- Data cable
- User manual
- Lutetium-Oxide test adapter
- Additional RadEye (PRD or N)

Detector	1 pancake GM-tube, window dia. 44 mm (1.7”), 1.8 – 2.0 mg/cm²
Measuring Range (gamma dose rate) Uncompensated or with opt. energy filter	0 - 2 mSv/h [0 - 200 mR/h] RadEye B20 0 - 100 mSv/h [0 - 10 R/h] RadEye B20-ER
Measuring Range (contamination)	0 - 10 kcps RadEye B20 0 - 500 kcps RadEye B20-ER
2 π Efficiency (ref. to 50 mm diameter without rubber sleeve)	Am-241: 28%; Co-60: 25%; Sr/Y-90: 36%; C-14: 19 %
Energy Range (with gamma energy filter)	17 keV – 1.3 MeV
Weight and maximum dimensions	300 g (0.7 lb); 13 cm x 7 cm x 6 cm (5.2” x 2.8” x 2.4”)
Alarm indication	LED, sound, vibrator

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The perfect solution for

- **Civil Defence/Fire Brigades**
- **Hospitals**
- **Nuclear Industry**
- **Pharmaceutical Industry**

RadEye G20-10 / G20-ER10

X-ray and gamma survey meters for ambient equivalent dose and dose rate measurement

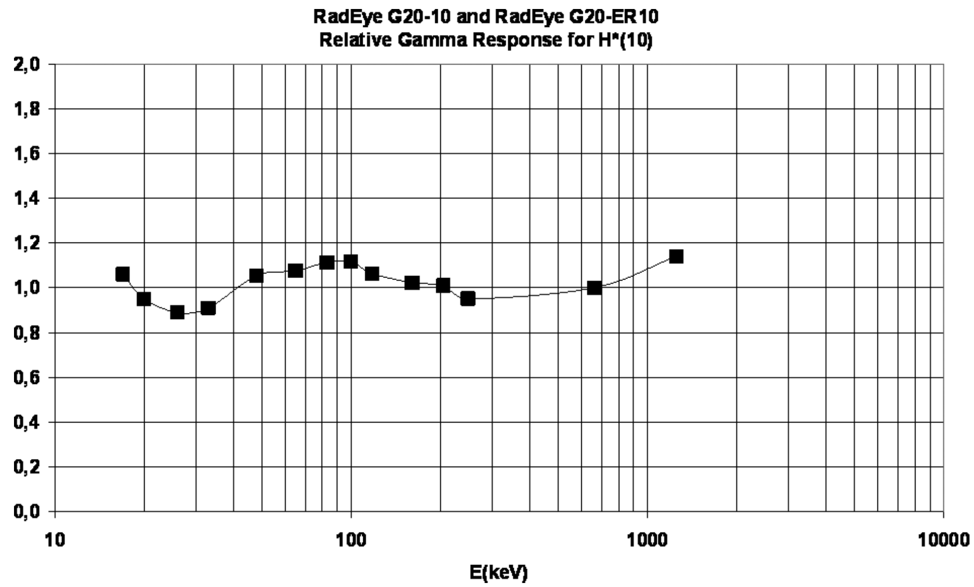
Features of RadEye G20-10/G20-ER10

- Fast response even below 1 µSv/h
- Light weight (300 g), excellent grip with and without gloves
- Rugged and compact design, thick rubber protective cover
- Low cost of ownership with > 500 h operation time with 2 AAA batteries – rechargeable NiMH-cells can be used
- Menu-driven user interface results in low training cost and immediate familiarity
- Huge internal data memory for both scaler results and continuous data recording
- Bright backlit LCD display – plain text messages - different languages can be selected
- Audible indication: single pulse or chirper mode proportional to count rate
- Earphone output for operation in loud environment
- Designed to meet and exceed IEC 60846-1

RadEye G20-10: 4250687
RadEye G20-ER10: 425068710

The RadEye G20-10 and G20-ER10 are excellent gamma survey meters with a flat energy response curve from 17 keV to 1.3 MeV according to ambient equivalent dose H*(10). The RadEye G20-ER10 model covers the whole dose rate range from background to 100 mSv/h.

The instrument is part of the growing RadEye family of high-end stand-alone meters, which are designed to meet the most demanding user expectations.



Accessories

Gamma test-adapter for RadEye G20-10/G20-ER10 (50 g Lu_2O_3): ***Order Number: 4254948***

62 mm diameter, 7 mm height (aluminium housing)
55 mm diameter, 3 mm height (Lu_2O_3 ceramics)

Induced net dose rate for RadEye G20: 0.25 µSv/h (25 µrem/h).
Time requirement for response verification approx. 5 min.

Car Adapter Interface ***Order number: 425067065***

- AAA NiMH cells can be charged in the instrument
- Continuous monitoring in the car / fire truck with lit backlight of the display
- RS 232 / USB / Bluetooth commumication options

Inductive RadEye charger ***Order number: 425067080***

In conjunction with the special battery lid (***Order number: 425067034)*** and 2 standard NiMH AAA-cells, the inductive RadEye charger allows permanent operation of a RadEye G20-10 or RadEye G20-ER10.

The RadEye remains galvanically isolated from the external DC-supply.

Special battery lid

Inductive charger

Detector	Pan cake GM with multi-element energy filter
Measuring Range (RadEye G20-10) **Measuring Range (RadEye G20-ER10)**	0.01 µSv/h – 2 mSv/h 0.01 µSv/h – 100 mSv/h
Energy Range (ambient equivalent dose rate)	17 keV – 1.3 MeV (± 20%)
Response	approx. 4 cps / µSv/h (every meter is individually calibrated)
Linearity	- 9% to +11%
Temperature Range	-20°C - +50°C

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RadEye G

Personal Radiation Detector

- Rugged and reliable
- Menu driven interface - no manuals needed
- Large, clear, backlit display for error free readings
- High sensitivity to low energy gamma radiation in harsh environments
- Durable - shock resistant design
- 2 x AAA batteries provide 600 h operation life
- Built in vibrator alarm and earphone connector for operation in noisy environment
- Low weight - only 160 g

RadEye G - The next generation of radiation meters

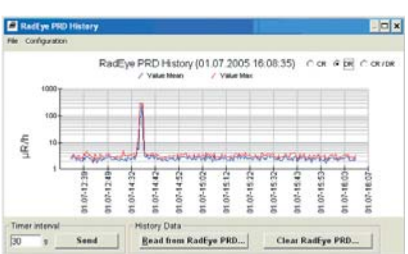
The RadEye G is a light-weight and very rugged instrument designed for quick and reliable measurement of gamma dose rates. Modern electronic circuitry guarantees excellent linearity over 6 decades of radiation intensity: from background level to 10 R/h - with overrange indication up to 1000 R/h.

The high-quality counter tube in conjunction with the non-metal instrument housing allows detection and reliable measurements down to very low gamma energies - a crucial feature in respect to accidents involving medical isotopes or Am-241 (a component of smoke detectors).

All essential functions can be easily accessed even while wearing protective gloves. The alarm-LED can be seen while the instrument is worn in a belt-holster. The instrument is also equipped with a built-in vibrator and an earphone-output for silent alarming or use in very noisy environment.

RadEye PC-Software for training and analysis

All settings and the data analysis can be done by an optional Windows™ -based PC-software and an accompanying reader device. Changes in configuration, occurring alarms and errors are saved in the RadEye memory. These events can be read out via the option "logbook".
In order to allow retrospective analysis of any event, the latest 1600 dose rate values are stored in the internal data memory. For each time interval both the mean and the maximum measurement values are stored.



RadEye G history data

RadEye belt holster with openings for alarm-LED and earphone connector

RadEye dash board adapter for mobile area survey applications including optional charging of the batteries

Large graphic display with clear prefix and bar-graph

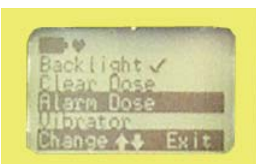
Background measurement
Alarm thresholds - two triangles in the bar-graph
Indication low

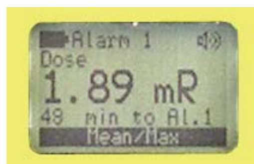
Approaching a source
Alarm thresholds - not yet exceeded
Trend arrow indicates increasing radiation level

Alarm level 1 exceeded
"Alarm 1" sign and "speaker" sign show up
Absence of trend arrow indicates stable radiation level - reading can be taken

Menu Operation

All factory-set parameters can be easily modified on the RadEye or using optional software. These menu operations can also be partially or fully blocked to simplify the instrument and to avoid any faulty operation. Navigation is made easy by a clear and intuitive user concept.





Customer specific logos are available

- Rugged and reliable - Removable rubber sleeve for extra protection
- Large display for clear information
- Bright LED-illumination allows operation in smoke and darkness
- Weighs only 160 g (96 x 61 x 31 mm) - true "pocket meter"
- Top alarm indication - can be operated in holster
- One hot and four advanced buttons - easy to use, no PC required
- Low power technology - 600 h operation time on 2 AAA cells
- Rechargeable batteries can be used - low cost of ownership
- Overload indication up to 1000 R/h - personal safety
- 1600 data points (mean/max.) - allows retrospective analysis
- PC-software with real-time graph - perfect for tutorial and training
- Adaptable user interface - can be optimized to application / user group
- Earphone output for noisy environment
- Alarm relay output - for area monitor application
- Designed to meet relevant NATO standards
- Designed to exceed ANSI 42.33 test criteria

Cost saving with rechargeable batteries

Detector	Energy compensated GM-tube
Measuring Range	5 µR/h - 10 R/h
Overrange Indication	1000 R/h
Energy Range (+/- 30 %)	45 keV - 1.3 MeV
Count Rate for Cs-137 (662 keV)	17 cps per mR/h

Thermo Scientific- a reliable partner of firebrigades and first responders worldwide

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TÜV CERT
DIN EN ISO 9001:2000
Zertifikat: 01 100 5093

Product Specifications

New pocket size
neutron radiation detector

RadEye N / NL

Personal Highly Sensitive
Neutron Radiation Detector

High sensitivity for neutron radiation

- Rapid warning of neutron radiation fields
- Applicable as an Area Monitor
- Exceeds the neutron response requirements of ISO 22188
- Ideal complement to passive and active neutron dosimeters

160g lightweight with low power technology

- Always ready for use - can be worn and operated in its holster
- Hands free operation with no restriction of personal mobility
- Rapid scanning of changing field intensities
- Detection of neutron shielding deficiencies and source presence
- Ideal complement to Rem-Counters

No spill-over from gamma radiation up to 10 mSv/h (1 R/h)

- Ideal for verification of neutron fields when dealing with unknown radiation sources
- No false "Neutron Alarm"
- Can be used in high gamma dose rate fields

RadEye N: # 4250677
RadEye NL: # 4250678

The RadEye N / NL is the ideal personal neutron radiation indicator for

- **users of industrial neutron sources, e.g. in geology and material testing**
- **operators and users of accelerators in medical science and research**
- **radiation protection staff and inspectors of nuclear facilities**
- **first responders and law enforcement officers**

RadEye Area Monitor for neutron radiation

Thermo
SCIENTIFIC

RadEye N / NL

The new RadEye N / NL closes a gap in the classical product spectrum of the radiation measurement technology. Rem-Counters for neutron detection with a He-3 or BF_3 tube are usually heavy and bulky since fast neutrons have to be moderated in order to be detected and to provide the correct neutron dose rate response. Low energy neutrons with their lower biological impact however have to be suppressed to a large extent. Dropping the demand for energy compensated dose rate response, a device can be built with one fiftieth of the weight and comparable or even a higher neutron response as compared to a Rem-Counter.

The RadEye N/NL is normally worn in a holster. In order to use it as a hand held survey meter and to increase the efficiency for fast neutrons the RadEye N/NL can be put into an optional moderator with handle. **# 425067110**

Features of RadEye N / NL

New!

- Rugged and reliable
- Removable rubber sleeve for extra protection
- Large display for clear information
- Top alarm indication - can be operated in holster
- One hot and four advanced buttons - easy to use, no PC required
- Rechargeable batteries can be used - low cost of ownership
- 1600 data points (mean/max.) - allows retrospective analysis
- PC-software with real-time graph - perfect for tutorial and training
- Adaptable user interface - can be optimized to application / user group
- Earphone output for noisy environment
- Alarm relay output - for area monitor application

Calibration factors for selected work places with known neutron spectra can be entered. [mrem/h, µSv/h]

Users (e.g. service staff) who travel on commercial aircraft should use the RadEye NL, with a He-3 pressure of 2.5 bar. In this case both the neutron sensitivity and the background effect is only half as much as of the RadEye N.

Weight	160 g (5.6 oz)
Dimensions	96 x 61 x 31 mm (3.8" x 2.4" 1.2")
Detector	He-3 tube with 10 bar filling pressure (RadEye N) He-3 tube with 2.5 bar filling pressure (RadEye NL)
Sensitivity when worn at the body (RadEye N)	approx. 0.3 cps per µSv/h (3 cps per mRem/h) for Cf-252, detects 0.01 µg Cf-252 in typically 2 - 3 s for 25 cm (10") distance
Background	approx 0.005 cps at 300 m above sea level (RadEye N)
Gamma spill-over	< 0.2 cps at 10 mSv/h (1 R/h) Cs-137 radiation
Measuring units	Count rate (cps) moving average over 10 s Mean value and peak value over any time period
Operation time (2 AAA alkaline batteries)	400 h (RadEye N), 500 h (RadEye NL)

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DIN EN ISO 9001:2000
Zertifikat: 01 100 5093

Thermo SCIENTIFIC

Product Specifications

Thermo Fisher Scientific offers an inexpensive Area Monitor designed to meet all of the requirements of dose rate area monitoring.

RMS-3

Area Monitor

- Inexpensive, fully featured area monitor
- Radnet compliant
- Supports most detector types
- Optional integrated HP-270 or HP-290 probe
- Networked (RS-485 and/or Ethernet)
- Windows™-based calibration

The Model RMS-3 utilizes a highly integrated electronics package that promotes low start up costs, operator friendliness, easy setup and quick calibration. This system supports a variety of different detector types including:

- HP-270 energy compensated GM tube to cover a dynamic detection range beginning at a few µR/h to 3 R/h (30 mSv/h).
- HP-290 allows the RMS-3 to be used up to 60 R/h.
- SPA8 or SPA3 NaI(Tl) for increased sensitivity.
- DA1-1 (0.01 to 100 mR/h), DA1-6 (0.1 to 10,000 mR/h), DA1-6C (criticality detector), and the DA1-8 detectors when an operating range of up to 10,000 R/h (100 Sv/h) or remote detector placement is required. Automated check sourcing is supported with these DA1-1 and DA1-6 detectors.
- SWENDI 2 or the NRD for neutron monitoring.

Alarms may be set anywhere over the entire operating range of the detector. An alpha-numeric, high visibility LED display gives continuous update of current conditions. Visual indicators for High Alarm, Alert Alarm, and Normal present the operational status of the entire instrument. A Sonalert built into the monitor provides audible warning any time the alarm set point has been exceeded. An alarm acknowledgment button located on the front panel allows users to silence the speaker.

The detector and electronics are enclosed in a resilient, splash proof enclosure that is designed to take up a minimum amount of wall space. Installation is as simple as hanging it on the wall and connecting AC power. Facilities using the optional relay or analog output capability of the RMS-3 will require additional wiring connections via a terminal block strip conveniently located inside the bottom of the monitor.

The RMS-3 area monitor uses an RS-232C communication port to permit connection to a PC running a Windows™-based setup/ calibration program. This program permits technicians to fully setup, calibrate and diagnose problems. Program features include automatic generation of high voltage plateaus, alarm set point selection, three levels of password protection, and complete control over all operating parameters.

The RMS-3 can easily be networked onto an existing Ethernet system with the use of a small serial-to-Ethernet converter. The Windows™ 98-ba network PC Client software uses UDP/IP communications and the new industry standard RadNet networking protocol, allowing multiple area mo tors as well as contamination and air monitors to be viewed by a client anywhere on the LAN. There is no limit to the number of clients that can play the current status of the monitor as well as the current reading. Multiple RMS-3's may also be networked via RS-485 to a Windows™-base network enabled PC using optional RadNet Server software that places the information onto the LAN for access by RadNet clients.

RMS-3 Specifications

Specification	Benefit
Range:	Background levels to 10,000 R/h (0.1 µSv/h to 100 Sv/h) over any four decades usi various standard Thermo Scientific detectors.
Linearity:	± 10% (using dead-time compensation).
High Voltage:	From 450 to 2,500 V dc.
Thresholds:	Upper and Lower Thresholds computer controlled (0.3 to 60 mV).
Alarm Range:	User-selectable over entire operating range (both Alert and High Alarm).
Units:	Measurement units are specified as text during calibration.
Temperature:	-40° to 60° C (-40° to 140° F).
Size:	241 H x 158.7 W x 127 mm D (9.5" x 6.25" x 5").
Weight:	Nominally 2.3 kg (5 lbs) without the detector.
Power:	100 to 240 V ac, 50/60 Hz, 15 W max.
PC Support:	Switch selectable RS-232 or RS-485 serial port using a DB-9 connector.
Relay Contacts:	240 V ac @ 8 A resistive, normally open and normally closed available.
Speaker:	Sonalert rated at 70 dB @ 60 cm.
Display:	6.86 mm (0.27") high twelve segment high visibility LED.
Visual Indicators:	LED's for High Alarm (Red), Alert Alarm (Amber), and Normal (Green).
Push Buttons:	Alarm Acknowledge.
Analog Output:	Optional 0 or 4 to 20 mA Logarithmic (jumper selectable).
Also Available:	Check Source Activation.

Options

- RMS3 OPT2 TTL Logic level input (Required for use with DA series detectors)
- RMS3 OPT3 4 to 20 mA or 0 to 20 V Logarithmic Analog Output
- RMS3 OPT4 High Alarm Flashing Strobe (Red)
- RMS3 OPT6 Wall Bracket with Handle
- RMS3 OPT6A Wall Bracket for use with DA1-X
- RMS3 OPT7 Windows™ Calibration Software Also Available: RadNet Networking Software and Hardware.

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The MinAlarm 7-10 is a mains operated installed radiation monitor with an audio/visual alarm that can be set to trip at any point on the scale. It is available with a variety of probes to suit different monitoring requirements.

MinAlarm 7-10 Series

Installed radiation alarm monitors

- Local and remote alarm indications
- Wide variety of available probes
- Battery backed mains operation

The MinAlarm models are simple, tough, metal-cased monitors for bench or wall mounting.

The semi-logarithmically scaled meter has an open scale at the lower end to indicate background levels of radiation without range switching.

Alarms, which can be tripped at any point on the scale, are indicated audibly and through 50,000 hr solid-state visual alarm condition lamps. There are also connections for alarm relay contacts and an analog output for remote indication of alarm status. A selectable latching/non-latching alarm facility is included.

Checks and safeguards on the MinAlarm include a probe failure alarm, check functions for both the internal circuit and alarm, and an internal lead-acid battery to provide operation in the event of a mains failure.

System Specifications

Models Available

MinAlarms 7-10G & 7-10GL
The 7-10G is a sensitive instrument using the MC70 G-M tube. The meter is scaled over the range 0.05 to 75 µSv/h (0.005 to 7.5 mR/h). The useful energy range is 55 keV to 1.25 MeV and above. The 7-10GL uses the MC71 low inherent background G-M tube and is intended for environmental monitoring. These models are not suitable for monitoring X-radiation.

MinAlarm 7-10C
The meter is scaled 1 to 2,000 counts s^{-1} for other G-M tubes and scintillation detectors from the Mini range. Scintillation probes from other manufacturers may also be used.

MinAlarm 7-10R
The meter is scaled over the range 0.5 to 5000 µSv/h (0.05 to 500 mR/h). The MC10 compensated G-M tube has a useful energy range from 45 keV to 1.25 MeV and above. It is not recommended for monitoring X-radiation from apparatus operating below 75 kVp.

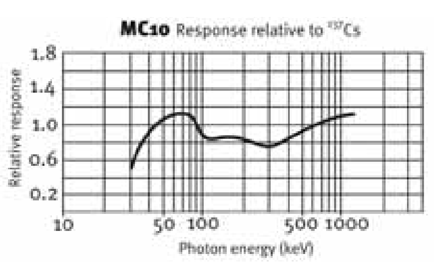
MinAlarm 7-12
The 7-12 is a special version that allows the probe to be sited up to 500 m (1640') from the instrument. Four matching probes are available. The MC74 covers the range 0.05 µSv/h to 75 µSv/h;
MC75: 0.5 µSv/h to 1 mSv/h
MC76: 1 µSv/h to 5 mSv/h and
MC77: 5 µSv/h to 10 mSv/h.
The energy response of these probes is 85 keV to 1.3 MeV ±30%.

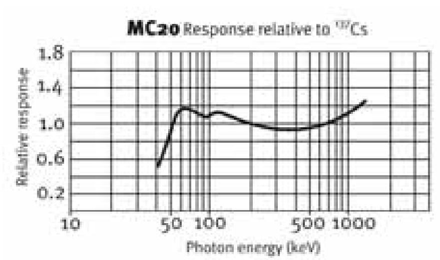
MinAlarm 7-10RL
Compensated G-M tube MC20 with an energy range of 50keV to 1.25 MeV. The meter is scaled from 0.5 to 1000 µSv/h (0.05 to 100 mR/h) with emphasis in the 1 to 10 µSv/h (0.1 to 1 mR/h) range. It is not recommended for monitoring X-radiation from apparatus operating below 75 kVp.

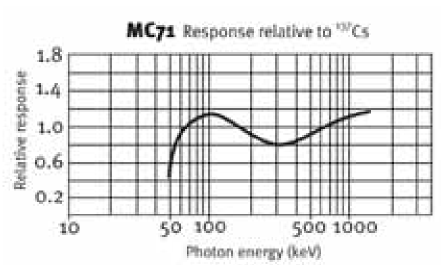
Non-ambient dose equivalent (H*(10)) versions are available as 7-10R, 7-10RL, etc.

Additional features

To augment the visual alarm, a red, high intensity xenon beacon can be mounted on top of the case to give 360° viewing. The audible alarm is also replaced by a high output unit.







Specifications

Weight:	2.5 kg (5.5 lbs)
Size:	15 H x 22 W x 15 D cm (6" H x 6" W x 8.5" W) overall.
Mains supply:	100 to 120 / 200 to 240 VAC, 50 to 60 Hz, approx. 10 Watts.
Back-up battery:	Sealed lead acid, 12 V 1.1 Ah.
Meter Integration time:	Set to match scale range: 1 to 10 s for R, RL; 1 to 20 s for G; 1 to 100 s for GL
Radiation detector:	Halogen quenched G-M tube or scintillation probe.
Detector supply:	300 to 1500 V, adjustable internally.
Overload protection:	No meter 'fallback' with intensities at least 100 times maximum scale reading.
Detector location:	Attached to MinAlarm or within 3 m (10') of the instrument.
Audible alarm:	90 dBa at 30 cm 400 Hz.
Indicator lamps:	Dual large area LED panel lamps showing green or red when tripped.
Detector energy response:	The response of types G/GL, R and RL are shown above. (Data for all the graphs was supplied by NRPB)
Cable length:	The detector cable length is normally 3 m (10'). Longer cable lengths, up to a maximum of 500 m (1640'), are only available in the 7-12 version.

Additional data for model 7-12

Probe location:	Up to 500 m (1640') from instrument.
Detector voltage:	500 to 1500 V produced by power supply mounted within probe housing.

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Thermo SCIENTIFIC

Product Specifications

MATRIX MRDS is an area threat detection network that provides real-time detection, analysis and location of radiation threats/incidents within a large area.

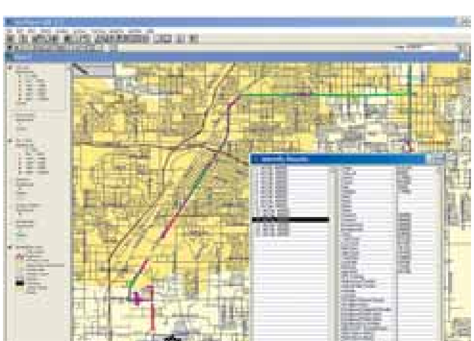
MATRIX MRDS™

Real-time Mobile Radiation Threat Detection Network

Benefits:
- Centralization of radiation threat information from multiple sources
- Detects, analyzes and locates all possible radiation threats
- Highly configurable: fixed, mobile or venue-driven

Features:
- Rugged and secure wireless network
- Highly sensitive probes provide fast detection of hidden radioactive sources
- Greatly reduces innocent alarms with NBR technology
- Self-diagnostic capabilities
- Expandable platform over 40 detectors

Applications:
- Municipalities
- Nuclear plants
- Critical facilities
- Chemical plants
- Special events



Fully Integrated GPS Capabilities

The Matrix MRDS (Mobile Radiation Detection System) is a state-of-the-art radiation threat detection network that provides real-time detection, analysis and location of radiation threats across a predetermined area. Incorporating an extremely robust wireless interconnect, Matrix MRDS ensures error-free data transmission whether used in fixed or mobile command centers.

The Matrix MRDS system has the capacity to integrate an unlimited number of sensors through expansion modules. The real-time threat assessment can be determined over a large area via wireless communications. The Matrix MRDS system also incorporates Natural Background Rejection (NBR) technology, greatly reducing innocent alarms by distinguishing between naturally occurring radiation sources and potential threats.

Thermo's full line of radiation probes offer an impenetrable radiation barrier which covers the complete spectra of artificial radiation sources that might be a threat to an area. Our detector network can be established in a fixed or mobile mode, which can be configured and reconfigured depending upon your detection objectives.

Highly sensitive probes provide fast detection of concealed radioactive sources. The Matrix MRDS is a highly-scalable, flexible platform which provides a clear path to additional centralized detection and analysis as it can be quickly upgraded to incorporate data from other sources.

The Matrix MRDS offers full flexibility with probes that can be either set in a fixed configuration (i.e.. bridge) or mobile (i.e.. mounted on a van) with no modification necessary. Additional types of detectors are being developed to detected chemical and explosive threats.

MATRIX MRDS Capabilities and Specifications

Advanced Imbedded Wireless Technology

Unaided signal distribution up to 1 mile wireless, aided signal unlimited area.

Data uplink capabilities via WiFi Technology

Wireless, direct, and hardened connectivity

- 2.4 GHz, secure, binary communication

Utilizes the methodology of spread spectrum transmission

- Allows signals to be spread over multiple frequencies for distribution over a larger set than would be used in conventional radio transmission. Resulting in reduced vulnerability to multi-path fading, interference and jamming.
- Methodology delivers a strong over-the-air protocol particularly well suited for challenging, sprawling or electrically noisy settings
- Error-free Data: 24-bit cyclic redundancy check (CRC) and automatic repeat-request (ARQ) features seamlessly detect errors and request retransmissions as needed, ensuring accurate network data

This technology has repeatedly proven to be superior to other communication protocols such as 802.11 in areas such as:

- Coverage
- Quality of signal
- Integrity of Data
- Less susceptible to interference

Detailed Capabilities

Detects, locates, and monitors any type of artificial radiation sources

- Completely integrated radiation detection probes
  - Neutron Probe
  - NBR Probe
- Capable of detecting and monitoring radiation sources ranging from 20 KeV to 1500 KeV.
  - Includes Weapons Grade Plutonium, Enriched Uranium, Cesium, Cobalt 60 & 57 and highly shielded medical waste
- Incorporates Natural Background Rejection Technology to eliminate natural radiation sources from the treat matrix.

Real-time data

- Completely customizable alarms setting for all activities

Remote system diagnostics

All data available in ArcView 3.3/8.3.

Detailed Features

Rugged design

- Complete vibration and shock tested

Multiple power options

- Battery power up to 3 hours
  - Incorporating Smart Battery Management Technology
- Vehicle AC power enabled

Detects, locates, and monitors any type of artificial radiation sources

Ease of maintenance

- Modular change out of all wireless communication components

Fully integrated GPS accurate up to 3 meters (9.8')

Self-diagnostic capabilities incorporated

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Thermo SCIENTIFIC

A one time investment
with unique advantages

Product Specifications

Lutetium Test Adapter [110 cm²]

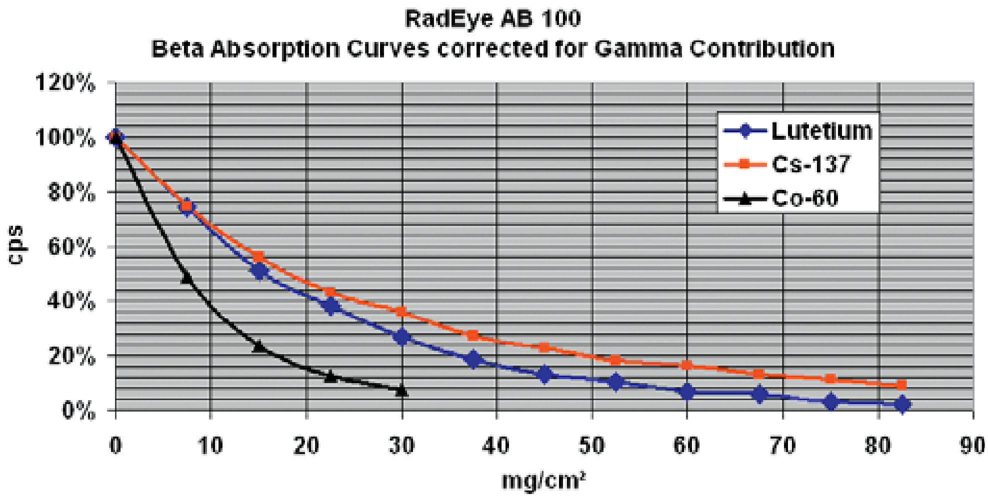
for large area beta contamination probes

- **Inherently homogeneous surface emission rate**
- **Emission rate 0.8 beta particles per cm²·s – perfect for training and calibration**
- **Same emission spectrum for <u>every</u> test adapter**
- **Same emission rate for <u>every</u> test adapter**
- **No half life correction required**
- **Robust – scratch proof high density ceramic surface**
- **Natural Lu_2O_3 (< 50 Bq/g Lu-176)**
- **Affordable and traceable**
- **110 cm² = exceeding detector area**

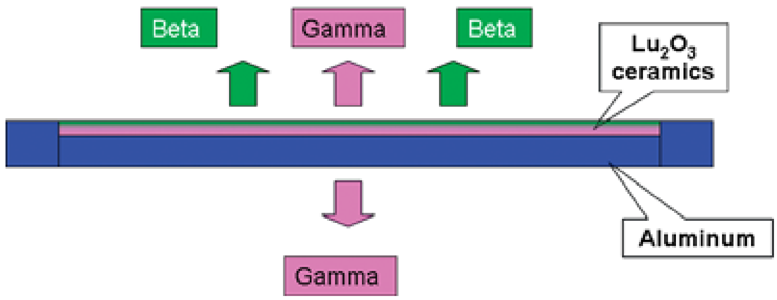
 # 425068371

Conventional test sources for beta contamination monitors suffer from a number of inherent problems: Every source is an individual and unique item regarding activity and surface emission rate. Sources from different manufacturers may have different spectra from the emitted particles depending on the production process. Furthermore large area test sources may have variations of the emission rate over the different sections of the surface and in many cases the user needs to correct for the decay of the radioisotope. The thin active surface is always a delicate part of the source.

Lutetium test adapters contain the isotope Lu-176 with 3.8E10 years half-life and a natural abundance of 2.6 %, which yields a specific activity of approximately 50 Bq/g of the pure element Lutetium. The unique feature of using a chemically pure bulk substance containing the radioisotope in its natural abundance results in a totally constant and homogeneous surface emission rate. Each and every source of the same surface area has the same beta emission rate, regardless of small variances in the thickness of the Lutetium-oxide ceramics. Furthermore, due to their natural origin and low specific activity, in respect to many national regulations these adapters are not considered as radioactive material. These new test adapters can contribute to a reduction of calibration cost and instrument downtime, as well as to an increased user confidence and familiarity with "his" or "her" instrument.



Absorption measurements show that the beta emission spectrum is right between Cs-137 and Co-60.
The calculated effective maximum beta energy of the thick Lu_2O_3 layer is approximately 480 keV.



Beta max. energy:*

Energy	188 keV	589 keV
Emission	0.9 %	99.1 %

The actual beta and conversion electron spectrum is broadened and shifted to lower energies due to energy loss in the Lu_2O_3 bulk material.

Conversion electrons (> 50 keV, > 1 %):*

Energy	77 keV	86 keV	136 keV	191 keV	199 keV	242 keV	296 keV
Emission	46 %	11 %	14 %	7.5 %	1.8 %	4.8 %	1.6 %

X-ray and Gamma lines:*

Energy	8 keV	54 keV	55 keV	63 keV	88 keV	202 keV	307 keV	401 keV
Emission	23 %	9.4 %	16.5 %	6.9 %	13 %	84 %	93 %	0.8 %

Technical data:

Weight	200 g total, thereof 80 g Lu_2O_3
Size	12 cm x 20 cm x 0.5 cm total 7.4 cm x 14.8 cm Lu_2O_3 surface

* *Nuclides 2000: An Electronic Chart of the Nuclides, Version 1.00 European Communities, 1999.*

The Lutetium Test Adapter [110 cm²] is also suitable for the following probes: FHZ 382, FHZ 380 SVG2, HP 380 AB, HP 380 B, DP6, BP19

Other dimensions on request!

Test adapter for pan cake probes **# 425068571**:
Acrylic glass housing: 50 mm diameter, 3 mm height.
Lu_2O_3 ceramics inlet: 40 mm diameter, 1 mm height.

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Thermo SCIENTIFIC

Lutetium Test Adapters

Product Overview

Thermo SCIENTIFIC

Thermo Scientific Lutetium Test Adapters are a real smart alternative to conventional check sources and offer a lot of unique advantages to our customers using radiation detectors.

- **A 3.7E10 year half-life means:**
  - <u>no need</u> for error-prone half-life corrections
  - <u>no need</u> for reoccurring purchase of the (decayed) check sources
- **The adapters provide a highly reproducible and uniform activity content of 50 Bq/g (1.3 nCi/g)**
- **All test adapters of the same type have virtually the same activity!**
- **Beta-type adapters provide nearly identical surface emission rates**
- **The design of a special shape enclosures and high density Lu_2O_3 ceramics minimizes the required activity for small size detectors**

Conventional test sources for radiation monitors suffer from a number of inherent problems: Every source is an individual and unique item regarding activity and surface emission rate. Sources from different manufacturers may have different spectra from the emitted particles depending on the production process. Furthermore large area test sources may have variations of the emission rate over the different sections of the surface and in many cases the user needs to correct for the decay of the radioisotope. The thin active surface is always a delicate part of the source.

Thermo Scientific Lutetium Test Adapters contain the isotope Lu-176 with 3.8E10 years half-life and a natural abundance of 2.6 %, which yields a specific activity of approximately 50 Bq/g of the pure element Lutetium. The unique feature of using a chemically pure bulk substance containing the radioisotope in its natural abundance results in a totally constant and homogeneous surface emission rate. Each and every source of the same surface area has the same beta emission rate, regardless of small variances in the thickness of the Lutetium-oxide ceramics. Furthermore, due to their natural origin and low specific activity, in respect to many national regulations these adapters are not considered as radioactive material. These new test adapters can contribute to a reduction of calibration cost and instrument downtime, as well as to an increased user confidence and familiarity with "his" or "her" instrument.

For more information please ask for a special paper:
"Test Adapters Based on Natural Lutetium - a Discussion of Benefits versus Conventional Check Sources".

Beta/gamma test adapters

High precision, low energy test adapters for performance verification of the RadEye B20 and other instruments with pancake detector.

Lutetium Test Adapter with 9 g Lu_2O_3: **# 425068571**
50 mm diameter, 3 mm height (acrylic glass housing)
40 mm diameter, 1 mm height (Lu_2O_3 ceramics inlet)
Typical net count rate for RadEye B20: 6 cps

Test adapters for large area beta contamination probes with an inherently homogeneous surface emission rate of 0.8 particles per cm²•s - perfect for training and calibration.

Lutetium Test Adapter with 80 g Lu_2O_3: **# 425068371**
Size: 120 x 200 x 5 mm total;
110 cm² (74 x 148 mm) Lu_2O_3 surface.

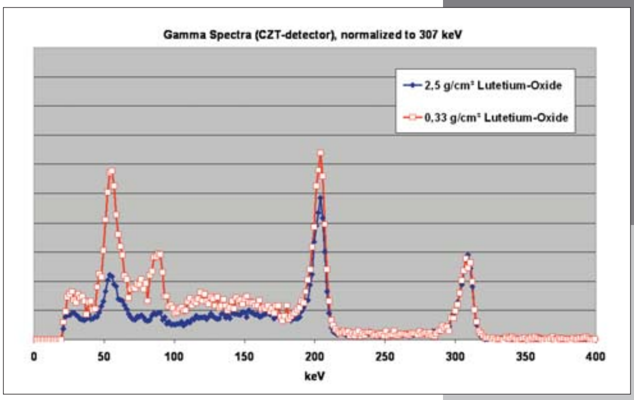
Please ask for a detailed data sheet!

Gamma test adapter for RadEye PRD

Special shaped lutetium test adapter to match the RadEye PRD housing.

Lutetium Test Adapter with 36 g Lu_2O_3: **# 425067071**
Typical net count rate for RadEye PRD: 100 cps
Indication of "low energy" NBR alarm. A carrying case is included.

Universal gamma test adapter for portable scintillation detectors and gamma spectroscopy



Lutetium Test Adapter with 50 g Lu_2O_3: **# 4254948**
62 mm diameter, 7 mm height (aluminium housing)
55 mm diameter, 3 mm height (Lu_2O_3 ceramics)
Typical net count rate for 2"x2" NaI(Tl) detectors: 300 cps
Immediate identification of "artifical" NBR alarm for FHZ 672 E-10,
net dose rate 30 nSv/h [3 µR/h]

Gamma test adapters for Thermo Scientific radiation portal monitors

FHT 1388 - FHT 1386 - SGS I - SGS II - ASM

Benefits:

- Challenge (response test) your system with a realistic “source” for best performance
- Determine detector degradation by measuring effective scintillator clarity with a realistic “source”
- Optimize your system setup parameters

Lutetium Test Adapter with 100 g Lu_2O_3: **# 4254949**
Dual disc design, can be mounted directly to the FHT 1388 area detectors (plastic housing).

171 mm length, 61 mm width, 17 mm height (aluminium housing)
2 x 55 mm diameter, 3 mm height (Lu_2O_3 ceramics)
Typical net count rate for large area detectors: 1000 cps
Immediate identification of “artifical” NBR-Cs alarm for FHT 1388 versions and FHT 1377 PackEye. Including carrying case.

Lutetium Test Adapter with 100 g Lu_2O_3: **# 425494910**
Same as above with holder for monitors with metal enclosure (ASM/SGS installations).

Lutetium Test Adapter with 200 g Lu_2O_3: **# 4254950**
Quattro disc design, can be mounted directly to the FHT 1388 area detectors (plastic housing). The adapter is recommended for locations with higher background.

4 x 55 mm diameter, 3 mm height (Lu_2O_3 ceramics)
Typical net count rate for large area detectors: 2000 cps
Immediate identification of “artifical” NBR-Cs alarm for FHT 1388 versions. Including carrying case.

Lutetium Test Adapter with 200 g Lu_2O_3: **# 425495010**
Same as above with holder for monitors with metal enclosure. (ASM/SGS installations).

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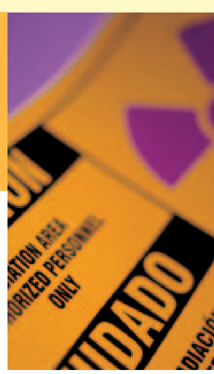
Thermo SCIENTIFIC

Product Specifications

The Thermo Scientific FH40 based K-O kit offers the complete suite of radiation detectors to monitor and identify any type of radiation or radioactive material in preventative scenarios as well as emergency situations.

Thermo Scientific FH40 K-O Kit

Emergency Radiation Detection Kits



Features

- Rugged construction
- Easy to use
- Complete radiation response solution
- Monitors Alpha, Beta, Gamma and Neutron radiation
- Identifies and classifies radioactive isotopes
- System utilizes plug-and-play smart probes for doserate and contamination surveys
- Networkable via wireless module

The high performance FH40GL multi-purpose survey/ratemeter is the heart of the system. It has an internal proportional detector to measure doserate in a stand-alone mode, or it can be connected with the included range of smart plug-and-play external detectors. The FH40GL can simultaneously work with any of these detectors and continue monitoring the area gamma doserate. The external detectors in the K-O kit are for monitoring Neutrons, Alpha and Beta contamination and Gamma radiation. For the most challenging search-and-find tasks without excessive false alarms, a high-sensitivity, large-volume NBR detector is also included, along with an extending teleprobe for sensitive or high level measurements at a distance. To identify the isotope and assist in defining form of response required to a radiation event, an identiFINDER®* handheld Radioactive Isotope Identifier (RIID), a FLIR System, Inc. product, is included. The identiFINDER can be ordered with a LaBr detector for improved resolution and identification capabilities.

This complete kit comes inside durable weatherproof cases with all the required chargers, cables and software.

The Thermo Scientific FH40 K-O Kit includes the same items without the IdF-NHG+ or IdF LaBr, for those organizations who do not need, or already have Radioisotope Identifiers.

Other probe options are available and specific probes can be added or removed as required; however, the specified probes have been selected to give the emergency responder the best performance for the likely range of radiation emergency scenarios.

The Teleprobe (telescoping adapter) can be used with many of the included probes. The adapter extends to 4 meters (13 feet), enabling the user of the probe to get close to any difficult-to-reach area, such as under a vehicle, to perform the most sensitive search and survey possible. It can also be used in a high doserate area to measure the radiation source closely, while keeping the operator at a safe distance. The FH40GL will display to the operator both the higher probe doserate at the end of the pole close to the source and the lower safer doserate where the user stands. Live data can be exported from the FH40 via an optional wireless module.

This may be networked using the Thermo Scientific ViewPoint System or the LifeLine System from Safe Environment Engineering.

Thermo Scientific Teleprobe FH40 TG

Thermo Scientific FH40 K-O Kit

The Thermo Scientific FH40 K-O Kit includes the following items	
2 x 4254004 - FH40G-L	Multi-Purpose stand-alone Surveymeter and Ratemeter used with plug-and-play probes. Doserate range of internal detector 1 uR/h to 100 R/h. Energy range 36 KeV to 1.3 MeV. All readouts on the FH40 automatically set to the units and range defined by the attached probe and all calibration parameters are set automatically
2 X 425400045	Spiral cable for plug and play probes: 0.3 m (11.8 in), stretches to 1.2 m (47.25 in)
4254036 - FHZ732	Alpha/Beta 15 cm^2 Pancake Geiger Probe for detecting radioactive contamination. Includes sturdy protective nylon bag
4254130 - FHZ382	Alpha/ beta contamination scintillation probe, 100 cm^2, additional LED indication of detected alpha radiation at the probe
4254066 - FHZ672E-10	High sensitivity NBR (Natural Background Rejection) search probe. For sensitive detection of artificial sources in fluctuating natural radiation fields. Simple red-green alarm system assists with effective search procedures. Energy range 48 keV to 1.3 MeV to H*10
4254149 - FHT752SH-2	High sensitivity neutron detection probe, fits in Teleprobe
4254028 - FHZ512A	High sensitivity 3.81 cm x 3.81 cm (1.5 in x 1.5 in) NaI Gamma probe, fits in Teleprobe
4254051 - FH40TG	Teleprobe (telescoping adapter) for FH40 plug-and-play probes; individually calibrated including dose rate detector FHZ612 (4254052) and protective cap (425405114)
425405120	Rugged aluminum case for FH40TG teleprobe and plug-and-play probes, approx. 90 x 16 x 15 cm (35.4 x 6.3 x 5.9 in)
425405116	Protective cap for FHZ 512/512A
425405117	Protective cap for FHT 752 S/SH; Recommended for use with telescopic pole.
4254026	Data interface cable (USB) for FH40G or RadEye desktop holder
A425409901	FH40G Configuration and data software.
A425409903	FH40G Calibration Software
FH40GOPT8	FH40 and probe heavy-duty canvas carry case
IDF-NGH	IdentiFINDER Handheld Isotope Identifier MCA with He3 Neutron Detector. 3.56 cm x 5.08 cm (1.4 in x 2.0 in) NaI detector, high range GM, holster, battery charger, data interface cables, data transfer software, and winTMCA analysis software. Optional identiFINDER LaBr model available on request
CCPL17	Wheeled Weatherproof #1750 Pelican Case, houses complete kit apart from Teleprobe
ZP11601139	Custom Foam insert to protect all kit items in Pelican case

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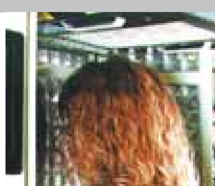
Thermo SCIENTIFIC

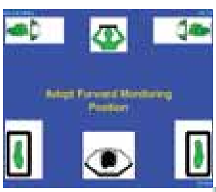
Product Specifications

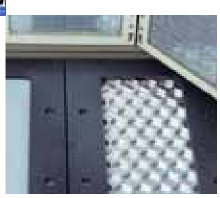
The IPM9 provides fast, thorough body monitoring with outstanding capabilities. It detects radioactive emissions over the whole body, including head, hands and feet.

IPM9

Installed Personnel Monitor







- Fast monitoring with total coverage
- Very high whole body sensitivity
- Easy to operate, calibrate and maintain
- Advanced detection algorithm
- Automatic background subtraction
- Robust construction, comfortable for users
- Minimal training for staff and users

The IPM9 is available in two physical formats - the closed cubicle IPM9A and the open IPM9D. A choice of thin window, gas flow detectors or rugged, sealed gas detectors is available, together with gamma scintillation detector options.

The two-stage monitoring procedure provides consistent body sensitivity for all user sizes. Users are guided by external traffic lights, internal LEDs, a colour graphic display and (optionally) voice prompts. Comfortable, easy to operate sensors ensure correct positioning and guarantee monitoring integrity. Large area detectors, with minimum ‘dead’ areas between adjacent detectors, give optimal body coverage. Hex-grills ensure maximum transmission and strength. Spring-loaded hand detectors, for maximum efficiency, monitor both sides of the hand simultaneously.

The instrument simultaneously maintains high sensitivity and maximum user throughput. A proprietary detection algorithm continuously calculates and applies the minimum monitoring time to achieve the preset sensitivity. It adapts automatically to background changes, enforces high preset confidence levels, gives very low false alarm rates and recognizes detector contamination.

Other standard features include menu-driven setup (no PC required), customizable alarm messages, modular plug-in circuit boards for easy maintenance, data-logging of results and radon rejection facility.

Options & Specifications

Detector Types

Gas Flow detectors (Standard, α & β)
These Ar/CH_4 detectors are extremely sensitive and have no internal dead areas. Their thin windows are protected by strong, fine hex-mesh grills, giving maximum strength vs. sensitivity factor, with 75% transmission. Flat plateau responses to all normally encountered α or β emitters guarantee stable long-term sensitivity and maximum gamma background rejection.
Sensitivities:

α	(^{241}Am)	240 dpm	0.04 Bq/cm^2
β	(^{137}Cs)	2400 dpm	0.4 Bq/cm^2
β	(^{60}Co)	5000 dpm	1.0 Bq/cm^2

Figures are averaged over the body.
Detection is based on: 100 cm^2 sources, 12 s monitoring time, 0.1 μSv/h (10 μR/h) background, 95% probability of detection, <0.005% false alarms per detector, i.e. <0.1% system false alarms.

Sealed Gas detectors (Optional)
These Ar/CO_2 detectors are mechanically interchangeable with standard gas flow detectors. They are permanently sealed and rugged, with 5 mg/cm^2 titanium windows. Their beta energy response extends down to ^{14}C energies (157 keV). Ar/CO_2 detectors are insensitive to alpha, less affected by radon, and have high gamma background rejection.
Efficiencies: (% surface emission, from large sources placed on the detector grille)

Radionuclide	Body	Hand	Foot
^{90}Sr/^{90}Y	39	37	31
^{36}Cl	37	32	30
^{60}Co	25	21	20
^{14}C	6	6	4
^{133}Ba	1.6	1.6	1.4
^{55}Fe	0.3	0.4	0.35

Integrated Gamma detectors (Optional)
There are two available configurations of additional gamma scintillation detectors. The passive internal monitor (PIM) option provides a lung/nasal/pharyngeal/gut gamma detector, plus lead shielding, mounted behind the body detector array. The 'full' gamma option provides six large-area body detectors with lead shielding behind the standard body detectors, plus a gamma foot detector. On the IPM9A, two additional hand detectors are installed in the back wall.

Options

Small Articles Monitor
This option provides convenient self-monitoring of tools, personal items, etc., and is available in both alpha/beta and alpha/beta/gamma versions.

Alpha-On-Body
Extra alpha channels analyze the body and head detector signals, providing whole body alpha monitoring.

Barrier Control (IPM9A only)
Full-height, polycarbonate glazed doors (illustrated overleaf) offer increased control, security and quality assurance of monitoring workers and personal items. Available as solo exit door or entrance and exit pair. Handing and window options are available. Turnstile operation is also supported.

Alpha Overhead Detector (IPM9A only)
The IPM9 auto-retracting overhead detector increases top-of-the-head sensitivity to alpha and beta emissions. The user pulls the counter-balanced detector down to suit their height. It retracts automatically when monitoring is complete.

Additional Gas Flow Foot Detector
Increased probability of detection, by monitoring each foot twice. Foot coverage can be maintained, even with one damaged foot detector.

Voice Prompts and Display Languages
Spoken user prompts are available in many languages, either as a single language or selectable multiple languages.
English, French, Spanish, Portuguese and Czech display languages are included as standard, but others can be installed on request. Display languages can be selected, from up to four installed languages, via the optional push-buttons or rotary switch kits.

Last Results Recall
This option provides a 'hot button' that will recall the last measurement result and display it by detector (as opposed to the standard mannequin display). This saves valuable time during daily source check and when confirming or quantifying alarms.

Networked Data-logging & Control system
The IPM9 Surveillance system remotely monitors IPM status and live measurement results, providing on-screen display and data-logging facilities. Multiple IPMs can be connected, via RS-485 network, to the PC, and can be grouped and named in the software. IPM monitoring results are displayed 'live' by detector layout. Results can be selectively logged and stored in a standard database (.mdb) file. Individual IPM setup menus can be viewed on-screen and set-up parameters can be remotely edited.

External LCD
An externally-mounted LCD display is available for the IPM9A.

Check sources
A range of point sources and check source jigs are available to aid setup and routine checking.

Key Specifications

Gas Flow detectors
18 body detectors, 4 for hands, 1 (or 2) for feet and 1 for the head (IPM9A option only).
Window: 0.9 mg/cm^2
Gas: 92.5% Argon, 7.5% Methane. Other gases possible. Connection via a bulkhead fitting to accept a 3 mm internal diameter tube.

Sealed Gas detectors
18 body detectors, 4 for hands, 1 (or 2) for feet and 1 for the head (IPM9A option only).
Window: 5 mg/cm^2
Gas: Argon/CO_2.

Scintillation Gamma detectors
Lead shielding: 20 mm (0.75")

Monitoring time
Autotime: 1 to 100 s in 1 s steps

Background Update Time
100 s rolling average

Precision
Defined by keypad-entered parameter.
Probability of false alarm: between 0.1 and 10 standard deviations.
Probability of detection: between 0 and 10 standard deviations.

Construction
Self-contained free-standing metal cubicle with fork truck lifting points.

Power Requirements
85 to 264 VAC, autoranging. 47 to 63 Hz, 360 VA max.

EMC Compatibility
IPM9s are CE marked and LVD compliant

Dimensions
IPM9A: 2290 H x 1130 W x 1000 D mm
(90" H x 44.5" W x 39.5"D)
plus 160 mm (6.3") per door.
IPM9D: 2250 H x 1100 W x 875 D mm
(88.5" H x 43.5" W x 34.5" D)

Weight
410 kg (900 lb) approx. net without gamma or scintillation options. Shipping weight, 580 kg (1280 lb) approx.

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Product Specifications

The identiFINDER®-U* hand-held instrument, a FLIR Systems Inc. product, is used to find and identify radionuclides in harsh environments, employing gamma spectrometry with doserate display, accumulated dose display, source finder and automatic nuclide identification capability.

identiFINDER®-U

Ruggedized, Underwater Hand-Held Radioisotope Identification Device

- Coast Guard, Navy and Marine Interdiction
- Underwater covert operations
- Transportation safety
- Emergency response
- Waste monitoring
- Contamination monitoring
- Environment control

identiFINDER-U is a user-friendly instrument that distinguishes man-made and natural isotopes and combines high sensitivity with a wide dose rate range. The instrument is a dual purpose design to facilitate locating missing or offending sources and then identifying the source via its gamma spectrometry and nuclide identification capability. IdentiFINDER-U employs a unique approach of template matching for more accurately identifying shielded and unshielded sources.

The identiFINDER-U is a complete digital gamma spectroscopy and dose rate system. It integrates multi-channel analyzer, amplifier, high voltage power supply, and memory with an integral scintillation detector.

The identiFINDER-U is suited for remote applications, advanced warning systems, hazardous environments and nuclear inventory monitoring. It is used with a standard 1.2 x 1.5″ (30 mm x 38 mm) NaI (TI) detector or CZT detector.

A built-in ^{137}Cs reference source (< 500 Bq/15 nCi) is used for online stabilization and in-situ calibration without user interaction. This special identiFINDER-U feature allows operational temperatures between -15 and 55 °C (4 to 131 °F) and large temperature gradients. The instrument is waterproof to 1 atm (10 m (33′)), and the integrated display and three push-button operations provide easy handling.

Connected to a desktop or notebook PC through a water-tight connector. There is no need to open the instrument to change the battery or download to PC. Up to 60 spectra of 1024 channels can be stored in the unit and directly transferred to any PC for further advanced analysis.

identiFINDER-U Specifications

User Selectable Nuclide Library

More than 72 reference spectra of gamma nuclides are categorized based on their main practical occurrence, including:

Medical:	^{131}I; ^{99m}Tc; ^{67}Ga; ^{123}I; ^{125}I; ^{111}In; ^{103}Pd; ^{201}Tl
On Site Inspection (OSI):	^{140}Ba; ^{116}Cd; ^{141}Ce; ^{144}Ce; ^{132}I; ^{140}La; ^{99}Mo; ^{96}Nb; ^{147}Nd; ^{144}Pr; ^{106}Rh; ^{103}Ru; ^{125}Sb; ^{132}Te; ^{131m}Xe;^{133}Xe; ^{133m}Xe; ^{135}Xe;^{95}Zr
Nuclear:	^{239}Pu ; ^{233}U; ^{235}U; ^{237}Np
Industrial:	^{110m}Ag; ^{241}Am; ^{133}Ba; ^{207}Bi; ^{109}Cd; ^{57}Co;^{58}Co; ^{60}Co; ^{134}Cs; ^{137}Cs; ^{51}Cr; ^{152}Eu; ^{155}Eu; ^{59}Fe; ^{192}Ir; ^{40}K; ^{54}Mn; ^{22}Na; ^{226}Ra; ^{75}Se; ^{232}Th-232; ^{238}U; ^{65}Zn; ^{228}Ac; ^{109m}Ag; ^{7}Be; ^{212}Bi; ^{214}Bi; ^{139}Ce; ^{181}Hf; ^{133}I; ^{134}I; ^{135}I; ^{56}Mn; ^{214}Pb; ^{106}Ru; ^{124}Sb; ^{127}Sb; ^{208}Tl; ^{88}Y; Annihilation Radiation

The operator can choose from 6 categories (Nuclear, Industrial, Medical, Customs (Medical, Nuclear and Industrial combined), OSI and USER).
All sub-libraries, except the OSI library can be edited by adding or deleting specific nuclides from the list.
Ten (10) reference spectra can be measured by the user and added to the predefined library spectra.
Identification is done by a template-matching correlation procedure.

Features

Functions:	Nuclide identification, spectrum analysis, dose rate calculation, total dose display, source finding
Integrated electronics:	Multi-Channel-Analyzer, PMT preamplifier, spectroscopy amplifier, power supply
Integrated detectors:	31 x 38 mm (1.2 x 1.5”) NaI (Tl) (standard)
Optional:	Standard: ^{3}He detector for neutron indication.

Physical Dimensions

Weight:	1340 g (2.95 lbs) with 30 mm x 38 mm (1.2” x 1.5”) NaI and batteries
Temperature range:	-15 to 55 °C (4 to 131 °F)
Protection:	water proof to 10 m (33’) or 1 atm, dust tight
Protection class:	IP 65
Durability:	ANSI Standard (10 x 50 g over 18 ms in 3 orthogonal axis)
Dimensions:	230 x 90 x 70 mm (9” x 3.5” x 2.75”)

Spectrometry System Specifications

Detector Type:	NaI, CdZnTe
HV-Bias:	50 - 1275 V selectable
Shaping type:	digital filter
INL, top 99%:	>0.05%
DNL, top 99%:	>0.01%
Spectrum length:	1024 channels
Pileup rejection:	400 ns, pulse pair res.
Throughput rate:	>50,000 cps
Input rate:	>500,000 cps
Spectrum memory:	60 spectra at 1024 channels
Real time presets:	1 s - 1,000,000 s
Live time presets:	1 s - 1,000,000 s

Dose / Dose-rate Measurement Specifications

Sensitivity:	>500 cps/ µSv/h (>5 cps/µrem/h) for 30 x 38 mm (1.2 x 1.5”) NaI (Tl) detector
Dose-rate range:	10 nSv/h - 1 Sv/h (1 µrem/h - 100 rem/h)
Dose range:	100 nSv - 1 Sv (10 µrem - 100 rem)
Energy range:	NaI: 20 keV – 3 MeV; GM: 60 keV – 1.5 MeV
Alarm levels:	Four preset levels (2 dose and 2 dose rate)

Special Features

Stabilization:	Temperature stabilitation; HV current. stabilization; Internal ^{137}Cs reference source for stabilization.
Calibration:	Automatic energy calibration; Detector efficiency calibration; Automatic dose calibration.
Remote control:	Real time measurements, setup and control.
Language:	German, English, French, Russian.

identiFINDER-U supplied in hard shell travel case with batteries, chargers, USB PC interface cable, holster, PC download software & operators manual

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www.thermoscientific.com/rmp

Thermo SCIENTIFIC

Product Specifications

identiFINDER®
Isotope Identifier

The identiFINDER®* isotope identifiers, a FLIR Systems, Inc. product, are a family of compact and lightweight instruments for finding and identifying radionuclides. The integrated display and straightforward three push-button operation ensures ease-of-use in the field. The accessories supplied with every identiFINDER ensure that the field user can easily reach-back to the experts with useful data, should the need arise.

Scope of supply — the main components of the identiFINDER system

The identiFINDER is a user-friendly instrument that identifies man-made and natural radionuclides and combines high sensitivity with a wide dose rate range. The instrument has a dual purpose design to facilitate locating missing or offending sources and then identifying the source via its gamma spectrometry and nuclide identification capability.

The identiFINDER instrument is a complete digital gamma spectroscopy and dose rate system. It integrates multi-channel analyzer, amplifier, high voltage power supply, and memory with an integral scintillation and GM detector. The identiFINDER detector is ideally suited for homeland security, industrial, medical, nuclear power generation and nuclear fuel cycle applications.

The identiFINDER detector also is available as an optional LaBR version, providing high-resolution spectroscopy at room temperature. This version delivers laboratory-type performance in a lightweight, hand-held device, enabling improved results for difficult identifications.

Features

- Top-of-the-line Ultra model available with patented pulsed LED stabilization and LTI deconvolution which no longer requires a built-in source for precise stabilization (±0.5% typical peak shift accuracy)
- Supplied with larger, more sensitive NaI(Tl) gamma detectors
- New, faster (5 to 10 x quicker identification) and lower power (longer battery life) electronics
- New, more rugged and ergonomic housing for easier use in the field
- Optional neutron detection now 50% more sensitive due to new ^{3}He detector

identiFINDER Isotope Identifier

Features	
Functions	Nuclide identification, spectrum analysis, dose rate calculation, total dose display, source finding
Integrated Electronics	Multi-Channel-Analyzer, PMT preamplifier, spectroscopy amplifier, power supply Standard Instruments: identiFINDER-NG+ with 35.5 mm x 50.8 mm (1.4 in x 2 in) NaI & GM detectors identiFINDER-NGH+ with 35.5 mm x 50.8 mm (1.4 in x 2 in) NaI, ^{3}He & GM detectors identiFINDER-NG Ultra with 35.5 mm x 50.8 mm (1.4 in x 2 in) NaI & GM detectors identiFINDER-NGH Ultra with 35.5 mm x 50.8 mm (1.4 in x 2 in) NaI, ^{3}He & GM detectors Specials (-L versions): with 30.5 mm x 35.5 mm (1.2 in x 1.4 in) LaBr with a resolution of <3.3% at 662 keV Watertight (-U versions): up to 1 atm (10 m or 33 ft) immersion Telescopic (-X versions): with ~1.2 m to 2.4 m (~4 ft to 8 ft) extension Safeguards: with 25.4 mm x 25.4 mm (1 in x 1 in) NaI (TI) tungsten shielded detector and specialized SNM firmware
Stabilization	In the non-Ultra models, a built-in ^{137}Cs reference source (<15 nCi/500 Bq) is used for online stabilization and in-situ calibration without user interaction. With either stabilization method this special identiFINDER feature allows operation over temperatures between -20°C and +55°C (-4°F and +122°F). The Ultra provides the user with the benefits of LED stabilization technology with or without a small 3nCi Cs137 source, as preferred for implementation and transportation.
Software	The identiFINDER provides for easy storage of up to 100 spectra and rapid transfer to a PC for reach-back and/or qualitative in-situ analysis with the software supplied.
User Selectable Nuclide Library	There are 74 reference spectra of radionuclides stored in six libraries: Nuclear, Industrial, Medical, U.S. Customs Service, OSI (On Site Inspection by IAEA officials), and Security. All sub-libraries except OSI can be edited by adding or deleting specific nuclides from the list. Ten reference spectra can be measured by the user and added to the predefined library spectra. Identification is done by a template-matching correlation procedure.

Physical Dimensions	
Weight	1250 g (2.75 lb) with 35.5 mm x 50.8 mm (1.4 in x 2 in) NaI and batteries
Temperature Range	-20°C to +55°C (-4°F to +122°F)
Protection	Water proof, dust tight
Protection Class	IP 54
Battery Life	10-12 hours; common batteries can also be used (i.e., emergency situations)
Dimensions	248.92 mm x 94 mm x 76.2 mm (9.8 in x 3.7 in x 3 in)
Spectrometry System Specifications	
HV-Bias	200 V to 1275 V automatically set to suit individual detector
Shaping Type	Digital filter
INL, Top 99%	<0.05%
DNL, Top 99%	<0.1%
Spectrum Length	1024 channels
Pileup Rejection	<100 nS, pulse pair res.
Throughput Rate	>100,000 cps
Input Rate	>350,000 cps
Spectrum Memory	100 spectra at 1024 channels
Real Time Presets	1 s to 1,000,000 s
Live Time Presets	1 s to 1,000,000 s
Dose/ Dose Measurement Specifications	
Sensitivity	>10,000 cps/mrem for 35.5 mm x 50.8 mm (1.4 in x 2 in) NaI (TI) detector
Dose-rate Range	1 µrem/h to 100 rem/h max dose-rate equivalent to max dose-rate of NAI
Dose Range	10 µrem to 100 rem
Energy Range	NaI: 15 keV to 3.0 MeV; GM: 60 keV to 1.6 MeV
Alarm Levels	Gamma: Four preset levels
Neutron	Separate neutron alarms for ^{3}He model, with blue indicator lamp

Front view of the identiFINDER with

1. Battery compartment lock
2. ON/OFF button
3. Blue LED (neutron alarm)
4. Selection buttons
5. Command line
6. Red LED (gamma alarm)
7. Internal GM tube
8. Internal ^{3}He tube (neutron detection)
9. Internal NaI(TI) scintillation detector

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www.thermoscientific.com/rmp

Thermo SCIENTIFIC

Product Specifications

The identiFINDER®* EOD kit provides two gamma/neutron detection systems that employ digital gamma spectrometers intended for rapidly identifying radioactive gamma/X-ray isotopes. The Thermo Scientific EOD Kit includes two identiFINDER detectors, a FLIR Systems, Inc. product, as well as check sources, carrying holsters, setup software, cables, and power adapters.

identiFINDER® EOD Isotope Identifier Kit

Explosive Ordinance Disposal configuration

The identiFINDER EOD kit is supplied with a custom made black P-1600 Pelican case that contains the following:

- 2 x identiFINDER-NGH units
- 2 x web-gear compatible black carrying holsters with positive lock clasp
- 2 x wrist lanyards
- 2 x universal ac power supply units with "micro" USB connector
- 2 x micro USB to USB serial communication cables
- 2 sets of winTMCA software, technical manuals & calibration records
- 1 custom set of exempt radioactive check sources (RRS-8 EOD)
- 1 factory optimized spare detector assembly with set up sheet

The identiFINDER-NGH (Gamma and Neutron) Complete System

The digital gamma spectrometer is intended for rapidly locating, accurately measuring, and quickly identifying radioactive gamma/X-ray isotopes. In addition, an integral PE moderated, ^{3}He-neutron detector provides an indication of neutron intensity in cpm.

The gamma detector is a 31 x 38 mm (1.2" x 1.5") NaI (TI) detector with integral, exempt (15 nCi) ^{137}Cs stabilization source, the useful measuring range is from background to 100 mrem/h. A vibration alarm feature is included, in addition to the audible and visual alarms, all of which can be preset for gamma dose & doserate levels and neutron countrate. This unit is easily distinguished from the standard gamma only unit by its blue aluminum end cap.

Explosive Ordinance Disposal configuration

Features	
Functions:	Nuclide identification, spectrum analysis, dose rate calculation, total dose display, source finding
Integrated electronics:	Multi-Channel-Analyzer, PMT preamplifier, spectroscopy amplifier, power supply
• Standard Instruments:	
	- identiFINDER-NG w/ 1.2”x1.5” NaI & GM detectors
	- identiFINDER-NGH w/ 1.2”x1.5” NaI, ^{3}He & GM detectors
	- identiFINDER-NG ultra w / 1.4”x2” NaI & GM detectors
	- identiFINDER-NGH ultra w/ 1.4”x2” NaI, ^{3}He & GM detectors
• Specials:	with 1.2"x1.4" LaBr with a resolution of <3.3% at 662 keV
• Watertight (-U versions):	up to 1 atm (33’) emersion
• Telescopic (-X versions):	with ~4’ to 8’ extension
• Safeguards:	with 1" x 1” NaI (TI) tungsten shielded detector and specialized SNM firmware
Stabilization:	In the non-Ultra models a built-in ^{137}Cs reference source (<15 nCi/500 Bq) is used for online stabilization and in-situ calibration without user interaction. With either stabilization method this special identiFINDER™ feature allows operation over temperatures between -4 and 122 °F (-20 to 55 °C)
Software:	The identiFINDER provides for easy storage of up to 100 spectra and rapid transfer to a PC for reach-back and/or qualitative in-situ analysis with the software supplied

User Selectable Nuclide Library

There are 74 reference spectra of radionuclides stored in 6 libraries (Nuclear, Industrial, Medical, Customs, OSI, and Security). All sub-libraries except OSI can be edited by adding or deleting specific nuclides from the list. Ten (10) reference spectra can be measured by the user and added to the predefined library spectra. Identification is done by a template-matching correlation procedure

Physical Dimensions	
Weight:	2.75lbs (1250g) with 1.4" x 2" NaI and batteries
Temperature range:	-20 to 55 °C (-4 to 122 °F)
Protection:	water proof, dust tight
Protection class:	IP 54
Drop test:	2' 8" on concrete
Dimensions:	9.8” x 3.7” x 3”

Spectrometry System Specifications	
HV-Bias:	200 - 1275 V automatically set to suit individual detector
Shaping type:	digital filter
INL, top 99%:	<0.05%
DNL, top 99%:	<0.1%
Spectrum length:	1024 channels
Pileup rejection:	<100 nS, pulse pair res.
Throughput rate:	>100,000 cps
Input rate:	>350,000 cps
Spectrum memory:	100 spectra at 1024 channels
Real time presets:	1 s - 1,000,000 s
Live time presets:	1 s - 1,000,000 s

Dose/ Dose Measurement Specifications	
Sensitivity:	>10,000 cps/mrem for 1.4"x2" NaI (TI) detector
Dose-rate range:	1 µrem/h - 100 rem/h
Dose range:	10 µrem - 100 rem
Energy range:	NaI: 15keV - 3.0 MeV; GM: 60 keV - 1.6 MeV
Alarm levels:	Gamma: Four preset levels
Neutron:	Separate neutron alarms for ^{3}He model, with blue indicator lamp

Figure 2
Overall view of the identiFINDER (front view) with
1-battery compartment lock,
2-ON/OFF button,
3-blue LED (neutron alarm),
4-selection buttons,
5- command line,
6-red LED (gamma alarm),
7- internal GM tube,
8-internal He-3 tube (neutron detection),
9-internal NaI(TI) scintillation detector

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www.thermo.com/rmp

Thermo SCIENTIFIC

Product Specifications

HP-360

Hand Probe Alpha/Beta/Gamma

Features

- Thin Window "Pancake" GM
- High Beta Sensitivity
- Protective Window Screen
- Ergonomic Enclosure

The Model HP-360 hand probe provides a sensitive beta detector, featuring a "Pancake" GM tube with a thin mica window. The HP-360 is identical to Thermo Electron's Model HP-260 with the exception of a new and stylish plastic housing.

This black housing is constructed from rugged ABS plastic and features an etched stainless steel screen (79% open area) over the GM tube to prevent punctures. The HP-360 design is also very ergonomic to fit in one's hand with greater comfort.

System Specifications

This detector permits useful beta sensitivities down to 40 keV and is alpha sensitive above 3 MeV. The background sensitivity to ^{137}Cs is approximately 3600 cpm/mR/hr and it is capable of seeing low energy photons down to approximately 10 keV.

The HP-360 is designed for contamination surveys on personnel, table tops, floors, equipment, etc. This detector is also available in a "Smart" configuration (Model SHP-360) for use with Thermo Electron's new generation of smart instruments like the Model E-600.

Operating Voltage
- 900 $\pm$ 50 Vdc

Plateau Length
- 100 Volts minimum

Plateau Slope
- 0.1 % per V maximum

Dead Time
- 50 µs maximum

Temperature Range
- -30 °C to 75 °C (-22 °F to 167 °F)

Mica Window Thickness
- 1.4 to 2.0 mg/cm^2

Mica Window Size
- 4.45 cm dia. (1.75")

Active Area
- 15.5 cm^2 (2.4 in^2)

Beta Efficiencies
- ^{137}Cs = 22%
- ^{60}Co = 16%
- ^{90}Sr ^{90}Y = 32%
- ^{99}Tc = 15%
- ^{14}C = 6%

Alpha Sensitivity
- 3 MeV at window

Connector
- BNC (Smart SHP-360 uses the Thermo Electron Smart connector)

Size
- 24.8 cm x 6.8 cm x 7 cm (9.75" L x 2.68" W x 2.75" H)

Weight
- 0.23 kg (0.5 lb)

OPTIONS

Smart Probe
Order part number SHP-360

Smart Probe Conversion
- To convert an existing HP-360 to a smart detector, order partnumber "SMARTPACBNC"

Check Source
- Order part number CS7A, approximately 5 uCi, ^{137}Cs

Probe Mounting Clip
- Order part number ZP11581038

About Thermo Fisher Scientific

Thermo Fisher Scientific (NYSE: TMO) is the world leader in serving science. The company enables its customers to make the world healthier, cleaner and safer by providing analytical instruments, equipment, reagents and consumables, software and services for research, analysis, discovery and diagnostics.

With annual sales of more than $9 billion, Thermo Fisher Scientific has 30,000 employees and serves more than 350,000 customers in pharmaceutical and biotech companies, hospitals and clinical diagnostic labs, universities, research institutions and government agencies, as well as environmental, industrial quality and process control settings.

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Thermo SCIENTIFIC

Product Specifications

HP-270/290

Hand Probes

Features

- Energy Compensated for Gamma Exposure Rate Measurements
- Sliding Beta Shield for Model HP-270

The HP-270 is an excellent general purpose GM probe with energy compensation and a beta shield, making it the choice for most health physics applications. The HP-270's energy compensation permits reliable exposure rate measurement from background to 100 mR/h for non dead time corrected instruments or up to 3 R/h for those equipped with dead time correction capability.

The HP-290 is a higher range GM probe with energy compensation, providing reliable exposure rate measurement from 0.1 mR/h to 10 R/h for non dead time corrected instruments or up to 80 R/h for those equipped with dead time correction capability.

System Specifications

	HP-270	HP-290
Operating Voltage	• 900 ± 50 V	• 550 ± 50 V
Plateau Length	• 100 V minimum	• 100 V minimum
Plateau Slope	• 0.1 % per V maximum	• 0.2 % per V maximum
Dead Time	• 100 µs typical	• 20 µs typical
Temperature Range	• -40 °C to 75 °C (-40 °F to 167 °F)	• -40 °C to 50 °C (-40 °F to 122 °F)
Wall Thickness	• 30 mg/cm^2 (tube only)	• 90 mg/cm^2 (tube only)
Wall Material	• Stainless Steel	• Stainless Steel
Gamma Sensitivity	• ~1200 cpm/mR/h (^{137}Cs)	• ~80 cpm/mR/h (^{137}Cs)
Energy Response	• See curve	• See curve
Housing	• ABS plastic	• ABS plastic
Connector	• BNC series coaxial	• BNC series coaxial
Size	• 3.5 cm x 15.2 cm (1.5” Ø x 6” Long)	• 2.9 cm x 8.9 cm (1” Ø x 3.5” Long)
Weight	• 142 g (5 oz)	• 57 g (2 oz)

AVAILABLE ACCESSORIES

Detector Cables

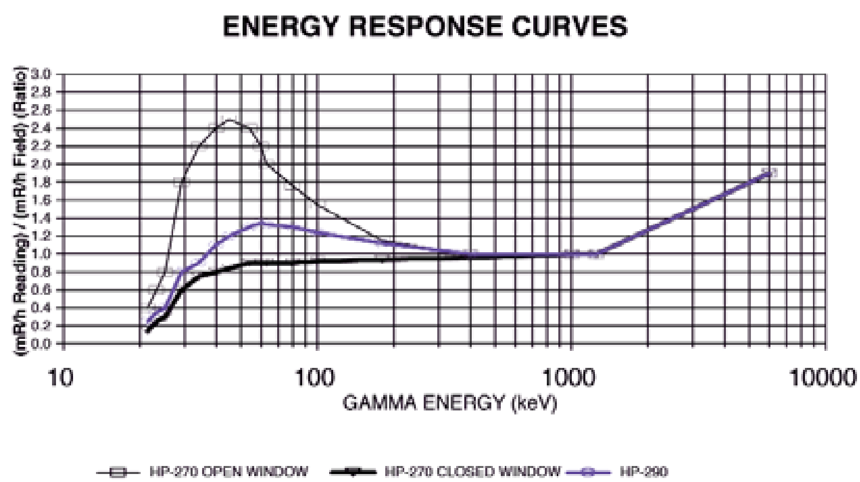
Instruments	36" Detector Cables	60" Detector Cables
E-120	CA-1-36	CA-1-60
RM-25	CA-16-36	CA-16-60
ASP-2	CA-16-36	CA-16-60
E-600	CA-102-36	CA-102-60

Check Source

- Model CS-7A, 5 µCi ^{137}Cs

Probe Clips

- ZP10434029



Energy Response of the HP-270 and HP-290 Hand Probes

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Thermo SCIENTIFIC

Product Specifications

The Scintillation HFM11-SC provides the proven class leading reliability and ease of use associated with the gas flow HFM11-GF, but with the added benefit of not requiring counting gas.

HFM11-SC

Scintillation hand and foot monitor

- Low power fan-less operation
- Large touch-screen color LCD display - no keyboard required
- Easy to maintain detector assemblies, minimal basic tools required
- Optional frisker probe
- Hex-mesh grills for greater comfort and detector protection
- Automated detector set-up and alarm checking routines
- Simultaneous monitoring of both sides of hand in compliance with IEC 61098
- Vertically mounted sprung hand detectors to minimize cross contamination

The HFM11-SC continues the development of this successful series of high performance hand and foot monitors. The hand and foot detectors use an established technique for monitoring alpha and beta radiation simultaneously. Sprung detectors clamp both sides of the hand monitor and monitor them simultaneously. The vertically mounted detectors minimize the risk of detector contamination, and the top-mounted occupancy sensors avoid blockages. Each foot detector utilizes two photomultiplier tubes in order to minimize the variation in efficiency across the area of the foot.

An optional frisker probe may be selected from the wide range of existing probes for monitoring alpha, alpha/beta, beta and low energy X-ray contamination. Status, instructions and results are clearly shown on the large colour LCD touchscreen making the monitor especially easy to use. This monitor does not require any peripherals to set up or configure; it is completely self contained.

The HFM11-SC is also designed with economy and reliability in mind. The low power consumption means there is no need for a cooling fan which might suck in dust and dirt, and there are no moving parts to fail - solid state Flash storage is used instead of a hard disk in the industrial PC controller, and photobeams are used in the positioning sensors instead of microswitches.

The modular 'X-channel' platform, with common controller boards and simple cabling, facilitates easy, low cost maintenance. It also provides detector intelligence and powerful controller functionality - such as the automated calibration and source checking with auto source decay correction routines. The X-channel architecture also allows easy retro-fitting of options such as the frisker probe. Sophisticated voltage scanning software is included which will clearly display the optimum voltage setting in order to discriminate between alpha and beta radiations.

HFM11-SC Radiological Specifications

Detectors:		**Hands**	**Feet**
Sensitive area:		260 cm^2	560 cm^2
Window:		1.2 $mg.cm^{-2}$ of aluminized Mylar	
Scintillator:		Zinc sulphide and plastic	

Radiological Performance		**Hands**	**Feet**
Alpha:	^{241}Am	34 %	26 %
(% of surface emission rate)	Nat U	12 %	6 %
Beta:	^{14}C	8 %	5 %
(% of surface emission rate)	^{60}Co	25 %	20 %
	^{36}Cl	45 %	37 %
Gamma: *(approx count rate in uniform field of 660 keV photons at 1 μSv/h)*		130	270
Uniformity:	^{241}Am	±15%	±75%
(variation across surface of detector)	^{90}Sr/^{90}Y	±15%	±60%

Monitor:		
Alarm settings:	By the use of large area calibrated sources or by touch-screen entry of calculated efficiencies. All HFMs are factory-tested with reference sources.	
Background update time:	100 s rolling average, with checking for changing background	
Monitoring time:	Auto assessment of time required to meet the statistical requirements in the given background: 1 to 100 s	
Control:	Audible and visual alarms occur if a hand or foot is out of position.	
Indications:	Digital screen displays for alpha and beta levels for each hand and foot. Magnitude and type of contamination is displayed.	
Audible indication:	Separate indications for 'Out Of Position', 'Clear' and 'Alarm' states, as on previous HFM versions.	
Probability of false alarm:	0.1 to 10 sigma in 0.1 sigma steps	
Probability of detection:	0 to 10 sigma in 0.1 sigma steps	
Self test:	High Voltage, detector response, detector contamination and background level are monitored.	
Digital I/O connections:	RS-232, Parallel printer port, Ethernet and USB.	
Environmental:	Operational temperature range: 5 °C to 45 °C (41 °F to 113 °F) Humidity: up to 95% at 35 °C (95 °F) (non-condensing)	
Power requirements:	90 to 264 VAC (auto-ranging power supply), 47 to 63 Hz, 85 VA max.	
Dimensions:	Height:	1400 mm (55.1") 1765 mm (69.5") with lid fully open
	Width:	876 mm (34.5")
	Depth:	825 mm (32.5")
Weight:	125 kg (275 lb) approx. unpacked.	

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Product Specifications

The FLM-3 Floor Monitor consists of a Delta 5 ratemeter and a choice of ruggedized 600 cm^2 scintillation probes for alphas, betas, or alphas and betas simultaneously.

FLM3

Floor Monitor

- Highly mobile, light-weight assembly
- Rapid, sensitive monitoring
- Includes background subtract, alarm settings and integrate mode
- Steel roller balls for smooth floors fitted as standard

The FLM3 Floor Monitor is suitable for monitoring large areas and surfaces for radioactive material. It is ideal for rapid, sensitive monitoring of controlled areas, truck beds, entrance rugs and similar applications. Enclosed ball cages are fitted to the standard monitor giving high mobility on flat surfaces. They provide complete freedom of movement in all directions with essentially total coverage including corners and edges. An optional external wheel mounting kit is available. It has alternative height settings and is used on uneven surfaces where extra window protection is desirable. The Monitor consists of a sensitive scintillation probe with a 600 cm^2 radiation window, protected by a rugged hex-mesh grill, plus a standard Delta 5 microprocessor-based ratemeter. Count rates are shown on a large, clear display. Additional features such as background subtraction, pre-settable alarms and integrated counts are used to increase the measurement precision. Audible signals occur for each particle detected. Headphones, for use in noisy environments, are included as standard.

The hinged handle and sturdy, durable, light-weight housing provide for effortless monitoring even over long periods of use. The FLM3 is available in different versions to improve the radiation selectivity Three versions are supplied as standard:

- FLM3A for alpha
- FLM3B for beta
- FLM3D dual channel for alpha and beta

FLM3 Specifications

TECHNICAL SPECIFICATIONS

DETECTOR	**FLM3A**	**FLM3B**	**FLM3D**
Radiation detected:	Alpha	Beta	Alpha and Beta
Window area:	30 x 20 cm (12” x 8”)	30 x 20 cm (12” x 8”)	30 x 20 cm (12” x 8”)
Window thickness:	1.2 mg.cm²	1.2 mg.cm²	1.2 mg.cm²
Efficiencies:	% surface emission counted hem a 15 x 10 cm source placed centrally on the grill		
241Am (a):	31%	-	28%
36Cl (b):	-	36%	31%
90Sr/90Y (b):	-	42%	36 %
60Co (b/g):	-	19%	12%
γ responses:	-	250 cps/mSv/h	180 cps/mSv/h
α channel background:	<0.2 cps	-	<0.2 cps
β channel background:	-	28 cps	20 cps
Grill:	Hex mesh, 80% transmission		

ON-BOARD DELTA 5 RATEMETER

- Ranges, 0.1 cps to 100,000 cps, or I cpm to 1,000,000 cpm
- High-contrast analog and digital liquid crystal display
- Alpha, beta, or alpha plus beta display modes
- Choice of displayed units
- Count rate mode
- Integrate mode
- Background store and subtract mode
- Setup mode with calibration facility
- Audio with alarm settings

Headphones:	Light weight, CD quality, stereo headphones with 3.5 mm (0.14“) jack connection to Delta 5
Temperature:	0 to 40°C (32 to 104°F)
Humidity:	up to 95% RH, non-condensing

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Thermo SCIENTIFIC

Product Specifications

FHT 1388 S

Modular Radiation Portal Monitors

The modular FHT 1388 S radiation portal monitors secure sites against the movement of contaminated material and orphan sources.

It is a proven radiation portal monitor in the European steel and recycling market. Our qualified Service Team and Service Partners are at call to maintain the performance and reliability of the FHT 1388 S monitors.

Since the introduction in 1995, the FHT 1388 series of radiation portal monitors have been periodically updated to keep up with market needs and technological developments.

Hundreds of installations in Europe and around the world provide protection against radioactive contamination day in and day out.

- Large plastic scintillation detectors for gamma radiation detection
- Immediate separation between NORM and artificial radiation through NBR (Natural Background Rejection) technology
- Optional moderated He-3 counting tube Neutron radiation detectors
- Effective false alarm suppression through automatic background radiation learning and SIGMA alarm threshold setting
- Recognition of objects plus speed alarm triggering
- Control of traffic lights, audible alarm indication via horn or visible via alarm lights
- Data transfer via RS 485 from the detector array to the operators room up to 1000 m
- Win XP based controller model FHT 8000 with 32 bit SGS2 software package
- Automated protocol printing also on a network printer
- Optional LAN video camera can easily integrated
- Optional axle counter insures alarm location information also for most demanding train applications

The FHT 1388 S detector panels are equipped with large area plastic scintillators for the efficient detection of gamma radiation. The panel housings are made of UV-stabilized PE material that is corrosion free even under demanding conditions. Low energetic radiation can penetrate through the PE material easily and is not shielded from the sensitive large area gamma radiation detector.

The detector panel array communicates with the electronics in the operator's room via a reliable RS 485 data bus over up to 1000 m. The modern design of the electronics comprising our controller model FHT 8000, operating Microsoft Windows XP. The advanced software package SGS2.EXE allows protected access on different user levels. Features like the FHT 8000's build-in Ethernet card or optional supervision software for up to 10 FHT 1388 S monitors underline this modern monitoring concept.

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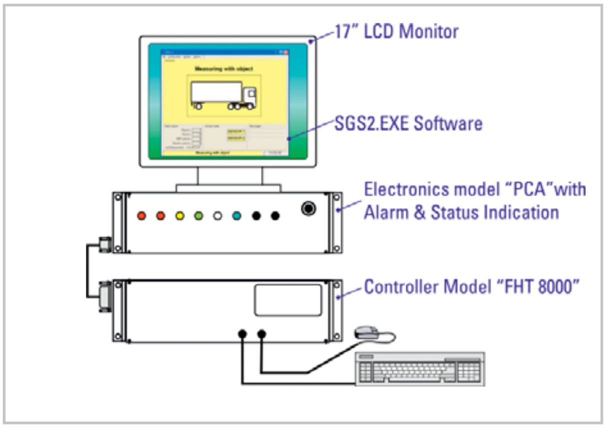


Standard supply of electronics for the operator's room.
(FHT 1388 S verions 1460 G VER, 3000 G VER & HOR, 6000 G HOR)

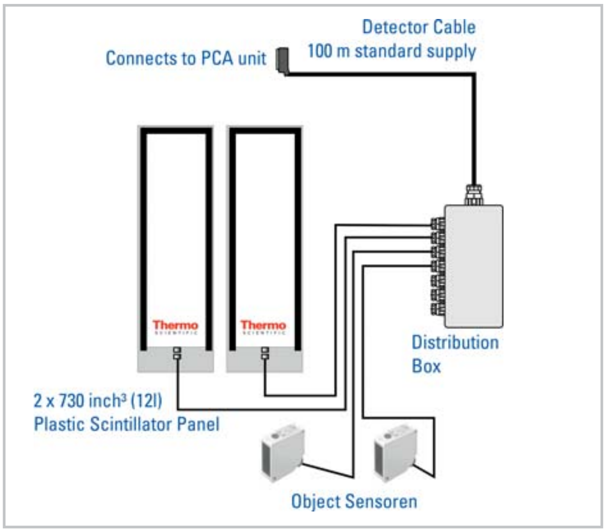
Technical Specifications:

Operating conditions for the electronics in the operator's room:
Ambient temperature range: 0 °C ... 40 °C, (32 °F ...104 °F)
Relative air humidity: 10% to 90% (not condensing)

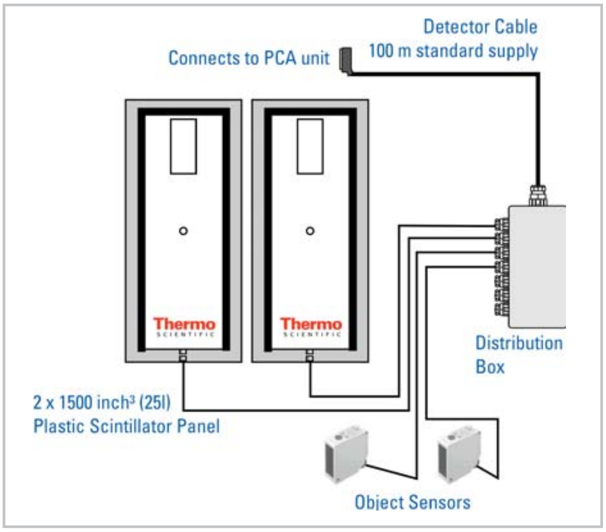
Operating conditions for the equipment at the detector array:
Ambient temperature range: - 40 …60 °C, (- 40 …140 °F)

Measured value:
Gamma radiation from approx. 40 keV

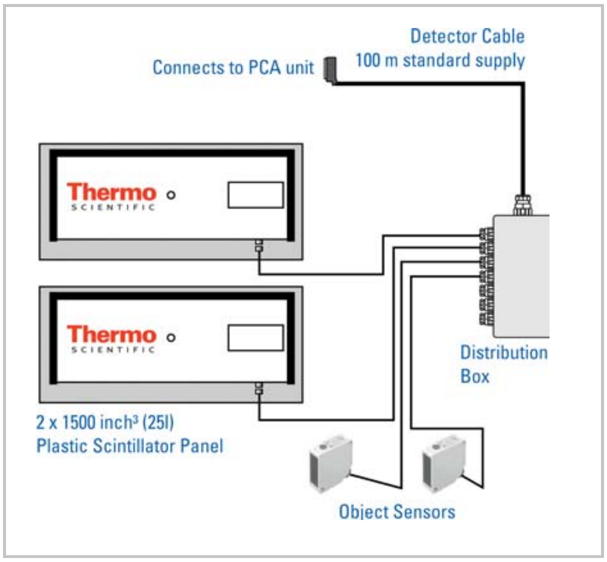
Available options:
Video camera (LAN), axle counter (train), protocol printer, modem for tele service, traffic lights (red & green), extra panels (gamma & neutron), lead shielding, alarm devices (sound & light), gamma test adapter (panel and system performance test), stanchions & installation.



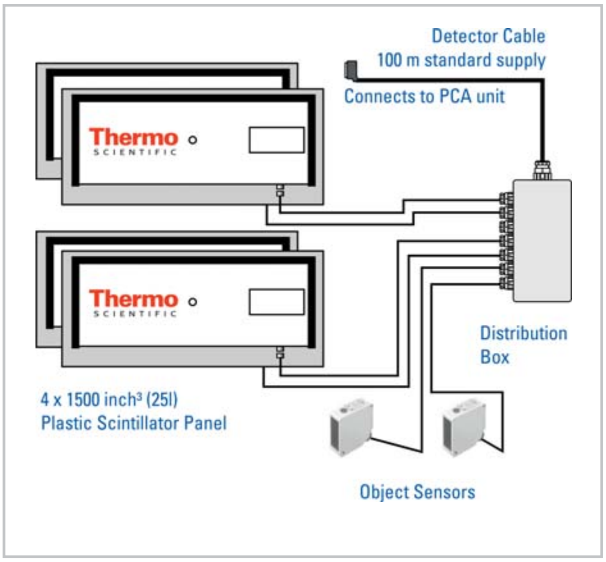
FHT 1388 S 1460 G VER: Standard equipment for the detector array



FHT 1388 S 3000 G VER: Standard equipment for the detector array



FHT 1388 S 3000 G HOR: Standard equipment for the detector array



FHT 1388 S 6000 G HOR: Standard equipment for the detector array

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SCIENTIFIC

Product Specifications

Radioactivity monitor with GPS-data logging for rapid response vans

FHT 1376 MobiSys

Mobile radioactivity monitor

Features

High sensitivity 5 liter plastic detector for locating radio-active source

Dose rate change in nSv/h range immediately detected

Natural Background Rejection (NBR) indicates artificial sources

Advanced Digital Filter (ADF) makes possible data collection at road speed

Automatic adjustment to background variations

Radiation data recorded with GPS and time stamp

Familiar Windows® operating environment

The Measurement System

The FHT 1376 MobiSys was developed for the rapid detection and location of gamma emitting radioactive sources in large areas. The FHT 1376 system provides survey teams with a tool for effectively addressing the problems of orphaned sources, radiological contamination, and maliciously introduced sources.

The system continuously records radiation data associated with GPS location and time data, while mounted in a moving vehicle. It is readily adaptable to a wide range of vehicles.

The FHT 1376 MobiSys consists of a high sensitivity, 5 liter plastic gamma radiation detector and a compact Global Positioning System (GPS). With the addition of an optional FH 40 GL-Ω advanced survey meter, accuracy is ensured in high radiation environments. All components (with the exception of the antenna) are contained in a rugged carrying case and can be transported in any conventional vehicle.

A notebook computer links the gamma radiation detector, the GPS system, and the FH 40 GL-Ω. The system may be powered by the vehicles 12 volt power supply or any equivalent supply. The GPS system uses an external magnetic mount vehicle antenna.

The FHT 1376 MobiSys makes use of both the Natural Background Rejection (NBR) and the Advanced Digital Filter (ADF) technologies. NBR identifies the signature of artificial radiation sources, while rejecting the signature of naturally occurring background sources which are always present and fluctuating. ADF ensures optimal extraction of the data. Together, NBR and ADF allow for the routine detection of artificial gamma radiation levels in the range of nSv/h in the presence of changing natural backgrounds.

The following data are collected and stored every second:

- GPS (i.g., position, velocity)
- Total gamma dose rate (1 nSV/h to 20 μSv/h measured by the NBR-detector)
- Total gamma dose rate (100 nSv/h to 100 mSv/h) measured by the optional FH 40 GL-Ω advanced survey meter
- Artificial gamma dose rate (NBR)
- Raw data count rates for offline analysis
- Date and time (UTC)

Display and alarms

Measured gamma radiation and GPS data are acquired and displayed by the notebook computer each second.
Gamma radiation anomalies, identified by NBR as artificial, will be indicated in real time by visible and audible alarms. System failures are also signaled.
The route of the FHT 1376 may be displayed in real time on the notebook computer GPS mapping system. The FHT 1376 system is implemented in German, English and French languages. Other languages available upon request.

Detector Specification

Technical data

Measured quantity:	Gamma radiation > approx. 100 keV
Sensitivity:	Typical 20000 cps/μSvh-1 (^{137}Cs)
Detection limits: Gross: NBR:	 approx. 2 nSv/h equivalent count rate relative to background level (^{137}Cs) 20% artificial dose rate contribution to the current natural gamma background level typically
Features of the equipment case: Dimensions: Accessories case: Total weight:	 approx. 520 x 280 x 200 mm (20.5” x 11” x 7.9”) approx. 360 x 280 x 140 mm (14.2” x 11” x 5.5”) approx. 14 kg (31 lbs.)
External connections and cables (5 m each):	12 VDC with connector for vehicle power supply GPS-antenna USB-interface to the notebook
Current consumption:	approx. 200 mA by 12 VDC (without notebook)
Notebook (optional):	Requirements: USB-interface, Pentium-processor, 32 MB RAM, hard disk 5 GB, Windows™ 98 or 2000, accumulator supply and/or 12 VDC vehicle power supply

Detector Specification

NBR = Natural Background Rejection

The NBR measurement method has been developed for extremely fast discrimination between natural and artificial gamma radiation. Worldwide more than 1000 devices, based on this technology, are in use.

NBR has a rapid response time. Artificial gamma radiation sources are identified in seconds by operators with basic training levels.

Unlike conventional spectroscopic based gamma identification systems, the systems using NBR do not require the presence and resolution of gamma spectral lines. Because of this flexibility, NBR can also definitively distinguish artificial high energy beta sources and heavily shielded gamma ray sources from fluctuating natural background sources.

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Product Specifications

The FHT 1372 Radioactivity Monitor is used as a stationary system for fully automatic monitoring of personnel airlocks or luggage belts for entrained radioactive sources.

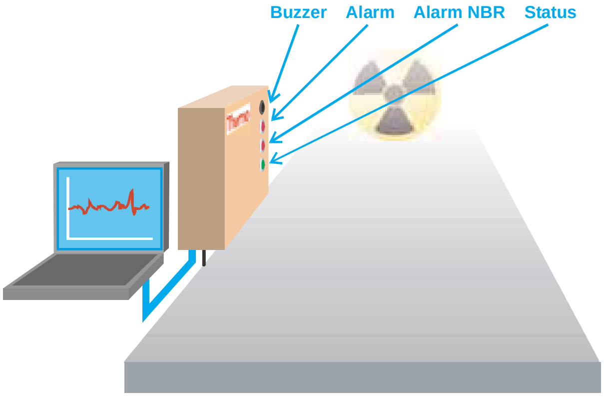
FHT 1372

Radioactivity monitor for personnel, cars, bikers and baggage

- Very high gamma sensitivity
- Selective detection of artificial radioactivity
- No user operation necessary
- Automatic or manual alarm reset selectable
- No installation required
- Optional monitoring channel for thermal and fast neutrons
- Access to system configuration with a notebook or PC

Implementations:

- Conveyor Belts
- Border Stations
- Indoor & Outdoor
- Airports
- Harbors



A highly sensitive scintillation detector, along with an ADF (Advanced Digital Filter), allows for extremely sensitive and rapid monitoring to take place. Regardless of the radioactive source's speed of travel, the optimum measuring mode is automatically set in each case. It is not necessary for the person or the object of measurement to stop in front of the monitor. Thus, the monitor can be operated unobtrusively without affecting the progress of the person or item of luggage.

Through use of the NBR process (NBR = Natural Background Rejection), developed by Thermo Fisher Scientific, it is possible to detect small amounts of artificial gamma radiation in the nSv/h range, even against a fluctuating natural background. Additionally an integral alarm level can be adjusted in order to detect an excessive total dose rate level.

If a radioactive source is detected an audible alarm is triggered. In addition, the alarm can trigger a relay which could transmit the alarm message to a remote alarm unit (horn, light, etc.). If the alarm is due to artificial radioactivity, the green LED will turn off and a red LED stay lit as long as the artificial gamma radiation is present. According to the user-selectable setup, the alarm can be cancelled automatically or may require the manual reset by a push-button built into the electronics of the FHT 6020, included with the FHT 1372 system.

FHT 6020

Built-in Electronic FHT 6020

The management of count rates and alarm settings is done by a FHT 6020 electronic.

The key features of this FHT 6020 electronic are:

- Obtains data every second
- Displays and stores approximately 2000 data points
- Controls alarm values
- Communicates with detectors via RS485
- System parameters configured via a serial connection to a PC via a Windows™ based program
- Configuration program is password protected so only authorized operators may change system parameters
- Four integrated LEDs indicate the current system status
- Installed buzzer to indicate an alarm
- Displayed gamma dose rate unit can be set to Sievert (Sv/hr) or Roentgen (R/hr)

Detection of fast and thermal neutrons

FHT 752 SH

The optionally available probe FHT 752 SH offers the secure monitoring of thermal and fast neutrons. This probe shows an excellent separation between neutrons and gamma rays and is placed inside the FHT 1372 housing.
The FHT 752 SH is compliant to the ITRAP requirements for hand-held neutron detectors.

Technical data

Dimensions of detector (effective detector volume):	standard: 220 x 220 x 100 mm (8.7” x 8.7” x 3.9”) other dimensions available on request
Sensitivity:	approx. 20000 cps/(Sv/h) for Cs-137
Background:	typ. 800 cps
Energy range:	approx. 30 keV ... 1.5 MeV
Recommended temperature range:	0 °C to 40 °C (32 °F to 104 °F)
Rel. air humidity:	10% to 80%, without condensation
Protection:	IP 54
Supply voltage:	AC 100 -250 V, DC 10 - 30 V optional
Relay contacts:	
Voltage (max):	150 VDC / 125VAC
Current (max):	2 A
Breaking current (max):	35 W (DC) / 60 W (AC)
Housing dimensions:	approx. 680 x 440 x 280 mm (26.8 “ x 17.3” x 11.0”)
Weight:	17 kg (37.5 lbs.)

NBR = Natural Background Rejection

The NBR measurement method has been developed by Thermo Fisher Sientific, Erlangen (Germany) for extremely fast discrimination between natural and artificial gamma radiation. Worldwide more than 1000 devices, based on this technology, are in use.

NBR has a rapid response time. Artificial gamma radiation sources are identified in seconds by operators with basic training levels.

Unlike conventional spectroscopic based gamma identification systems, the systems using NBR do not require the presence and resolution of gamma spectral lines. Because of this flexibility, NBR can also definitively distinguish artificial high energy beta sources and heavily shielded gamma ray sources from fluctuating natural background sources.

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Thermo SCIENTIFIC

Product Specifications

For simultaneous evaluation of 6 or 12 samples with ø 60 mm concerning alpha- and beta/gamma-activity

FHT 770 T

Multi Low Level Counter with 32-bit user Windows™ software

Low limits of detection and decision

By the extremely low background measurement of typically ≤ 1 pulse/min (0,017 s^{-1}) in beta/gamma-operating mode, very small limits of detection can be achieved. For that purpose, the utilized proportional window counter tubes are coupled anticoincidentally with a guard counter and surrounded by a lead shielding of 100 mm (4") thickness.

Time gained by multiple measurement

The standard version of the Low Level Counter is equipped with 3 sample slides for 2 samples each. Alternatively, the Low Level Counter can be delivered with 6 sample slides for 12 samples in total. In this case, the overall height increases by app. 5 cm (0.2").

Processing of measured values

The standard version (6 sample planchets) of the Low Level Counter is equipped with one 16-channel counter board, the extension (12 sample frames) with a second 16-channel counter board used for signal processing. Above each measuring position a counter tube with 60 mm (2.4") window diameter is mounted. A simultaneous evaluation of alpha and beta/gamma-activity is possible by applying pulse height discrimination. Individual measuring parameters can be assigned to each measuring frame, such as measuring time, calibration factors etc. Of course, the measuring frames may be configured identically for a series of measurements with many similar samples.

Documentation of measured values

Documentation of measured values in current protocols and formats is getting more and more important. To do this the user can determine the size of data sampling and data storage himself (option). By using different printing possibilities, the measured values can be issued in prefabricated protocol-layouts (e.g. in conformity with DIN ISO 7503). If the number of samples is high, it is also possible to issue them structured line by line. The report generator which can be obtained optionally allows to issue individual protocol formats. The measured values as well as the selected additional information can be stored either in ASCII- or ACCESS data- or file format respectively. The integration of a network card or a modem (option) contributes to the ease of operation.

High flexibility

The completely revised evaluating system which is designated for 32 bit operating systems (WINDOWS™ NT) was developed in close dialog with the users.

With this method, once defined measuring tasks can be stored together with the required parameters in so-called "job-files" which are available when needed for a special measuring task. Different access authorizations make sure that relevant changes in measuring parameters can only be carried out by authorized persons.

Specification

FHT 770 T

Radiological characteristics

Alpha background measurement: ≤ 0.05 min^{-1}	
Beta/gamma background measurement: ≤ 1 min^{-1}	
Sensitivity: (typical values, measured with ø 60 mm (2.4”) sample discs)	
Cs-137:	0.38 s^{-1}/Bq
Co-60:	0.25 s^{-1}/Bq
C-14:	0.24 s^{-1}/Bq
Am-241 (α):	0.26 s^{-1}/Bq

Mechanical characteristics

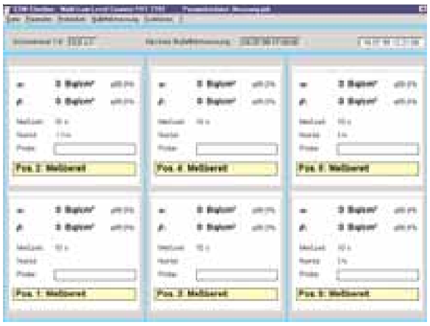
Dimensions:	for 6 sample frames: 62 x 45 x 65 cm (24.4” x 17.7” x 25.6”)
	for 12 sample frames: 62 x 50 x 65 cm (24.4” x 19.7” x 25.6”)
Weight:	930 kg/1150 kg (2050 lb/2535 lb)
Counter gas:	Ar/CH4; Ar/CO2 (test gas quality)
Operating voltage:	110 V/230 V, 50-60 Hz

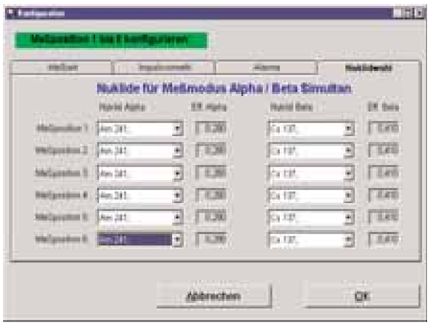
Software FHT 770 T

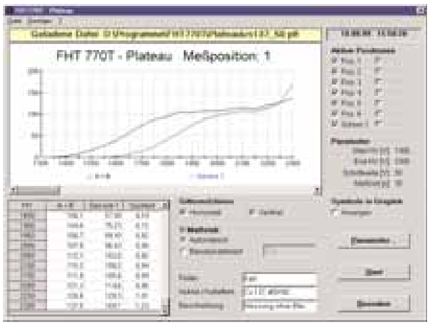
The software of the Multi Low Level Counter meets current requirements of modern network software for Windows NT. It can be handled easily and offers high flexibility. Therefore, the operating software comprises modules for automatic plateau curve measurement of the counter tubes as well as a comfortable calibration software.

The measuring program of the FHT 770 T offers e.g.:

- Menu guided entry of all measuring parameters.
- Starting and stopping of measurement by inserting or removing the slide.
- Free preselection of nuclides and free selection of the measuring time for each sample frame.
- Output of all raw count rates by using "short cuts" for test purposes.
- Monitoring of alarm and failure can be set for each measuring frame.
- Layout of the measuring protocol can be selected freely (option).
- Up to 5 freely configurable calibration and calculation parameters can be set.
- Calculation of the limits of detection and decision according to ISO 11929, p. 1.
- Automatic calculation of measuring time to comply with predetermined limiting values.
- Storing of data in ASCII- or ACCESS-format alternatively.
- Different operator access levels.
- Automatic background measurement at a predetermined point of time.
- Multiple measurement for one sample can be selected.
- Automatic plateau measurement which can be stored and printed.
- Calibration of counter tube and transfer of efficiency values to an internal nuclide table.
- Input of a sample identification.
- Automatic monitoring of the counter tube operating points.







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Thermo SCIENTIFIC

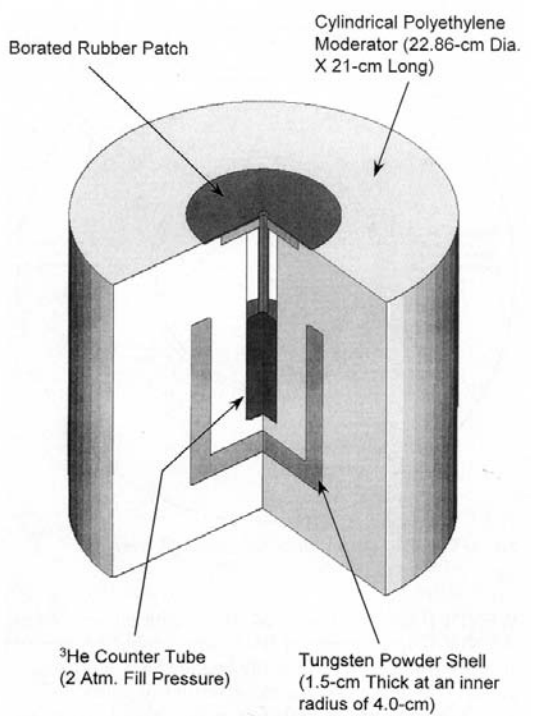
Product Specifications

The FHT 762 is a neutron dose rate detector featuring a high sensitivity and an excellent energy- and angular response

FHT 762 Wendi-2

Wide Energy Neutron Detector

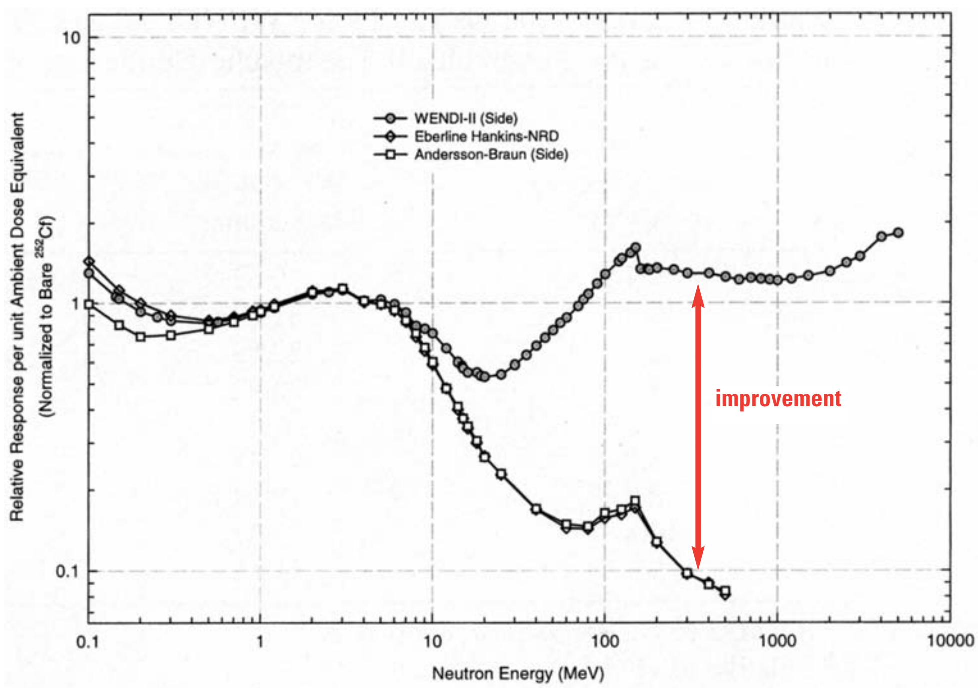
- Thermal to 5 GeV energy range according to H*(10), ICRP 74
- High sensitivity due to large He-3 tube
- Excellent gamma rejection
- Fits to FHT 6020 area monitor and FH 40 G survey meter



Reference: Olsher et al, Health Physics, 79(2): 170ff, 2000

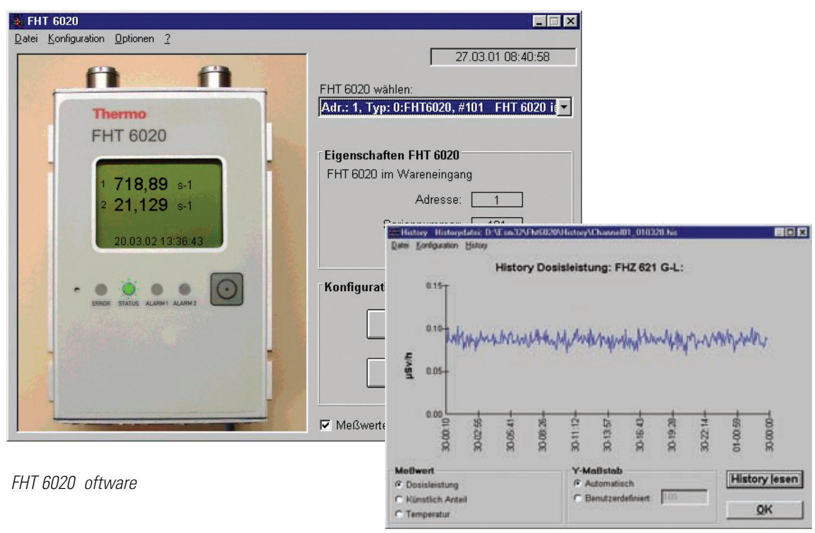
FHT 762 Wendi-2 with FH 40 G survey meter

The Wide Range Neutron Detector FHT 762 combines excellent energy response in the "normal" energy range up to 15 MeV with a close match to the H*(10) behaviour up to 5 GeV. As well excellent angular response and gamma rejection data are provided by the WENDI-2-design which was originally developed at Los Alamos. No significant spill-over needs to be considered for gamma dose rates up to 1 Sv/h.



Reference: Olsher et al, Health Physics, 79(2): 170ff, 2000

FHT 6020 area monitor



FHT 6020 oftware

Technical Specification

FHT 762 Wendi-2

Measuring range	0.01 µSv/h to 100 mSv/h Cf-252	**Gamma-sensitivity**	1 to 5 µSv/h at 100 mSv/h, 662 keV
Sensitivity	0.84 cps/(µSv/h) Cf-252	**Ambient temperature**	-30 to +50 °C
Energy range	25 meV to 5 GeV according to ICRP 74 (1996)	**Humidity**	up to 90 % non condensing
Angular dependence	±20 % all directions	**Atmospheric pressure**	500 to 1500 hPa
Linearity	±20 %	**Height**	320 mm (12.6")
Diameter	230 mm (9")	**Weight**	13.5 kg (29.8 lb)

Thermo SCIENTIFIC

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Product Specifications

The new generation of truly smart radiation detectors.

FHT 40 NBR

Portable NBR radiation monitor

Operational areas

- First responders
- Civil defense
- Fire brigades
- Environmental monitoring
- Remediation

FHZ 672 E-10

The detector of the new FHZ 672 E-10 is a complex combination of organic scintillator material, a NaI(Tl)-crystal and extremely fast evaluation electronics.

With this combination of detectors, an energy characteristic according to the ambient dose equivalent H*(10) is achieved.

The high efficiency of this detector allows an accurate determination of the dose rate within a few seconds and an immediate decision about whether it is natural or artificial radiation.

FH 40 GL-10

The development of the high-tech radiation meter FH 40 GL-10 was governed by customers' requirements and the need for versatility.

Flexible data storage

The stored measured values can be accessed any time and seen on the display of the advanced survey meter. For further processing and archiving purposes, it is possible to transfer the history contents to a PC via the FH 40 GL-10 interface.

Intelligent Ratemeter-Algorithm (ADF-Mode)

Guarantees that even the smallest changes of dose rate are immediately detected, while at the same time, statistical fluctuations are effectively suppressed.

Configuration by PC

The desired functions can be activated or hidden to the user by using the Windows™ based operating system. This means that the characteristics of the FH 40 GL-10 precisely correspond to the measurement task, thus operator errors are minimized. It can be made as simple or complex as the users application needs.

Technical data

FH 40 GL-10	
Energy range:	30 keV to 4.4 MeV
Measuring range:	500 nSv/h to 100 mSv/h
Sensitivity:	approx. 2 s-1 / µSv/h
Weight:	approx. 410 g (0.9 lbs.) without batteries
Operating time without FHZ 672 E-10:	> 250 h
Operating time with FHZ 672 E-10:	> 30 h

FHZ 672 E-10	
Energy range:	48 keV to 6 MeV
Measuring range:	1 nSv/h to 100 µSv/h
Sensitivity:	approx. 2000 s-1 / µSv/h
Detection limit of artificial gamma radiation:	< 20 % of natural dose rate typically
Weight:	approx. 4000 g (8.8 lbs.)

NBR = Natural Background Rejection

- The NBR measurement method has been developed by Thermo Fisher Scientific, Erlangen (Germany) for extremely fast discrimination between natural and artificial gamma radiation. Worldwide, more than 1000 devices based on this technology are in use.
- NBR has a rapid response time. Artificial gamma radiation sources are identified in seconds by operators with basic training levels.
- Unlike conventional spectroscopic based gamma identification systems, the systems using NBR do not require the presence and resolution of gamma spectral lines. Because of this flexibility, NBR can also definitively distinguish artificial high energy beta sources and heavily shielded gamma ray sources from fluctuating natural background sources.

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Thermo SCIENTIFIC

Product Specifications

Hand and foot monitor with flow type counter tubes or sealed xenon counter tubes for alpha/beta or gamma monitoring

FHT 65 LL/LLX

Hand and foot monitor

- Superior performance
- Rational, cost-effective design without loss of measuring quality
- Ease of installation by virtue of small foot print and flexible positioning of the FHT 6020 display unit
- Comfortable and easy configuration of the FHT 65 LL/LLX using the FHT65LL Windows™ configuration program
- The FHT 65 LL allows simultaneous alpha/beta measurement
- Identical hand and foot counter tubes
- Clear user information in different languages

The FHT65 LL/LLX hand and foot monitors measure and record surface contamination on the hands, wrists and feet of personnel in the medical, radiochemistry and nuclear industries.

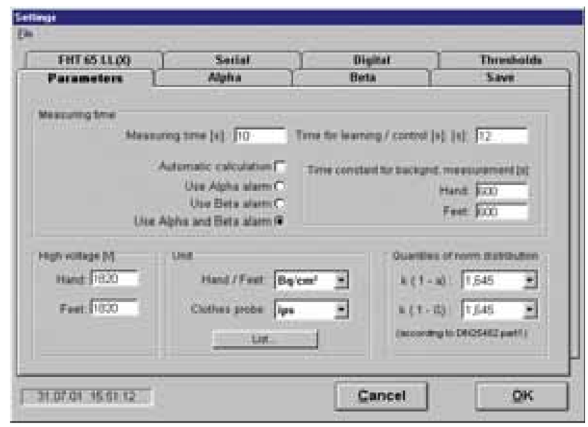
FHT 65 LL: Flow-type counter tubes for Ar/CH_4, Ar/CO_2 or C_{h4} for alpha/beta monitoring.

FHT 65 LLX: Sealed xenon counter tubes for gamma monitoring.

By virtue of its compact size and light weight, the FHT 65 hand and foot monitors are readily transportable and can be moved through any standard doorway. The monitors are also durable, with the counters having a large surface area and protection by built-in stainless steel grills.

The monitors are configured with a PC, via the FHT 6020 display units interface, using a supplied configuration program, illustrated below.

Measurement parameters



The “FHT65” tab

Technical Specifications

Size (in operation):	Approx. 1400 H x 380 W x 750 D mm (55" H x 15" W x 29.5" D)
Weight:	35 kg (77.2 lbs) approx.
Ambient temperature:	+5 °C to +50 °C (41 °F to 122 °F)
Relative air humidity:	10 % to 90 %, non-condensing
Protection system:	IP30
Voltage:	85 to 285 VAC, 47 to 63 Hz
Power requirements:	< 10 W
Display ranges:	0.01 to 1000 s^{-1} 0.01 to 1000 Bq/cm^2

For more technical information and details please ask for technical specification ZT-020.

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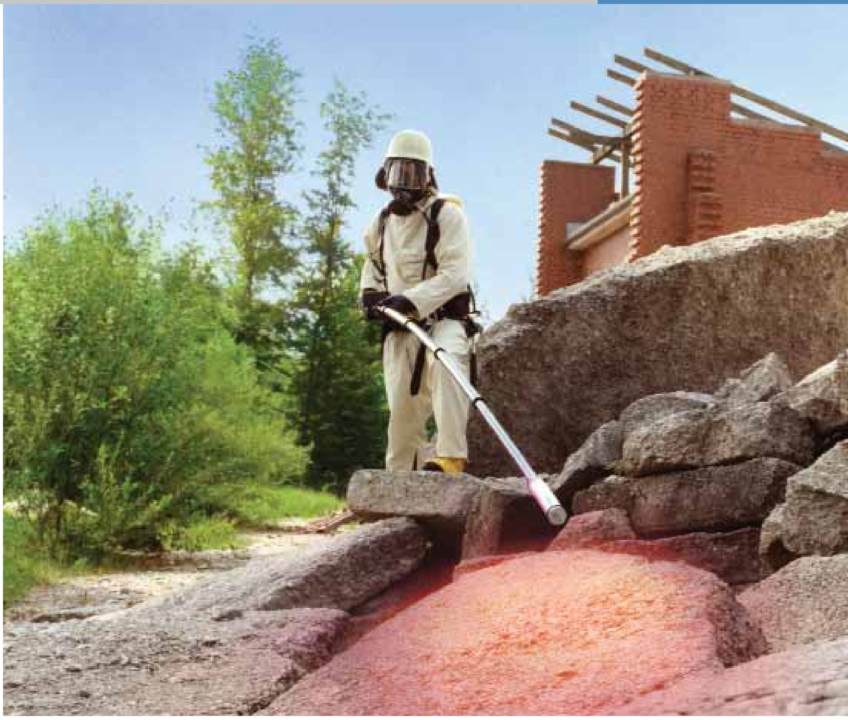
Thermo SCIENTIFIC

Measurement of dose and dose rate
with a secure distance.

Product Specification

FH 40 TG

Teleprobe



- Simultaneous operator dose and doserate measurement
- Modular design allows easy exchange of components
- Teleskop reinforced, isolating fiberglass material, fully watertight
- Extendible up to 4 meters (approx. 13 ft.)
- 100 nSv/h - 10 Sv/h (10 µR/h - 1000 R/h)
- Interchangeable probes for different measurement tasks
- "Smart probe" with individual calibration

Application range:

Nuclear power plants

Nuclear industry

Recycling industry

Emergency response

Fire brigades

Nuclear medicine

Research

Security

- The TeleprobeFH 40 TG is a valuable tool for all situations where an extended range is required, or high radiation may occur.
- It acts as an external detector to the FH 40 G dose and dose rate meter. A lightweight but very rugged telescope extends up to 4m (approx. 13 ft).
- The FH 40 TG System allows the simultaneous dose and dose rate measurement at the operator end while measuring the dose rate at the teleprobe end - 4 meters (13’) away. In normal use the measured values of the teleprobe detector is displayed, but with the push of a button the operator can check the dose rate where he is actually standing.

Alarms

For both detectors independent alarm levels may be set - this is especially useful during search applications. The acoustic alarm is activated upon reaching either alarm level. Thus the dose of the operator is also monitored.

Flexibility

- The standard detector of the teleprobe, FHZ 612, contains two energy compensated Geiger-Müller tubes covering a range from normal background up to 10 Sv/h (1000 R/h).
- For special applications, the detector head can be exchanged with a 1" x 1"-NaI(Tl) detector for high gamma sensitive or special neutron detectors. There is also a beta-sensitive probe available.
- And, of course, the FH 40 G Survey Meter itself can be used with a number of different external probes.

Optional

- Aluminium case for Teleprobe FH 40 TG und Survey Meter FH 40 G. Dimensions: Approx. 950 x 160 x 150 mm (38” x 6” x 6”).
- FH 40 G-X Display-Unit (optional): FH 40 G without internal detector.

Detector options

FHZ 612	wide range γ, Hx	2 GM-tubes	0,1 µSv/h - 10 Sv/h	> 82 keV	2 cps/µSv/h (662keV)	0,15 kg (0.3 lb)*
FHZ 612-10	wide range γ, H*(10)	2 GM-tubes	0,5 µSv/h - 10 Sv/h	> 60 keV	"	0,15 kg (0.3 lb)
FHZ 612-B	wide range γ, Hx	2 GM-tubes	0,1 µSv/h - 10 Sv/h	> 82 keV	"	0,15 kg (0.3 lb)
FHZ 632 L	medium range γ, Hx	Prop. tubes	0,1 µSv/h - 0,1 Sv/h	> 36 keV	"	0,1 kg (0.2 lb)
FHZ 632 L-10	medium range γ, H*(10)	Prop. tubes	0,1 µSv/h - 0,1 Sv/h	> 30 keV	"	0,1 kg (0.2 lb)
FHZ 512	sensitive γ-sniffer	1"x1"- NaI	1 - 100 000 cps		300 cps/µSv/h (662keV)	0,5 kg (1.1 lb)**
FHT 752 S	sensitive neutron sniffer	BF3-tube	1 - 100 000 cps		2 cps / µSv/h (Cf-252)	0,8 kg (1.8 lb)**
FHT 752 SH	sensitive neutron sniffer	He-3-tube	1 - 100 000 cps		6 cps / µSv/h (Cf-252)	0,8 kg (1.8 lb)**

* Standard in FH 40 TG

** A heavy duty, low-cost telescope version is alternatively available which fits all above mentioned detector options (weight: 1,5 kg (3.3 lb); length: 1,6 - 3 m (5.3 to 9.8’) ; material: aluminium).

Technical Data

FH 40 TG	
Telesprobe FH 40 TG with standard detector FHZ 612	
Measuring range:	0,5 µSv/h - 10 Sv/h
Detectors:	Two energy compensated GM tubes with automatic switch-over
Telescope:	5 segments, reinforced fibre glass
Weight:	2,6 kg (5.7 lb) telescope with detector 3,0 kg (6.6 lb) complete with FH 40 G
Length:	Extended length: > 4 m (13’)

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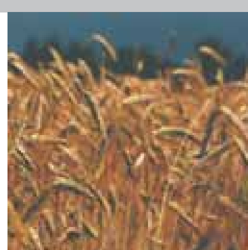
Thermo SCIENTIFIC

Product Specifications

The FH 40 LAB-1 is an efficient supplement to the multipurpose radiameter FH 40 G for first responder task forces.

FH 40 LAB-1

Portable equipment for the detection of $\alpha + \beta$ radiation in samples in combination with the multipurpose Radiameter FH 40 G



The FH 40 LAB-1 / FH 40 G is used for immediate in-situ measurements of alpha+beta contaminations, e.g.

- Filters and filter systems
- Smear tests
- Soil samples
- Foodstuff, milk, …
- Water etc.

The multipurpose radiameter FH 40 G itself is able to determine the actual gamma doserate.

The portable measuring equipment FH 40 LAB-1/ FH 40 G will strongly reduce the loss of time in cases of an emergency involving radioactive contaminations. It is an easy-to-handle mobile radiation laboratory configured specifically for on-site operation. In addition to offering a high degree of mobility, the FH 40 Lab-1 offers advantages in the reproducible sample geometry and comparability of measurements.

1. Sample planchet, flat
2. Sample holder FH 770 G
3. Filter papers and spatula
4. Sample planchet, high
5. Protective gloves
6. Operation manual
7. Contamination probe FH 732 GM
8. Radiameter FH 40 G (option)
9. Spare batteries

Specifications

FH 40 LAB-1

FHZ 732 GM Alpha-Beta-Gamma Probe for Radiameter FH 40 G	
Overall size:	245 mm x 68 mm (9.6” x 2.7”)
Weight:	0.32 kg (0.7 lb)
Detector window:	~ 2 mg/cm², ∅ 44 mm (1.8”)
Sensitive area:	15 cm²
Measuring range:	0.1 - 10,000 cps
Background:	~ 0.6 cps
Sensitivity (cps/Bq):	~ 15 % (Am-241)
(filters)	~ 25 % (Cs-137)
Gamma:	~ 4 cps/µSv/h (Cs-137)

Temperatures:	- 30 °C to +50 °C (-22 °F to 122 °F) operation
	- 40 °C to +70 °C (-40 °F to 158 °F) storage

Sample Holder FHT 770 G	
Dimensions:	base plate ∅160 x 10 mm (∅6.3” x 0.4”)
	Sample holde 95 x 60 mm (3.7” x 2.4”)
Weight:	3.7 kg (8.2 lb)
Material:	brass
Total height	~ 100 mm (3.9”) incl. grip

Case	
Dimensions:	430 x 305 x 105 mm (16.9” x 12” x 4.1”)

Operating Sequence for a Sample Measurement

1. The sample holder is opened and a sample planchet or sample cup is inserted.
2. With the FHZ 732 GM probe above the sample, the cover is closed.
3. A measurement with the radiameter FH 40 G, using preset time or preset count, can be executed.
4. The result can be stored in the internal memory of the survey meter.

With a measuring time of only 5 minutes, the detection limit is approximately 500 Bq/ kg for Cs-137. This allows the user to monitor limit values according to WHO intervention guidelines (e.g. fruits 7000 Bq/kg; milk 4500 Bq/kg; drinking water 7000 Bq/kg).

The radiological equipment for 371 special NBC detection vehicles was delivered by Thermo Fisher Scientific. The “Bundesamt für Zivilschutz” (German Federal Office for Civil Defense) chose the NBR radioactivity detection system because of the advanced technology offered by the Thermo Scientific radiation detection systems. The system is comprised of: the FH 40 G radiameter with an integrated proportional counter tube, and an FHZ 672-2 NBR scintillation probe. While driving, the high-sensitivity of the scintillation probe recognizes a minimum of artificial gamma radiation in the measurement range of nSv/h, even in a wide area. The measured track of radioactivity is automatically shown on a digital map sup-ported by GPS. As the main instrument of the radiological equipment, the Radiameter FH 40 G has the German PTB approval as well as the German Fire-Brigade-Approval.he patented NBR-technology has also been approved by the TÜV Hannover/ Sachsen-Anhalt.

NBR = Natural Background Rejection

The NBR measurement method was developed by Thermo Fisher Scientific, Erlangen (Germany) for extremely fast discrimination between natural and artificial gamma radiation. Worldwide, more than 1000 devices based on this technology are in use.

NBR has a rapid response time. Artificial gamma radiation sources are identified in seconds by operators with basic training levels.

Unlike conventional spectroscopy-based gamma identification systems, the systems using NBR do not require the presence and resolution of gamma spectral lines. Because of this flexibility, NBR can also definitively distinguish artificial high-energy beta sources, and heavily shielded gamma ray sources, from fluctuating natural background sources.

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Thermo SCIENTIFIC

To complement the EPDMk2, Thermo Fisher Scientific offers a range of readers. All these readers connect directly to the PC via a serial or optional USB interface. They are compatible with the full range of Mk2 software products and require no power supply.

Readers for EPD® Mk2™

ACT 4

IrDA Reader

The basic IrDA reader, is ideal for office environments and mobile applications. For more demanding environments, and where it is necessary to ensure that only one specific EPD can be ‘seen’ by the reader, the desktop model ACT-5 may be used. The IrDA and ACT-5 are compatible with EasyEPD2 and EasyIssue software.

ACT 5

Basic IrDA Reader

PC Connection:	Serial RS232 or USB 1.1 and 2.0 compatible interface direct to PC
Cable length:	Serial 1.2m USB 1.0m
Size and Weight:	60 x 30 x 20 mm (2.5” x 1” x 0.8”), 50 grams (0.1 lbs.)
Power:	None required, driven from PC

ACT-5 Desktop Reader

PC connection:	Serial RS232 or USB 1.1 and 2.0 compatible interface direct to PC
Cable length:	Serial 1.2m USB 1.0m
Size and Weight:	180 x 125 x 70 mm (7” x 5” x 3”), 1.1 kg (2.5lbs)
Power:	None required, drives from PC

ACT-4 Desktop Reader with Keypad

PC Connection:	Serial RS232 or USB 1.1 and 2.0 compatible interface direct to PC
Cable length:	Serial 1.2m USB 1.0m
Keyboard Connection:	PS/2 style mini-DIN. Accepts input from full keyboard. PS/2 cable provided to connect to PC system unit (length 2m, (6.5’)). Keypad/Keyboard key operated selector switch.
Size and Weight:	240 x 125 x 85 mm (10” x 5” x 3”); 1.75 kg (4lb)
Power:	No external power required - IrDA reader and keypad powered from PC.

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Thermo SCIENTIFIC

Product Specifications

The Thermo Fisher Scientific EPD-N2 combines excellent photon dosimetry with full-spectrum neutron response, making this dosimeter ideal for those working in mixed neutron/gamma fields.

EPD™-N2

Electronic Personal Gamma-Neutron Dosimeter

Applications include:

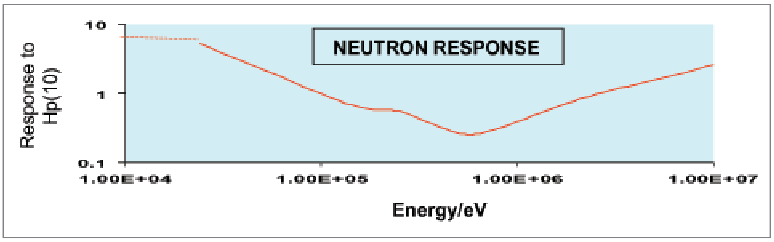
- Reactors
- Spent fuel and glass waste transport
- Reprocessing and plutonium finishing
- MOX - plants
- Neutron source manufacture
- Many types of nuclear and university research
- Accelerator facilities
- Medical facilities

- Advanced radiological performance, 20keV-10MeV (photon), thermal (0.025eV) - 15MeV (neutron)
- Excellent performance in mixed gamma/neutron fields
- Multi-detector technology
- Excellent performance for low-dose measurements
- Direct display of Hp(10) for neutrons and for photons
- Outstanding immunity to electromagnetic interference
- AA battery, lithium or alkaline, interchangeable
- Compatible with current or upgradeable Thermo Scientific EPD readers, software and accessories

EPD-N2 Specifications

Radiological

- Sensitive to X- and γ-radiation (E > 20keV) and neutrons 0,025eV < E < 15MeV
- Direct readout of Hp(10) for neutron & photon dose
- Multiple diode detectors with converters and energy compensation shields
- Display units: Sv & rem (with prefixes μ, m), set via internal software
- Generally in accordance with ANSI standards 13.11, 13.27 & 42.20 (photons performance) and most aspects of IEC 61525 (neutrons & photons)
- Dose display & storage: 0μSv to > 16Sv, auto-ranging
- Resolution for display: 1μSv (< 10mSv/1rem) (γ, and neutron under best conditions)
- Resolution for storage: 1/64μSv (~1.5μrem) (γ), 1μSv for neutron dose under best conditions
- Dose rate display: 0μSv/h to > 4Sv/h (400rem/h), auto-ranging, variable resolution



Electrical & Mechanical

- Power supply: 1 x AA battery, 1.5V alkaline or 3.6V lithium, interchangeable without any adjustment
- Operating life (see assumptions below)
  - Continuous use: 1.5V alkaline: typically 42 days; 3.6V lithium: 4.5 - 5 months
  - 8h/24 with use of 'OFF' standby state: 1.5V alkaline: ~ 2.5 months; 3.6V lithium: ~ 9 months
  - Assumptions: average dose rate < 5μSv/h (<0.5mrem/h), IR communications < 5s, 2x/day, audible alarm sounding <2h total during battery life
- Communications: IR interface, < 1m range (39")
- Display and enabled functions controlled by button on front face of EPD (button recessed and sealed)
- Size: 86 x 63 x 18.5 mm, without clip, (approx 3.4 x 2.5 x .75")
- Weight:: 108 g (~4oz) incl. battery & clip
- Case material: high impact polycarbonate blend
- Clip: high impact plastic, easily renewed, strong clamp, with eyelets for lanyard (optional lanyard-only version)
- Energy response (γ): ± 20% 25keV to 1.5MeV; ± 30% 20keV to 6MeV; ± 50% 6MeV to 10MeV
- Energy response (n): see energy response curve above. With a single calibration, the neutron dose estimated by the EPD-N2 will be within approximately ± 30% of the true value for many workplace fields
- Angular response: Hp(10) (γ) ± 20% up to ± 75° Cs-137; Hp(10) (n) ± 30% up to ± 60° Am-Be
- Internal detector self -test under CPU control
- Accuracy: Hp(10) (γ) 10% Cs-137; Hp(10) (n) 20% Am-Be

Alarms

- Audible & visual alarms: Photon dose rate (2), photon dose, combined photon + neutron dose, neutron dose rate, neutron dose, over-range, failure, count - down timer, low battery, 'return for read'. Alarm tone, pattern, sound level, mutability and red LED configurable via external software
- 'Beep' for gamma dose with configurable sensitivity
- Alarm sounder: sealed, typically 98-100 dB(A) @ 20cm on 4kHz 'loud'setting

Memory

- 10 year data retention without battery
- Short term and Total dose registers for Hp(10) γ & n
- Storage of peak photon & neutron dose rates, with date & time (1s resolution for all stored times)
- 23 most recent alarms or events stored with date & time
- Dose profile storage: ~ 500 dose data points for γ & neutron dose with date & time

Environmental

- Operating temperature: -10 °C to 40 °C (15 to 105 °F)
- Storage temperature: -25 °C to 70 °C (-13 to 158 °F)
- Humidity: 20% - 90% RH, non-condensing
- Protection rating: IP55 (protection against dust ingress & low pressure jets of water from all directions)
- Vibration: IEC 1283 (2 g, 15 min.,10-33 Hz)
- Shock: 1.5 m drop onto concrete on each surface
- EMI/EMC: Exceeds MIL STD 461D RS103; IEC 1283 & IEC 61525

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Thermo SCIENTIFIC

Product Specifications

Thermo Scientific EPD Mk2+ combines unequalled radiological performance with advanced software and hardware features.

Thermo Scientific EPD Mk2+

Electronic Personal Dosimeter

Key Features

- Advanced radiological performance, 15 keV to 10 MeV, in a small, lightweight design
- Most complete dosimeter per IAEA Active Personal Dosimeter Intercomparison study IAEA-TECDOC-1564
- Multi-detector technology
- Excellent response to gamma, beta, and X-radiation
- Improved power management and battery monitoring
- Loud configurable audible alarm
- Excellent immunity to electromagnetic interference
- Enhanced, easy-to-read display with optional backlight
- Rugged battery cap and enhanced clip retention
- Improved reliability of LCD and case
- Additional software features provided
- Single AA battery powers the unit

The Thermo Scientific EPD Mk2+ builds upon the high performance of the original MK2 design, while providing enhanced features. The EPD Mk2+ is suitable for use as a single, stand-alone dosimeter, or as a component of a comprehensive dosimetry management system using our renowned hardware and software packages. The high quality of the Mk2+ provides low lifetime costs as well as advanced radiological performance.

The Thermo Scientific Mk2+ electronic personal dosimeter is perfect for organizations, utilities, agencies, and research laboratories to monitor employee dose and dose rates. The Mk2+ also boasts a ruggedized battery cap and an improved display.

The unit is powered by a single standard AA cell, either 1.5V alkaline or 3.6V Lithium Thionyl Chloride for maximum battery life. Pre-use integrity checks may be initiated over the IR (Infra-Red) communications link as part of the EPD Issue process of access control or dosimetry management systems. These checks include detector tests, battery test and battery voltage read. Display and function are controlled by a single button on the front of the unit, recessed to prevent inadvertent operation.

EPD Mk2+ Specifications

Radiological

Sensitive to X and gamma radiation, ß particles	
Direct readout of dose equivalents Hp (10) [deep/whole body] and Hp (0.07) [shallow/skin]	
Display Units:	Sv and rem (with prefixes) OR scaled in Sv and cGy (with prefixes)
Neutron Response:	< 2%
Dose Display and Storage:	0 µSv to > 16 Sv (0 mrem to > 1600 rem)
Display Resolution:	1 µSv (0.1 mrem), up to 10 Sv
Storage Resolution:	1/64 µSv (=1.5 µrem)
Dose Rate Display:	0 µSv/h to >4 Sv/h (0 mrem/h to >400 rem/h); auto ranging
Energy Response:	Photon: Hp(10): [All ref. ^{137}Cs]: ±50% 15 keV to 17 keV; ±20% 17 keV to 1.5 MeV; ±30% 1.5 MeV to 6 MeV; ±50% 6 MeV to 10 MeV
	Photon: Hp(0.07): [All ref. ^{137}Cs]: ±30% 20 keV to 6 MeV; ±50% 6 MeV to 10 MeV
	Beta: Hp(0.07): ±30% 250 keV to 1.5 MeV (ref. ^{90}Sr/^{90}Y)
Angular Response:	Hp(10) ^{137}Cs ±20% up to ±75º; Hp(10) ^{241}Am ±50% up to ±75º; Hp(0.07) ^{90}Sr/^{90}Y ±30% up to 55º
Accuracy:	Hp(10) ^{137}Cs ±10%; Hp(0.07) ^{90}Sr/^{90}Y ±20%
Dose Rate Linearity:	Hp(10) ^{137}Cs: ±10% <0.5 Sv/h (<50 rem/h); ±20% 0.5 to 1 Sv/h (50 to 100 rem/h); ±30% 1 to 2 Sv/h (100 to 200 rem/h); ±50% 2 to 4 Sv/h (200 to 400 rem/h); Between 4 and 50 Sv/h continues to accumulate dose at a rate > 1 Sv/h
	Hp(0.07) ^{90}Sr/^{90}Y: ±20% <1 Sv/h (<100 rem/h); Between 1 Sv/h and 50 Sv/h continues to accumulate dose at a rate > 1Sv/h

Electrical and Mechanical

Single, recessed button controls display and function	
Power Supply:	Single AA battery, 1.5V alkaline cell, OR 3.6V lithium thionyl chloride; battery voltage is displayable (subject to display configuration settings); ON/OFF modes switchable over IR communications link or from button (when enabled), for power-saving in intermittent usage application:
Typical Battery Life:	1.5V alkaline - 45-50 days continuous, extending to 70-80 days of typical use of OFF mode 3.6V lithium - 5 months continuous, extending to ~ 10 months of typical use of OFF mode
Alarm:	Audible and LED visual alarms for dose, dose rate, count down time, read time, and failure mode; fully sealed; Time to Dose alarm display, based on current dose rate; audible alarm typically 98dB(A) at 20 cm with multiple modes; Hp(10) dose chirp settable from 0.01 to 100 µSv/chirp (1 µrem to 10 mrem/chirp); optional acoustic coupler/earpiece
Communications:	Infrared (IR) interface up to 1 meter range (39”)
Dimensions:	85 x 63 x 19 mm (3.3” x 2.5” x 0.8”), excluding clip
Weight:	95 g (3.2 oz), including battery and clip
Case Material:	High-impact polycarbonate/ABS blend

Memory

10 year data retention without battery	
Short term dose registers for Hp(10) and Hp(0.07)	
Additional total-dose stores for multiple job periods	
Peak dose rates with time of occurrence	
All stored times have 1 second resolution	
Selectable fast dose rate response setting	
Dose clear events recorded	
Count Down Timer:	1 hour, 39 minutes, 59 seconds maximum, resolution 1 second
Event Log:	23 entries for time recording of alarms, etc., for incident assessments
Dose Profile History:	Settable interval from 2 seconds to 35 hours, store transitions of Hp(10) and Hp(0.07) at a resolution of 1 µSv (0.1 mrem); will store up to 579 records for transitions up to 127 µSv or less

Environmental

Operating Temperature:	-10ºC to +50ºC (+14ºF to +122ºF)
Humidity:	20% to 90% RH, non-condensing
Vibration:	IEC 1283: 2g, 15 minutes, 10 to 33 Hz
Shock:	1.5 m (5’) drop on each surface onto concrete
EMI/EMC (incl. static discharge):	Exceeds IEC 61526 requirements; exceeds more stringent MIL Standard 461D RS103

Please consult your local sales representatives for details. Literature Code RMP EPD Mk2+ 200905

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Thermo SCIENTIFIC

The Thermo Fisher Scientific EPD Auto Irradiator IRR-2 provides sensitive, automated calibration checking of EPDs Mk1 and/or Mk2.

Product Specifications

EPD® IRR-2™

EPD® Auto Irradiator

- Multiple verification pathways:
  - Comparison with reference EPD
  - Comparison with previous measurements with the same EPDs
  - Checking against dose and EPD counters
- Compact, bench top unit
- No need for special shielded facility
- Accepts 10 EPDs in one load
- Operates automatically under software control
- Comprehensive safety features β and γ sources check all EPD counting channels simultaneously
- Interfaces with the EPD Maintenance Database, EMDS2

General

The Auto Irradiator is a complete package for periodic calibration checking of MK1 and/or MK2 EPDs. It operates under the control of a PC running the Auto Irradiator software supplied with the instrument. The IRR-2 is intended to operate in conjunction with the EPD Maintenance Database System (EMDS2), described in a separate data sheet.

A carousel holding up to 10 EPDs, either Mk1 or Mk2 but not mixed, is loaded onto the IRR-2. On starting the cycle, all dosemeters are status-checked before irradiation commences. On completion of each EPD irradiation the dose and counter data is uploaded to EMDS2 which can run on the same PC as the Auto Irradiator software. Here the data is compared with preprogrammed limits and any historical data in the database for individual EPDs.

EPD Auto Irradiator Specifications

Radiological

Radioactive Sources:	γ:	Am-241 3.7 GBq (100 mCi) Sealed source, special form
	β:	Cl-36 100 kBq (2.7 µCi) Sealed disc source
Irradiator Performance:	^{241}Am	60 keV Statistical accuracy better than ± 2% (2 min irradiation time) (15 °C - 25 °C (59 °F to 77 °F), 95% confidence level)
	^{36}Cl	714 keV b (Emax) Statistical and positional accuracy better than + 10% (2 min irradiation time)
External Radiation:	Radiation dose rate at 50 mm from any surface not greater than 1µSv/h (0.1 mrem/h) under normal operating conditions	

Environmental

Operating Temperature:	+5 °C to 40 °C (41 °F to 104 °F)
Storage Temperature:	-25 °C to 70 °C (-13 °F to 158 °F)

Indicators

Indicator Lamps:	Power On (yellow), Lid Closed (red), Sources Shielded (green), Sources Exposed (red), Unlatch Lid Switch (green)

Mechanical

Size:	470 x 400 x 320 mm (19” x 16” x 13”)
Weight:	37 kg (82 lbs)

Electrical & Safety

Supply Voltage:	110 V ± 10%, 47 to 63 Hz 240 V ± 10%, 47 to 63 Hz
Power:	300 W Maximum
Power Supply Interruption:	Unit will operate normally with a supply interruption of less than 50 ms. Interruption of more than 5 seconds causes irradiation cycle in progress to be terminated.
Fuses:	2A T, 20 x 5 mm (1” x 2”) dia. @ 240 V 3A T, 20 x 5 mm (1” x 2”) dia. @ 110 V
Power Connector:	IEC 320 (local IEC320 mains power cord required Outside UK)
Safety & EMC Specification:	Equipment for indoor use only. Complies with BS EN 61010-1 1993. Installation/over-voltage Category II, Pollution degree 1.

Computer Hardware Requirements

Note:	The IRR-2 requires a PC-compatible computer, which is not supplied as part of the IRR-2. A suitable PC can be supplied by Thermo Fisher Scientific if required and at extra cost.
Hardware Requirements:	IBM compatible Pentium PC, 166 MHz 32 MB RAM, 60 MB hard disk drive, CD-ROM drive, Vacant I/O card slot, Mouse, or other pointing device, Keyboard, 2 serial ports
Operating System:	Microsoft Windows™ or NT
IRR-2 Interface:	PCL 725 I/O card, or equivalent. (supplied with IRR-2)

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Thermo SCIENTIFIC

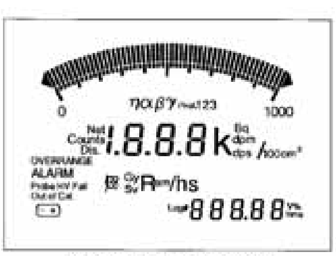
Product Specifications

The Model E-600 multipurpose survey meter is the latest, most sophisticated, and user friendly instrument in the family of Thermo Fisher Scientific's E-Series of portable instruments. Traditional feel and advanced control functions offer users a portable instrument capable of performing many radiation monitoring functions.

E-600

Multipurpose Survey Meter

- Accepts conventional and Smart probes
- Background subtraction
- Data logging
- Built-in Pulse Height analyzer



Display showing all segments

The E-600 represents a new generation of portable survey meters that provides enhanced capabilities for users.

Foremost among the advanced capabilities of the E-600 is the compatibility of the instrument with a multitude of detector probe types. Probes include various newer "smart probes" and conventional probes in widespread use. The smart probes provide interchangeability for performing various types of radiation measurements, the probe recognizes the instrument, and vice versa.

The E-600 can memorize up to three configurations for any given probe, permitting a single probe to be set up and operated in different ways. For alpha/beta monitoring applications this allows switching between the alpha, beta and alpha + beta monitoring channels. Switching between each channel automatically adjusts the thresholds, alarm settings, response times and the preferred audible click signature for differentiation between the alpha and beta counts. This multi-channel capability is also useful for performing Pulse Height Analysis (PHA) where three separate views can be programmed with the user readily switching from one to another.

The high-contrast, custom display allows the user an easy view of the full range of the instruments capabilities, blending traditional analog information with alphanumeric digital data. The display is backlit for use in poorly lighted areas, and is operational through a wide temperature range. The simulated linear analog meter movement provides a familiar feel to users.

System Specifications

The E-600 has five operating modes plus a check mode accessible to the operator. The operating modes are Ratemeter, Integrate, Scaler, Peak Trap and Background Accumulation. The custom LCD display automatically adjusts for each operating mode to notify the user and to allow rapid switching. The E-600 uniquely performs active background subtraction when selected by the user.

Routine surveys are best served with the built-in data logging capability that can store up to 500 data points. Each data point includes the location, date, time, detector channel, operating mode, displayed value, unit of measurement, instrument and probe serial numbers and the instrument status. Location data may be read directly by the E-600's serial port via a laser scanner, alphanumeric keypad, Global Positioning System, or other smart RS-232 devices capable of outputting the data in an ASCII format.

The E-600 offers an optional Windows™ based PC program that is necessary to calibrate or configure the instrument with Thermo Fisher Scientific's Smart probes. Connection to the PC is through the E-600's serial port that provides for the exchange of data, as well as setting up the instrument and its probes.

A real time clock is incorporated into the design to provide tighter controls and support precise data gathering. This is especially useful for data logging applications where each logged data point is time stamped.

Another powerful application is time-stamping the calibration of the instrument and any of the Smart probes. A calibration date and time are carried with the probe calibration data, as well as a calibration due date. If administratively enabled, any probe utilized past its due date will automatically take itself out of service and inform the user that the calibration is no longer valid. The same control may also be invoked for each E-600 instrument. The E-600 case is also designed to withstand rigorous handling in all environments, indoors and outdoors.

Specifications

Dimensions:	34 x 16.5 x 23 mm (8.5" x 4.12" x 5.75") (including handle)
Weight:	1.47 kg (3.25 lbs) (including batteries)
Color:	Beige/ Brown
Batteries:	3 Alkaline "C" cells, life approximately 100 hours
Operating Humidity:	Up to 95% non-condensing
Operating Temperature Range:	40 °C to 80 °C (-40 °F to 176 °F)
Storage Temperature Range:	-50 °C to 185 °C (-58 °F to 365 °F)
Display:	High contrast LCD, 7.5 cm wide by 5 cm high (3" x 2") Red backlight.
Response Times:	Slow, Medium and Fast. Each time can set between 1 and 255 seconds
Audible Alarm:	85 dB at 30 cm (11.81")
Alarm Level Settings:	Up to three alarms per detector probe adjustable over entire range of probe. Alarm settings are available for both rate and integrate modes.
Dead Time Correction:	0 to 999 microseconds
Probe Connector:	Smart, Proprietary Thermo Fisher Scientific Design
High Voltage Range:	500 to 2,500 VDC
Operating Modes:	Rate meter, Scaler, Integration, PeakTrap and Background
Accumulation Controls:	Instrument off, check mode, five operating modes, speaker on/off, gross/net counts display, up/down range scale, log data, multi-function soft key, display back-light and channel select

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Thermo SCIENTIFIC

Product Specifications

The CM11 Contamination Monitor is designed for radiation workers to monitor themselves, their clothing and belongings effectively after a minimum of training and supervision. It has the versatility of advanced portable monitors without complexity.

CM11

Easy-to-use and versatile personnel contamination monitor

Versatility:
The dual channel CM11 operates with a large range of sensitive probes

Easy to use correctly:
No user controls or adjustments, clear displays and annunciators, direct readout

Compactness:
Slim profile with suitable fixtures for mounting to a wall, a personnel monitor or the bench

The CM11 is effective as an add-on device to personnel monitors to increase monitoring throughput rates. This contamination monitor also works well as a monitoring station during temporary work such as plant maintenance. The CM11 is ideal where space is restricted. It is easy to install and to set up, and equally easy to assign to the next application.

The CM11 is ideal as a backup boundary monitor; to confirm Personnel Monitor alarms, to pin-point the position of contamination and amount per 100 cm^2, to differentiate radon nuisance alarms from others and for use in an emergency or when AC supplies are down. Monitoring applications arise within power and fuel handling sites, also defense establishments, government laboratories and hot labs in hospitals and industry.

Thermo Fisher Scientific's different versions, CM11A to CM11F, carry hangers for the 20, 50, and 100 cm^2 scintillation probes and the DP11 gas flow probe. The following types of radiation may be monitored:

- α, β, simultaneous
- α plus β,
- low energy gamma
- simultaneous ^{125}I and β.

System Specifications

Measurement

Background is measured and stored until the proximity sensor is tripped or the probe lifted from the hanger, when monitoring starts. Background is then subtracted from the counts before they are displayed. The peak hold feature makes it easier to pinpoint spots of contamination, and their levels, by simultaneously displaying the peak and instantaneous readings.

Results are shown on a log scale ranging from 0.2 to 10 alarm levels, and on a digital display in units of countrate, total activity or specific activity. The two readout channels are normally configured for alpha and beta/gamma, but can be configured to separate ^{125}I from beta/gamma when used with the GP13 low energy gamma probe. Versions in which the probe window faces out allow hands to be monitored before actually touching the probe.

Special Performance Features

- Radon recognition algorithm - eliminates nuisance alarms by distinguishing radon alarms from others.
- Gas flow and scintillation detectors both use a standard coaxial cable.
- Signal processing for smoother displays of changing countrate with better detection of contamination.
- Internal power source gives at least 2.5 hours operation without main power.
- Operating point can be set by cursor from graphic display of plateau.
- Built-in routines; high voltage scan, plateau plot S plus B and S^2/B values for probe characterization.
- Gas flow rate and pressure are monitored by electronic means.
- Passive infra-red proximity sensor, or footswitch (optional), allows hands to be monitored before touching the probe.

QA Features

- A continuous self-test program prevents monitoring of invalid or fault conditions
- The probe can be tested for contamination after each measurement.
- Selectable count-averaging times and confidence levels on the alarms.
- Data recording possibilities; peak readings for each measurement, setup parameters and HV scan results (using the serial port and an external printer).

Typical Applications

- Monitoring clothing in parallel with hand/foot monitors to speed up throughput.
- Monitoring items next to an IPM or PCM.
- Detection of radon nuisance alarms.
- With a DP6 or DP11 probe, to quantify and pinpoint IPM/PCM alarms from diffuse contamination that pancake geigers cannot detect.
- As a temporary monitoring station.
- A workstation or exit monitor in a small zone.
- As a subchangeroom monitor.
- As a specialized monitor for low energy γ radiation.
- To provide monitoring for feet, identity cards, laundry, tools etc. in combination with special probes.

Specifications

Display Units: cps, cpm, Bq*, dpm*, Bq.cm^{-2}*, nCi* (*Probe efficiency and area are entered during setup).
Alarm Levels: 0.1 to 100,000 display units.
Display Channels: α, β/γ, α plus β/γ, ^{125}I plus β/γ.
Monitoring Update Time: 0.1 to 10 s.
Background Update Time: 10 to 100 s.
User Control: Removal of probe from hanger (or triggering optional proximity sensor activates measurement cycle with back ground subtracted. Replacement of probe causes resumption of background measurements.
Display: CCFL backlit LCD, resolution 240 x 128 pixels. Digital, bargraph and graphic display. Timed count rate, timed disintegration rate, HV scan and plateau plot.
Audible Indications: Distinct tones for particle detected, alarm and fault condition.
Printout: Peak results, parameter settings and HV scan results.
External Printer: Any RS 232 serial printer.
Temperature Range: 5 to 40 °C, (41 to 104 °F) operational -10 to 50 °C (14 to 122 °F) during storage.
Humidity: Up to 95% RH.
Power: 85 to 264 VAC, 74 to 63 Hz, 40VA.
Dimensions: 240 x 380 x 160 mm approx. (9.5” x 15” x 16.5”)

DP11 Gas Flow Probe used with CM11F Technical Specifications

Sensitive Area: 150 x 67 mm (100 cm^2).
Window: 0.9 mg.cm^{-2} aluminized mylar.
Efficiencies: (% surface emission, 100 cm^2 source) ^{241}Am, 32%; ^{14}C, 38%; ^{60}Co, 49%; ^{137}Cs, 58%.
Gamma Response: 40 cps (approx.) in a uniform field of 1 mSvh^{-1} (100 mRh^{-1} due to ^{137}Cs).
Gas: Ar/CH_4, 90/10 % to 95/5 % proportion.
Control: Built-in control/cut-off valve and electronic flowmeter.
Consumption: 1.5 liters/hour (25 cc/minute)

Options and Accessories Include

Proximity Sensor, Footswitch, IPM mounting kit, Bench mounting kit,Trolley for CM11 and gas bottle, Gas bottle kit, Large area check sources

Please note: Probe, cable and accessories are ordered as separate items. For assistance in selecting the appropriate items, please contact our sales staff.

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Thermo SCIENTIFIC

ASP-2e/NRD

Portable Neutron REM Meter

Portable, convenient, and easy to use, the ASP-2e/NRD survey meter employs a highly responsive neutron detector, measuring dose equivalent rates over the energy range from 0.0025 eV to about 10 MeV. The detector's BF_3 tube provides excellent gamma ray rejection. The probe can be easily detached from the meter to provide better coverage in ergonomically difficult positions. A user-friendly LCD complements the analog meter

Features

- Neutron Dose Equivalent Rate
- BF_3 Tube Allows High Gamma Rejection
- User-Friendly Analog/Digital Display
- Ratemeter, Integrate & Scaler Operating modes
- Quick Computer Assisted Calibration
- Alarm Annunciation
- Built-In Speaker

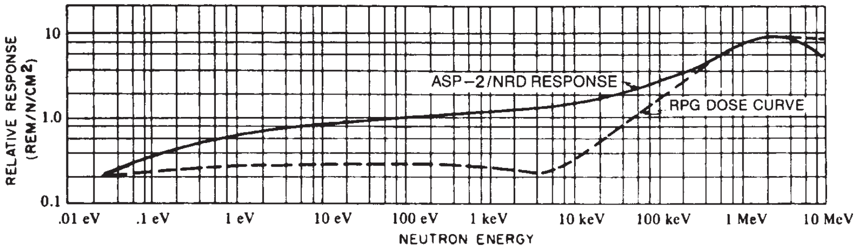
The ASP-2e/NRD is a portable, battery operated counter designed for the measurement of dose equivalent rate from neutrons (Rem). The detector employed is a 22.9 cm (9") diameter, cadmium loaded polyethylene sphere with a BF_3 tube in the center. This detector has been shown to have a response which closely follows theoretical dose equivalent from neutrons over the energy range from 0.0025 eV (thermal) to about 10 MeV. The BF_3 tube also provides excellent gamma rejection.

The accompanying instrument is the model ASP-2e. This design combines the best features from conventional analog counters and marries them with state-of-the-art digital technologies to present the user with a very capable and user-friendly instrument.

A dual analog/digital display facilitates the measurement process by presenting informative data in an optimum format. While the traditional analog meter scale presents relative scale and movement of the counts received, the digital display forwards exact count rate readout together with the units employed, the counting interval or elapsed time (depending upon the operating mode selected) along with other key operational parameters such as response time selected, alarm setpoints, high voltage, battery level, etc.

Microprocessorr-based, the ASP-2e/NRD corrects for coincidence loss so that the upper limit range of the detector is increased by a factor of ten or more. When the useful range is exceeded, an over-range alarm is given. The instrument has a built-in speaker, serial port for PC setup and calibration, and an easy access external battery compartment to facilitate battery replacement.

System Specifications



DETECTOR

Detector Type
- BF_3 tube in a 22.9 cm (9"), cadmium loaded polyethylene sphere

Detector Sensitivity
- Approximately 45 cpm/mrem/hr (3000 counts per mrem)

Plateau
- Approximately 200 V with a slope of 5% per 100 V

Operating Voltage
- Between 1600 to 2000 V

Directional Response
- Within ±10%

Energy Range
- Thermal to approximately 10 MeV

Gamma Rejection
- Up to 500 R/h. Rejection is dependent on voltage selected
- The factory default is 10 mR/h

SURVEY METER

Count Range
- 1 to 1.3 million cpm

Response Time
- Slow, Medium, Fast. Each time setting is programmable between 0 to 255 seconds

Audible Alarm
- 85 dB @ 30 cm (11.8")

Dead Time Correction
- 0 to 255 µSec

Operating Modes
- Ratemeter, Integration, Scaler

Controls
- Instrument off, check mode, 3 operating modes, speaker on/off, meter back light, multi-function soft key

COMBINED DETECTOR/METER

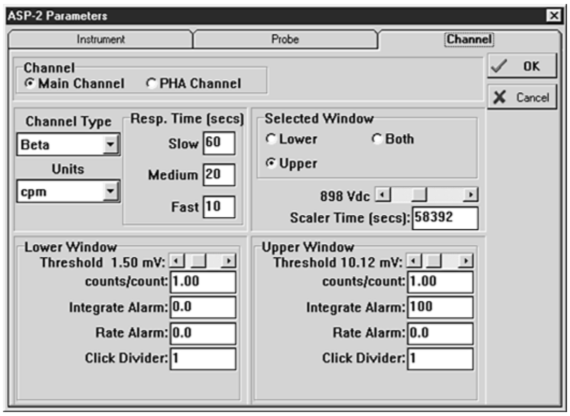
Size
- 40.6 H x 22.9 W x25.7 D cm (16" H x 9" W x 10.13" D)

Weight
- 7.93 Kg (17.5 lb)

Operating Temperature
- -20 °C to 50 °C (-40 °F to 122 °F)

ORDERING INFORMATION

- Model ASP-2e/Nrd
- Comes complete with 22.9 cm (9") NRD detector, ASP-2e counter, detector bracket for attaching detector to counter and a 0.9 m (36") connecting detector cable.



OPTIONS

- CA-104-60 PC Serial Communications Cable
- ASP2 OPT1 PC Calibration/ Configuration Software, Windows™

About Thermo Fisher Scientific

Thermo Fisher Scientific (NYSE: TMO) is the world leader in serving science. The company enables its customers to make the world healthier, cleaner and safer by providing analytical instruments, equipment, reagents and consumables, software and services for research, analysis, discovery and diagnostics.

With annual sales of more than $9 billion, Thermo Fisher Scientific has 30,000 employees and serves more than 350,000 customers in pharmaceutical and biotech companies, hospitals and clinical diagnostic labs, universities, research institutions and government agencies, as well as environmental, industrial quality and process control settings.

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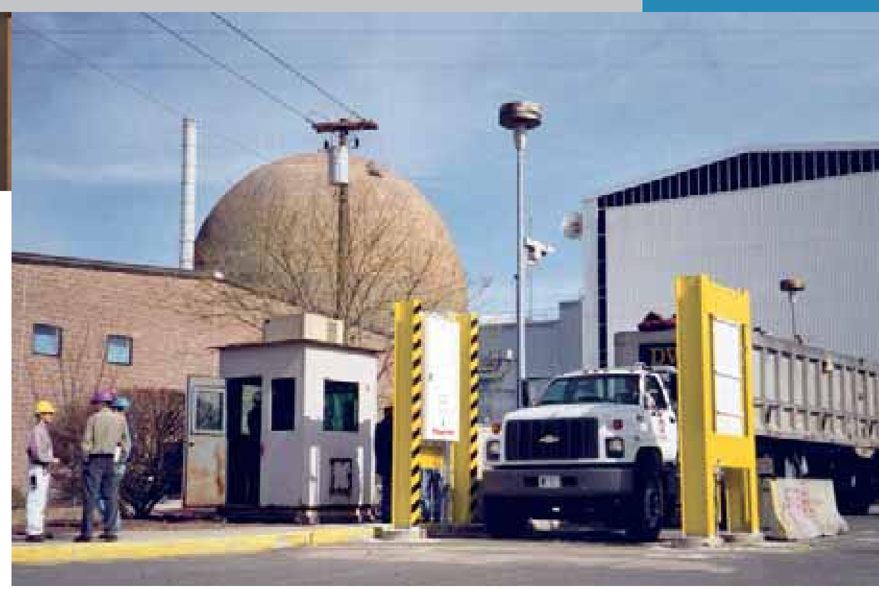
Thermo SCIENTIFIC

Product Specifications

The ASM/III Vehicle Monitoring Systems are designed to scan vehicles for radioactive materials. These systems offer unparalleled sensitivity and reliability.

ASM/III

Vehicle Monitoring System



- Graphic Display
- Language options
- User configurable alarm messages
- Networkable
- Simple to operate and maintain

The ASM/III vehicle monitoring systems are designed to utilize industry-proven detector designs. The system uses state-of-the-art, Reality Based Detection algorithms, and advanced, low-noise electronics technology, to provide the perfect solution for vehicle monitoring applications.

Detector configurations that provide both vertical coverage of the vehicle (detector width) have been cornerstone of ASM detector designs since 1987. These large-area plastic scintillation detectors are shock-mounted and housed in lead-lined, NEMA rated stainless steel detector enclosures, and are proven to withstand the rigors of industrial vehicle monitoring applications in the harshest environments.

Data analysis and management is processed by the ASM/III System Control Unit and is available in two configurations; a wall mountable unit, incorporating an industrial grade PC or a desktop POD and commercially available PC. Designed to be operated with little or no operator intervention, the ASM/III SCU features simple, one-button response to alarm conditions, while providing detailed scan and alarm data at the request of the operator. A color graphic display allows the viewing of detector data, alarm history and location of the detected source in the vehicle.

ASM III Specifications

Detector Assemblies

2 detectors in total, 1 per assembly

Detector Material:	BC-408 premium plastic scintillator
Radiations detected:	Medium and high energy gamma emitters eg. ^{60}Co, ^{137}Cs, ^{192}Ir, ^{226}Ra/Th, also neutrons
Detection volume:	49.2 litre (3000 in^3) in total
Detection surface area:	0.9 m^2 (1440 in^2) in total
Shielding:	lead on all sides except the front
Vehicle separation:	4.84 m (16 ft.) or less for optimum performance
Electronics:	Remotely controlled high voltage supply, photo multiplier divider assembly, pulse height discriminator and line driver
Vehicle speed sensors:	Heavy duty industrial grade photobeams with cowling for weather and damage protection
Cable to Control Unit:	Belden type 9777 multiconductor, OD 0.82 in. nom (Weatherproof conduit recommended)
Housing:	Stainless steel, weatherproof (NEMA 4) with gasketed, hinged, coated aluminum access door
Temperature ranges:	-35 ^{0}C to 50 ^{0}C (-31 ^{0}F to122 ^{0}F)
Relative Humidity:	10 to 95% RH
Dimensions:	1829 x 457 x 203 mm (72 in x 18 in x 8 in), each housing
Weight:	340 kg (750 lbs) per assembly
Installation:	Mounting hole pattern for installation on client-provided I-beams

Control Unit

Sensitivity:	Maximum sensitivity is set automatically. Radiation increases equivalent to 1-10% of background are detectable Vehicle speed: up to 8 kph (5 mph) with audible and visual alarms if the limit is exceeded.
Indicator lights:	READY (green), WAIT (amber), ALARM (red)
Operator control:	A single pushbutton illuminates when a radiation alarm occurs. Pressing the pushbutton silences the alarm and resets the system.
Background compensation:	Automatic
Phone modem:	Telephone link to easy maintenance teleservicing network
Other Controls:	Power ON/OFF; 12-key lockable numeric keypad for System setup, self-test & maintenance. (not required for normal operation)
Self-diagnostics:	Detector operation, wiring integrity and photocell alignment are monitored by internal self-tests. For added reliability, separate hardware monitors the microprocessor
Mountings:	Wall-mounting is standard, other styles are optional
Temperature range:	4 ^{0}C to 35 ^{0}C (40 ^{0}F to 95 ^{0}F)
Relative humidity:	10% to 75%
Dimensions:	380 x 600 x 204 mm (15 x 23.6 x 8 in)
Power:	117 Vac, 60 Hz or 220 Vac, 50 Hz
Cable:	NEMA 15-5 3 terminal plug on 6' lead

SYSTEM SHIPPING WEIGHT:
726 kg (1600 lbs)

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Product Specifications

The ASM Vehicle Monitoring Systems are designed to provide the ultimate sensitivity for vehicle scanning in industrial applications.

ASM/III

Model 6000, 9000 and 12000 Vehicle Monitoring Systems

ASM6000

ASM9000

ASM12000

- Graphic Display
- Language options
- User configurable alarm messages
- Simple to operate and maintain
- Built-in printer
- Modem included

The ASM/III vehicle monitoring systems are designed to utilize industry-proven detector designs. The system uses state-of-the-art, detection algorithms, and advanced, low-noise electronics technology, to provide the perfect solution for industrial vehicle monitoring applications requiring unparalleled sensitivity and reliability.

Detector configurations that provide both vertical coverage of the vehicle (detector height) as well as dwell time (detector width) have been cornerstone of ASM detector designs since 1987. These large-area plastic scintillation detectors are shock-mounted and housed in lead-lined, NEMA rated stainless steel detector enclosures, and are proven to withstand the rigors of industrial vehicle monitoring applications in the harshest environments.

Data analysis and management is processed by the ASM/III System Control Unit and is available in two configurations; a wall mountable unit, incorporating an industrial grade PC or a desktop POD and commercially available PC. Designed to be operated with little or no operator intervention, the ASM/III SCU features simple, one-button response to alarm conditions, while providing detailed scan and alarm data at the request of the operator. A color graphic display allows the viewing of detector data, alarm history and location of the detected source in the vehicle.

System Specifications

DETECTOR ASSEMBLIES

- ASM6000 - 2 detector modules
- ASM9000 - 3 detector modules
- ASM12000 - 4 detector modules

Detector material
- Premium plastic scintillator

Radiations detected
- Low, medium and high energy gamma emitters
- For example, ^{241}Am, ^{60}Co, ^{137}Cs, ^{921}Ir, ^{226}Ra/Th, also neutrons

Detection volume
- Over 49.2 L (3000 in^3) per detector module; 2 detectors/module

Detection surface area
- Over 0.9 m^2 (1500 in^2) per detector module

Vehicle separation
- 4.84 m (16 ft) or less for optimum performance, (14 ft recommended)

Electronics
- Remote dual channel, R5485 controlled, intelligent high-voltage/bias/amp. digitizer electronics

Vehicle speed sensors
- Heavy duty industrial grade photobeams with cowling for weather and damage protection

Cable & Communication
- Remote controlled data transmission through 2 independently shielded 20AWG twisted pair cables

Housing
- Lead lined, stainless steel, weatherproof (NEMA rated) with gasketed, hinged, coated aluminum access door

Temperature ranges
- -40 °C to 50 °C (-40 °F to 122 °F)

Relative Humidity
- 10 to 95% RH

Dimensions
- 183 x 91 x 30 cm (72” W x 36” H x 12” D)

Weight
- 340 kg (750 lb) per assembly

Installation
- Mounting hole pattern for installation on client-provided I-beams

CONTROL UNIT

Sensitivity
- Maximum sensitivity is set automatically
- Radiation increases equivalent to 5-10% of background are detectable

Vehicle speed
- up to 8 kph (5 mph) with audible and visual alarms if the limit is exceeded

Indicator lights
- Panel Lights: ready (green), wait (amber), alarm (red)
- Illuminated controls: alarm override (amber), toggle display (green), alarm acknowledge (red)

Simple operator control
- A single push-button illuminates when a radiation alarm occurs
- Pressing the push-button silences the alarm and resets the system

Background compensation
- Automatic

Phone modem
- Telephone link to easy maintenance teleservicing network

Other controls
- Power ON/OFF
- keyboard provided for system setup, (password protection, self-test & maintenance) but not required for day-to-day operation

Self-diagnostics
- Detector operation, wiring integrity and photocell alignment are monitored by internal self-tests
- For added reliability, separate hardware monitors the microprocessor

Mountings
- Wall-mounting is standard
- POD/ PC version designed for desk mount

Temperature range
- 4 °C to 35 °C (40 °F to 95 °F)

Relative humidity
- 10% to 75%

Dimensions of control unit
- Wall-mounted: 380 x 600 x 204 mm (15”W x 24”H x 8”D)
- POD (PC not included): 400 x 104 x 255 mm (15.75”W x 4”H x 10” D)

Power:
- 117 Vac, 60 Hz or 220 Vac, 50 Hz

Cable
- NEMA 15-5 3 terminal plug on 1.8 m (6 ft) lead

SYSTEM SHIPPING WEIGHT:
- ASM 6000: 909 kg (2000 lb)
- ASM 9000: 1409 kg (2900 lb)
- ASM 12000: 1818 kg (3800 lb)

Worldwide
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Thermo SCIENTIFIC

Product Specifications

The Alpha-7A is a Continuous Air Monitor (CAM) designed to provide early warning to workers exposed to airborne releases of alpha-emitting radionuclides to reduce the internal inhaled dose.

Alpha-7A Alpha Particulate

Continuous Air Monitor

- Simultaneously monitors up to 8 isotopes
- Advanced peakshape algorithms
- Alpha spectral data updated every second
- Radial or inlinie smart detector heads
- Concentration, dose, and activity alarms
- Stand-Alone or network configurable

The Model ALPHA-7A is a modern, PC-based continuous air monitor providing faster and more powerful algorithms for the identification and quantification of airborne releases of alpha-emitting radionuclides, primarily transuranics such as ^{238}Pu and ^{239}Pu.

The ALPHA-7A has adjustable alarms, at both DAC and DAC-hour levels, to rapidly warn workers of potentially dangerous releases.

This instrument design has succesfully passed the rigorous ANSI N42.17B testing in the US and is CE qualified for European and other international operations. The Lovelace Respiratory Research Institute has also successfully tested the ALPHA-7A for particle collection efficiency and uniformity on the collection filter. The ALPHA-7A is fully RadNet compliant.

The ALPHA-7A can serve as a stand-alone CAM, or be incorporated into an Ethernet-based network. In addition to monitoring work areas, it is also an excellent solution for monitoring stacks and ducts.

The ALPHA-7A offers two detector designs; the radial entry head for ambient air monitoring and the inline head for process or stack monitoring applications. Either head may be used remotely from the central display and control unit.

Alpha 7A Specifications

Detector:	Solid state, 490 mm^2 active area
Effeciency:	Pu-239 27% (4 pi geometry).
Sample rate:	.5 to 2 CFM (14 to 60 lpm).
Connections:	RJ-45 for 10/100 Base T Ethernet (calibration and/or networking)
	PS2 Keyboard and mouse (local control of the Alpha-7A)
	DB15 External video (local view of the spectrum and for calibration)
	Terminal blocks for analog input, analog output, and alarm relays.
Power:	85-264 V ac, less than 100 watts, 45-63 Hz.
Analog inputs:	0 or 4-20 mA (logarithmic signal proportional to stack flow).
Analog outputs:	0 or 4-20 mA analog output, assigned to various measured items, for example
	slow concentration, fast concentration, sample flow rate, stack flow rate.
Alarms:	Red visual beacon, acknowledgeable from front panel. Sonalert for audible annunciation.
	Alarms for alert and high activity for fast concentration, slow concentration, DAC-h, stack release, flow alarms.
	Data Recording: Microsoft™ Access format database.
Nuclide library:	Fully editable Microsoft Access database for any number of user-specified isotopes.
Output relays:	Relay contact for alarm, fail, alert, and high activity alarms.
Vacuum supply:	Suggested is the RAP-1 (or RAP1-220 for 220V operation).
Approvals:	Electrical approval: CE mark certified.
	ANSI: ANSI N42.17B
	Particle collection/efficiency: Lovelace Respiratory Research Institute

Display module

Size:	311 H x 279 W x 165 D mm
	(12.25” H x 11” W x 6.5” D)
Weight:	7.8 kg (17 lb)

Radial detector head

Size:	20 H x 152 W x 216 D mm
	(8” H x 6” W x 8.5” D)
Weight:	3 kg. (6.5 lb)

Inline detector head

Air inlet:	The Alpha-7 in-line head uses 2.5 cm (1”) tubing.
Size:	318 H x 191 W x 159 D mm
	(12.5” H x 7.5” W x 6.25” D)
Weight:	5 kg (11 lb)

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FAG

Radiation
Measuring Technology

Operating Manual for the

FAG FH 40 F1-F6 RADIAMETER

FAG Kugelfischer Georg Schäfer KGaA

DB-001-860612 E

Dose rate meter in accordance with DIN 6818
Dose rates up to 10 Sv/h (1000 R/h)

I. FH 40 F Basic Meter

Purpose and description

1.

The FH 40 F basic meter is used for measurement of gamma and X-radiation. Design approval for calibration (FH 40 F1 ... F4) and approval for use in fire services (FH 40 F1/F3) have been received.

2.

According to the desired dose rate range there are four versions of the basic meter available:

Type	Measuring range *)	Counter tube
FH 40 F 1	3 µSv/h ... 1 Sv/h	ZP 1310
FH 40 F 2	0,01 µSv/h ... 10 mSv/h	ZP 1200
FH 40 F 3	300 µR/h ... 100 R/h	ZP 1310
FH 40 F 4	1 µR/h ... 1 R/h	ZP 1200

*) As from 1981 the legal unit for dose rate equivalent is "Sievert per hour" (Sv/h).

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FAG FH 40 F RADIAMETER

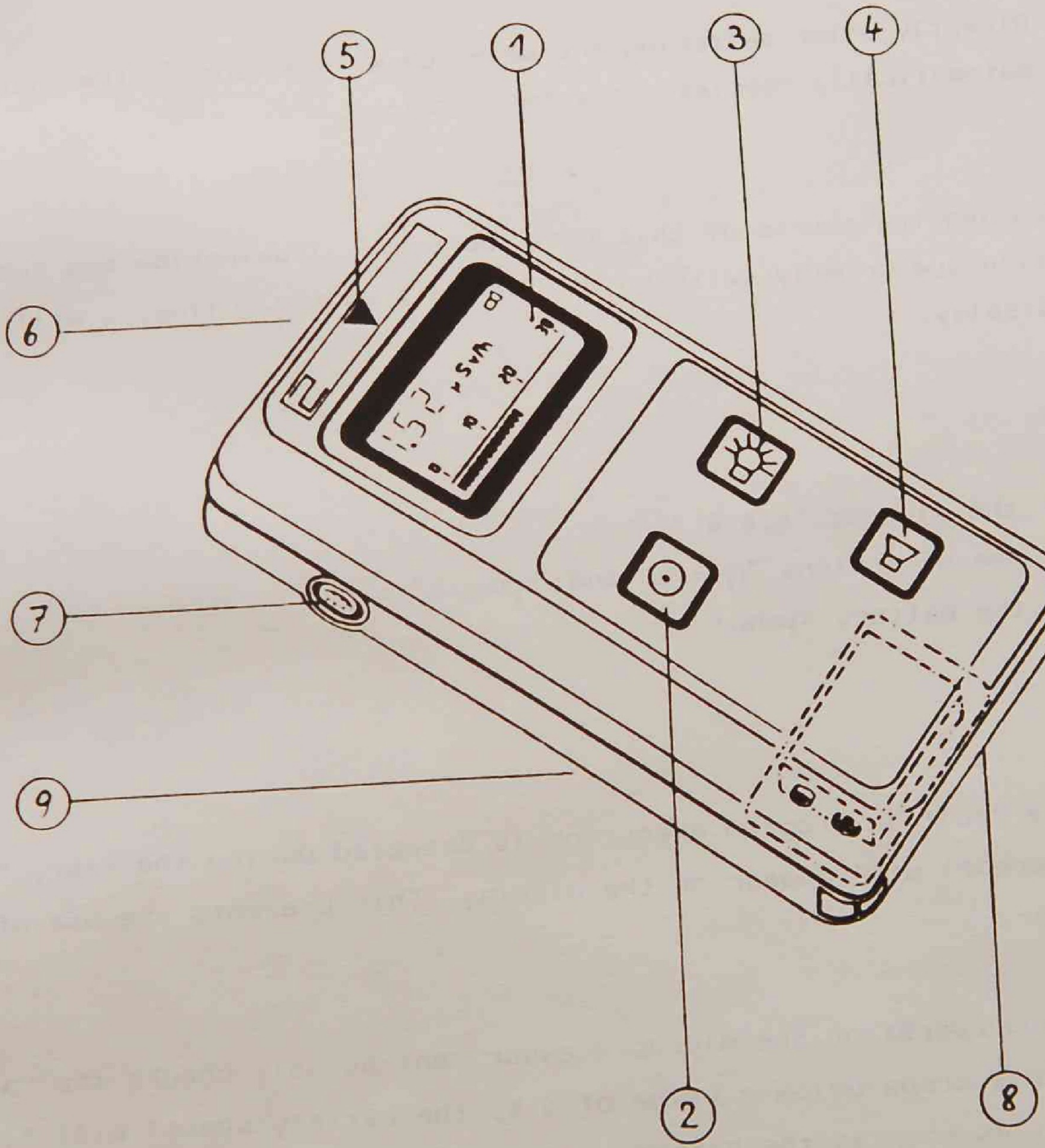


Fig. 1

08.01.1986 Lorenz/mü

6.

On the top of the meter (Figure 1) are the following:

- Readout scale (1)
- ON/OFF button ⊙ (2)
- Readout illumination button (3)
- Audible indication button (4)
- Yellow arrow to indicate direction of incidence of radiation (5)

7.

The end face of the meter has a

- circular yellow mark (6)
  for applying a test source.

8.

On the lefthand side of the case (Figure 1) is fitted the

- connection socket for an external probe.

9.

On the back of the radiameter are the

- battery compartment cover (8)
- and an adhesive plate with summary operating instructions (9).

Appendix 1

Specification

Measured variable	:	Photon dose rate equivalent (in Sv/h) or standard ion dose rate (in R/h)
Measuring range with integral high dose counter tube ZP 1310	:	$2 \cdot 10^{-4}$ ... 0.99 Sv/h ($2 \cdot 10^{-2}$ ... 99 R/h)
with integral low dose counter tube ZP 1200	:	$5 \cdot 10^{-7}$ ... $9.9 \cdot 10^{-3}$ Sv/h ($5 \cdot 10^{-5}$ ... 0.99 R/h)
Limits of error due to influence of energy	:	± 30 % in the range from 40 keV ... 3 MeV for FH 40 F1/F3 in the range from 45 keV ... 1,3 MeV for FH 40 F2/F4
directivity	:	± 20 % in the range ± 45 °

due to influence of temperature	:	± 20 % in the range from -30 ... +50 °C
due to influence of atmospheric pressure	:	± 5 % referred to a reading at 1013 hPa for a surrounding air pressure between 300 and 1300 hPa
due to influence of atmospheric humidity	:	± 5 % referred to a reading of 60 % relative humidity in the range from 0 to 95 % relative humidity
Indication error (calibration error)	:	20 % at Cs-137 radiation (662 keV)

FAG FH 40 F1-F4 RADIAMETER

Measurement and indication ranges

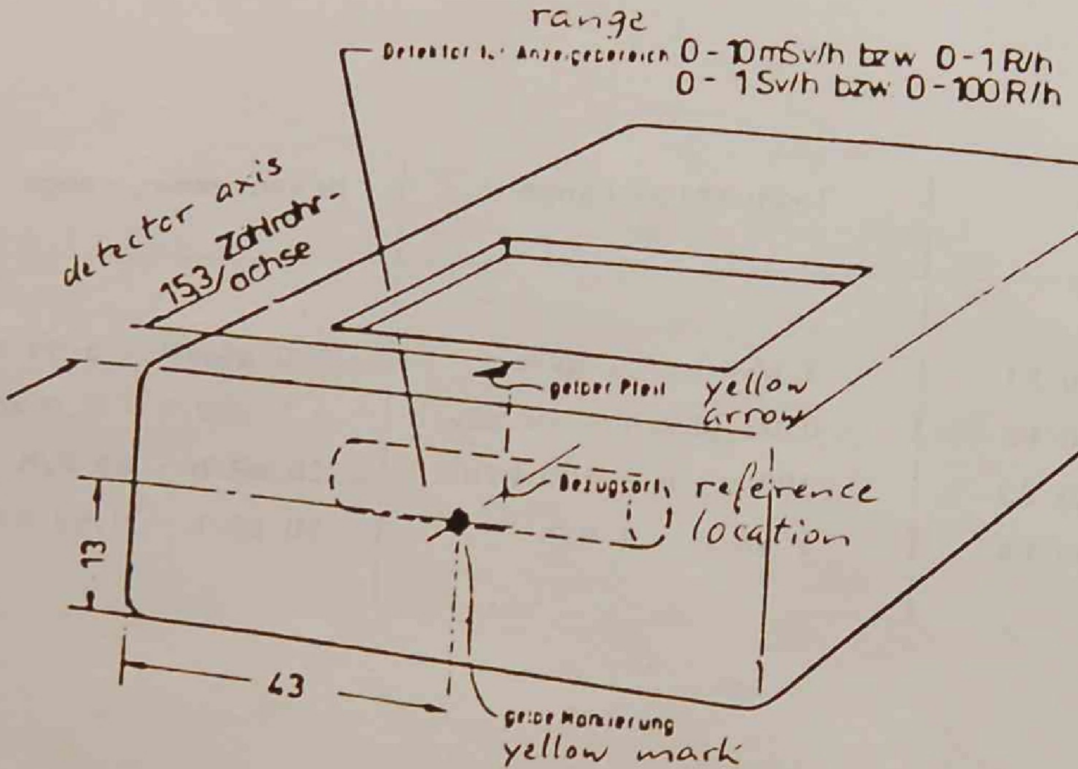
Meter	Indication range	Measurement range
FH 40 F1	3 µSv/h - 1 Sv/h	200 µSv/h - 0,99 Sv/h
FH 40 F2	0,01 µSv/h - 10 mSv/h	0,5 µSv/h - 9,9 mSv/h
FH 40 F3	300 µR/h - 100 R/h	20 mR/h - 99 R/h
FH 40 F4	1 µR/h - 1 R/h	50 µR/h - 0,99 R/h

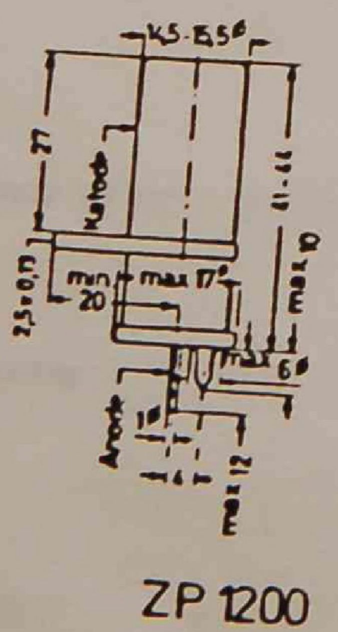
Detectors (Geiger-Müller counter tubes)

Meter	Detector
FH 40 F1	ZP 1310
FH 40 F2	ZP 1200
FH 40 F3	ZP 1310
FH 40 F4	ZP 1200

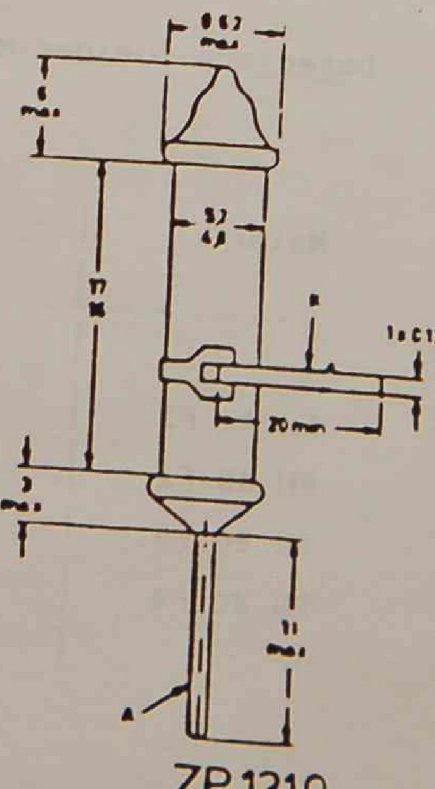
FAG FH 40 F RADIAMETER

Position and dimensions of counter tubes





ZP 1200



ZP 1310

Warm up and response time (DIN 6818 Part 1)

Scale		Response time	
		FH 40 F2/ FH 40 F4	FH 40 F1/ FH 40 F3
0 ... 1 µSv/h	0 ... 100 µR/h	90 s	-
0 ... 3 µSv/h	0 ... 300 µR/h	45 s	-
0 ... 10 µSv/h	0 ... 1 mR/h	35 s	-
0 ... 30 µSv/h	0 ... 3 mR/h	35 s	-
0 ... 100 µSv/h	0 ... 10 mR/h	15 s	40 s
0 ... 300 µSv/h	0 ... 30 mR/h	10 s	25 s
0 ... 1 mSv/h	0 ... 100 mR/h	8 s	20 s
0 ... 3 mSv/h	0 ... 300 mR/h	8 s	10 s
0 ... 10 mSv/h	0 ... 1 R/h	8 s	8 s
0 ... 30 mSv/h	0 ... 3 R/h	-	8 s
0 ... 100 mSv/h	0 ... 10 R/h	-	8 s
0 ... 300 mSv/h	0 ... 30 R/h	-	8 s
0 ... 1 Sv/h	0 ... 100 R/h	-	8 s

FAG FH 40 F1-F4 RADIAMETER

Power supply	:	9 volt alkali-manganese battery conforming to IEC 6 LF 22 or lithium battery 9 volt or accumulator
Operating life	:	min. 70 hours in normal ambient radiation with alkali-manganese battery (without scale illumination)
Measured value display	:	LCD; in digital form by means of 3 digit value with appropriate unit of measurement. In analog form by means of bar along linear scale, autoranging.
Battery check	:	flashing of battery symbol when battery voltage is too low.
Audible single pulse indication	:	sound level 85 dB(A) at a distance of 10 cm
Dimensions	:	approx. 160 mm long approx. 85 mm wide approx. 40 mm high
Weight	:	approx. 500 g (with battery)

The meter is splashproof in accordance with DIN 40 050, degree of protection IP 65.

08.01.1986 Lorenz/mu

Time constant in FH 40 F1/F3

The given values of time constant are valid, if no great changes of dose rate occur. Otherwise the time constant will be less.

Time constant [s]	FH 40 F1/F3	External FHZ 130 (high dose)	probe FHZ 173 (ß/γ)
40	0 ... 20 µSv/h 0 ... 2 mR/h	0 ... 80 µSv/h 0 ... 8 mR/h	0 ... 2,5 s^{-1}
20	20 ... 200 µSv/h 2 ... 20 mR/h	80 ... 800 µSv/h 8 ... 80 mR/h	2,5 ... 25 s^{-1}
8	0,2 ... 2 mSv/h 20 ... 200 mR/h	0,8 ... 8 mSv/h 80 ... 800 mR/h	25 ... 250 s^{-1}
2	2 ... 20 mSv/h 0,2 ... 2 R/h	8 ... 80 mSv/h 0,8 ... 8 R/h	250 ... 1000 s^{-1}
1	20 ... 1000 mSv/h 2 ... 100 R/h	0,8 ... 10 Sv/h 8 ... 1000 R/h	

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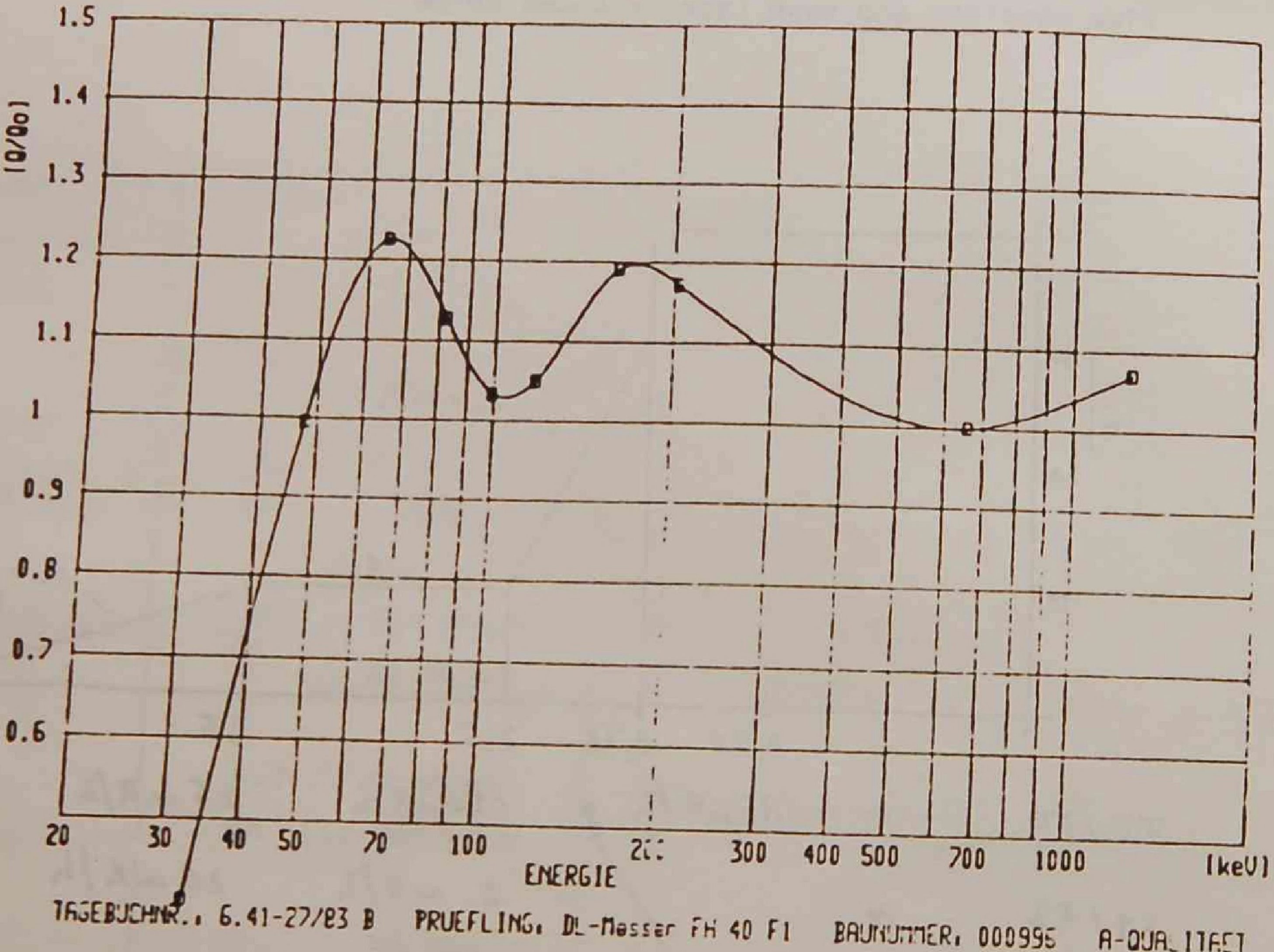
FAG FH 40 F RADIAMETER

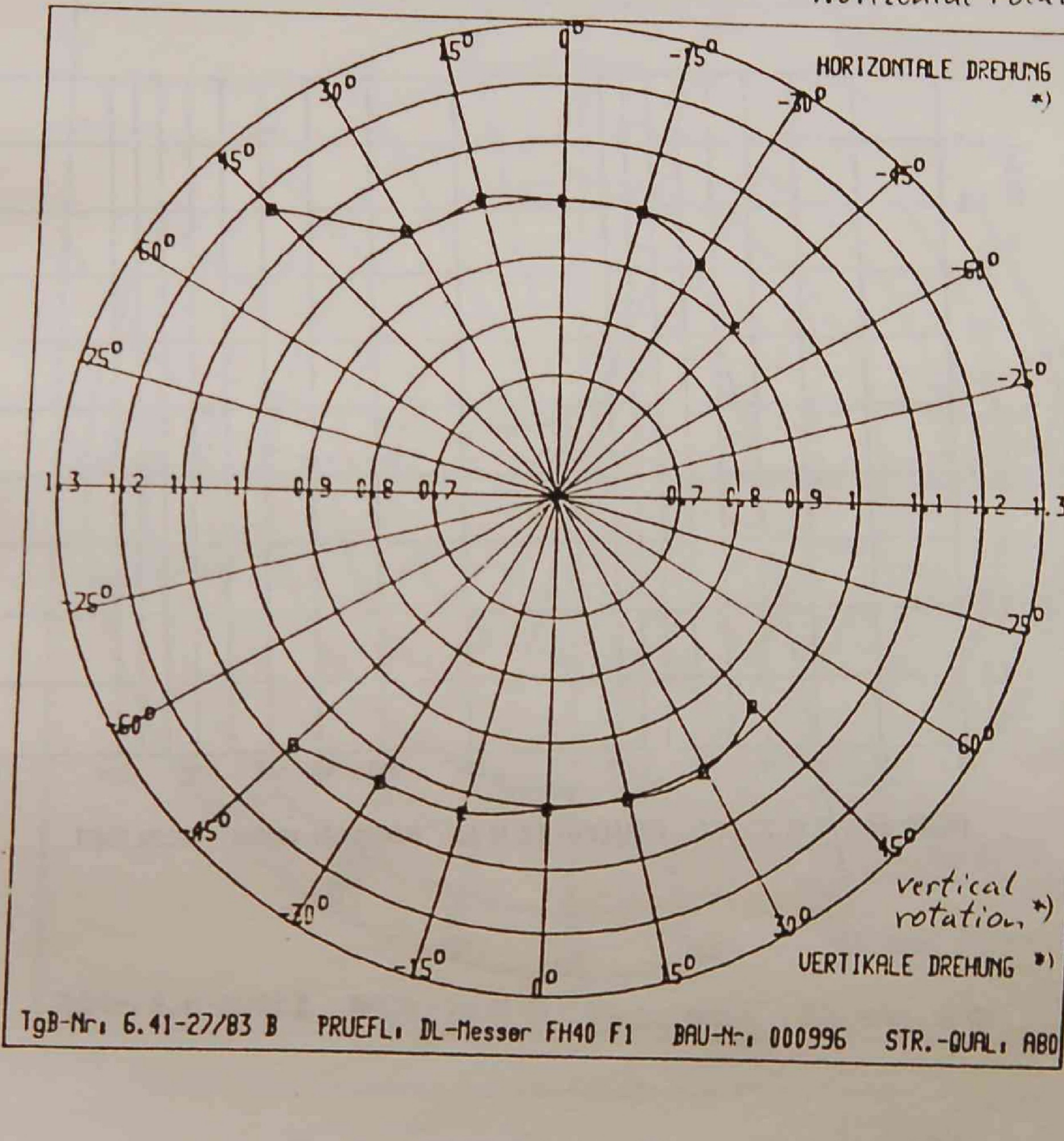


FH 40 F1/F3 Energy dependance of reading

Fig. 4

FAG FH 40 F RADIAMETER

horizontal rotation *)



FH 40 F1/F3 Directivity of reading
in angular range -45° ... +45°

Fig. 5

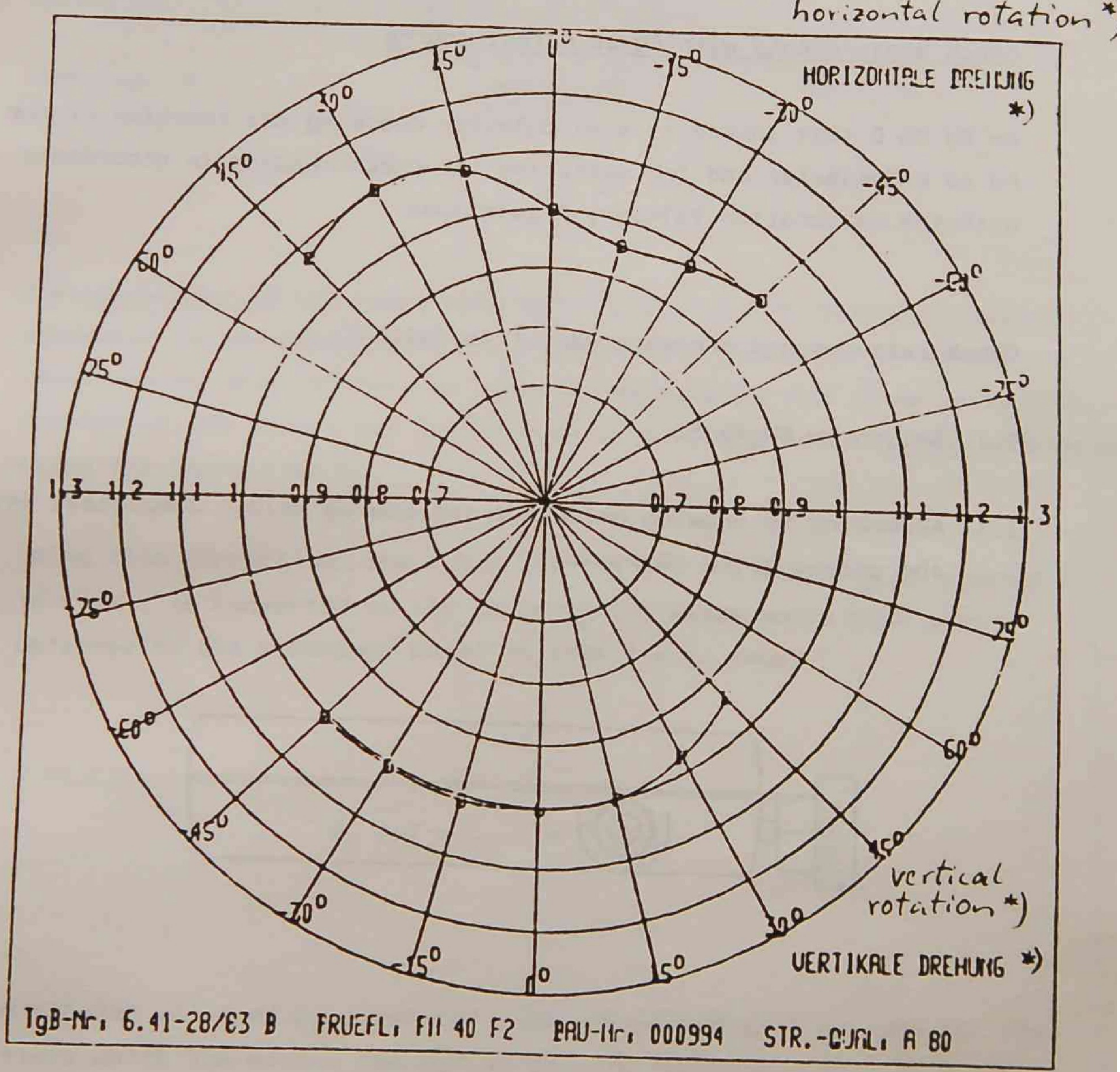
*) see page no. 17/18

FAG FH 40 F RADIAMETER

FH 40 F2/F4 Energy dependance of reading

Fig. 6

FAG FH 40 F RADIAMETER



FH 40 F2/F4 Directivity of reading
in angular range -45° ... +45°

Fig. 7

*) see page no. 17/18

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ARMY
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70007
(PART 4)

26/GS Trg Publications/2704

NUCLEAR TRAINING

(ALL ARMS)

VOLUME I

PAMPHLET No. 2

RADIAC INSTRUMENTS LESSON PLANS

PART 4

METER, SURVEY, RADIAC No. 2

By Command of the Defence Council,

Henry Hardman

MINISTRY OF DEFENCE,
23rd October 1964

Method of instruction

6. (*a*) Only experienced instructors should be allowed to teach the use, preparation for use and care and maintenance of the Meter, Survey, Radiac, No. 2 but latitude should be allowed in the methods they adopt. They must teach in the most interesting way without deviating from the facts, drills and safety precautions laid down.

(*b*) The Meter, Survey, Radiac, No. 2 is an operational instrument and is not capable of registering the low intensities which, for safety reasons, are produced by the various training sources. As a result, only the drills for the use of the instrument can be taught. Practical application of these drills to the tasks of monitoring and radiological survey have to be taught by using the Meter, Dose-rate, Portable, Trainer, No. 1 (*see* Part 3).

(*c*) All instructors should study the following pamphlets:—

(i) "Successful Instruction", 1951 (Code No. 8670).

(ii) Nuclear Training (All Arms) Vol I, Pamphlet No. 1 "Precautions against Nuclear Attack" (Code 9466) (AP 3349).

(iii) Part 3 of this pamphlet entitled, "Meter, Dose-rate, Portable, Trainer, No. 1".

(iv) "The Nuclear Handbook for Instructors and Staff Officers" (Code No. 9405) (AP 3321), Appendix D, Introduction to Radiac Instruments.

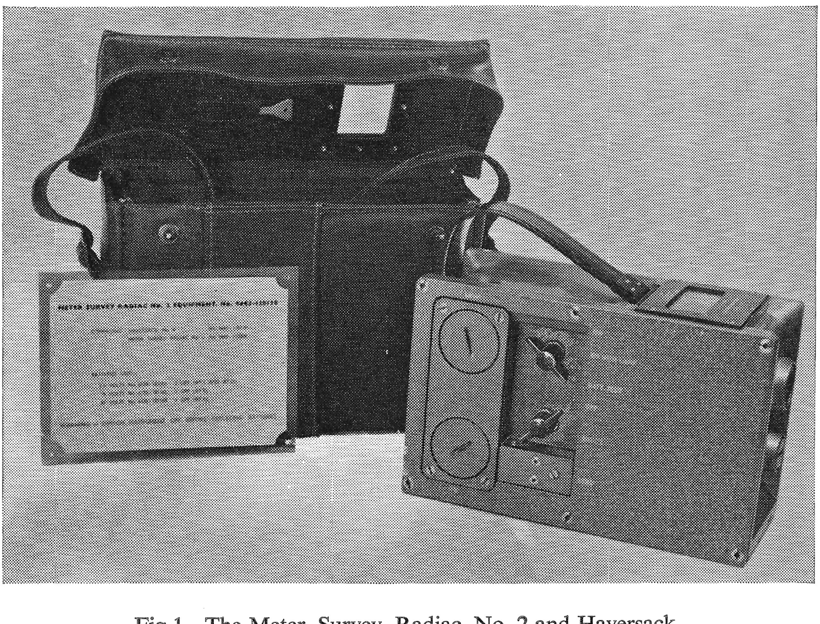


Fig 1—The Meter, Survey, Radiac, No. 2 and Haversack

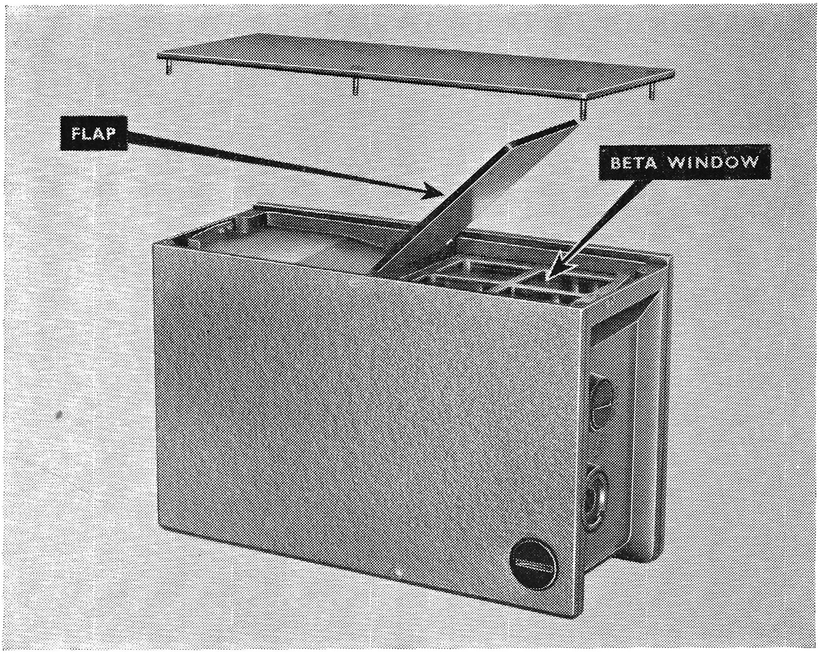


Fig 6—The beta window assembly

Fig 8—Radiological survey from a vehicle

26. After monitoring for beta, see that the hinged flap is in the "closed" position over the beta window, replace the base plate, check that the instrument is free from contamination by cleaning and then replace it in its haversack.

Fig 9—Monitoring personnel with the Meter, Survey, Radiac, No. 2

27. When monitoring personnel, the subject should stand facing the monitor, with his arms outstretched, and about one yard from him. The monitor works over him starting with the head and face and proceeding downwards and across the body (including the arms to their extremities) to the feet. The subject then turns about and the process is repeated covering the back and ending with the feet which are lifted in turn to enable the soles to be monitored.

Tests during use

28. During use, make the following checks and tests from time to time:—

(*a*) Ensure that the instrument is switched ON.

(*b*) Ensure that the scales are used correctly or the instrument may be damaged, eg, too low a scale in too high an intensity.

(*c*) Check the batteries (BATT TEST) frequently.

(*d*) Check ZERO frequently.

56. Do not teach it to beginners or to those of limited intelligence. It will be found useful, however, when answering questions that the lessons do not cover and for more advanced training for those likely to make instructors.

SECTION 4—TECHNICAL DETAILS

Basic circuit description

57. The basic circuit is shown diagrammatically at Fig 13.

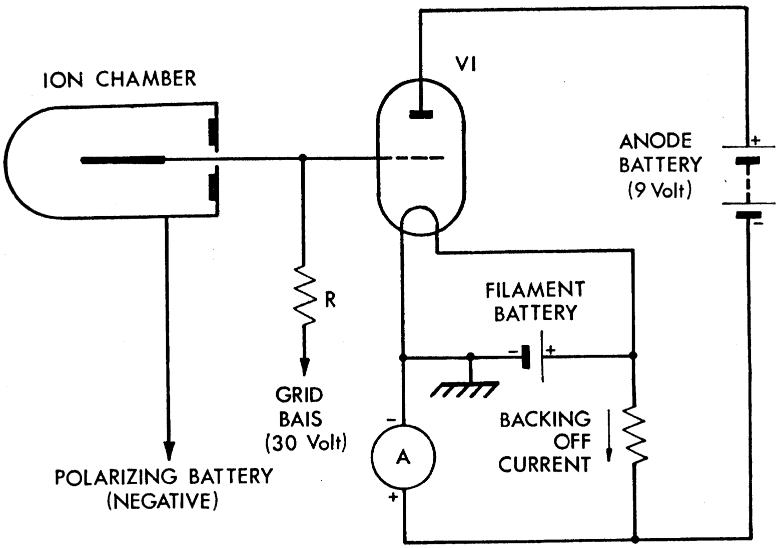


Fig 13—Basic circuit diagram

When a gamma ray passes through the walls of the ion chamber the air in the chamber is ionized (ie, the molecules lose electrons), a discharge occurs and a voltage pulse is produced. After a short period of insensitivity the chamber recovers and the process is repeated for the next gamma ray. The pulses pass from the anode (positively charged part) of the chamber through an electrometer valve (an amplifying valve with an exceptionally high insulation) to the meter which is calibrated in roentgens per hour which, for all military purposes can be accepted as rads per hour. The strength of the current will depend on the degree of ionization which, in turn, will depend on the degree of radio-activity.

58. The pointer in the meter is adjusted to ZERO by adjusting the valve grid bias until the anode current is equal to the "backing off" current (*see* Fig 13).

Warning—TEST PLUG

59. At the same end of the instrument case and below the "HUMIDITY INDICATOR" a TEST PLUG is fitted. This plug is for attaching a test instrument for calibration purposes and should not be removed by the user as this will break the hermetic seal.

Power supplies

60. The instrument requires the following power supplies:—

Battery	Army Vocab Section and Joint Services Catalogue No.	Approx working life (hours)	Nearest commercial equivalents
30-volt	Y3/6135-99-910-1163	400	Drydex 523 Ever Ready B123 Pertrix 8123 Siemens S123
9-volt	Y3/6135-99-910-1162	400	———
1·5-volt cell Filament or Lamp	Y3/6135-99-910-1101	150 16	Ray-o-Vac 2LP Ever Ready U2 Drydex T20 GEC BA6103 Oldham 532 Siemens T1 Vidor V0002

NOTE. In an emergency, if the instrument has not been used much for night work, the lamp cell can be used to replace the filament cell.

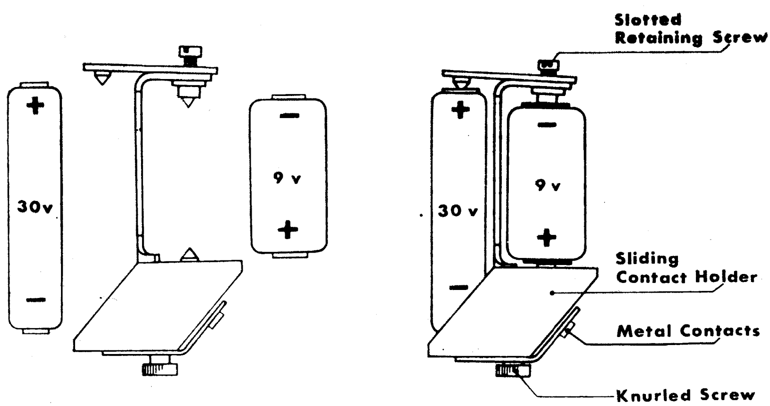


Fig 14—Battery holder assembly

Battery holder assembly

61. The battery holder consists of a metal framework on the bottom end of which is a sliding bakelite end holding two of the three metal contacts which connect with three corresponding contacts in the battery compartment. The movement of this sliding end to make contact with the 30-volt battery is controlled by the KNURLED screw operated by the fingers only. When the 30-volt battery has been positioned, the 9-volt battery can be fitted and the slotted screw tightened sufficiently to make good contact but no more. Over tightening of the contact screws will distort the framework of the holder. The metal top of the holder is insulated and protected with a rubber cap which incorporates a projection to assist in removing the holder from the battery compartment.

Dimensions

62. *Meter, Survey, Radiac, No.* 2

	inches
Length	$9\frac{1}{4}$
Width	$3\frac{3}{4}$
Height	$5\frac{3}{4}$

Haversack Assembly, Special, No. 6

Length	$11\frac{1}{2}$
Width	5
Height	7

4 kg

RESTRICTED

Thermo Scientific RadEye SPRD
Personal Radiation Detector

- Locate and Identify Radioactive nuclides
- Only pager sized NBR radiation detector
- Built for real-life

Definitive answers
through pin-point accuracy

Thermo
SCIENTIFIC

Thermo Scientific RadEye SPRD

Personal Radiation Detector

When the threat is real, you need quick and accurate identification.

The Thermo Scientific™ RadEye™ SPRD Spectroscopic Personal Radiation Detector helps you locate and identify radioactive nuclides such as those employed in nuclear weapons and dirty bombs in a pager sized PRD.

SMART ALARM INTERPRETATION

- Automatically and quickly distinguish between threatening and non-threatening radioactive sources
- Provides neutron presence indication as standard with the base RadEye SPRD

BUILT FOR REAL-LIFE

- Can be worn in holster on standard service belt
- Does not interfere with sitting or squatting
- Small and lightweight
- Long battery life
- Rugged, drop resistant construction

HIGH VALUE

- Numerous accessories and add-ons such as contraband detector or rapid deployable area monitor kit
- Same rugged and proven design as full RadEye family simplifies adoption
- Leverage our high volume RadEye production and the latest cost effective technology

Easy-mode Operation

Easy mode simplifies responding with the device for infrequent users. It quickly guides you through the next steps after an alarm.

Natural Background Rejection

NBR is a technology used to eliminate fluctuating natural background levels while measuring radiation. This proprietary and patented technology is used to quickly differentiate between natural and artificial radiation by stripping away any natural background radiation that is registering, delivering you a more accurate result of artificial radiation levels.

The RadEye SPRD offers the next generation of NBR. The added fidelity of the new multi-channel NBR algorithm provides higher sensitivity to positively differentiate between natural and man-made radiation during search and find operation and better detection performance against masked isotopes. Once an alarm indicates the presence of significant gamma radiation the RadEye SPRD can automatically switch into radionuclide identification mode for immediate analysis. The editable trigger list allows users to select nuclides of concern from a list that includes all in the ANSI N42.48 standard. Users may also define custom subsets based on their areas of interest such as medical or industrial applications.

Our Lutetium test adaptor ensures quick and reliable performance verification

Law enforcement, border guards and special forces

The SPRD is ideal for primary inspection of its surroundings and provides basic secondary inspection, allowing users to quickly adjudicate the most common alarms such as distinguishing medical patients from RDDs or crates of bananas from orphaned sources.

Law enforcement officers can take advantage of its small, wearable size and its affordability to provide a sensitive and significant network of sensors to locate radiation. Rapidly determine identity and type of radiation, providing key information faster to determine if HAZMAT or CBRN teams are needed.

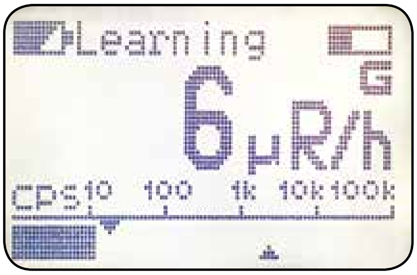
Metal recyclers

Detect, locate and identify orphan radionuclides in your incoming scrap material.

Specifications and ordering information

Model	 RadEye SPRD	 RadEye SPRD-GN	 RadEye SPRD-H
Radiation detected	Gamma	Gamma Neutron	Gamma
Detector	CsI	CLYC (Cs2LiYCl6)	CeBr3
Energy resolution (662 keV)	7.5%	7.5%	4%
cps per µSv/h (662 keV)	100	110	170
ID-time @ 1µSv/h	< 5 min	< 5 min	< 2 min
Detection from	40 keV	50 keV	20 keV
NBR (Natural Background Rejection)	good	good	very good
PSD (Pulse Shape Discrimination)	no	Yes	no
Neutron Alarm Response ANSI N42.48-2008	no	Yes (<2 s)	no
Neutron verification	via prompt gamma	thermal neutrons & fast neutrons	via prompt gamma
Estimated Battery Life	180 hrs	120 hrs	180 hrs
	First Preventers use for both interdiction and personal protection when radiation monitoring is not your primary function. Capable of distinguishing NORM sources such as granite or bananas from artificial sources such as medical, industrial and SNM immediately through advanced NBR. ID capability can fully adjudicate medical patients from threat nuclides. Respond to an emergency at a hospital, alarms that dose rates are high near the blood irradiation area	4 times more sensitive to neutrons compared to RIID devices Ideally suited as primary screeing tool at borders, on boats and remote outposts where larger detection systems are not available	Increased sensitivity Higher resolution Can detect and ID hidden, masked and shielded sources Can be used as a secondary screeing tool accompanying the PackEye GN-2 backpack radiation detector and as an alternative to a large RIID for source localization and identification

We have an expansive library of radionuclide information. Our easy to read display allows you to quickly set thresholds and identify dose rates.



Our screen continuously shows you dose rate. As we are also monitoring count rate you will be alerted by an audible or vibrating alarm if your count rate suddenly increases suggesting you are facing an immediate threat.

Learn more about SPRD at
www.thermoscientific.com/sprd

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Thermo SCIENTIFIC
A Thermo Fisher Scientific Brand

BR-RMSI-SPRD-0116

Product Specifications

The SVG 2 Radiacmeter is a hand-held, battery powered ratemeter for gamma and neutron radiation measurement ruggedized to meet the demands of the military and first responders.

SVG 2 Radiacmeter

NATO Stock Number 6665-12-358-1874

- Measures:
  - Gamma Dose Rate
  - Gamma & Neutron Dose
  - Alpha & Beta Contamination
- NATO Approved
- User-Friendly Display
- Data-Logging
- Ruggedized Kit
- Impervious to TREE, NEMP & EMV Interferences
- Interface to GPS & PC

The SVG 2 Radiacmeter incorporates the newest generation of hardened microprocessor technology to support battlefield radiological measurements for alpha. beta, gamma and neutron. This NATO approved system is designed to provide critical measurements for nuclear incidents and attacks.

The initial and residual dose rate from gamma and neutron radiation are detected by state-of-the-art semiconductor detection devices to provide the required sensitivity and durability necessary in hostile conditions. Contamination measurements for alpha and beta emmitters are also supported in a unique external detector design.

This instrument is designed with ease of handling in mind and are supported by its low weight and power consumption. Both the current gamma dose rate and the integrated gamma dose may be displayed. Alarm thresholds for all detection modes are adjustable. The alarms are annunciated by an optically flashing red LED and acoustical signal via the earphone.

The measured dose and dose rate are stored internally in memory. Built-in function keys permit the stored values to be recalled and displayed or transmitted over a serial interface to a PC to facilitate further investigation or report generation.

The SVG 2 kit is comprised of the following items:

- Radiac Survey Meter with internal detector
- Short Telescopic Handle for External Probe
- Two Carrying Bags
- External ABG Probe (Alpha/Beta/Gamma)
- Long Telescopic Handle for External Probe
- Earphone
- Detector Cable Set

Specifications

Residual Gamma

Gamma Dose rate:	0.01 uGy/h to 2.000 cG/h (Gy/h switchable to Sv/h) (1 uR/h to 2000 Rad/hr).	
Gamma Dose:	0.01 uGy to 2.000 cGy (Gy switchable to Sv) (1 Rad/hr to 2000 Rad/hr).	
Energy Range:	70 keV to 3 MeV.	

Initial Radiation

Gamma Radiation:	1 cGy to 2,000 cGy (1-2000 Rad/hr).	
Neutron Radiation:	1 cGy to 2,000 cGy (1-2000 Rad/hr).	

Alpha-Beta-Gamma External Probe

Alpha Measurement Range:	0 to 300,000 cps.	
Beta Measurement Range:	0 to 300,000 cps.	
Gamma Measurement Range:	0.01 uGy/h to 50 cGy/h (1 uRAD/h to 50 RAD/h).	
Efficiency: *(pulse X cm2/beta particle)*		
	^{14}C:	0.047
	^{137}Cs:	0.40
	^{204}Tl:	0.39
	^{90}Sr^{90}Y:	0.57

General Specifications

Battery Life:	Approximately 130 hours.	
Temperature Range:	- 30 to 55° C (-22 to 131° F).	
TREE:	10 cGy/s neutron (10 RAD/s).	
NEMP:	75 kV/m, norm pulse slope 5 ns.	
EMV per VG95373:	SA 02 G, protocol 1 and 2. SA 04 G, protocol 5 and 6. SA 03 G, protocol 7, 8, 9 and 10.	
Heat Flash:	2 s with 59 J/cm2.	
Salt Fog:	48 hours per MIL STD 810D.	
Protection Class:	IP 67 per VG 95332, page 12, level 6.	
Weight:	3.5 kg (7.6 lbs).	
Dimensions:	SVG2:	160 x 90 x 78 mm (6.3” x 3.5” x 3.1”).
	w/Bag:	250 x 120 x 170 mm (9.8” x 4.7” x 6.7”).

Available Accessories

- Spare Parts
- GPS Receiver
- PC program to acquire stored data
- Laptop or Desktop PC

Additional Features

Display:	- Autoranging display with correct radiological units
	- Displays status, mode & function
	- Flashing symbols alert user to alarm conditions
	- Large, backlit LCD display
	- Analog trend indication of dose rate
	- Digital display of radiological value
Keypad:	- Large area dedicated function keys
	- Water tight
	- Illuminated keypad

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Frauenauracher Strasse 96 — +49 (0) 9131 909-0
D 91056 Erlangen, Germany — +49 (0) 9131 909-205 fax

United Kingdom
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Reading RG7 5PR United Kingdom — +44 (0) 118 971 2835 fax

United States
27 Forge Parkway — +1 (508) 520-2815
+1 (800) 274-4212 toll-free
Franklin, MA 02038 USA — +1 (508) 428-3535 fax

www.thermo.com/rmp

Thermo SCIENTIFIC

RadEye Selection Guide

08/2012

Handheld Detection for Any Scenario

Thermo
SCIENTIFIC

RadEye Product Family

With the RadEye Product Family, Thermo Fisher Scientific offers a wide range of advanced handheld instruments for radiation detection, gamma dose rate measurements and area monitoring.
This guide offers a brief description and technical characteristics for each instrument. For more detailed technical specifications, please contact your local sales representative or your appropriate customer service assistant.

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China

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Singapore

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Any nation not listed

customerservice.eid.erlangen@thermofisher.com

Contents

RadEye Product Family

Features

- Rugged and reliable
- Large graphic display
- Lightweight instruments, starting from 160 g
- Simple and intuitive user interface
- Easily configured for specific tasks
- Durable and shock resistant
- Accurate with excellent EMI immunity
- Low power technology
- Use of rechargeable standard-size batteries

RadEye - The next generation of radiation meters

Thermo Scientific offers a comprehensive range of advanced instruments for radiation detection, dose rate and contamination measurements.

The characteristic features of this versatile pocket meter are the small size, the ease and flexibility of operation and its superior measurement performance, which is provided by the use of sophisticated low power technology. Fully automated self-diagnosis minimizes required maintenance.

All essential functions are easily accessed, even while wearing protective gloves.

The top-mounted alarm-LED can be seen while the instrument is worn in a belt-holster. A built-in vibrator and an earphone-output provide silent alarming for use in very noisy environments.

Menu operation

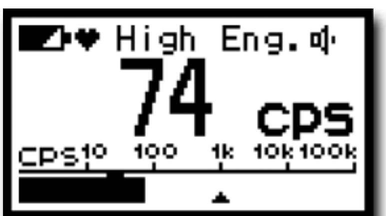
All of the parameters can be easily modified on the RadEye or using the optional software. These menu operations can also be reconfigured to simplify the instrument and to avoid any faulty operation. Navigation is made easy by a clear and intuitive interface.

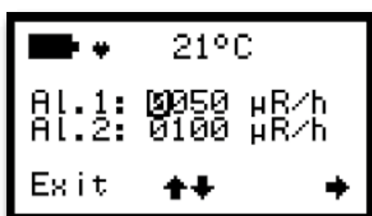
1 Opens the configuration menu.
Once the menu is opened, features are selected by 1 2 3 4

2 Additional information (e.g., the accumulated dose, remaining time in a certain radiation field as well as mean and maximum measuring values) can be displayed.

3 On-switch and key lock - similar operation to your mobile phone.

4 5 Operation of the audible indicator and alarm acknowledgement.

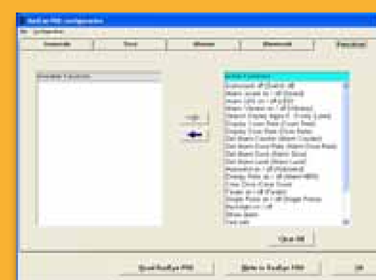


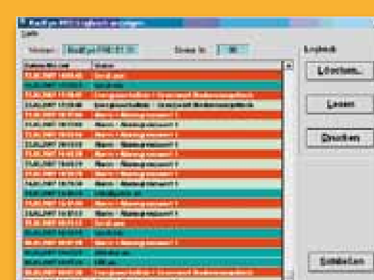


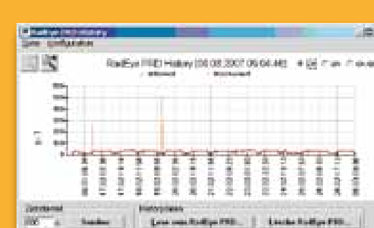
RadEye software

All settings and the data analysis can be done using the optional Windows®- based PC-software, and an accompanying reader device. In order to allow post-event analysis, the latest 1,600 dose rate values are stored in the data memory. For each datalogging interval both the mean and the maximum measurement values are stored.

Changes in configuration, along with alarms and errors, are saved in the RadEye memory. These events can be read out via the “logbook”. It is shown as a table and can be saved to the PC or printed. The logbook has a maximum of 250 data sets. Several events that occur at the same time are saved as one record. On the display every event is shown in one line for a clear view.


RadEye PRD configuration


RadEye PRD logbook


RadEye PRD history

RadEye PRD/PRD-ER

Search and Find

Features

- High quality PMT for excellent response from 30 keV
- EMI immunity much better than photodiode instruments
- NaI(Tl)-Detector for high response to SNM and RDD´s
- True dose and dose rate calculation avoids significant overestimation of low gamma energies
- Automatic background update, (i.e., no user action necessary)
- NBR allows very low alarm levels for artificial radioactivity
- Designed to meet ANSI 42.33/1, 42.32 and IEC 62401
- Energy response behavior in Roentgen

RadEye PRD

The "orphan source" phenomena is a serious global problem as sources showing up unexpectedly in scrap yards, border crossings or numerous other public locations are a significant potential threat. The RadEye PRD represents a high-performance measuring device for anyone responsible for finding radiation sources whether they be first preventers (border guards, customs officers) or first responders (emergency services and law enforcement).

The RadEye PRD is 5,000 - 100,000 times more sensitive than a typical electronic dosimeter.

When looking for lost or hidden radiation sources or contaminated materials, it is paramount to use a tool with high sensitivity and high selectivity.

The RadEye PRD achieves this through a special technique based on our patented Natural Background Rejection (NBR) technology. It is the only instrument of its type and size to achieve this.

The RadEye PRD incorporates a high sensitivity NaI(Tl) scintillation detector with a miniature photo-multiplier allowing the detection of very low radiation levels with particular emphasis on gamma emissions below 400 keV. Thus, in case of a nuclear accident, the RadEye PRD is ideal for sensitive I-131 detection and measurement.

Detector	NaI(Tl)-detector with high quality micro photomultiplier; software switch for R or Sv energy response and calibration
Measuring range	PRD: 1 µR/h - 25 mR/h [0.01 µSv/h – 250 µSv/h] PRD-ER: 1 µrem/h - 10 rem/h [0.01 µSv/h – 100 mSv/h]
Overrange indication	PRD: Tested up to 1,000 R/h [10 Sv/h] PRD-ER: Tested up to 10,000 rem/h [100 Sv/h]
Energy range (+/- 30 %)	60 keV - 1.3 MeV, excellent detection from 30 keV
Response for Cs-137 (662 keV)	1.5 cps per µR/h [150 cps per µSv/h]
Response for Am-241 (60 keV)	30 cps per µR/h [2000 cps per µSv/h]
Linearity error (Cs-137)	PRD: max. ± 10 % PRD-ER: max. ± 20 %
Enhanced alarming sensitivity by NBR	Yes, down to 1 µR/h [0.01 µSv/h] at low gamma energies
Cosmic radiation background	Suppression typically > 95 %

RadEye PRD #4250671
Factory calibrated in exposure rate R/h

RadEye PRD #425067120
Factory calibrated in H*(10) µSv/h

Applications

- Search and Safety
- Security
- First responders
- Steel and Recycling
- Environmental Monitoring

RadEye PRD-ER

Special proprietary circuitry allows the energy compensated dose and dose rate measurement up to 100 mSv/h (or 10 rem/h). Thus the RadEye PRD-ER is the ideal tool for both interdiction and response.

Unlike instruments using two different detectors for the low dose rate range and the high dose rate range, the single detector arrangement in the RadEye PRD-ER offers the following unique advantages over the whole measuring range:

- Consistent angular dependence
- No mutual shielding of neighboring detectors
- Consistent energy response
- No transition range with annoying hysteresis effects
- No high activity source for function test of high dose rate detector required

With the help of the RadEye PRD-ER test adapter, users can check the full detector performance on a regular basis – without the need of a high dose rate calibration facility.

RadEye PRD-ER #425067102
Factory calibrated in exposure rate R/h
Yellow front cover

RadEye PRD-ER #425067122
Factory calibrated in H*(10) µSv/h
Yellow front cover

RadEye PRD-ER #425067104
Factory calibrated in exposure rate R/h
Black front cover

Lutetium Test Adapter for PRD and PRD-ER

For additional information please see pages 37-38.

RadEye variants PRD-S and PRD-ER-S

The special firmware variants RadEye PRD-S # 425067130 and RadEye PRD-ER # 425067135 includes the capability for scaler measurement.

For additional information please ask for a separate data sheet.

RadEye PRD-S gamma laboratory kit # 425069015, e.g. for sensitive measurement of small food samples.

RadEye GN

High Sensitivity Gamma Neutron Pagers

Features:

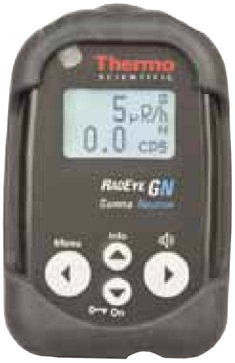
- Pocket-sized gamma neutron pager
- Very high neutron and gamma sensitivity
- Ideal for law enforcement officers and first responders
- Immediate classification of gamma source (NORM/non-NORM)
- Energy compensated gamma dose rate
- Dual gamma/neutron display
- No false neutron alarms for even intense gamma sources

The new Thermo Scientific RadEye™ GN Gamma Neutron Pager combines the superior performance of the Thermo Scientific RadEye PRD Gamma Pager with a very high neutron sensitivity that exceeds the time-to-alarm requirements of ANSI 42.32 and IEC 62401. Furthermore the RadEye GN shows a significantly enhanced performance of the built-in NBR circuitry (NBR = Natural Background Rejection). It is now even more capable of differentiating artificial sources from NORM than previous RadEye™ PRDs, due to the resolution and stability of the scintillator material.

The RadEye GN identifies to the user whether the alarms are due to gamma or neutron by a different colored alarm LED, different tones and flashing the count rate/dose rate display readings with an inverted display background of the alarming channel or both channels as appropriate. The device also has different audible alarms, discriminating between elevated background/NORM and any artificial isotope alarm. The gamma and neutron audible alarms are clearly different. This gives the RadEye GN audible and visual identification using NBR of the type of material detected.

In conjunction with the optional moderator (# 425067177), the RadEye GN pager can be transformed into an even more powerful gamma/neutron search device at very little additional cost. An estimation of the neutron dose rate can thus be achieved for perimeter marking as well.

NBR = Natural Background Rejection
The NBR measurement method has been developed by Thermo Fisher Scientific, for extremely fast discrimination between natural and artifical gamma radiation. Many thousands of devices, based on this technology, are in use worldwide.



The display has large 8 mm numerals and large clear radiation units:

It includes a quick-view bar graph of current count-rate / dose-rate and alarm set points, including the floating sigma alarm point, if utilized.

The display also shows alarm status:

- Artificial low energy alarm
- Artificial mid energy alarm
- Artificial high energy alarm
- NORM balanced alarm
- Gross gamma count or dose rate alarms (2 alarm levels)
- Gross neutron count rate alarm
- Gamma dose alarm (2 alarm levels)
- Safety alarm (gamma)

A bright orange LED for gamma alarms and a bright blue LED for neutron alarms is viewable from the front and above. When a dual gamma and neutron alarm is detected, both LEDs flash. Both readings on the display are flashed with a reversed background. The RadEye GN can be fitted with the Bluetooth™ (#425067087) back that can be set to talk to a PC, or to other devices for networking.

Technical details of the Thermo Scientific RadEye GN Gamma Neutron Pager

Size	96 mm x 61 mm x 31 mm
Weight	160 g
Battery life time	> 300 h
Detection capability	Gamma count-rate from 30 keV to 1.3 MeV Energy compensated gamma doserate from 45 keV to 1.3 Mev (H*(10)) from 1 µRem/h to 25 mRem/h (0,01 µSv/h to 250 µSv/h) Neutron count-rate from 0,1 to 1000 cps
Gamma efficiency	900 cps per µSv/h (Am-241); 130 cps per µSv/h (Cs-137); 60 cps per µSv/h (Co-60)
Neutron efficiency	4.3 cps/20,000 n/s Cf-252; shielded in 1 cm lead 25 cm in front of instrument with 30 cm x 30 cm x 15 cm PMMA phantom. Exceeds ANSI 42.32 and IEC 62401 alarm requirements
Order number	RadEye GN: #4250630

RadEye G/G-10

Gamma Safety Surveys

Applications

- Gamma surveys from background up to personal safety levels
- First Responders
- Nuclear Power Industry
- Radiography
- Radiation Protection
- Radiography
- G-10 is for H-10 deep dose rate measurements

Wide range survey meter RadEye G-10 (SI-units) and RadEye G (US-market)

The RadEye G and RadEye G-10 are lightweight and very rugged instruments designed for quick and reliable measurement of gamma dose rates.

Modern electronic circuitry guarantees excellent linearity over six decades of radiation intensity: from background level to 100 mSv/h (10 R/h) - with unlimited overrange indication. Both devices incorporate a large energy compensated GM-tube for precise dose rate measurement for gamma and X-ray.

Detector	Energy compensated GM-tube
Measuring range	RadEye G: 50 µR/h - 10 R/h RadEye G-10: 0.5 µSv/h - 100 mSv/h [50 rem/h - 10 rem/h]
Energy range (according to IEC 60846-1)	RadEye G: 45 keV - 3 MeV RadEye G-10: 50 keV - 3 MeV
Count rate for Cs-137 (662 keV)	17 cps per mR/h [1.7 cps per µSv/h]

RadEye	Color front cover	Order no.
RadEye G-10	red	# 4250676
RadEye G-10	white	# 425067602
RadEye G-10 PTB	red	# 4250675
RadEye G	black	# 4250674
RadEye G	yellow	# 425067401

Common features of RadEye G and GF series

Key features

- Pocket size
- Accurate
- Lightweight
- Large graphic display with clear prefix and bar graph
- Extreme low power consumption for permanent operation
- Energy compensated up to 3 MeV

Check source

To ensure top functionality of the RadEye G series, we offer a test adapter based on 200 kBq Ba-133 - exempt quantity referring to e.g. NRC/IAEA/EU regulations. # 425067072

For use in the US, a 5 µCi Cs-137 test adapter is available as well. # 425067075CS137

Applications

- High range measurement
- Radiography
- Safety

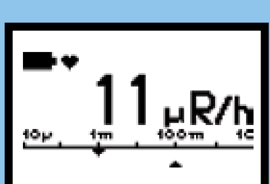
High range gamma survey meter RadEye GF-10 (SI-units) and RadEye GF (US-market)

The intelligent ratemeter algorithm (ADF mode) guarantees that even the smallest changes in dose rate are immediately detected, while at the same time, random fluctuations are effectively suppressed.

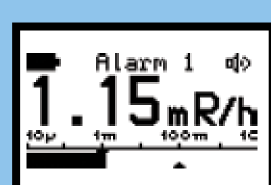
All essential functions are easily accessed while wearing protective gloves. The alarm-LED can be seen while the instrument is worn in a belt-holster. The instrument is also equipped with a built-in vibrator and an earphone-output for silent alarming or use in very noisy environment.

Detector	Energy compensated GM-tube
Measuring range	RadEye GF: 0.5 mR/h - 300 R/h RadEye GF-10: 5 µSv/h - 3 Sv/h [0.5 mrem/h - 100 rem/h]
Energy range (according to IEC 60846-1)	RadEye GF: 45 keV - 3 MeV RadEye GF-10: 50 keV - 3 MeV
Count rate for Cs-137 (662 keV)	RadEye GF: 1.3 cps per mR/h RadEye GF-10: 0.13 cps per µSv/h

RadEye GF: # 425067475 RadEye GF-10: # 425067675



Background measurement
Alarm thresholds - two triangles in the bar graph, indication low



Alarm level 1 exceeded
"Alarm 1" and "speaker" signs show up
Absence of trend arrow indicates stable radiation level - reading can be taken

Approaching a source
Alarm thresholds - not yet exceeded.
Trend arrow indicates increasing radiation level

RadEye G-Ex series

Intrinsically Safe Gamma Surveys

Features

- Intrinsically safe according to ATEX standards
- Efficient and reliable dose and dose rate measurements
- Large, clear and backlit display for error-free readings
- Rugged and reliable
- Lightweight, only 160 g (5.6 oz.)
- Low power technology

New!

RadEye G-Ex series - intrinsically safe personal radiation detectors

In emergency response and in industry flammable and explosive materials like gases, dust and fibers can occur. In such potentially explosive atmospheres it is necessary to use ATEX certified devices for your measurements.

The Thermo Scientific RadEye G-Ex series comprises four versions of intrinsically safe handheld devices for gamma and dose rate measurements. They are designed according to the latest ATEX standards to meet the needs of their operator in and around hazardous areas.

Devices certified as "intrinsically safe" are designed to be unable to release sufficient electrical or thermal energy to cause ignition of flammable materials like gas, dust or particulates.

Beside the ATEX tags, the visual difference between the RadEye versions is noted by the orange color of the front panel of the intrinsically safe versions.

Inside, the RadEye G-Ex devices have been re-engineered to reduce energy safety issues and avoid the generation of heat and electrical sparks. They are premium products designed for ultimate safety and accurate dose rate measurements.

ATEX Certification RadEye G-Ex Instruments

II 2G-EX ia IIB T4

	ATEX examination mark. This sign is required on all devices used in European hazardous areas.
II 2G	Classification of zones. II = device is approved for all non-mining areas. 2 = category of the device, here it means that the device is rated for the second most hazardous areas. G = designates atmosphere, in this case gas, vapors and mist.
Ex	Explosion protection based on European Ex-regulations.
ia	Explosion protection type, "ia" is the highest level of protection.
IIB	Gas group for average reactive gases (except hydrogen, acetylene or disulfide)
T4	Temperature class gives the user the maximum temperature of a surface that may be in contact to the Ex atmosphere under fault conditions. T4 is rated at 135 °C.

RadEye G-10-Ex: # 425067660
RadEye GF-10-Ex: # 425067670
RadEye G-Ex: # 425067460
RadEye GF-Ex: # 425067470

Applications

- Hazmat teams
- Fire brigades
- Refineries
- Oil platforms
- Locations with risk of explosion
- Marines and Coast Guard

Measuring range	RadEye G-10-Ex: From 0.5 µSv/h to 100 mSv/h RadEye GF-10-Ex: From 5 µSv/h to 3 Sv/h	SI-units
Sensitivity (Cs-137, 660 keV)	RadEye G-10-Ex: ~1.9 cps/µSv/h RadEye GF-10-Ex: ~0.13 cps/µSv/h	

Measuring range	RadEye G-Ex: From 50 µR/h to 10 R/h RadEye GF-Ex: From 0.5 mR/h to 300 R/h	USA
Sensitivity (Cs-137, 660 keV)	RadEye G-Ex: ~17 cps/mR/h RadEye GF-Ex: ~1.3 cps/mR/h	

Dose	0.5 µSv to 10 Sv
Linearity error	max. +/- 10 % in the measuring range
Alarm thresholds	Two each thresholds for dose and dose rate
Energy range	45 keV – 3 MeV according to IEC 60846-1
Working temperature	-20 °C ... + 50 °C
Relative humidity	10 ... 90 % at 35 °C
Protection degree	IP 65 according to EN 60 529
ATEX classification	II 2G Ex ia IIB T4 IBExU10ATEX1096
Size	96 x 61 x 31 mm without rubber protector
Weight	approx. 160 g, including 2 batteries
Internal memory	The latest 1600 measured values are saved and can be read out via PC-program. Logbook with 250 entries for changes of configuration, occurring alarms and errors

Check source

To keep the radiation detector functionality of the RadEyeG and RadEyeG-10 we offer a test adapter based on 200 kBq Ba-133 - exempt quantity referring to e.g. NRC/IAEA/EU regulations. # 425067072

For use in the U.S., a 5 µCi Cs-137 test adapter is available as well. # 425067075CS137

RadEye G20-10/G20-ER10

Gamma Surveys Including X-rays

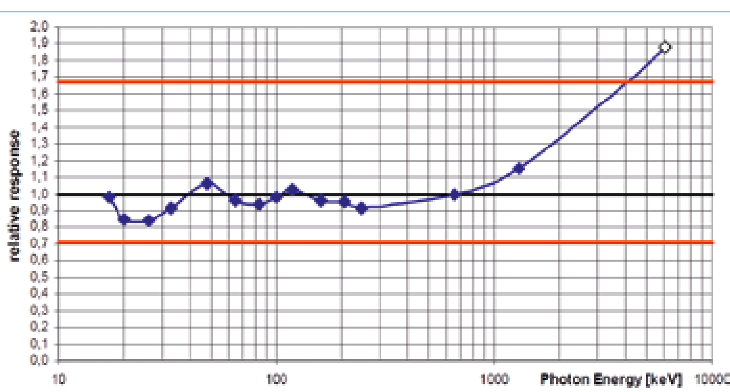
Features

- Energy compensated measurements from low energy to high energy
- Low level measurements are easier and more stable than Ion Chambers
- Leight weight (300 g), excellent grip with and without gloves
- Rugged and compact design, thick rubber protective cover
- Low cost of ownership with > 500 h operation time with 2 AAA batteries – rechargeable NiMH-cells can be used
- Menu-driven user interface results in low training cost and immediate familiarity
- Huge internal data memory for both scaler results and continuous data recording
- Bright backlit LCD display – plain text messages – different languages can be selected
- Audible indication: single pulse or chirper mode proportional to count rate
- Earphone output for operation in loud environment

RadEye G20-10/G20-ER10

The RadEye G20-10 and G20-ER10 are excellent gamma survey meters with a flat energy response curve from 17 keV to 3 MeV according to ambient equivalent dose H*(10).

The devices are suitable for dose rate measurements for X-ray scanner and for medical isotopes including I-125.



RadEye G20-10 and RadEye G20-ER 10 Relative Gamma Response for H*(10)

Gamma test adapter (50 g Lu_2O_3) for RadEye G20/ G20-ER and portable scintillation detectors: # 4254948

- 62 mm diameter, 7 mm height (aluminum housing) 55 mm diameter, 3 mm height (Lu_2O_3 ceramics)
- Induced net dose rate for RadEye G20: 0.25 μSv/h (25 μrem/h).
- Time requirement for response verification approximately 5 minutes

For immediate response verification a 200 kBq Ba-133 (exempt quantity) or other gamma test sources can be used.

For additional information please see pages 37-38.

RadEye G20-10: # 4250687
RadEye G20-ER10: # 425068710
Holster for RadEye G20/B20: # 425068519

RadEye B20/B20-ER

For Alpha/Beta Surface Contamination

Applications

General radiation protection for:

- Homeland security
- Fire departments
- Emergency response
- Hospitals
- Nuclear power industry
- Pharmaceutical industry
- Universities

RadEye B20/B20-ER

The RadEye B20/B20-ER models are the best choice for contamination and dose rate measurements. They are modern, compact and measure alpha, beta, gamma and X-ray radiation.

The RadEye B20/B20-ER models can also be used for accurate dose rate surveys if used with correct energy compensated doserate filter (17 keV– 3 MeV).

For emergency response purposes alpha and beta contamination can be discriminated using another optional filter. The RadEye B20 will automatically switch to the proper measuring unit, if an auto detection filter is fitted to the face of the B20 detector. This automatic function helps to avoid accidental misuse.

The instrument is part of the growing RadEye family of high-end stand-alone meters, which are designed to exceed the most demanding user expectations.

B20 is for normal measurements,
B20-ER is for high range measurements.

Features

- Lightweight (300 g), excellent grip with and without gloves
- Rugged and compact design, thick rubber protective cover
- Low cost of ownership with > 500 h operation time with 2 AAA batteries – rechargeable NiMH-cells can be used
- Menu-driven user interface results in low training cost and immediate familiarity
- Huge internal data memory for both scaler results and continuous data recording
- Bright backlit LCD display – plain text messages – different languages can be selected
- Easy adaptation to different tasks by supervisor configuration, calibration, selection of measuring units
- Versatile operation modes:
  - Scaler/Timer with preset count and preset time for sample measurements
  - Continuous ratemeter mode for frisker operation
  - Dose rate mode
- Audible indication: single pulse or chirper mode proportional to count rate
- Earphone output for operation in loud environment
- IR PC Interface or Bluetooth® as option
- Advanced Windows® software is available as option

RadEye B20: # 4250685
RadEye B20-ER: # 425068510
Holster for RadEye B20/G20: # 425068519

RadEye B20/B20-ER

Surface Contamination/Gamma Survey

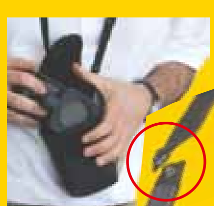
Application	Contamination $\alpha\beta\gamma$	Contamination $\beta\gamma$	Dose Rate H*(10)	Dose Rate H'07
Autodetection Filter	No Filter	Alpha Blocker 425068581	H*(10)Filter 425068582	H'07 Filter 425068583
RadEye B20 / B20-ER				
Filter Code displayed at the LCD	No Code	(α Blocker)	(H*(10))	(H'07)
Related Units	cps cpm Bq/cm² Bq dpm dps	cps cpm Bq/cm² Bq dpm dps	Sv/h rem/h	Sv/h rem/h

Automatic recognition of the filter by the RadEye's processor

Automatic recognition of the filter by the RadEye's processor

Detector	1 pancake GM-tube, window dia. 44 mm (1.7"); 1.8 – 2.0 mg/cm²)
Measuring range (gamma dose rate) Uncompensated (662 keV) or with opt. energy filter:	0 - 2 mSv/h [0 - 200 mrem/h] RadEye B20 0 - 100 mSv/h [0 - 10 rem/h] RadEye B20-ER
Measuring range (contamination):	0 - 10 kcps RadEye B20 0 - 500 kcps RadEye B20-ER
2 π efficiency (ref. to 50 mm diameter without rubber sleeve):	Am-241: 28 %; Co-60: 25 %; Sr/Y-90: 36 %; C-14: 19 %
Energy range (according to IEC 60846-1); with gamma energy filter H*(10) and H´(0.07)	17 keV – 3 MeV
Weight and maximum dimensions	300 g (0.7 lb.); 13 x 7 x 6 cm (5.2" x 2.8" x 2.4")
Alarm indication	LED, sound, vibrator

Excellent grip with gloves



Holster with neckband for RadEye B20/G20 versions, safety locking at the neckband: #425068519

RadEye B20/B20-ER

Gamma Surveys Including X-rays

First responder laboratory kit *

Pelican case # 425069011 containing:

- Sample changer for use with the RadEye B20
- Sample planchets with different lip heights
- Disposable gloves, spatula
- 50 mm paper filters

Space for optional items:

- Data cable and desktop holder
- User manual
- Lutetium-Oxide test adapter
- RadEye B20/B20-ER
- Additional RadEye (PRD or N)
- Two removable energy filters

* Please order a RadEye B20 or B20-ER separately

Lutetium Test Adapter

High precision, low energy test adapter for performance verification # 425068571

- 9 g natural Lutetium-Oxide with 50 Bq/g (1.4 nCi/g)
- Due to half life of 37,000 million years of Lu-176, there are no error-prone half life corrections necessary by the user
- Extremely uniform activity content and surface emission rate
- <u>Identical</u> surface emission rate for each test source

New!

Extensions for RadEye instruments

Using the extensions, the hand is much less exposed if the RadEye B20/B20 ER comes close to a source.

For more information please see page 35.

425067177

RadEye NL
Neutron Search and Find

Features

- Rapid warning of neutron radiation fields
- Applicable as an area monitor
- Exceeds the neutron response requirements of ISO 22188
- Ideal complement to passive and active neutron dosimeters
- Detection of neutron shielding deficiencies and source presence
- Ideal complement to Rem-counters
- No spill-over from gamma radiation up to 10 mSv/h (1 R/h)
- Ideal for verification of neutron fields when dealing with unknown radiation sources
- "No false neutron alarms due to gammas"
- Can be used in high gamma dose rate fields
- Can be made into dose rate device

RadEye NL

The RadEye NL closes a gap in the classical product spectrum of the radiation measurement technology.
While conventional Rem-counters with a He-3 or BF3 tube are usually heavy and bulky instruments, the RadEye NL is a compact and lightweight device, even in use with a moderator.

Weight	160 g (5.6 oz.)
Dimensions	96 x 61 x 31 mm (3.8 x 2.4 x 1.2")
Detector	He-3 tube with 2.5 bar absolute pressure
Sensitivity when worn at the body (RadEye NL)	approx. 0.2 cps per µSv/h (2 cps per mRem/h) for Cf-252, detects 0.01 µg Cf-252 in typically 2 - 3 s for 25 cm (10") distance
Background	approx. 0.003 cps at 300 m above sea level
Gamma spill-over	< 0.2 cps at 10 mSv/h (1 R/h) Cs-137 radiation
Measuring units	Count rate (cps) moving average over 10 s Mean value and peak value over any time period
Operation time (2 AAA alkaline batteries)	approx. 500 h
Calibration factors	The calibration factors for selected work places with known neutron spectra can be entered [mrem/h, µSv/h].

Provisional values for the measured ambient dose equivalent H*(10) response of the moderated RadEye NL, with the bottom of the moderator oriented toward to neutron source.

	Neutron Energy (MeV)	Measured H*(10) Response (Moderator 'Bottom') (cps / µSv hr^{-1})
Van de Graaff	0.14	0.98
Van de Graaff	0.57	0.32
Am-Li	0.47*	0.64
Cf (D_2O-moderated)	0.54*	1.05
Cf (bare)	2.10*	0.24
Am-Be	4.20*	0.18

*Mean energy of radionuclide-based source spectrum

RadEye NL: # 4250678

Applications

- Users of industrial neutron sources (e.g., in geology and material testing)
- Operators and users of accelerators in medical science and research
- Radiation protection staff and inspectors of nuclear facilities
- First responders and law enforcement officers

The RadEye NL is normally worn in a holster. In order to use it as a handheld survey meter and to increase the efficiency for fast neutrons, the RadEye NL can be put into an optional moderator with handle.

RadEye NL moderator: # 425067110

For simultaneous gamma and neutron dose rate measurements a RadEye G-10 can be fixed to the moderator.

Holder for optional second RadEye: # 425067073

While the RadEye NL is worn in a Rem-holster close to the body, the handheld RadEye G-10 displays the measurements of both devices. Thereby the communication between the two RadEye instruments is enabled via two optional RadEye Bluetooth communication battery covers (page 36).

RadEye BTcom battery cover: # 425067087
RadEye Rem-holster with boron inlet: # 425067710
RadEye BTcom Combo with 2 ea. paired BTcom battery covers # 425068102

RadEye NL Area Monitor with additional alarm unit.

RadEye Area Monitor: # 4250680
Alarm unit: # 425068010

RadEye AB100

Simultaneous and separate Alpha/Beta Contamination Measurements

Features

- Lightweight (900 g), excellent grip with or without gloves
- Rugged and compact design
- Low cost of ownership
- Menu-driven user interface
- Huge internal data memory
- Bright backlit LCD display – plain text messages – different languages can be selected
- Easy adaptation to different tasks
- Supervisor configuration, calibration, selection of measuring units
- Versatile operation modes:
  - Scaler/Timer with preset count and preset time for sample measurements
  - Continuous ratemeter mode for frisker operation
  - Alpha, beta and alpha + beta modes
  - Gross or net counting
- Audible indication: single pulse for alpha, chirper mode for beta - proportional to count rate
- Easy adaptation to different tasks

Applications

General radiation protection for

- Civil defense
- Fire brigades
- Hospitals
- Nuclear industry
- Pharmaceutical industry

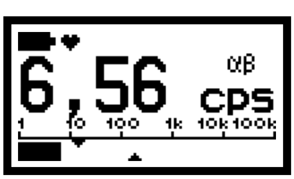
RadEye AB100

The RadEye AB100 is a modern contamination meter for surface contamination measurements with excellent alpha/beta discrimination. The user can select the proper calibration factor within a list of isotopes (e.g., Bq, Bq/cm², dpm).

The instrument is part of the growing RadEye family of high-end stand-alone meters, which are designed to meet the most demanding user expectations.

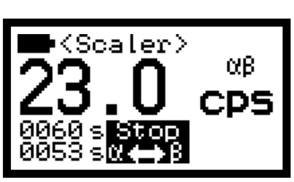
Efficiency (per surface emission)	Am-241: 36 % (α) Co-60: 23 % (β) Sr/Y-90: 49 % (β)
Gamma response (Cs-137)	approx. 40 s^{-1}/(μSv/h) 0.4 s^{-1}/(μR/h)
Window thickness/ Active area	Thickness: 0.87 mg/cm² aluminized plastic film Sensitive area of 69 x 145 mm [2.71" x 5.71"]; Open area of approx. 85 %
Dimensions/ Weight	355 x 100 x 180 mm [14 x 4 x 7.1"] / approx. 0.9 kg [2 lb.]

RadEye AB100: # 4250683



Simultaneous measurement of alpha, beta and gamma radiation

Alpha alarm is indicated



Scaler mode

Dual display

Features

- The RadEye X survey meters can operate with virtually any manufacturer's GM probe, with dual phosphor α/β, NaI(Tl) and plastic probes and proportional detectors
- Up to 16 different probe configurations are selectable in a submenu
- Easy to replace probes in the field, with a simple button-push
- Weighs only 160 g (5.6 oz.) with rubber protection, without cable
- 110 x 67 x 62 mm (4.3 x 2.6 x 2.4")
- Versatile operation modes
- RadEye BTcom cover for Bluetooth® communication

RadEye X series

As part of the growing RadEye product family of high-end stand-alone meters, the RadEye X series is designed to exceed the most demanding user expectations.

The RadEye X series comprises three different types of modern and compact multi-purpose survey meters that fit most any external counter tubes that have already been in use (e.g., the nuclear industry):

- RadEye GX for Geiger-Mueller detectors
- RadEye SX for scintillation detectors
- RadEye PX for proportional detectors

General count rate and surface contamination measurements can be performed as well as dose rate measurements. Due to the clear and large display, all essential functions and software parameters can be easily accessed. The display and the alarm-LED can be seen while the instrument is worn in the transparent case.

All settings and the data analysis can be done by an optional Windows®-based PC-software and a reader device. The last 1,600 mean and maximum values of the count rate or dose rate are recorded internally and can be read out via a serial interface. Additionally, the instruments log the last 250 alarms, error messages and changes of the configuration.

Operation modes:

- Scaler/Timer with preset count and preset time for sample measurements
- Continuous ratemeter mode for frisker operation
- Dose rate mode

The Thermo Scientific RadEye BTcom cover provides wireless communication and data transfer between the RadEye X series and a PC.

RadEye X series

Features

- Universal interface via non-proprietary coax cable
- Connection to a large variety of probes
- Approved detectors can be kept in use
- Improved performance, (e.g., measuring range, built - in datalogging, computer interface)
- 90 % weight and size reduction compared to conventional survey meters
- Compatible to all RadEye accessories

Technical details RadEye X series

Measured quantities	Count rate (cps, cpm), surface contamination (Bq, dps, dpm, Bq/cm^2), dose rate (R/h, Sv/h, rem/h)	
Background subtraction	In count rate and contamination mode	
Measuring range (Default)	RadEye GX: 10,000 cps RadEye SX: 100,000 cps RadEye PX: 100,000 cps	extendable by individual probe calibration
Probe cables	RG 58, max. 1.5 m (59”) – MHV connector, different (probe-side) HV connectors available, please call us	
High voltage range	RadEye GX: 350 V…1100 V with output impedance 1 MΩ RadEye SX: 300 V…1400 V with output RadEye PX: 300 V…1400 V with output	
Probe library	16 different detectors with corresponding high voltage, calibration factor, dead time correction, overload threshold, detector area and timeout for detector failure.	
Alarm threshold	Two alarm thresholds for count rate, activity, dose and dose rate each	
Audible alarm intensity	80 dB at a distance of 30 cm (11.8”)	
Working temperature	-20 °C ... + 50 °C (-4 °F ... 122 °F)	
Relative humidity	10 ... 90 % at 35 °C (95 °F) not condensing	

Operating voltage	1,8... 4 V, battery low voltage starting from 2.3 V	
Scaler/timer	Preset count, preset time	
EMC	Disturbance emission: EN 61000-6-3, immunity : EN 61000-6-2	
Size	110 x 67 x 62 mm (4.3” x 2.6” x 2.4”), with rubber protection, without cable	
Weight	Around 160 g (0.35 lb.) including AAA cells and protection sleeve	
Internal memory	The last 1600 measured values are saved and can be read out via PC program. Max and mean value of count rate and dose rate. The time interval is factory preset to 120 s by default. As well scaler measurements and momentaneous readings can be stored manually. Logbook with 250 entries for changes of configuration, occurring alarms and errors	
Averaging filters	Ratemeter filter type: Advanced Digital Filter (ADF), Digital RC-Filter with time constant, 1 s...180 s, depending on count rate and count rate change.	
Battery life time	RadEye GX: > 500 h RadEye SX: > 500 h RadEye PX: Approx. 200 h	Depends on external detector (required high voltage and dynode chain impedance), for instrument alone

RadEye GX: # 4250692
RadEye SX: # 4250693
RadEye PX: # 4250694

Features

- Accepts a wide range of GM-detectors
- Dose rate measurement
- Contamination measurement
- Parameters for up to 16 different probes can be stored in the memory

RadEye GX

Compact multi-purpose survey meter for Geiger-Mueller detectors.

The RadEye GX can store data of up to 16 individually adjusted and calibrated probes.

RadEye GX: # 4250692

New!

RadEye GX-L

The economy version is limited to a count rate of 10,000 cps (600,000 cpm), and is perfect for connection of contamination detectors.

RadEye GX-L: # 425069205

RadEye SX
For External Scintillation Detectors

Features

- Accepts a wide range of dual phosphor (α/β), NaI(TI) and plastic probes
- Dual channel display
- Count rate measurements
- Dose rate measurements
- Surface contamination measurements
- Parameters for up to 16 different probes can be stored in the memory

RadEye SX

Compact multi-purpose survey meter for scintillation counter tubes.

RadEye SX: # 4250693

High Sensitivity Gamma Food Monitor

Routine inspections for radiation in food are performed most economically and user friendly with the Thermo Scientific High Sensitivity Gamma Laboratory Kit.

It supports the laboratory and also field measurement program for contamination resulting from a nuclear accident.

Gamma Food Monitor: # 425069025

New!

RadEye SX with DP6

A large, dual phosphor scintillation probe for monitoring personnel, tools and work areas with efficient alpha/beta discrimination. Adapter for connecting the RadEye SX to the detector types: AP5A, AP5B, BP19A, BP19B, DP6A, DP6B. Adapter # 425069360

A hand probe with a lightweight and rugged design for general purpose alpha/beta survey and frisking. Adapter for connecting the RadEye SX to the detector types: HP380A, HP380B, HP380AB, AP2/4A, AP4/4B, BP7/4A, BP7/4B, DP2/4A, DP2/4B, AP4/4A, AP4/4B, BP4/4A, BP4/4B. Adapter # 425069361

RadEye SX with HP 380 AB

RadEye SX with DP8

A probe with rectangular-shaped 600 cm^2 windows for monitoring large-area flat alpha/beta surface contamination. Adapter for connecting the RadEye SX to the detector types: AP6A, AP6B, BP17A, BP17B, DP8A, DP8B. Adapter # 425069363

A floor monitor probe with a choice of ruggedized 600 cm^2 scintillation alphas, betas, or alphas and betas simultaneously. Adapter for connecting the RadEye SX to the FLM3. Adapter # 425067079

RadEye SX with FLM3

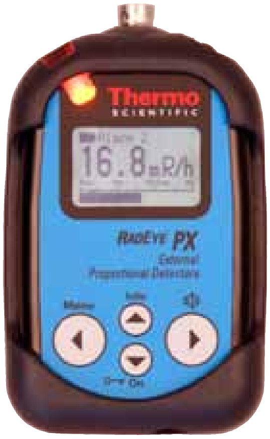
RadEye SX with SPA3

A rugged, high-sensitivity gamma detector used for pulse-height applications. Adapter for connecting the RadEye SX to the SPA3. Adapter # 425069365

Features

- The RadEye PX can operate with proportional detectors
- Lightweight, only 160 g (5.6 oz.)
- Compact size, 110 x 67 x 62 mm (4.3 x 2.6 x 2.4")
- Dose rate measurements
- Surface contamination measurements
- Parameters for up to 16 different probes can be stored in the memory

RadEye PX is for Proportional detectors such as He-3 and BF_3 neutron detectors and an excellent replacement for the much larger and heavier E-600 and ASP-2 style meters.



RadEye PX

Compact multi-purpose survey meter for proportional detectors. Count rate and surface contamination measurements can be performed as well as dose rate measurements in combination with gas filled proportional counter tubes.

For neutron dose rate measurements, which are typically operated in combination with He-3 or BF_3 based Rem-counters, the new RadEye PX meter is an excellent replacement for the much larger and heavier E-600 and ASP-2 style meters.

RadEye PX: # 4250694

Adapter for connecting the RadEye PX to the NRD general purpose neutron "REM-ball". Adapter # 425069501 enables the use of NRD instruments previously connected to other survey meters.

RadEye PX with NRD: # 4250695

RadEye PX with WENDI: #425069461

Adapter for connecting the RadEye PX to the WENDI wide energy range neutron detector. Adapter # 425069460 enables the use of WENDI instruments previously connected to other survey meters.

RadEye NBR

Portable High Sensitivity Gamma Radiation Monitor

New highly sensitive Thermo Scientific radiation detector system for fast discrimination between natural and artificial gamma radiation.

Key Features:

- Alarm on small traces of artificial gamma radiation
- Ideal for detection of shielded sources
- Weighs approx. 3 kg only
- One hand operation

The RadEye™ NBR is a combination of the Thermo Scientific RadEye SX multi-purpose meter and the FHZ 674 NBR detector. Even in case of large variations of the natural background during the search, very small contributions of artificial gamma radiation can be detected by a NBR detector (Natural Background Rejection). Especially for shielded or remote gamma sources, the RadEye NBR system will generate unambiguous audible and visual alarm indication within seconds, even if the incremental dose rate is just in the order of 0,01 µSv/h or less.

Compared to the well-known system FHT 40 NBR, battery operation time has been increased by 5 times, weight has been reduced by 1 kg and, as an additional eature, the possible presence of artificial radiation is indicated on a 0 to 200 %-scaled bar graph (100 % = NBR alarm set point). This feature is extremely helpful during any active search mission. Furthermore, following multiple user suggestions, the audible indication for positive detection of artificial radiation is now well distinguished from the typically much more frequent gross gamma alarms that are caused by changing background conditions. Unlike the FHT 40 NBR, where the dose rate range is extended up to 1 Sv/h (FH 40 G-10 as control unit), the RadEye NBR dose rate range is limited to 100 µSv/h. For higher dose rates, the use of an additional gamma survey meter (e.g. the RadEye G-10) is recommended.

NBR = Natural Background Rejection
The NBR measurement method has been developed by Thermo Fisher Scientific, for extremely fast discrimination between natural and artifical gamma radiation. Many thousands of devices, based on this technology, are in use worldwide.

RadEye NBR

Portable High Sensitivity Gamma Radiation Monitor

Operational Areas:
- First responders / Fire brigades
- Security professionals
- Environmental monitoring
- Remediation

The RadEye NBR system # 4250751 consists of RadEye SX, FHZ 674 NBR detector, detector cable and rugged carrying case.

Technical specification of the Thermo Scientific RadEye SX

Order number	# 4250693
Measured quantities (with FHZ 674 NBR)	Count rate (cps, cpm), dose rate (Sv/h, rem/h), NBR
Probe cables	RG 58, max. 1.5 m (59") – MHV connector
High voltage range	300 V…1400 V with output impedance 2 MΩ, typically 600 V for FHZ 674 NBR
Alarm threshold	Two alarm thresholds for count rate, dose and dose rate each, NBR
Audible alarm intensity	80 dB at a distance of 30 cm (11.8")
Working temperature	-20 °C ... + 50 °C (-4 °F ... 122 °F)
Scaler/Timer	Preset count, preset time
EMC	Disturbance emission: EN 61000-6-3, Immunity: EN 61000-6-2
Size	110 mm x 67 mm x 62 mm (4.3" x 2.6" x 2.4"), with rubber protection, without cable
Weight	Around 160 g (5.6 oz) including 2 ea. AAA cells and protection sleeve
Internal memory	The last 1600 measured values are saved and can be read out via PC program. Max and mean value of count rate and dose rate. The time interval is factory preset to 120 s by default. As well scaler measure ments and momentaneous readings can be stored manually. Logbook with 250 entries for changes of con figuration, occurring alarms and errors
Battery life time	Typically 150 h with FHZ 674 NBR

For detailed information about the Radeye SX and the connectivity options of further probes please ask for a separate data sheet.

Technical specification of the Thermo Scientific FHZ 674

Order number	# 4250750
Detection Sensitivity	approx. 4000 cps per µSv/h at 662 keV, highly sensitive from 15 keV (front), respectively 30 keV (side)
Energy response (H*(10))	Exceeds IEC 62533* requirements (+/- 30 % for Am-241, Cs-137, Co-60)
Dose rate range (Cs-137)	0.01 µSv/h to 100 µSv/h
Weight	2800 g excluding shoulder strap (200 g) and RadEye SX (160 g)
Dimensions	308 mm x 230 mm x 110 mm

*IEC 62533 Highly sensitive hand-held instruments for photon detection of radioactive material.

Recommended alternative test adapters for HV-fine adjustment and test indication of artificial (= non-background) gamma alarms.

Exempt check source Cs-137	3.7 kBq (0.1 µCi), sealed in a 1" resin chip	# SM149479010
Lutetium Test Adapter 50 g Lu203	approx. 50 Bq/g Lu-176, 62 mm dia. chip (aluminium housing)	# 4254948
Lutetium Test Adapter 36 g Lu203	approx. 50 Bq/g Lu-176; for use with Radeye PRD as well	# 425067071

RadEye HEC
Stand-alone scaler counter

Features
- Simultaneous alpha/beta measurements
- 800 hours battery operation
- Non-volatile data storage
- Customized library of up to 16 test sources with automated half life correction
- Library of up to 16 nuclide efficiencies
- Simple detector performance verification with 9 g Lutetium Test Adapter

RadEye HEC - alpha/beta sample counter

The RadEye HEC is a sample counting system that provides simultaneous alpha and beta measurements.

The system incorporates a 2” (5 cm) dual scintillation phosphor mated to a sliding drawer accommodating a 2” (5 cm) diameter sample. Using a height-adjustable sampling area the drawer permits the use of different sample types and must slide fully to the rear to initiate the counting.

The housing is made of durable plastic to withstand even rough handling. The built-in handle, in combination with the battery option, allows up to 800 hours field use before the batteries have to be charged again.

The last 4500 values of the measured data in the selected measuring unit are recorded internally and can be read out via serial or USB interface. Additionally the RadEye HEC logs the last 250 alarms, errors and changes of the configuration. All events can be read out via serial interface. A real time clock is provided to add a time stamp to all buffer data.

The characteristic features of the RadEye HEC are the use of sophisticated low power technology components, well known from all RadEye versions, and microprocessor based fully automatic self checks. No maintenance is required.

Detector	2” (5 cm) diameter alpha and beta sensitive scintillator
Efficiency	Typical 2 π efficiencies (50 mm sources) Alpha: ^{239}Pu typical 85 % (surface deposition) ^{241}Am typical 75 % (activated Al-layer of 6 µm) Beta: ^{99}Tc typical 45 % ^{90}Sr-^{90}Y typical 70 % ^{14}C typical 20 %
Background	<70 counts per minute (cpm) in the beta channel and < 2 cpm in the alpha channel in a background of 0.25 µSv/h (25 µR/h) gamma
Crosstalk	^{241}Am alpha to beta crosstalk < 10 %, ^{90}Sr-^{90}Y beta to alpha crosstalk 0.1 %
Sample drawer	2.03” (51.6 mm) diameter x 0.38” (9.6 mm) thick maximum. The sample thickness can be adjusted between 5/16” (3.2 mm) to 1/8” (7.9 mm). The sample holder and slide are black anodized for ease of decontamination
Mechanical	Single package design to allow for portability
Units	Counts, cpm, cps, Bq, Bq/cm², dpm, dps
Count time	User selectable count time between 1 second and several hours
Preset count	User selectable between 1 and 9999
Background update	User selectable count time 1 second to 60 minutes utilized in background subtraction of sample counts

RadEye HEC

Stand-alone scaler counter

Alarms	User-defined alarm limits on samples
Calibration	Via PC program
PC-software	Standard RadEye.exe > version 1.17
Power supply	100-240 VAC, 50-60 Hz
Count storage	Datalog samples using sequential up to 4500 samples. Each data point will include sample ID, sample count result, time and date
Temperature	0 to 50 °C (32 to 122 °F)
Humidity	10 to 90 % non-condensing
Count range:	1 to 6 million cpm (100, 000 cps) for beta and 1 to 0.6 million cpm (10,000 cps) for alpha
Audible	The RadEye HEC audible output is used to signal: - When the sample has completed its count - Whenever an alarm occurs (when activated) - Presence of alpha radiation (when activated)
Size and weight	15 x 4.75 x 12” (38.1 x 12.1 x 30.5 cm); 9 lbs. (4.1 kg)
Testing	CE approved

RadEye HEC accessories

Lutetium Test Adapter 9 g for RadEye HEC sample counting system # 425068571

Upgrade Kit for HandECount (with Palm™ Computer) available # 425069704

RadEye Area Monitor

Area Monitor

Applications

- Nuclear Power
- Nuclear Process
- Industrial
- Personal/Worker Safety

RadEye Area Monitor

The RadEye Area Monitor is an application suitable for several different RadEye types. The following applications are possible:

- Gamma dose rate measurement (RadEye G)
- Highly sensitive alarm indication for radioactive gamma sources (RadEye PRD)
- Detection of neutron sources (RadEye NL)

The wall-mounted RadEye Area Monitor extends the application range to convenient and cost-effective gamma and neutron area monitoring. In case of exceeding a preset threshold, the system sets off an audible/optical alarm and the RadEye can be immediately used as a portable instrument.

- Area monitor and flexible handheld instrument in one
- No additional handheld instrument for locating the source is necessary
- In case of power failure the RadEye is still operational due to rechargeable batteries and built-in battery charger
- Simultaneous gamma and neutron monitoring with two RadEye Area Monitors

1. Alarm Indication

Acoustical and optical alarm is indicated by the RadEye Area Monitor and the optional external alarm indicator.

Horn and bright flash light can be acknowledged even if radiation level is still elevated.

2. No need for an additional portable instrument!

Authorized staff takes the RadEye out of the box.

3. Finding the radiation source

4. Re-insertion of the RadEye

The green light of the external indicator turns on once the RadEye is reinstalled in the box. Now the Area Monitor is ready for action again.

The RadEye Area Monitor can be complemented with an external alarm unit with horn and beacon. An occurring alarm can be acknowledged remotely controlled. Thereby the alarm unit should not be installed at a distance of >10 m (other lengths upon request).

RadEye Area Monitor: # 4250680

RadEye Area Monitor: Enclosure with transparent door; car adapter; AC/DC adapter with 2 m cable + connector; red light on enclosure; RS 232 interface 9 pin D-SUB connector (watertight); connector for external alarm unit. The RadEye has to be ordered separately.

Additional alarm unit # 425068010

Additional external alarm unit consisting of: 5 m cable with connector fitting to connector at 4250680; small box with latching relay and acknowledgement button; 5 m cable between the box, strobe and horn with wall mount holder.

RadEye GR

Wireless radiation detection system for grapple installation

Features

- Rugged radiation detection and alarm system
- Small size – negligible load capacity reduction
- Enhanced sensitive for low gamma energies
- Superior value - small investment and low cost of ownership
- Multiple portable RadEye R display units possible
- Extremely high battery lifetime
- Nearly maintenance free
- Very straightforward installation process
- Simple and comprehensive datalogging and reporting via RadEye Safety Kit Software (pages 33-34)
- Only one person required for radiation test
- Real time monitoring and system integration on request

RadEye GR - Wireless radiation detection system for grapple installation

Long recognized as providing leading-edge vehicle and portable radiation monitoring solutions to the metal recycling industry, Thermo Scientific's RadEye GR grapple-mounted radiation detection system is the latest application-specific system designed to minimize the threat of radioactive material in the scrap metal stream.

The Thermo Scientific RadEye GR is a radiation detection device designed and proven through extensive testing for the extreme forces and harsh conditions experienced when installed in a grapple. While the detector inside the RadEye GR grapple monitor is smaller than the detectors used in a portal monitor at the entrance of a facility, it more than makes up for any loss in sensitivity as the RadEye GR detector is much closer (law of $1/r^2$ for the radiation field) and the radioactive source is less shielded by the surrounding scrap. Furthermore, the contact time is longer than for a portal monitor which is the other critical element in determining sensitivity. Therefore, the RadEye GR grapple monitor is an extremely powerful tool to detect radioactive threats in the scrap and should be considered for use in addition to the portal monitors already found at most facilities.

The detector unit is installed quickly and easily at most of the common grapple types. Its compact size takes a minimum of space and so does not significantly impact the grapple's carrying capacity.

The RadEye GR provides superior response to radiation exactly at the energy range of importance to catch shielded radiation sources.

The battery powered receiver RadEye R displays current readings, annunciates alarms and logs data wirelessly whether you are in the cabin of the crane or nearby the grapple. Multiple RadEye R units can receive data from one grapple detector over a distance > 100 m (at 1mW transmitting power).

For details, please ask for additional product information.

Features

- Accessory for RadEye PRD/PRD-ER and RadEye R
- Highly sensitive to gamma radiation
- Compact, rugged and lightweight
- Advanced personal radiation protection
- Provides precise periodic measurement sampling and documentation with enclosed software
- Suitable for vehicle surface scans and area monitoring

RadEye PRD Safety Kit - in conjunction with RadEye PRD, PRD-ER and RadEye R

The Thermo Scientific RadEye PRD is the first choice for highly portable, personal radiation detection in the recycling industry. The well-proven RadEye, which has served thousands of law-enforcement and homeland security professionals since 2005, is also available in conjunction with an application-tailored "RadEye Safety Kit." Geared specifically to the industrial user, this configuration provides the following advantages and possibilities:

- Small size and belt holster means it can be worn at all times for non-stop vigilance at any facility
- Adapter and extender poles allows the user's reach to be extended up to 14 feet (4 m) enabling easier and faster searching
- Data capture hardware and software allow target vehicle radiation data to be tagged with user input meta-data, for better quality control/documentation
- Lutetium test adapter uses naturally occurring material of very low specific activity to verify the performance of your PRD or other radiation detection instrumentation safely and accurately

Radiation detection is personal protection

The Thermo Scientific RadEye PRD offers unmatched sensitivity to gamma radiation and true dose rate calculation. When worn in its holster, the RadEye PRD protects its owner at all times, long before radiation health concerns come into consideration. With this roving detector orphan sources may be found at your facility. The RadEye short handle provides dramatic reduction in the dose rate at the user's hand, if the RadEye PRD is close to the source (compared to the RadEye PRD directly held in the hand). Optional 4 ft. (1.2 m) and 14 ft. (4 m) extensions ease the measurement of vehicle loads or piles of suspicious material. The large backlit LCD, the bright Alarm-LED and the built-in vibration alarm facilitate the ease of use of this instrument while the nylon holster and rubber shock protection ensure its durability and reliability.

RadEye Safety Kit

Content of the RadEye PRD Safety Kit # 425067193

2 Holster for the RadEye PRD
3 Universal RadEye PRD "snap in" adapter
4 RadEye PRD Test Adapter (natural lutetium oxide)
5 Short handle for "snap in" of the universal RadEye PRD adapter
6 USB to the RadEye PRD's IR port adapter cable
7 RadEye PRD desktop stand with mounting support of the adapter cable
8 Special application-specific software and handbook

<u>The RadEye has to be ordered separately</u>!

1 High sensitivity gamma pager

RadEye PRD:
up to 25 mR/h # 4250671
up to 250 µSv/h # 425067120

RadEye PRD-ER:
up to 10 R/h # 425067102
up to 100 mSv/h # 425067122

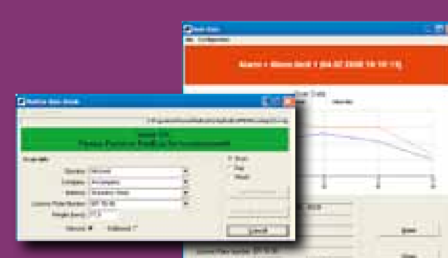
<u>Options:</u>
425067076: 1.2 m extension
425067076-59: 59'' extension (America only)
425067077: 4.0 m telescopic extension

Scanning for contamination is assurance of quality

If the RadEye PRD is used for the manual scanning of in- or outbound vehicles, then the application-specific RadEye Software documents via printing of the scanning protocol that no radiation was found in the inspected load. Additional text information such as "Company," "Material," "Weight," etc. may be entered and stored or printed with the measurement values.

Recording and documentation

- Vehicle surface scans
- Work days/weeks
- Simple area monitoring



The software "GateCheck.exe," in combination with a RadEye R, provides precise periodic measurement sampling and documentation. Thus it is easy for the user to get a daily protocol of all loadings.

RadEye extensions

RadEye telepole

1. Telepole for 2 ea. RadEye units with Bluetooth communication capability. # 425067175

New!

Features

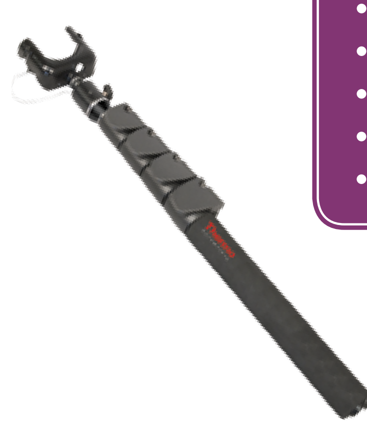
- High quality
- Free adjustable segments
- Durable material selection
- Professional design
- Max. length with/without RadEye: 2325 mm/2280 mm
- Min. length with/without RadEye: 800 mm/845 mm
- Total weight with/without 2 each RadEye devices: 2.4 kg/2.1 kg

RadEye extensions

1. RadEye adapter with connector to the handle or extensions: # 425067078 (without RadEye)
2. Short handle, length 0.35 m: # 425067075 (without RadEye)
3. Aluminum extension, length 1.2 m: # 425067076 (without RadEye)
4. Telescopic extension up to 4.0 m: # 425067077 (without RadEye)

New!

RadEye extension



RadEye extension # 425067177

Features

- High quality
- Durable material selection
- Reach up to 1.5 m / 5 ft.
- Four free adjustable segments
- Handle with convenient grip
- Professional and durable design
- Weight: 630 g
- Max length: 1520 mm / ~ 5 ft.
- Min length: 460 mm / 18"

RadEye BTcom Cover

Features

- Suitable for communication to PCs with Bluetooth® interface
- Fits all RadEye versions (except RadEye AB100)
- Low power consumption
- Fast and easy installation
- Lightweight, only 11 g (0.4 oz.)
- No external power supply needed

New!

RadEye BTcom cover

The Thermo Scientific RadEye BTcom cover is the latest accessory development for the successful RadEye product family.

It is designed to provide Bluetooth® communication between the RadEye devices and a PC equipped with Bluetooth® technology. Also, data from one RadEye instrument can be displayed on another RadEye as a second measurement device.
Typical applications: display of RadEye NL neutron data or RadEye B20 contamination data as second line in gamma RadEye display.

The cover fits all types of RadEye (except the RadEye AB 100) and is powered by the internal batteries of the RadEye instrument.

The plug and play installation is extremely easy and needs no special requirements or qualifications. Once installed the RadEye BTcom cover has a coverage of about 15 m (49.2 ft.) at line-of-sight conditions and may be used worldwide without registration.

The RadEye BTcom cover comes in a transparent plastic box together with a short manual and a CD with the RadEye BTcom cover manual, RadEye.exe update installation file and some additional information about the RadEye product family. # 425067087

In addition we also offer a factory predefined set of two BTcom covers to ensure an immediate and secure communication between two RadEye devices. # 425068102

Degree of protection	IP54 (when applied to a RadEye)
Working temperature	-25 °C to +50 °C (-13 °F to +122 °F)
RF transmission	Bluetooth® V2.0 + EDR, SPP profile (serial port protocol), +4 dBm output power max. (Class 2), -82 dBm receive sensitivity
Range	10m at line-of-sight-condition
Baud rate	115.2 kBd (8 data bits, no parity, 1 stop bit)
Size and weight	59 x 36 x 10 mm (2.3 x 1.4 x 0.4”); 11 g (0.4 oz.)
Operating voltage	1.5 - 3 V (powered by standard AAA cells of the RadEye)
Power consumption	Battery voltage: 3.0 V; 4.3 mA (standby); 5.5 mA (connected) 19.5 mA (cyclic readout: 1 s); 7.4 mA (cyclic readout: 10 s)

Features of Lutetium Test Adapters

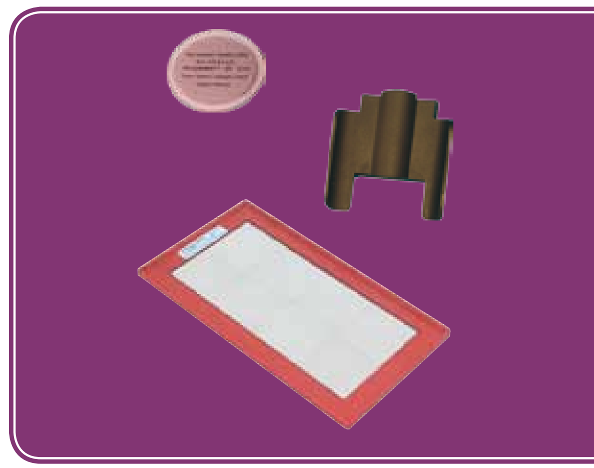
- A 3.7E10 year half-life means:
  - no need for error-prone half-life corrections
  - no need for reoccurring purchase of the (decayed) check sources
- The adapters provide a highly reproducible and uniform activity content of 50 Bq/g (1.3 nCi/g)
- All test adapters of the same type have virtually the same activity!
- Beta-type adapters provide nearly identical surface emission rates
- The design of special shape enclosures and high density Lu_2O_3 ceramics minimize the required activity for small size detectors

Thermo Scientific Lutetium Test Adapters

Lutetium Test Adapters are a real smart alternative to conventional check sources and offer a lot of unique advantages to our customers using radiation detectors.

Conventional test sources for radiation monitors suffer from a number of inherent problems: Every source is an individual and unique item regarding activity and surface emission rate. Sources from different manufacturers may have different spectra from the emitted particles depending on the production process. Furthermore, large area test sources may have variations of the emission rate over the different sections of the surface and, in many cases, the user needs to correct for the decay of the radioisotope. The thin active surface is always a delicate part of the source.

Lutetium Test Adapters contain the isotope Lu-176 with 38 billion years half-life (= much longer than the age of the universe) and a natural abundance of 2.6 %, which yields a specific activity of approximately 50 Bq/g of the pure element Lutetium. The unique feature of using a chemically pure bulk substance containing the radioisotope in its natural abundance results in a totally constant and homogeneous surface emission rate. Each and every source of the same surface area has the same beta emission rate, regardless of small variances in the thickness of the Lutetium-oxide ceramics. Furthermore, due to their natural origin and low specific activity, in respect to many national regulations these adapters are not considered as radioactive material. These new test adapters can contribute to a reduction of calibration cost and instrument downtime, as well as to an increased user confidence and familiarity with “his” or “her” instrument.



Beta/gamma test adapters

High precision, low energy test adapters for performance verification of the RadEye B20 and other instruments with pancake detector.

Lutetium Test Adapter with 9 g Lu_2O_3: # 425068571
50 mm diameter, 3 mm height (acrylic glass housing)
40 mm diameter, 1mm height (Lu_2O_3 ceramics inlet)
Typical net count rate for RadEye B20: 6 cps

For more information please ask for a special paper: “Test Adapters Based on Natural Lutetium - a Discussion of Benefits versus Conventional Check Sources”.

RadEye Test Adapters

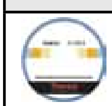
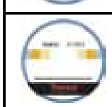
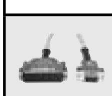
Test adapters for large area beta contamination probes with an inherently homogeneous surface emission rate of 0.8 particles per cm²•s - perfect for training and calibration.
Lutetium Test Adapter with 80 g Lu_2O_3: # 425068371
Size: 120 mm x 200 mm x 5 mm total; 110 cm² (74 x 148 mm) Lu_2O_3 surface.

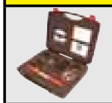
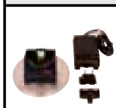
Lutetium Test Adapter for RadEye PRD variants and RadEye GN

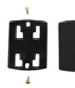
A specially shaped housing, matching the contours of the RadEye instrument, contains 36 g of natural Lu_2O_3 ceramic material. This test adapter is used to verify and fine-adjust the gamma performance of the RadEye PRD and GN: Quick, save, easy and precise.
Typical net count rate for RadEye PRD: 100 cps
Indication of "low energy" NBR alarm.
A carrying case is included.
425067071

Thoriated (2 %) Tungsten Test Adapter for RadEye GN

A specially shaped housing, matching the contours of the RadEye instrument, contains 10 g of thoriated (2 %) tungsten welding rods. This test adapter can be used to simulate neutron alarms in the training mode of the RadEye GN. Furthermore, the alarm behavior performance in respect to NORM can be checked: # 425063015

	Part number	Description	G/G-10/GF/GF-10	PRD/PRD-ER	GN	B20/B20-ER	G20-10/G20-ER10	NL	GX/SX/PX	NBR	AB100	HEC	Ex series	R
Extension poles														
	425067075 425067076 425067077	Short handle Aluminum extension, length 1.2 m 2 segment telescopic exten. up to 4 m; All extension poles require 425067078	•	•	•	•	•	•						
	425067078	RadEye adapter with connector to 425067075, 425067076, 425067077	•	•	•	•	•	•						
	425067177	4 segment telescopic extension up to 1.5 m (including holder for RadEye)	•	•	•	•	•	•						
Energy filters for RadEye B20, B20-ER														
	425068581	Alpha rejection filter				•								
	425068582	Gamma filter, H*(10) compensation (deep dose equivalent)				•								
	425068583	Gamma filter, H'07 compensation (shallow dose equivalent)				•								
Data communication														
	425067087 425068102	RadEye BTcom battery cover Two factory paired BTcom covers	•	•	•	•	•	•	•	•				
	425069951	User software "RadEye.Exe"	•	•	•	•	•	•	•	•	•	•	•	•
	425069952	Calibration software "Cal-RadEye.Exe"	•	•	•	•	•		•	•			•	
	4254026	Data cable USB via desktop holder 425067060 and AB100 direct	•	•	•	•	•	•	•	•	•		•	•
	4254029	Data cable RS 232 via desktop holder 425067060 and AB100 direct	•	•	•	•	•	•	•	•	•		•	•
	425067060	Desktop holder for RadEye (data cable not included)	•	•	•	•	•	•	•	•			•	•
Others														
	425067110	RadEye NL Moderator				•		•						
	425067073	RadEye holder for second RadEye mounted to moderator (425067110)	•	•		•	•	•						

	Part number	Description	G/G-10/GF/GF-10	PRD/PRD-ER	GN	B20/B20-ER	G20-10/G20-ER10	NL	GX/SX/PX	NBR	AB100	HEC	Ex series	R
Others														
	425067193	RadEye Safety Kit for PRD/PRD-ER (RadEye not included)		•										•
	4250680 and 425068010	RadEye area monitor and external alarm unit (RadEye not included)	•	•	•			•						•
	42506901001	Sample changer for RadEye B20				•								
	42506901002	Brass sample holder for RadEye PRD (material analysis of steel samples)		•										
	425069011	First Responder Laboratory Kit for RadEye B20 and B20-ER, including sample changer 42506901001, various dishes, gloves, spatula and filters				•								
	KT162245107	MHV right angle plug for GX/SX/PX							•					
Earphone / Headset														
	425067037	Earphone for RadEye series	•	•	•	•	•	•	•	•				•
	425067042	Headset for RadEye	•	•	•	•	•	•	•	•				•
Charger														
	425067065	Docking station ("car adapter") with charging circuitry (8-30 V DC, cigarette lighter plug), alarm relay and RS 232 interface. 2 ea. AAA NiMH rechargeable batteries included	•	•	•	•	•	•	•	•				•
	425067066	AC/DC converter for AC-supply of docking station 425067065 (100 – 240 V AC; 15 V DC, 600 mA), US, UK, EU connector	•	•	•	•	•	•	•	•				•
	425067080	Inductive charger (11.5 - 15 V DC) with coiled cable and cigarette lighter plug; requires special battery compartment lid 425067034	•	•	•	•	•	•	•	•				•
	425067083	Inductive charger AC-table version, requires special battery compartment lid 425067034	•	•	•	•	•	•	•	•				•
	425067034	Battery compartment lid with inductive charging circuitry	•	•	•	•	•	•	•	•				•

	Part number	Description	G/G-10/GF/GF-10	PRD/PRD-ER	GN	B20/B20-ER	G20-10/G20-ER10	NL	GX/SX/PX	NBR	AB100	HEC	Ex series	R
Car Adapter														
	425067064	Goose neck mounting kit for attachment to the windshield; fits to docking station 425067065 or desktop holder 425067060	•	•	•	•	•	•	•	•			•	•
	425067059	Flat mounting kit, incl. plates for screw- and adhesive mounting; fits to docking station 425067065 or desktop holder 425067060	•	•	•	•	•	•	•	•			•	•
	425067061	Goose neck screw-mounting kit; fits to docking station 425067065 or desktop holder 425067060	•	•	•	•	•	•	•	•			•	•
	425067063	Knuckle joint screw-mounting kit; fits to docking station 425067065 or desktop holder 425067060	•	•	•	•	•	•	•	•			•	•
	425067062	Pivot arm screw-mounting kit; fits to docking station 425067065 or desktop holder 425067060	•	•	•	•	•	•	•	•			•	•
Holster and Bags														
	425067044	Safety lanyard and transparent plastic bag for RadEye PRD, NL, G and G-10 versions	•	•	•			•	•					•
	425067046	Holster for RadEye PRD, NL, G and G-10 versions. Sized to insert instrument with rubber shock protection	•	•	•			•					•	•
	425067710	RadEye Rem-holster with boron-inlet for dose rate measurement						•						
	425068519	Holster for RadEye G-20 and B-20 versions. Sized to insert instrument with rubber shock protection.				•	•							
	SM149142238	Holster for up to 2 RadEye B-20 energy filters				•								
	SM149142246	Aquapac - 100 % waterproof case	•	•	•			•						

Adapters for one-hand operation of RadEye SX, PX and probe, please see pages 24-25.

RadEye - Technical characteristics of variants with internal detector

	PRD	PRD-ER	GN	G G-Ex	G-10 G-10-Ex
Detector	NaI(TI)	NaI(TI)	Li-6 doped glas scintillator	GM	GM
For use in explosive atmosphere				G-Ex	G-10-Ex
Gamma and X-rays (detection)	> 30 keV ★★★★★	> 30 keV ★★★★★	> 30 keV ★★★★★		
Gamma and X-rays (dose rate)	> 60 keV ★★★	> 60 keV ★★★	> 60 keV ★★★	> 48 keV ★★★★★	> 48 keV ★★★★★
Beta dose rate					
Alpha/beta contamination					
Alpha/beta discrimination					
Neutron source detection			★★★★★		
Neutron source verification			★★★★		
Measuring units – dose rates are energy compensated	cps Sv/h rem/h R/h	cps Sv/h rem/h (R/h)	γ, n: cpm, cps γ: Sv/h, rem/h (R/h)	R/h	Sv/h rem/h
Upper dose rate limit	250 µSv/h 25 mR/h 25 mrem/h ★★★	100 mSv/h 10 rem/h ★★★★	250 µSv/h 25 mR/h 25 mrem/h ★★★	10 R/h ★★★★	100 mSv/h 10 rem/h ★★★★
cps at 1 µSv/h (100 µrem/h), 662 keV	150 ★★★★	150 ★★★★	120 ★★★★	1.7 ★★★	1.7 ★★★

*Absolute pressure (=1.5 bar gauge pressure at standard conditions)

GF GF-Ex	GF-10 GF-10-Ex	G20-10	G20-ER10	B20	B20-ER	NL	AB100
GM	GM	Pancake GM	Pancake GM	Pancake GM	Pancake GM	2.5 bar He-3*	Dual phosphor scintillator
GF-Ex	GF-10-Ex						
				> 5 keV ★★★★	> 5 keV ★★★★		
> 48 keV ★★★★★	> 48 keV ★★★★★	> 17 keV ★★★★★	> 17 keV ★★★★★	> 17 keV with filter ★★★★★	> 17 keV with filter ★★★★★		
				★★★	★★★		
				★★★★★	★★★★★		★★★★★
				Via filter (★★)	Via filter (★★)		★★★★★
						★★★	
						★★★★★	
R/h	Sv/h rem/h	Sv/h rem/h	Sv/h rem/h	cps, cpm Bq, dpm, dps Sv/h, rem/h	ps, cpm Bq, dpm, dps Sv/h, rem/h	cps	cps, cpm Bq, dpm, dps
300 R/h ★★★★★	3 Sv/h 300 rem/h ★★★★★	2 mSv/h 200 mrem/h ★★★	100 mSv/h 10 rem/h ★★★★	2 mSv/h 200 mrem/h ★★★	100 mSv/h 10 rem/h ★★★★		
0.16 ★★	0.16 ★★	4 ★★★	4 ★★★	4 ★★★	4 ★★★		

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Defence Equipment and Support

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Ministry of Defence
Radiation Calibration Qualified Persons Committee
(MRCQP)

Radiation Detection and Monitoring Equipment

Calibration Protocols

Contents

Issue 4.3 Jan 09

Sponsor: - MRCQP Committee

Authors: - CBRN Delivery Team

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Standard Radiological Monitoring Instrument Statutory Test

Protocol 15 Doserate Meter Type NIS 295B

Function Gamma / X-ray and Beta Dose Rate Monitor

Publications AP 112G-1314-0 – Radiation Monitor type NIS 295B

NSN 6665-99-111-6865

Required Reference Standards

Gamma Reference Standards - ^{137}Cs & ^{241}Am
X-radiations - ISO Narrow Series
All irradiations shall offer traceability to national standards.
Check Source ^{Nat}U Amersham code UAC 1623 NSN 6665-99-193-3906

Equipment Overview
Description and Use
The NIS 295B is a photon monitor designed to measure gamma and X-radiation. It can also be used for beta radiation detection. The instrument has a single logarithmic scale up to a full-scale deflection of 5000 µSv.h^{-1}.
Physical Construction: Unit construction; a steel case with detector protruding from the front. All controls, meter & handle are on top with battery access through a panel on the bottom.
Detector Type: Zinc loaded plastic scintillator optically matched to a conventional 13-stage photomultiplier.
Doserate Range: 0.5 µSv/h – 5000 µSv/h ADE H*10.
Energy Range: 45 keV – 2.5 MeV (Gamma & X-ray).

Controls

1. The NIS 295B has the following controls:

a. **Function Switch.** The function switch has 5 positions:

(i)	OFF	
(ii)	BATT	Indicates condition of battery, within battery marker band.
(iii)	CHECK 7V	Indicates 7V setting, within narrow band at top of scale.
(iv)	SET ZERO	Indicate the electrical zero and can be adjusted using the SET ZERO control
(v)	OPERATE	Selects operational mode.

b. **Response Adjustment.** The SET ZERO control is used to adjust the electrical zero.

c. Two variable resistors which are accessed by removal of the case:

RV3 Set EHT control (set for 1 mSv.h^{-1})
RV5 Set SCALE control (set for 50µSv.h^{-1})

Note: RV3 and RV5 are dependent upon each other and should be used in conjunction with each other to optimise the reading.

Standard Test Protocol

2. All tests should be recorded for Qualified Person inspection and certificate production.

Pre-radiation Tests, Electrical and Physical Examination

3. The following tests must be undertaken prior to both Category 1 and 2 tests.

   a. **Battery Test.**
   Ensure batteries are in good order and provide the necessary voltage for operation.
   Replace as necessary.

   b. **Check 7 V.** Set the function switch to CHECK 7V and check that the reading is within the 7 V sector.

   c. **Set Zero.** Set the function switch to SET ZERO and adjust the SET ZERO control for a meter reading of zero.

   d. **Mechanical checks.**
   Check the mechanical integrity of instrument.
   Replace defective parts as necessary.

Radiation Tests

4. **Category 1 Test: Test before First Use.** These tests must be undertaken on each instrument before introduction into service, the test regime must also be employed where repairs/modifications may have altered detector response.

   a. **Background Dose Rate.**
   Position the unit under test (UUT) in a low background environment (where measurement of background is undertaken in the exposure room, a collimator/detector spacing of at least 1000mm should be maintained).

   Record the instrument background doserate on the calibration certificate.

   (i) Acceptance / Pass criteria – Instrument response should reflect ± 10% of the known dose rate for the area.

   b. **Response to High Dose Rates.**
   Expose the UUT to a doserate >10 times scale maxima for at least thirty seconds.

   (ii) Acceptance / Pass criteria - The instrument should maintain an overload state throughout testing, where FSD is reported there should be no evidence of fallback. Where overload delivery NOT achievable by the facility, the instrument shall report a response conforming to within ±30% of the delivered reference rate.

Note: Test houses incapable of generating rates at or greater than scale maxima should undertake high doserate testing at a level >10 times the maximum credible doserate which could be encountered during operational use. Units tested in this manner shall carry a "Limited Cal" tally, supported by a statement on the calibration certificate defining the limits of the testing.

   c. **Linearity of Response. (^{137}Cs)**
   Expose the UUT to at least one doserate per decade of operation listed in the table below (example min/max ranges have been provided such that errors up to ±30% will NOT pull the unit into a lower/higher decade. Where decades cannot be tested due to facility restrictions, the limit of the calibration should be covered by the statement defining the limit of calibration on the calibration certificate.

   Obtain a mean reported figure from the instrument for each delivered rate, mean figures should be background corrected and recorded on the calibration certificate.

Decade of Operation	% of Decade	Example Min/Max ^{137}Cs Doserates
H*(10)	**H*(10)**	**H*(10)**
1 - 10 μSv.h^{-1}	<40% of Decade	1.5 – 3.5 μSv.h^{-1}
1 - 10 μSv.h^{-1}	>40% of Decade	6.6 – 7.6 μSv.h^{-1}
10 - 100 μSv.h^{-1}	<40% of Decade	14.3 – 27.5 μSv.h^{-1}
10 - 100 μSv.h^{-1}	>40% of Decade	66 – 76 μSv.h^{-1}
100 - 1000 μSv.h^{-1}	<40% of Decade	150 – 350 μSv.h^{-1}
100 - 1000 μSv.h^{-1}	>40% of Decade	660 – 760 μSv.h^{-1}
1 – 5 mSv.h^{-1}	<40% of Decade	1.5 – 3.5 mSv.h^{-1}

(i) Acceptance / Pass criteria - is instrument response within ± 30% i.e. within the permitted ranges shown above.

d. **Energy Response Test**
Expose the instrument to a 65 keV ISO narrow series x-ray or Am-241 doserate reflecting one of the doserates used during the 'Linearity of Response' testing. Record the observed reading and calculate a response ratio using the normalised ^{137}Cs value.

(i) Acceptance / Pass criteria – The ^{137}Cs:'Tested energy' response shall indicate a ratio of 1:0.67 (±30%) when exposed to the same ADE rate

Example ^{137}Cs Response	**Example 'Tested Energy' Permitted Range**
H*(10)	**H*(10)**
25 μSv.h^{-1}	11.7 – 21.8 μSv.h^{-1}

e. **Directional Dependency**
Expose the instrument in the -90° and +90° orientation (as shown below) to the same doserate/energy combination used during the 'Energy Response Test', record the observed reading and calculate a response ratio using the frontal response obtained during the 'Energy Response Test'

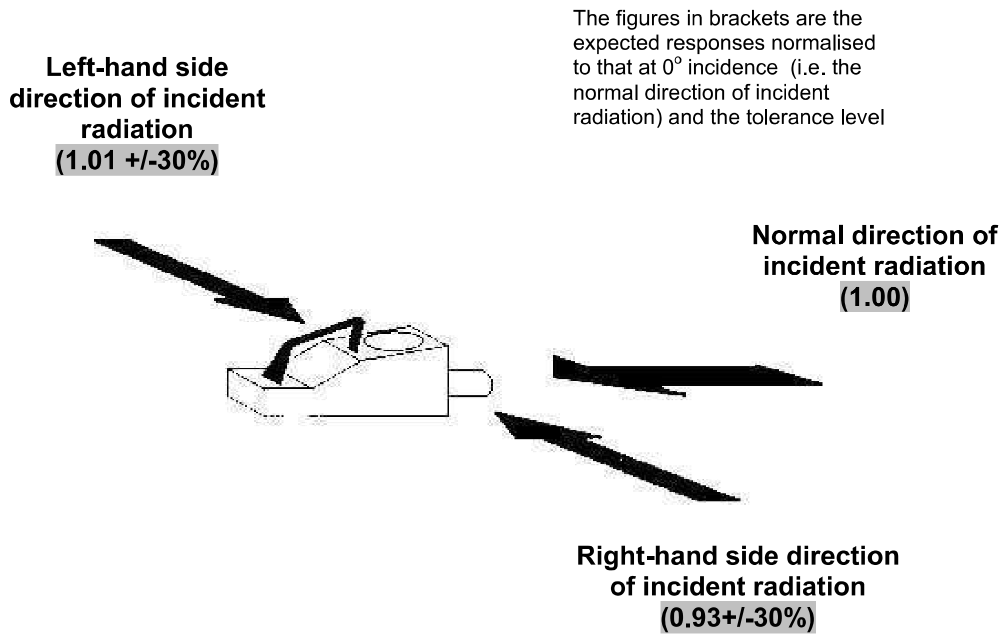


Figure 1: **Expected Directional Dependency**

(i) Acceptance / Pass criteria - instrument response should be ± 30% type test data.

f. **Check Source Response.** Place the Check Source centrally on the front of the NaI detector, i.e. with the beta absorber removed, and the record the response.

(i) Acceptance / Pass criteria - check source response should be 10.2μSv/hr ± 20%.

5. **Category 2: Annual Test.**
Complete all Category 1 tests with the exception of the Directional Dependency Test 4.e.

(i) Acceptance / Pass Criteria - reflects those noted for Category 1 tests.

6. **Category 3: Test Before Operational Use.**
Complete Category 1 test "Check Source Response" at paragraph 4.f.

(i) Acceptance / Pass criteria - check source response should be ±20% of the response recorded on the extant calibration certificate.

Certification (Qualified Person authorisation required)

7. Certificate all test results, failed instruments must be certified with a relevant failure certificate and re-tested after repair using Category 1 or Category 2 test protocols as dictated by the nature of the repair.

Standard Radiological Monitoring Instrument Statutory Test

Protocol 16 Doserate Meter PDR1, IDR1, PDR1Sv and PDR1/R&G

Function Low Level Gamma Survey Monitor

Publications
A: NE Technology Instruction Manual Intrinsically Safe Dose Ratemeter IDR1
B: NE Technology Instruction Manual Portable Dose Ratemeter PDR1
C: NE Technology Instruction Manual Portable Dose Ratemeter PDR1/R&G
D: NE Technology Instruction Manual Portable Dose Ratemeter PDR1Sv

NSN 6665-99-726-3084

Required Reference Standards

Gamma Reference Standards	-	^{137}Cs & ^{241}Am sources shall offer traceability to national standards.
X-radiations	-	65 keV ISO Narrow Series X-ray irradiations shall offer traceability to national standards.

Check Source No check source is currently assigned to this unit.

Equipment Overview

Description and Use: The PDR1 provides a general purpose gamma survey capability for determination of low rate emissions.
Physical Construction: The housing is of moulded plastic construction, comprising a logarithmic analogue meter and ratemeter electronics.
Detector Type: Energy compensated GM tube.
Doserate Range: 0.05μSv.h^{-1} to 100μSv.h^{-1}.
Energy Range: 40 keV – 1.3 MeV.

Controls

1. A comprehensive summary of the instrument functions is contained within Publications Reference A, B, C or D.

Standard Test Protocol

2. All tests should be recorded for Qualified Person inspection and certificate production.

Pre-radiation Tests, Electrical and Physical Examination.

3. The following tests must be undertaken prior to both Category 1 and 2 tests.

    a. **Battery tests.**
    Switch the rotary control to the 'BATT CHECK' position and ensure the battery level on the analogue meter falls within the black portion of the display.
    Replace as necessary.

    b. **Mechanical checks.**
    Examine the instrument for damage, ensuring the plastic case and handle assembly are free from cracks, the analogue meter and rotary control knob remain fit for use.
    Replace defective parts as necessary.

c. Energise the unit and ensure the meter remains stable and does not exhibit excessive fluctuation.

Radiation Tests

5. **Category 1 Test: Test before First Use.** These tests must be undertaken on each instrument before introduction into service, the test regime must also be employed where repairs/modifications may have altered detector response.

a. **Background Dose Rate.**
Position the unit under test (UUT) in a low background environment (where measurement of background is undertaken in the exposure room, a collimator/detector spacing of at least 1000mm should be maintained).

Record the instrument background doserate on the calibration certificate.

(i) Acceptance / Pass criteria - Instrument response should reflect ± 10% of the known dose rate for the area.

b. **Response to High Dose Rates.**
Expose the UUT to a doserate >10 times scale maxima for at least thirty seconds.

Note: Test houses incapable of generating rates at or greater than scale maxima should undertake high doserate testing at a level >10 times the maximum credible doserate which could be encountered during operational use. Units tested in this manner shall carry a "Limited Cal" tally, supported by a statement on the calibration certificate defining the limits of the testing.

(i) Acceptance / Pass criteria – The instrument should maintain an overload state throughout testing, where FSD is reported there should be no evidence of fallback. Where overload delivery NOT achievable by the facility, the instrument shall report a response conforming to within ±30% of the delivered reference rate.

c. **Linearity of Response. (^{137}Cs)**
Expose the UUT to at least two doserates per decade of operation, representing values greater/less than 40% of the decade under test. Test guidance has been provided in the table below (example Min – Max ranges have been provided such that errors up to 30% will NOT pull the unit into a lower/higher decade).

Obtain a mean reported figure from the instrument for each delivered rate, mean figures should be background corrected and recorded on the calibration certificate.

Decade of Operation	**% of Decade**	**Example Min/Max ^{137}Cs Doserates**
H*(10)	**H*(10)**	**H*(10)**
1 - 10 μSv.h^{-1}	<40% of Decade	1.5 – 3.5 μSv.h^{-1}
1 - 10 μSv.h^{-1}	>40% of Decade	6.6 – 7.6 μSv.h^{-1}
10 – 100 μSv.h^{-1}	<40% of Decade	15 – 30 μSv.h^{-1}
10 - 100 μSv.h^{-1}	>40% of Decade	58 – 76 μSv.h^{-1}

(i) Acceptance / Pass criteria – Instrument responses shall reflect conformity to within to ±30%of delivered reference rates.

d. **Energy Response Test (60 keV ^{241}Am)**

Expose the instrument to a doserate reflecting one of the doserates used during the 'Linearity of Response' testing. Record the observed reading and calculate a response ratio using the normalised ^{137}Cs value.

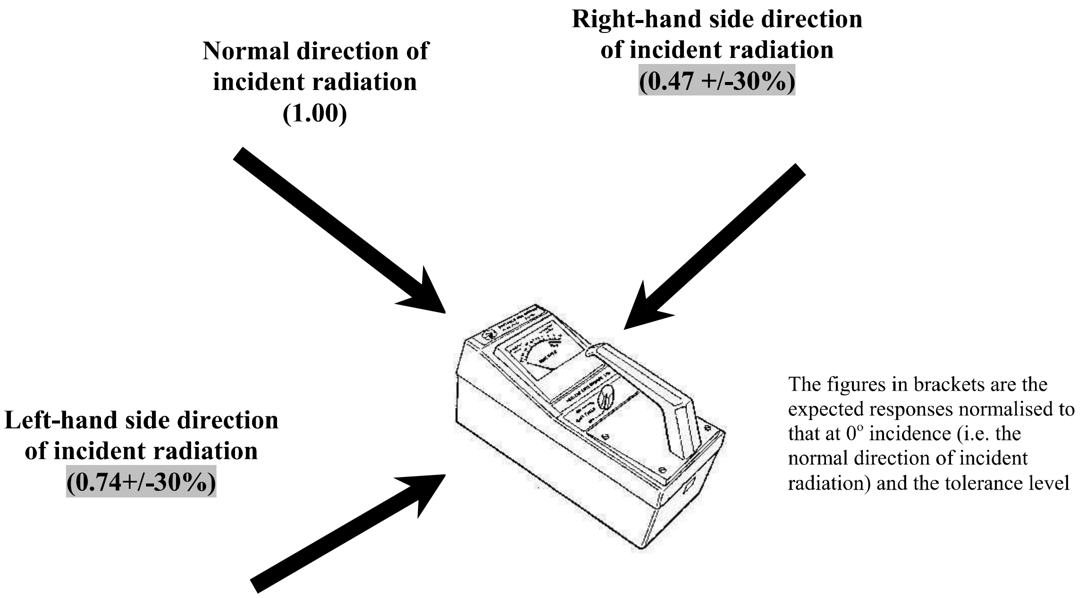
(i) Acceptance / Pass criteria – The ^{137}Cs: ^{241}Am response shall indicate a ratio of 1:0.86 (±30%) when exposed to the same ADE rate, an example is provided below.

Example ^{137}Cs Response for PDR1	**Example ^{241}Am Permitted Range**
H*(10)	**H*(10)**
25 µSv.h^{-1}	15.05 – 27.95 µSv.h^{-1}

e. **Directional Dependency**

Expose the instrument in the -90° and +90° orientation (as shown below) to the same doserate/energy combination used during the 'Energy Response Test', record the observed reading and calculate a response ratio using the frontal response obtained during the 'Energy Response Test'.

Figure 3. **Expected Directional Dependency**



(i) Acceptance / Pass criteria – The responses shall reflect the responses detailed in Figure 1.

f. **Check Source Response.**

No check source is currently assigned to this unit.

6. **Category 2: Annual Test.**
Complete all Category 1 tests except Directional Dependency Test 4.e.

(i) Acceptance / Pass criteria – Criteria reflects those noted for Category 1 tests.

7. **Category 3: Test before Operational Use.**
Complete Category 1 test "Check Source Response" at paragraph 4.f.

(i) Acceptance / Pass criteria – Response should be ±20% of the response recorded on the extant calibration certificate.

Standard Radiological Monitoring Instrument Statutory Test

Protocol 24 Doserate Meter Type FAG FH40F2M

Function Digital Gamma Survey Monitor

Publications A: AP112G-1326-0 Radiation Monitor Type FH40
B: ESM Instruction Manual FH40F2M RADIACMETER

NSN 6665-12-326-4538

Required Reference Standards

Gamma Reference Standards	-	^{137}Cs & ^{241}Am sources shall offer traceability to national standards.
X-radiations	-	65 keV ISO Narrow Series X-ray irradiations shall offer traceability to national standards.

Check Source ^{Nat}U Isotrak code UAC 1623 (NSN 6665-99-193-3906)

Equipment Overview

Description and Use: The FH40F2M provides a dose/rate monitoring capability and offers connectivity and ratemeter support to an external probe.
Physical Construction: The unit is of two piece plastic construction, the upper section houses the membrane keypad, LCD display and sounder assembly. The lower portion accommodates the battery and associated printed circuit boards.
Detector Type: 1 off GM Tube (energy compensated).
Doserate Range: 0.01µSv/h to 9.99mSv/h
Energy Range: 45keV – 1.3MeV

Controls

1. A comprehensive summary of instrument functionality is contained within 'Publications' Reference A & B.

Standard Test Protocol

2. All tests should be recorded for Qualified Person inspection and certificate production.

Pre-radiation Tests, Electrical and Physical Examination.

3. The following tests must be undertaken prior to both Category 1 and 2 tests.

   a. **Battery tests.**
   Ensure the battery compartment is in good order and batteries provide the necessary voltage for operation.
   Replace as necessary.

   b. **Mechanical checks.**
   Ensure the instrument chassis (including machine screws), input socket, membrane keypad and LCD Display are free from damage.
   Replace defective parts as necessary.

   c. **Ancillary Equipment.**
   Ensure the instrument carry case / strap are free from damage.
   Replace as necessary.

   d. Energise the unit and check operation of all controls (when switched on, the ratemeter self test routine will activate).

Radiation Tests

4. **Category 1 Test: Test before First Use.** These tests must be undertaken on each instrument before introduction into service, the test regime must also be employed where repairs/modifications may have altered detector response.

   a. **Background Dose Rate.**
   Position the unit under test (UUT) in a low background environment (where measurement of background is undertaken in the exposure room, a collimator/detector spacing of at least 1000mm should be maintained).

   Record the instrument background doserate on the calibration certificate.

   (i) Acceptance / Pass criteria - Instrument response should reflect ± 10% of the known dose rate for the area.

   b. **Response to High Dose Rates.**
   Expose the UUT to a doserate >10 times scale maxima for at least thirty seconds.

   Note: Test houses incapable of generating rates at or greater than scale maxima should undertake high doserate testing at a level >10 times the maximum credible doserate which could be encountered during operational use. Units tested in this manner shall carry a “Limited Cal” tally, supported by a statement on the calibration certificate defining the limits of the testing.

   (i) Acceptance / Pass criteria – The instrument should maintain an overload state throughout testing, where FSD is reported there should be no evidence of fallback. Where overload delivery is NOT achievable by the facility, the instrument shall report a response conforming to within ±30% of the delivered reference rate.

   c. **Linearity of Response. (^{137}Cs)**
   Expose the UUT to at least one doserate per decade of operation listed in the table below (example min/max ranges have been provided such that errors up to ±30% will NOT pull the unit into a lower/higher decade. Where decades cannot be tested due to facility restrictions, the limit of the calibration should be covered by the statement defining the limit of calibration on the calibration certificate.

   Obtain a mean reported figure from the instrument for each delivered rate, mean figures should be background corrected and recorded on the calibration certificate.

Decade of Operation	Example Min/Max ^{137}Cs Doserates
H*(10)	**H*(10)**
1 – 10 μSv.h^{-1}	1.5 – 7.5 μSv.h^{-1}
10 – 100 μSv.h^{-1}	15 – 75 μSv.h^{-1}
100 – 1000 μSv.h^{-1}	150 – 750 μSv.h^{-1}
1 – 10 mSv.h^{-1}	1.5 – 7.5 mSv.h^{-1}

   (i) Acceptance / Pass criteria – Instrument responses shall reflect conformity to within ±30% of delivered reference rates.

   d. **Dose Test (^{137}Cs).**
   Reset the accumulated dose following instructions documented in publications A & B, expose the instrument to a doserate/time combination enabling dose accumulation to the target levels below. On completion of the tests, record the results on the calibration certificate.

^{137}Cs Dose Target	^{137}Cs Permitted Range
H*(10)	**H*(10)**
1 mSv	700 μSv – 1.3 mSv

(i) Acceptance / Pass criteria – Instrument response shall reflect conformity to within ±30% of the target dose value.

e. **Energy Response Test (60 keV ^{241}Am or 65 keV ISO Narrow Series X-ray)**
Expose the instrument to a doserate reflecting one of the doserates used during the 'Linearity of Response' testing. Record the observed reading and calculate a response ratio using the normalised ^{137}Cs value.

(i) Acceptance / Pass criteria – The ^{137}Cs: ^{241}Am/X-ray response shall indicate a ratio of 1:1.07 (±30%) when exposed to the same ADE rate, an example is provided below.

Example ^{137}Cs Response	**Example ^{241}Am/X-ray Permitted Range**
H*(10)	**H*(10)**
25 μSv.h^{-1}	18.73 – 34.78 μSv.h^{-1}

f. **Directional Dependency**
Expose the instrument in the -90° and +90° orientation (as shown below) to the same doserate/energy combination used during the 'Energy Response Test', record the observed reading and calculate a response ratio using the frontal response obtained during the 'Energy Response Test'.

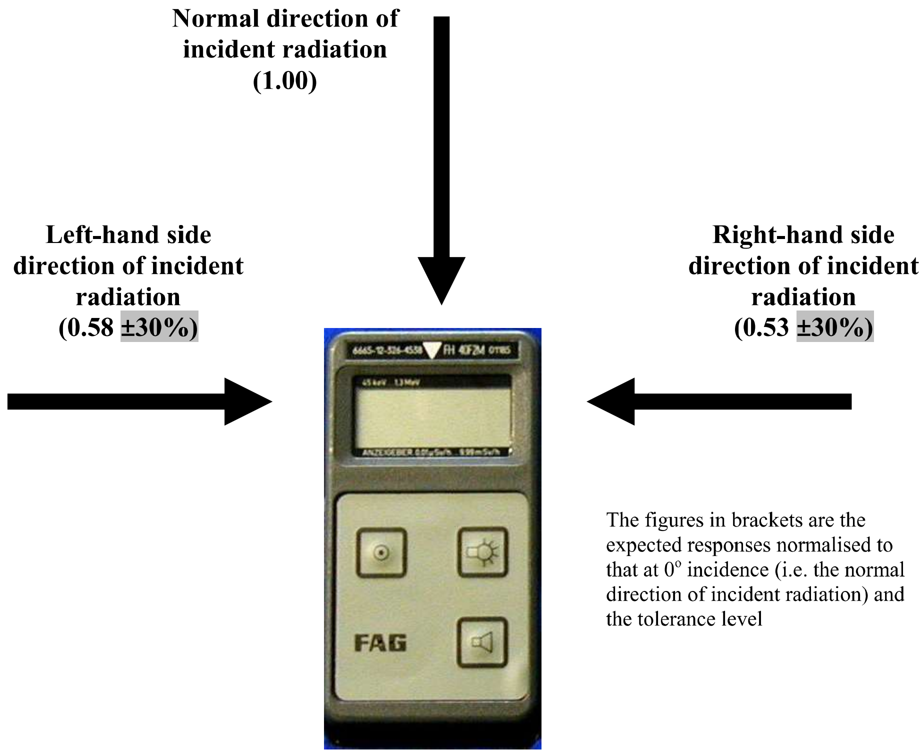


Figure 6. **Expected Directional Dependency**

(i) Acceptance / Pass criteria – The responses shall reflect the responses detailed in Figure 1.

g. **Check Source Response.**
Unscrew the UAC 1623 check source from its protective enclosure, place the source such that the black circular portion is centrally positioned and in direct contact with the front of the instrument (the inverted triangle provides a reference point for this measurement). Allow approximately 30 seconds for the instrument to stabilize and record the reading.

(i) Acceptance / Pass criteria – The check source response should be 2.48 μSv/h ± 30%.

5. **Category 2: Annual Test.**
Complete all Category 1 tests except Directional Dependency Test 4.f.

(i) Acceptance / Pass criteria – Criteria reflects those noted for Category 1 tests.

6. **Category 3: Test before Operational Use.**
Complete Category 1 test "Check Source Response" at paragraph 4.g.

(i) Acceptance / Pass criteria – Response should be ±20% of the response recorded on the extant calibration certificate.

Certification (Qualified Person authorisation required)

7. Certificate all test results, failed instruments must be certified with a relevant failure certificate and re-tested after repair using Category 1 or Category 2 test protocols as dictated by the nature of the repair.

Standard Radiological Monitoring Instrument Statutory Test

Protocol 31 Mini Monitor Series 900 + 42b Probe

Function Photon Surface Contamination Monitor

Publications
A: AP112G-1325-0 Mini Monitor 900 Series
B: Instrument Operating handbook Series 900 Scintillation Mini Monitor with types 41, 42A/B & 44A/B probes.

NSN 6665-99-570-5736

Required Reference Standards

Extended area - All sources shall be suitably filtered to remove alpha/beta emissions and must be emission rate calibrated, offering traceability to national standards.

^{55}Fe Photon Reference Source Isotrak code IERB 4536;

^{238}Pu Photon Reference Source Isotrak code PPRB 4472;

^{129}I Photon Reference Source Isotrak code ISRB 4474;

^{241}Am Photon Reference Source Isotrak code AMRB 4473;

^{57}Co Photon Reference Source Isotrak code CTRB 3504;

^{137}Cs Photon Reference Source Isotrak code CDRB 4475;

^{60}Co Photon Reference Source Isotrak code CKRB 4476.

Small area (16mm Active Diameter) - All sources shall offer traceability to national standards and must be emission rate calibrated.

^{90}Sr/Y Isotrak code SIR 01011, SIR 01021 and SIR 01031.

Check Source ^{Nat}U Isotrak code UAC 1623 NSN 6665-99-193-3906.

Equipment Overview

Description and Use: The Mini Monitor 900/'42b' probe combination provides a general purpose Photon contamination / leakage monitoring capability.
Physical Construction: Ratemeter – The ratemeter is of two piece construction, the rear section, formed from sheet aluminium houses the battery cradle, charging circuitry and sounder. The steel front panel accommodates the user controls and analogue meter.
Probe – The probe comprises a spun Aluminium body housing the detector, photo multiplier tube, dynode resistors and a Pet-100 series HV connector mounted at the upper end.
Detector Type: Beryllium windowed NaI crystal.
Photon Energy Range: 5.9 keV (Fe-55) to 1.25 MeV (Co-60) significant reduction at >200 keV.
Detector Active Area: 4.1 cm^2.

Mini Monitor 900 + 42B probe

Controls

1. A comprehensive summary of instrument functionality is contained within 'Publications' reference A & B.

Standard Test Protocol

2. All tests should be recorded for Qualified Person inspection and certificate production.

Pre-radiation Tests, Electrical and Physical Examination.

3. The following tests must be undertaken prior to both Category 1 and 2 tests.

   a. **Battery tests.**
   Ensure the battery compartment is in good order and batteries provide the necessary voltage for operation.
   Replace as necessary.

   b. **Mechanical checks.**
   Ensure the instrument chassis (including machine screws), analogue meter, rotary control knob, cable, probe case, detector window and probe connectors are free from damage.
   Replace defective parts as necessary.

   c. Energise the unit and check operation of all controls

Radiation Tests

4. **Category 1 Test: Test before First Use.** These tests must be undertaken on each instrument prior to initial introduction to service, the test regime must also be employed where major repairs/modifications may have altered detector response.

   a. **Determination of Operating Voltage.**
   The operating voltage of the equipment is preset and cannot he quantitatively altered without disassembling the instrument. Therefore no operating voltage plateau can be measured for this instrument.

   Note: The operating voltage should only be altered if the unit response to ^{55}Fe is low, this operation requires the front panel to be removed and internal potentiometers adjusted, set up details are provided in within 'Publications' reference A & B.

   b. **Background Count Rate.**
   Remove the probe from the sources and record the instrument background doserate on the calibration certificate.

   (i) Acceptance / Pass criteria - The background level should be less than 8 cps in a field of < 0.25 μSv.h^{-1}, H*(10) from ^{137}Cs 662 keV.

   c. **Light Sensitivity. (With Light Source Only)**
   The probe should be exposed to an appropriate light source, any significant change in background should be observed.

   (i) Acceptance / Pass criteria - The background level should remain unaffected by the presence of the light source.

   d. **Light Sensitivity. (With Radioactive Source)**
   Due to the small area of the probe it is likely that positioning a radioactive source beneath the detector during the test will obscure light entering the probe therefore this test is NOT applicable to the unit.

   e. **Response To Photon Contamination.**
   The responses detailed below are for the specified extended area reference standards, with a source to detector face separation of 3mm. For each source record at least three observations of response to obtain a mean figure, mean figures should be background corrected and recorded on the calibration certificate. Details of the derivation of contamination responses (cps per **em^{-1}.cm^{2}**) and equivalent 2 π efficiency (%) are given in part 2 of JSP 425.

Nuclide	cps.em^{-1}.cm^{2} (P=2)		2π Efficiency %	
	Mean Response	Permitted Range	Mean Efficiency	Permitted Range
^{55}Fe	0.44	0.31 – 0.57	10.66	7.46 – 13.86
^{238}Pu	1.75	1.23 – 2.28	42.60	29.82 – 55.38
^{129}I	1.34	0.94 – 1.74	32.75	22.92 – 42.57
^{241}Am	1.70	1.19 – 2.21	41.47	29.03 – 53.91
^{57}Co	0.80	0.56 – 1.04	19.62	13.74 – 25.51
^{137}Cs	0.22	0.15 – 0.29	5.30	3.71 – 6.89
^{60}Co	0.20	0.14 – 0.26	4.98	3.48 – 6.47

(i) Acceptance / Pass criteria – The instrument response should be within ±30% of the mean efficiencies reported above.

f. **Linearity of Response.**
Place each of the small area sources listed in 'Required Reference Standards' centrally in turn 3mm below the detector. Record the net response (cps) for each source and calculate the ratio of indicated response to source emission rate.

(i) Acceptance / Pass criteria – Each individual ratio should agree with the mean of all three ratios to within ± 30%.

g. **Uniformity of Response.**
Due to the small window area a uniformity test is NOT required on this unit.

h. **Check Source Response.**
With the source in its screw container, place the thick end of the container centrally in contact with the end of the probe. Allow 30 seconds for the reading to stabilize and record the response on the instrument calibration certificate.

5. **Category 2: Annual Test.** Complete all Category 1 tests noting the asterisk marked sources in the 'Response to Alpha Contamination' tests.

(i) Acceptance / Pass criteria – Criteria reflects those noted for Category 1 tests.

6. **Category 3: Test Before Operational Use.** Complete Category 1 test "Check Source Response" at paragraph 4.h.

(i) Acceptance / Pass criteria – Response should be ±20% of the response recorded on the extant calibration certificate.

Certification (Qualified Person authorisation required)

7. Certificate all test results, failed instruments must be certified with a relevant failure certificate and re-tested after repair using Category 1 or Category 2 test protocols as dictated by the nature of the repair.

Standard Radiological Monitoring Instrument Statutory Test

Protocol 32 Mini Monitor Series 900 + 44b Probe

Function Photon Surface Contamination Monitor

Publications
A: AP112G-1325-0 Mini Monitor 900 Series
B: Instrument Operating handbook Series 900 Scintillation Mini Monitor with types 41, 42A/B & 44A/B probes.

NSN 6665-99-801-3983

Required Reference Standards

Extended area - All sources shall be suitably filtered to remove alpha/beta emissions and must be emission rate calibrated, offering traceability to national standards.

^{55}Fe Photon Reference Source Isotrak code IERB 4536;

^{238}Pu Photon Reference Source Isotrak code PPRB 4472;

^{129}I Photon Reference Source Isotrak code ISRB 4474;

^{241}Am Photon Reference Source Isotrak code AMRB 4473;

^{57}Co Photon Reference Source Isotrak code CTRB 3504;

^{137}Cs Photon Reference Source Isotrak code CDRB 4475;

^{60}Co Photon Reference Source Isotrak code CKRB 4476.

Small area (16mm Active Diameter) - All sources shall offer traceability to national standards and must be emission rate calibrated.

^{90}Sr/Y Isotrak code SIR 01011, SIR 01021 and SIR 01031.

Check Source ^{Nat}U Isotrak code UAC 1623 NSN 6665-99-193-3906.

Equipment Overview

Mini Monitor 900 + 44b Probe

Description and Use: The Mini Monitor 900/'44b' probe combination provides a general purpose Photon contamination / leakage monitoring capability.
Physical Construction: Ratemeter – The ratemeter is of two piece construction, the rear section, formed from sheet aluminium houses the battery cradle, charging circuitry and sounder. The steel front panel accommodates the user controls and analogue meter.
Probe – The probe comprises a spun Aluminium body housing the detector, photo multiplier tube, dynode resistors and a Pet-100 series HV connector mounted at the upper end.
Detector Type: Beryllium windowed NaI crystal.
Photon Energy Range: 5.9 keV (Fe-55) to 1.25 MeV (Co-60) significant reduction at >200 keV.
Detector Active Area: 8.0 cm^2.

Controls

1. A comprehensive summary of instrument functionality is contained within 'Publications' reference A & B.

Standard Test Protocol

2. All tests should be recorded for Qualified Person inspection and certificate production.

Pre-radiation Tests, Electrical and Physical Examination.

3. The following tests must be undertaken prior to both Category 1 and 2 tests.

   a. **Battery tests.**
   Ensure the battery compartment is in good order and batteries provide the necessary voltage for operation.
   Replace defective parts as necessary.

   b. **Mechanical checks.**
   Ensure the instrument chassis (including machine screws), analogue meter, rotary control knob, cable, probe case, detector window and probe connectors are free from damage.
   Replace defective parts as necessary.

   c. Energise the unit and check operation of all controls

Radiation Tests

4. **Category 1 Test: Test before First Use.** These tests must be undertaken on each instrument prior to initial introduction to service, the test regime must also be employed where major repairs/modifications may have altered detector response.

   a. **Determination of Operating Voltage.**
   The operating voltage of the equipment is preset and cannot he quantitatively altered without disassembling the instrument. Therefore no operating voltage plateau can be measured for this instrument.

   Note: The operating voltage should only be altered if the unit response to ^{55}Fe is low, this operation requires the front panel to be removed and internal potentiometers adjusted, set up details are provided in within ‘Publications’ reference A & B.

   b. **Background Count Rate.**
   Remove the probe from the sources and record the instrument background doserate on the calibration certificate.

   (i) Acceptance / Pass criteria - The background level should be less than 15 cps in a field of < 0.25 μSv.h^{-1}, H*(10) from ^{137}Cs 662 keV.

   c. **Light Sensitivity. (With Light Source Only)**
   The probe should be exposed to an appropriate light source, any significant change in background should be observed.

   d. **Light Sensitivity. (With Radioactive Source)**
   Due to the small area of the probe it is likely that positioning a radioactive source beneath the detector during the test will obscure light entering the probe therefore this test is NOT applicable to the unit.

   (i) Acceptance / Pass criteria - The background level should remain unaffected by the presence of the light source.

   e. **Response To Photon Contamination.**
   The responses detailed below are for the specified extended area reference standards, with a source to detector face separation of 3mm. For each source record at least three observations of response to obtain a mean figure, mean figures should be background corrected and recorded on the calibration certificate. Details of the derivation of contamination responses (cps per em^{-1}.cm^{2}) and equivalent 2 π efficiency (%) are given in part 2 of JSP 425.

Nuclide	**$cps.em^{-1}.cm^2$ (P=2)**		**2π Efficiency %**	
	Mean Response	Permitted Range	Mean Efficiency	Permitted Range
^{55}Fe	2.31	1.62 – 3.00	28.91	20.24 – 37.59
^{238}Pu	7.09	4.96 – 9.22	88.57	62.0 – 115.14
^{129}I	7.14	5.00 – 9.28	89.20	62.44 – 115.96
^{241}Am	8.58	6.01 – 11.15	107.28	75.09 – 139.46
^{57}Co	6.46	4.52 – 8.40	80.71	56.5 – 104.92
^{137}Cs	1.57	1.01 – 2.04	19.68	13.78 – 25.59
^{60}Co	1.07	0.75 – 1.39	13.35	9.35 – 17.36

(i) Acceptance / Pass criteria – The instrument response should be within ±30% of the mean efficiencies reported above.

f. **Linearity of Response.**
Place each of the small area sources listed in 'Required Reference Standards' centrally in turn 3mm below the detector. Record the net response (cps) for each source and calculate the ratio of indicated response to source emission rate.

(i) Acceptance / Pass criteria – Each individual ratio should agree with the mean of all three ratios to within ± 30%.

g. **Uniformity of Response.**
Due to the small window area a uniformity test is NOT required on this unit.

h. **Check Source Response.**
With the source in its screw container, place the thick end of the container centrally in contact with the end of the probe. Allow 30 seconds for the reading to stabilize and record the response on the instrument calibration certificate.

5. **Category 2: Annual Test.** Complete all Category 1 tests.

(i) Acceptance / Pass criteria – Criteria reflects those noted for Category 1 tests.

6. **Category 3: Test Before Operational Use.** Complete Category 1 test "Check Source Response" at paragraph 4.h.

(i) Acceptance / Pass criteria – Response should be ±20% of the response recorded on the extant calibration certificate.

Certification (Qualified Person authorisation required)

7. Certificate all test results, failed instruments must be certified with a relevant failure certificate and re-tested after repair using Category 1 or Category 2 test protocols as dictated by the nature of the repair.

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Standard Radiological Monitoring Instrument Statutory Test

Protocol 33 Mini Monitor Series 900 + 'E' Probe

Function Alpha/Beta Surface Contamination Monitor

Publications A: Mini Monitor Series 900, Models E, EL, S, SL & X operators Manual

NSN N/A

Required Reference Standards

All must be emission rate calibrated: -

Extended area

^{241}Am Type WRS 7/E Amersham code AMR 07032 or Type WRS 6/E AMR 06032;

^{238}Pu Type WRS 7/E Amersham code PPR 07032 or Type WRS 6/E PPR 06032;

^{Nat}U Type WRS 7/E Amersham code UAR 07032 or Type WRS 6/E UAR 06032;

^{14}C Type WRS 7/E Amersham code CFR 07032 or Type WRS 6/E CFR 06032;

^{36}Cl Type WRS 7/E Amersham code CIR 07032 or Type WRS 6/E CIR 06032;

^{147}Pm Type WRS 7/E Amersham code PHR 07032 or Type WRS 6/E PHR 06032;

^{90}Sr/Y Type WRS 7/E Amersham code SIR 07032 or Type WRS 6/E SIR 06032;

^{60}Co Type WRS 7/E Amersham code CKR 07032 or Type WRS 6/E CKR 06032;

^{137}Cs Type WRS 7/E Amersham code CDR 07032 or Type WRS 6/E CDR 06032.

Small area (16mm Active Diameter)

^{90}Sr/Y Type WRS 1/E Amersham code SIR 01011, SIR 01021 and SIR 01031.

^{241}Am Type WRS 1/E Amersham code AMR 01011, AMR 01021 and AMR 01031.

Description

1. The Mini Monitor Series 900 is a common rate meter, when used with the 'E' probe is scaled from 0-2 kCPS. The unit has a control knob on the front panel allowing the following operations, OFF, BAT, ON and ON WITH MUTED AUDIO. The battery check is displayed on the green and white band of the meter. The unit has an alarm function which is set using the SET ALARM potentiometer on the front of the unit (a source is required for this procedure). The 'E' is an Alpha/Beta probe comprising of a thin end window GM tube with a stainless steel grille for protection from damage.

Mini Monitor Series 900 + 'E' Probe

Probe Active Area: 2 cm^2

Controls

2. A comprehensive summary of the ratemeter functions is contained within the Publication, Reference A.

Standard Test Protocol

3. All tests should be recorded for Qualified Person inspection and certificate production. This protocol is specifically designed for dedicated probe and ratemeter combinations. Where separate testing of probe and ratemeter is required appropriate subsidiary tests should be completed, to confirm suitability of replacement probe or ratemeter. These tests may be derived from those detailed in this protocol.

Pre-radiation Tests, Electrical and Physical Examination.

4. The following tests must be undertaken prior to both Category 1 and 2 tests.

   a. **Battery test.** Check meter battery indication and condition of battery compartment and terminations. Replace as necessary.

   b. **Mechanical checks.** Check mechanical integrity of ratemeter case, cables, and cable connections, probe case and window. Replace as necessary.

   c. Check operation of all controls

Radiation Tests

5. **Category 1 Test: Test before First Use.** These tests must be undertaken on each probe before introduction into service for the first time. They must also be carried out after any repair that may have altered probe response. At least three observations of the surface contamination response should be made.

   a. **Light Sensitivity.** The probe should be exposed to an appropriate light source, any change in background should be observed. Record the probe's response to one of the small area sources listed in Required Reference Standards, with and without the presence of the light source.

      (i) Acceptance / pass criteria is that the background count should not be elevated and the response to the source should not be affected by the presence of the light.

   b. **Response To Alpha/Beta Contamination.** The responses detailed below are for the specified reference standards, with a source to detector grille separation of 3 mm. Details of the derivation of contamination responses (cps per Bq.cm^2) and equivalent 2 π efficiency (%) are given in part 2 of JSP 425. Responses must be determined for all nuclides listed. Details are given below for type test responses.

   Note: Nuclide's identified by a * are desirable for category two tests only.

Nuclide	**Cps.Bq^{-1}.cm^2 (P=2)**		**2π Efficiency %**	
	Mean Response	Permitted Range	Mean Efficiency	Permitted Range
^{241}Am	0.99	0.69 – 1.29	31.33	21.93 – 40.73
^{238}Pu	0.87	0.61 – 1.13	27.77	19.44 – 36.10
^{NAT}U	1.67	1.17 – 2.17	53.80	37.66 – 69.94
^{14}C	0.37	0.26 – 0.48	11.75	8.22 – 15.27
^{36}Cl	1.33	0.93 – 1.73	42.58	29.81 – 55.35
^{147}Pm	0.93	0.65 – 1.20	23.88	16.71 – 31.04
^{90}Sr/Y	1.32	0.92 – 1.71	42	29.40 – 54.59
^{60}Co	1.12	0.79 – 1.46	35.59	24.91 – 46.26
^{137}Cs	1.28	0.90 – 1.67	40.82	28.57 - 53.06

   (i) Acceptance / pass criteria is instrument response within ± 30% i.e. within the expected levels shown above.

c. **Check Source Response. (no check source has been assigned to this unit)**.

d. **Linearity of Response.** Place the small area sources listed in Required Reference Standards centrally in turn 3mm below the detector. Record the net response (cps) for each planar disc source.

(i) Acceptance / pass criteria are that the ratio of indicated response to source emission rate should be determined for each of the three sources. Each individual ratio should agree with the mean of all three ratios to within ± 30%.

e. **Uniformity of Response.** A uniformity check is not required on this probe due to its small active area.

f. **Background Count Rate.** Remove the probe from the sources and record the monitor background count rate.

(i) Acceptance / pass criteria is a background level of approx. < 2 cps in a field of < 0.15 μSv.h^{-1}, H*(10) from ^{137}Cs 662 keV.

6. **Category 2: Annual Test.** Complete all Category 1 tests.

(i) Acceptance / pass criteria are the same as Category 1 tests.

7. **Category 3: Test Before Operational Use.** Complete Category 1 test “Check Source Response” at paragraph 5.c.

(i) Acceptance / Pass criteria check source response should be ± 20% of the response recorded at Para. 5.c.

Certification (Qualified Person authorisation required)

8. Certificate test results as appropriate. Failed instruments must be re-tested after repair using Category 1 or Category 2 test protocols as dictated by the nature of the repair.

Standard Radiological Monitoring Instrument Statutory Test

Protocol 34 Mini Monitor Series 900 + 'EL' Probe

Function Alpha/Beta Surface Contamination Monitor

Publications A: Mini Monitor Series 900, Models E, EL, S, SL & X operators Manual

NSN N/A

Required Reference Standards

All must be emission rate calibrated: -

Extended area

^{241}Am Type WRS 7/E Amersham code AMR 07032 or Type WRS 6/E AMR 06032;

^{238}Pu Type WRS 7/E Amersham code PPR 07032 or Type WRS 6/E PPR 06032;

^{Nat}U Type WRS 7/E Amersham code UAR 07032 or Type WRS 6/E UAR 06032;

^{14}C Type WRS 7/E Amersham code CFR 07032 or Type WRS 6/E CFR 06032;

^{36}Cl Type WRS 7/E Amersham code CIR 07032 or Type WRS 6/E CIR 06032;

^{147}Pm Type WRS 7/E Amersham code PHR 07032 or Type WRS 6/E PHR 06032;

^{90}Sr/Y Type WRS 7/E Amersham code SIR 07032 or Type WRS 6/E SIR 06032;

^{60}Co Type WRS 7/E Amersham code CKR 07032 or Type WRS 6/E CKR 06032;

^{137}Cs Type WRS 7/E Amersham code CDR 07032 or Type WRS 6/E CDR 06032.

Small area (16mm Active Diameter)

^{241}Am Type WRS 1/E Amersham code AMR 01011, AMR 01021 and AMR 01031.

Description

1. The Mini Monitor Series 900 is a common rate meter, when used with the EL probe is scaled from 0-600 cps. The unit has a control knob on the front panel allowing the following operations, OFF, BAT, ON and ON WITH MUTED AUDIO. The battery check is displayed on the green and white band of the meter. The unit has an alarm function which is set using the SET ALARM potentiometer on the front of the unit (a source is required for this procedure). The 'EL' is an Alpha/Beta probe comprising of a thin end window organically quenched GM tube with a stainless steel grille for protection from damage.

Mini Monitor Series 900 + 'EL' Probe

Probe Active Area: X cm^2

Controls

2. A comprehensive summary of the ratemeter functions is contained within Publication, Reference A.

Standard Test Protocol

3. All tests should be recorded for Qualified Person inspection and certificate production. This protocol is specifically designed for dedicated probe and ratemeter combinations. Where separate testing of probe and ratemeter is required appropriate subsidiary tests should be completed, to confirm suitability of replacement probe or ratemeter. These tests may be derived from those detailed in this protocol.

Pre-radiation Tests, Electrical and Physical Examination.

4. The following tests must be undertaken prior to both Category 1 and 2 tests.

   a. **Battery test.** Check meter battery indication and condition of battery compartment and terminations. Replace as necessary.

   b. **Mechanical checks.** Check mechanical integrity of ratemeter case, cables, and cable connections, probe case and window. Replace as necessary.

   c. Check operation of all controls

Radiation Tests

5. **Category 1 Test: Test before First Use.** These tests must be undertaken on each probe before introduction into service for the first time. They must also be carried out after any repair that may have altered probe response. At least three observations of the surface contamination response should be made.

   a. **Light Sensitivity.** The probe should be exposed to an appropriate light source, any change in background should be observed. Record the probe's response to one of the small area sources listed in Required Reference Standards, with and without the presence of the light source.

      (i) Acceptance / pass criteria is that the background count should not be elevated and the response to the source should not be affected by the presence of the light.

   b. **Response To Alpha/Beta Contamination.** The responses detailed below are for the specified reference standards, with a source to detector grille separation of 3 mm. Details of the derivation of contamination responses (cps per $Bq.cm^2$) and equivalent 2 π efficiency (%) are given in part 2 of JSP 425. Responses must be determined for all nuclides listed. Details are given below for type test responses.

   Note: Nuclide's identified by a * are desirable for category two tests only.

Nuclide	**$Cps.Bq^{-1}.cm^2$ (P=2)**		**2π Efficiency %**	
	Mean Response	Permitted Range	Mean Efficiency	Permitted Range
^{241}Am	3.13	2.19 – 4.06	32.07	22.45 – 41.69
^{238}Pu	2.94	2.06 – 3.82	30.32	21.22 – 39.41
^{NAT}U	4.76	3.33 – 6.19	49.14	34.39 – 63.88
^{14}C	1.09	0.76 – 1.41	11.23	7.86 – 14.60
^{36}Cl	3.70	2.59 – 4.81	39.01	27.30 – 50.71
^{147}Pm*	1.89	1.32 – 2.45	19.27	13.49 – 25.06
$^{90}Sr/Y$	3.85	2.69 – 5.00	40.51	28.35 – 52.66
^{60}Co	2.94	2.06 – 3.82	30.86	21.60 – 40.12
^{137}Cs*	3.57	2.50 – 4.64	37.10	25.97 – 48.23

   (i) Acceptance / pass criteria is instrument response within ± 30% i.e. within the expected levels shown above.

c. **Check Source Response. (no check source has been assigned to this unit)**.

d. **Linearity of Response.** Place the small area sources listed in Required Reference Standards centrally in turn 3mm below the detector. Record the net response (cps) for each planar disc source.

(i) Acceptance / pass criteria are that the ratio of indicated response to source emission rate should be determined for each of the three sources. Each individual ratio should agree with the mean of all three ratios to within ± 30%.

e. **Uniformity of Response.** A uniformity check is not required on this probe due to its small active area.

f. **Background Count Rate.** Remove the probe from the sources and record the monitor background count rate.

(i) Acceptance / pass criteria is a background level of approx. <2cps in a field of < 0.15 $\mu Sv.h^{-1}$, H*(10) from ^{137}Cs 662 keV.

6. **Category 2: Annual Test.** Complete all Category 1 tests.

(i) Acceptance / pass criteria are the same as Category 1 tests.

7. **Category 3: Test Before Operational Use.** Complete Category 1 test "Check Source Response" at paragraph 5.c.

(i) Acceptance / Pass criteria check source response should be ± 20% of the response recorded at Para. 5.c.

Certification (Qualified Person authorisation required)

8. Certificate test results as appropriate. Failed instruments must be re-tested after repair using Category 1 or Category 2 test protocols as dictated by the nature of the repair.

Standard Radiological Monitoring Instrument Statutory Test

Protocol 35 Mini Monitor Series 900 + ‘X’ Probe (Contamination Response)

Function Alpha/Beta Surface Contamination Monitor

Publications A: Mini Monitor Series 900, Models E, EL, S, SL & X operators Manual

NSN N/A

Required Reference Standards

All must be emission rate calibrated:-

Extended area

^{55}Fe Photon Reference Source Amersham code IERB 4536;

^{238}Pu Photon Reference Source Amersham code PPRB 4472;

^{129}I Photon Reference Source Amersham code ISRB 4474;

^{241}Am Photon Reference Source Amersham code AMRB4473;

^{57}Co Photon Reference Source Amersham code CTRB3504;

^{137}Cs Photon Reference Source Amersham code CDRB4475;

^{60}Co Photon Reference Source Amersham code CKRB4476;

Small area (16mm Active Diameter)

^{90}Sr/Y Type WRS 1/E Amersham code SIR 01011, SIR 01021 and SIR 01031

Description

1. The Mini Monitor Series 900 is a common rate meter, when used with the X-ray probe gives the ability to search for X-ray leakage and high energy Beta emitters. The unit is scaled 0.5 – 2000 CPS and has a control knob on the front panel allowing the following operations, OFF, BAT, ON and ON WITH MUTED AUDIO. The ‘X’ is an X-Ray/Beta probe comprising of a thin end window GM tube with a diameter of 17mm. The probe response is approximately 2 cps per µGy/h in air for ^{137}Cs and 15 cps per µGy/h in air for ^{241}Am.

Mini Monitor Series 900 + ‘X’ Probe

Probe Active Area: X cm^2

Controls

2. A comprehensive summary of the ratemeter functions is contained within Publication, Reference A.

Standard Test Protocol

3. All tests should be recorded for Qualified Person inspection and certificate production. This protocol is specifically designed for dedicated probe and ratemeter combinations. Where separate testing of probe and ratemeter is required appropriate subsidiary tests should be completed, to confirm suitability of replacement probe or ratemeter. These tests may be derived from those detailed in this protocol.

Pre-radiation Tests, Electrical and Physical Examination.

4. The following tests must be undertaken prior to both Category 1 and 2 tests.

   a. **Battery test.** Check meter battery indication and condition of battery compartment and terminations. Replace as necessary.

   b. **Mechanical checks.** Check mechanical integrity of ratemeter case, cables, and cable connections, probe case and window. Replace as necessary.

   c. Check operation of all controls

Radiation Tests

5. **Category 1 Test: Test before First Use.** These tests must be undertaken on each probe before introduction into service for the first time. They must also be carried out after any repair that may have altered probe response. At least three observations of the surface contamination response should be made.

   a. **Light Sensitivity.** The probe should be exposed to an appropriate light source, any change in background should be observed. Record the probe's response to one of the small area sources listed in Required Reference Standards, with and without the presence of the light source.

      (i) Acceptance / pass criteria is that the background count should not be elevated and the response to the source should not be affected by the presence of the light.

   b. **Response To Photon Contamination.** The responses detailed below are for the specified reference standards, with a source to detector grille separation of 3 mm. Details of the derivation of contamination responses (cps per $Bq.cm^2$) and equivalent 2 π efficiency (%) are given in part 2 of JSP 425. Responses must be determined for all nuclides listed. Details are given below for type test responses.

   Note: Nuclide's identified by a * are desirable for category two tests only.

Nuclide	**$Cps.Bq^{-1}.cm^2$ (P=2)**		**2π Efficiency %**	
	Mean Response	Permitted Range	Mean Efficiency	Permitted Range
^{55}Fe	TBA	± 30%	TBA	± 30%
^{238}Pu	TBA	± 30%	TBA	± 30%
^{129}I	TBA	± 30%	TBA	± 30%
^{241}Am	TBA	± 30%	TBA	± 30%
^{57}Co	TBA	± 30%	TBA	± 30%
^{137}Cs*	TBA	± 30%	TBA	± 30%
^{60}Co	TBA	± 30%	TBA	± 30%

      (i) Acceptance / pass criteria is instrument response within ± 30% i.e. within the expected levels shown above.

   c. **Check Source Response. (no check source has been assigned to this unit)**.

   d. **Linearity of Response.** Place the small area sources listed in Required Reference Standards centrally in turn 3mm below the detector. Record the net response (cps) for each planar disc source.

      (i) Acceptance / pass criteria are that the ratio of indicated response to source emission rate should be determined for each of the three sources. Each individual ratio should agree with the mean of all three ratios to within ± 30%.

e. **Uniformity of Response.** A uniformity check is not required on this probe due to its small active area.

f. **Background Count Rate.** Remove the probe from the sources and record the monitor background count rate.

(i) Acceptance / pass criteria is a background level of approx. <3cps in a field of < 0.15 $\mu Sv.h^{-1}$, H*(10) from ^{137}Cs 662 keV.

6. **Category 2: Annual Test.** Complete all Category 1 tests.

(i) Acceptance / pass criteria are the same as Category 1 tests.

7. **Category 3: Test Before Operational Use.** Complete Category 1 test "Check Source Response" at paragraph 5.c.

(i) Acceptance / Pass criteria check source response should be ± 20% of the response recorded at Para. 5.c.

Certification (Qualified Person authorisation required)

8. Certificate test results as appropriate. Failed instruments must be re-tested after repair using Category 1 or Category 2 test protocols as dictated by the nature of the repair.

Standard Radiological Monitoring Instrument Statutory Test

Protocol 35a Mini Monitor Series 900 + 'X' Probe (Doserate Response)

Function Alpha/Beta Surface Contamination Monitor

Publications A: Mini Monitor Series 900, Models E, EL, S, SL & X operators Manual

NSN N/A

Required Reference Standards

Check Source ^{Nat}U Amersham code UAC 1623 NSN 6665-99-193-3906

Description

1. The Mini Monitor Series 900 is a common rate meter, when used with the X probe gives the ability to search for X-ray leakage and high energy Beta emitters. The unit is scaled 0.5 – 2000 CPS and has a control knob on the front panel allowing the following operations, OFF, BAT, ON and ON WITH MUTED AUDIO. The 'X' is an X-Ray/Beta probe comprising of a thin end window GM tube with a diameter of 17mm. The probe response is approximately 2 cps per µGy/h in air for ^{137}Cs and 15 cps per µGy/h in air for ^{241}Am.

Mini Monitor Series 900 + 'X' Probe

Probe Active Area: X cm^2

Controls

2. A comprehensive summary of the ratemeter functions is contained within Publication, Reference A.

Standard Test Protocol

3. All tests should be recorded for Qualified Person inspection and certificate production. This protocol is specifically designed for dedicated probe and ratemeter combinations. Where separate testing of probe and ratemeter is required appropriate subsidiary tests should be completed, to confirm suitability of replacement probe or ratemeter. These tests may be derived from those detailed in this protocol.

Pre-radiation Tests, Electrical and Physical Examination.

4. The following tests must be undertaken prior to both Category 1 and 2 tests.

   a. **Battery test.** Check meter battery indication and condition of battery compartment and terminations. Replace as necessary.

   b. **Mechanical checks.** Check mechanical integrity of ratemeter case, cables, and cable connections, probe case and window. Replace as necessary.

   c. Check operation of all controls

Radiation Tests

5. **Category 1 Test: Test before First Use.** These tests must be undertaken on each instrument before introduction into service for the first time and also if any major repair or modification which may have altered the response of the detector is made.

a. **Background Dose Rate.** Remove the instrument from sources and record the instrument background dose rate.

(i) Acceptance / Pass criteria - instrument response should reflect ± 10% of the known dose rate for the area

b. **Response to High Air Kerma Rates.** Expose the instrument to a dose rate in excess 1 $mGy.h^{-1}$ for at least thirty seconds.

(i) Acceptance / Pass criteria the instrument should maintain the overload reading throughout the test. If the instrument reaches full-scale deflection no evidence of fold over is to be shown.

c. **Check Source Response. (No check source has been assigned to this unit)**

d. **Linearity of Response. (^{137}Cs)** Expose the instrument to a range of dose rates and record the observed measurements. At least three repeat measurements of the observed dose rate response should be carried out.

Note: As a minimum, 1 reading for each decade within the type test data range shown should be tested.

Air Kerma Rate	**^{137}Cs Permitted Range**
Air Kerma	**C.P.S.**
10 µGy.h-1	14 – 26
25 µGy.h-1	35 – 65
100 µGy.h-1	140 – 260
500 µGy.h-1	700 – 1300

(i) Acceptance / pass criteria is instrument response within ± 30% i.e. within the permitted ranges shown above.

e. **Energy Response Test at 60 keV (60 keV ^{241}Am).** Expose the instrument to a 60 keV ^{241}Am radiation field at a dose rate of $25 \mu Gy.h^{-1}$.

Air Kerma Rate	**^{241}Am Permitted Range**
Air Kerma	**C.P.S.**
$25\ \mu Sv.h^{-1}$	263 – 488

(i) Acceptance / Pass criteria is within ± 30% i.e. within the permitted range shown above.

f. **Directional Dependency at 60 keV (^{241}Am or 65 keV ISO X-ray Quality).** Expose the instrument to ^{241}Am or 65 keV ISO X-ray Quality radiation field at a dose rate of $25 \mu Sv.h^{-1}$ the expected polar responses are shown in Figure 1.

Graphic to be inserted

Figure 1: **Expected Directional Dependency**

(i) Acceptance / Pass criteria check source response should be ± 30% type test data.

6. **Category 2: Annual Test.** Complete all Category 1 tests with the exception of the Directional Dependency Test 5.f.

   (i) Acceptance / pass criteria are the same as Category 1 tests.

7. **Category 3: Test Before Operational Use.** Complete Category 1 test "Check Source Response" at paragraph 5.c.

   (i) Acceptance / pass criteria check source response should be ±20% of the response recorded at Para. 5.c.

Certification (Qualified Person authorisation required)

8. Certificate test results as appropriate. Failed instruments must be re-tested after repair using Category 1 or Category 2 test protocols as dictated by the nature of the repair.

Standard Radiological Monitoring Instrument Statutory Test

Protocol 36 Neutron Doserate Meter Type Mk 7NRM

Function Neutron Dose Rate Meter

Publications
A: BR 2053(13)
B: Manufactures Technical Manual and User Guide
C: Good Practice Guide No.14 – The Examination, Testing and Calibration of Portable Radiation Protection Instruments, March 1999
D: Joint Services Publication 425 – Examination and Testing of Ionising Radiation Protection Instruments, Edition 3
E: Mk7 NRM Neutron Monitor Check Source Assembly Protocol, June 1997
F: Response Characteristics of Neutron Survey Instruments – NRPB Report No R333 (Revised February 2002)
G: IEC61005 – Radiation Protection Instruments – Neutron Ambient Dose Equivalent (Rate) Meters, June 2004
H: ICRP 74 - Conversion coefficients for use in radiological protection against external radiation

NSN 6665-99-721-2702

Required Reference Standards

Calibration Source Reference Standards

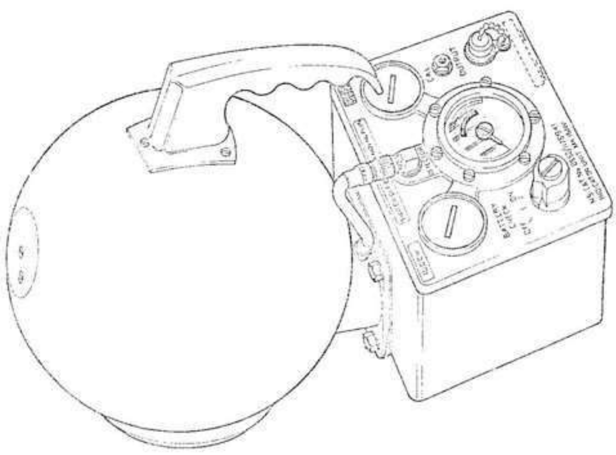
Reference D recommends the following selected standards for the calibration of Neutron Dose Rate Meters.

$^{241}Am/^{9}Be$
^{252}Cf
$^{2}H_2O$ Moderated ^{252}Cf
Deuterium-Tritium Accelerator

Check Source Reference Standard $^{241}Am/^{9}Be$ Check Source – NSN 2090-99-930-7770

Description

1. The ratemeter indicates on a quasilogarithmic scale neutron dose equivalent rate in the range of 0 to 10,000 $\mu Sv.h^{-1}$ over a range of neutron energies from thermal to 14 MeV. The neutron detector consists of a 208.3mm (8.2") diameter polyethylene sphere, an intermediate perforated cadmium layer and a 33 mm diameter Helium–3 filled spherical proportional counter mounted in the centre. The proportional counter detects the thermal neutrons that have been moderated by the polyethylene sphere.



Neutron Monitor Mk 7 NRM

Controls

2. A comprehensive summary of the ratemeter functions is contained within the Publications, Reference A & B.

Standard Test Protocol

3. This protocol has been produced in accordance with the guidelines detailed within References C, D, E & G. All tests should be recorded for Qualified Person inspection and certificate production. This protocol should only be used in conjunction with calibrated reference standards.

Pre-radiation Tests, Electrical and Physical Examination.

4. The following tests must be undertaken prior to both Category 1 and 2 tests unless stated otherwise.

   a. **Battery test.** Check meter battery indication and condition of battery compartment and terminations. Replace batteries as necessary.

   b. **Mechanical checks.** Check mechanical integrity of ratemeter case, cables, and cable connections, polyethylene sphere and meter. Replace as necessary.

   c. **Functionality.** Check operation of all controls

   d. **Electrical Set-up**. For Category 1 Tests only; Check electrical settings in accordance with References A & B.

Radiation Tests

Note: References C & D provide guidance on the tests that must be conducted under each category. Additionally, Reference H provides the conversion factors that should be used for the calculation of fluence to Ambient Dose Equivalent (ADE) H*(10) response. The fluence response characteristics for calibration sources should also be applied in order to obtain an overall instrument response. Refer to Reference F, Page 17 Table 4 for further details.

Note: - For $^{241}Am/^{9}Be$ and ^{252}Cf sources correction factors should be applied to the true doserate to reflect the instrument response. Reference response for Leak Detector 0.24 cps/μSvh^{-1}.

The tests that are required for each category are detailed below: -

5. **Category 1 Test: Test before First Use.** These tests must be undertaken on each instrument before introduction into service for the first time and also if any major repair or modification which may have altered the response of the detector is made.

   a. **Background Dose Rate.** Remove the instrument from the influence of any radiological sources and record the instrument background doserate.

      (i) Acceptance / Pass criteria meter indication of less than $1\mu Svh^{-1}$ or instrument response should reflect ± 10% of the known dose rate for the area.

   b. **Response to High Dose Rates.** Expose the instrument to a dose rate in excess of that which it could reasonably encounter in practice, for at least thirty seconds.

      (i) Acceptance / Pass criteria the instrument should maintain the reading through out the test. If the instrument reaches full-scale deflection no evidence of fold over is to be shown.

Note: Where possible, instruments should be overload tested at 10 times the maximum scale indication. It is recognised that for a number of test houses this is impracticable. In these instances instruments should be tested at 5 or 10 times the maximum credible dose rate to which the instrument could be exposed. These instruments shall be labelled "Limited Cal" and the calibration certificate shall clearly state the limits of the overload and range testing.

   c. **Gamma Rejection** – Expose the instrument to a suitable gamma source i.e. ^{137}Cs or ^{60}Co, at $10mSvh^{-1}$ H*(10). See Reference C & D for further details of gamma rejection.

(i) Acceptance/Pass criteria meter indication of less than 5μSvh^{-1}.

d. **Sensitivity.**

Expose the instrument to the doserate stated in Table 1 for the time period detailed. Conduct a second measurement with the reference source suitably stored for the same period. Determine the sensitivity of the instrument utilising the appropriate correction factors taking account for any geometrical effects that make influence the response of the instrument.

Table 1 – Sensitivity

Nominal Doserate H*(10) ^{241}Am/^{9}Be	**Count Period (secs)**
500μSvh^{-1}	100s
Background	100s

(i) Acceptance/Pass criteria the instrument background corrected sensitivity shall be within ±30% of the nominal reference response.

e. **Linearity of Response.** Expose the instrument to the range of doserates indicated in Table 2 and record the observed background corrected measurements. Reference G, Paragraph 6.1.2.2 states that instruments with a logarithmic scale should be checked at one value within each decade of that scale. This is readily achieved by the doserates detailed within Table 2. However, additional doserates may be included at the discretion of the Qualified Person. Reference C, Section 4.2 recommends that at low dose rates sufficient measurements should be taken to establish a mean indication with a suitable accuracy. (i.e. ±10% standard deviation of the mean).

Note: As a minimum, 1 reading from each decade within the type test data range shown should be tested.

Table 2 – Linearity of Response doserates

Nominal Doserate H*(10) ^{241}Am/^{9}Be	**Relative Response Tolerance**
7.5μSvh^{-1}	±30%
50μSvh^{-1}	±30%
500μSvh^{-1}	±30%
2000μSvh^{-1}	±30%

(i) Acceptance/Pass criteria – the instrument background corrected response shall be within ±30% of the relative response at each doserate measured.

f. **Energy Dependency.** The response of the instrument will be dependent on the energy spectrum in which it is to be exposed. Expose the instrument to the doserate indicated in Table 3 and record the observed measurement. Reference C – Appendix A2.5 discusses Neutron Energy Dependence.

Table 3 – Energy Dependence doserate

Nominal Doserate H*(10) ^{252}Cf	**Relative Response Tolerance**
50μSvh^{-1}	±30%

(i) Acceptance/Pass criteria – the instrument response shall be within ±30% of the relative response.

g. **Directional Dependency** – Expose the instrument to the doserate indicated in Table 4. Take a measurement at 0° and record the instrument response. Rotate the instrument through 90° clockwise and record its response. Return the instrument to its original position. Repeat the measurement at 90° in anti-clockwise direction and record it response. The instrument response must be normalised to unity for normal radiation incidence, with the instrument in a horizontal orientation.

Table 4 – Directional Dependency doserate

Nominal Doserate H*(10) $^{241}Am/^{9}Be$	Tolerance wrt normalised response at 0°
180μSvh^{-1}	±30%

(i) Acceptance/Pass criteria – the instrument response should be within ±30% of the normalised response. Reference C, Section 4.4 for further details.

h. **Check Source Response** – Remove the plug from polyethylene sphere. Place the $^{241}Am/^{9}Be$ check source into the sphere and record the instrument response.

(i) Acceptance/Pass criteria – check source response should provide a reading of 55μSvh^{-1} ±30%. See Reference E for further details.

6. **Category 2: Annual Test.** Complete all Category 1 tests with the exception of the Directional Dependency Test 5.g.

(i) Acceptance / Pass criteria are the same as Category 1 tests.

7. **Category 3: Test Before Operational Use.** Complete Category 1 test “Check Source Response” at paragraph 5.h.

(i) Acceptance / Pass criteria check source response should be ±20% of the response recorded at Para. 5.g.

Certification (Qualified Person authorisation required)

8. Certificate test results as appropriate. Failed instruments must be re-tested after repair using Category 1 test protocols.

Standard Radiological Monitoring Instrument Statutory Test

Protocol 37 Dosimeter Electronic Personal (PED) Type SAIC PD-12i / PD-2i (Submarine Reactor Compartment Emergency Response)

Function Electronic Personal Dosimeter

Publications A: SAW Operation and Maintenance Manual REV

NSN PD12i - 6665-01-445-0695
PD2i - 6665-XX-XXX-XXXX

Required Reference Standards

Description

1. This personal radiation monitor operates as a pager sized stand-alone Electronic Personal Dosimeter unit. The visual readout is based on a backlit LCD. The user can define the display on the dosimeter which steps through Total Dose, Dose Rate and Stay-time. Excess exposure above pre-set Dose and Doserate alarms are indicated by a chirp tone, additionally icons flash on the LCD unit. Dose management / history facilities are accessed through a separate SAIC PDR-1 Dosimeter Reader using a standard RS232C interface with SAIC PDRC3 Version 2.04 (release date March 1996) software running on a PC.

   a. Radiation detection is based on a miniature energy compensated Geiger-Muller tube. Exposure to a radiation field above the predefined EEPROM default is indicated by;

Dose alarm	-	Repeated double bleep.
Doserate	-	Repeated single bleep.

   b. In the Submarine Reactor Accident Emergency Response Protection scenario. The measurement quantity of interest is Absorbed Dose, cGy (not to be confused with air KERMA, also with units Gy).

Controls

2. The PD-12i / PD-2i dosimeters have the following controls:

   a. **Run button** Turns unit on / off and illuminates display.
   b. **Mode button** Selects display function.

Operation of PDRCS Dosimeter Software.

3. See instruction manual Dosimeter Software package 20.L800 REV 061996 for full and complete details.

4. **Operation of PDR-1 Dosimeter Reader.**

   a. Turn on the dosimeter using the RUN button. Place the dosimeter on the PDR-1 dosimeter reader unit with dosimeter clip facing upwards. To Dose reset the PD-12i/2i, depress DOSE RESET membrane pad on the PDR-1 (the status light will change to red momentarily to indicate action). In PDRC3 software "Main Menu Options" Press R for reset of Dosimeter. Dosimeter unit will bleep twice confirming a reset to dose zero.

   b. In main menu options menu select option A "EDIT". Software will enter Menu "PD12i/2i EEPROM EDITINGO UTILITY" The Dosimeter will then be read by the EEPROM utility program.

c. On the left-hand side of the computer display, select Pre-set Total Dose or Dose Rate as required for the functional role required. Use the tab key to navigate around the menu. Change Dose rate and Dose alarms accordingly. Press keyboard escape key and then press enter key to write changes to the dosimeter. The Dosimeter will chirp to indicate that a change of EEPROM default has occurred.

d. Toggle through the Dosimeter LCD display using the MODE button to ensure that the required defaults have been successfully set.

5. **Setting of PD-12i/2i EEPROM Dose Management Functions test points**.

(i) The PD-12i/2i internal settings and calibration test points vary depending on the operational use of the instrument as shown below. It will be necessary to alter the various settings as required during the calibration process.

Standard Test Protocol

6. All tests should be recorded for Qualified Person inspection and certificate production.

Note: The instrument should be orientated such that the LCD display faces upwards and the green/white SAIC label (dependant on model) is facing the source of radiation. The reference center for the Geiger is marked as a cross on the sidewall and the left edge of the label at the rear of instrument for the Geiger centerline.

Pre-radiation Tests, Electrical and Physical Examination.

7. The following tests must be undertaken prior to both Category 1 and 2 tests.

a. **Battery test.** Check meter battery indication and condition of battery compartment and terminations. Replace as necessary.

b. **Mechanical checks.** Check mechanical integrity of dosimeter case. Replace as necessary.

c. Check operation of all controls

Radiation Tests

8. **Category 1 Test: Test before First Use.** These tests must be undertaken on each instrument before introduction into service for the first time and also if any major repair or modification which may have altered the response of the detector is made.

a. For Submarine Reactor Compartment Emergency Response Purposes, source terms must be realized in terms of Absorbed Dose.

b. Configure the internal settings of the PD-12i/2i as follows:-

(i) Dose alarm D-Alm set point 70 cGy Absorbed Dose (equivalent to 639 mGy air KERMA)

(ii) Dose alarm D-Alm set point 140 cGy Absorbed Dose (equivalent to 1277 mGy air KERMA)

Note: For derivation of calibration source terms utilize;

^{137}Cs: 1.096 cGy Absorbed Dose = 1.000 cGy Air KERMA

c. **Dose Test.** - Expose the instrument to the following ^{137}Cs integrated dose.

Absorbed Dose cGy	**^{137}Cs Expected Response**
70 cGy	614 - 920 mSv
140 cGy	1227 - 1841 mSv

d. **Directional Dependency at 60 keV (^{241}Am or 65 keV ISO X-ray Quality).** Reset the accumulated dose and expose the left hand side (+90$^{o)}$ instrument to a 60 keV 241Am or 65 keV ISO X-ray Quality radiation field to a dose rate and time combination which will allow the dose to accumulate to 50μSv. This test should be repeated for the right hand side (-90^{o}) of the instrument.

Note: If using a PMMA slab to achieve Personal Dose Equivalent quantity, keep the PMMA slab immobile and rotate the instrument in front of the slab.

Dose Applied/Orientation of Instrument	**^{241}Am/65 keV X-rays Permitted Range on PMMA Phantom**	**^{241}Am/65 keV X-rays Permitted Range Free in Air**
50 μSv - Left-hand Side	TBA	TBA
50 μSv - Right-hand Side	TBA	TBA

(i) Acceptance / pass criteria response should be within ±30% of type test data.

9. **Category 2: Annual Test.** Complete all Category 1 tests except Directional Dependency Test 8d.

(i) Acceptance / pass criteria are the same as Category 1 tests.

10. **Category 3: Test Before Operational Use.** Not Required.

Certification (Qualified Person authorisation required)

11. Certificate test results as appropriate. Failed instruments must be re-tested after repair using Category 1 or Category 2 test protocols as dictated by the nature of the repair.

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Standard Radiological Monitoring Instrument Statutory Test

Protocol 37a Dosimeter Electronic Personal (PED) Type SAIC PD-12i / PD-2i
(Non Destructive Testing & Health Physics Use)

Function Electronic Personal Dosimeter

Publications A: SAW Operation and Maintenance Manual REV

NSN PD12i - 6665-01-445-0695
PD2i - 6665-XX-XXX-XXXX

Required Reference Standards

Description

1. This personal radiation monitor operates as a pager sized stand-alone Electronic Personal Dosimeter unit. The visual readout is based on a backlit LCD. The user can define the display on the dosimeter which steps through Total Dose, Dose Rate and Stay-time. Excess exposure above pre-set Dose and Doserate alarms are indicated by a chirp tone, additionally icons flash on the LCD unit. Dose management / history facilities are accessed through a separate SAIC PDR-1 Dosimeter Reader using a standard RS232C interface with SAIC PDRC3 Version 2.04 (release date March 1996) software running on a PC.

   a. Radiation detection is based on a miniature energy compensated Geiger-Muller tube. Exposure to a radiation field above the predefined EEPROM default is indicated by;

Dose alarm	-	Repeated double bleep.
Doserate	-	Repeated single bleep.

PD12i

   b. In the Non-Destructive Testing and Health Physics Protection scenario, the measurement quantity of interest is Personal Dose Equivalent, μSv H_p (10).

Controls

2. The PD-12i/2i dosimeter has the following controls:

   a. **Run button** Turns unit on / off and illuminates display.

   b. **Mode button** Selects display function.

Operation of PDRCS Dosimeter Software.

3. See instruction manual Dosimeter Software package 20.L800 REV 061996 for full and complete details.

4. **Operation of PDR-1 Dosimeter Reader**.

   a. Turn on the dosimeter using the RUN button. Place the dosimeter on the PDR-1 dosimeter reader unit with dosimeter clip facing upwards. To Dose reset the PD-12i/2i, depress DOSE RESET membrane pad on the PDR-1 (the status light will change to red momentarily to indicate action). In PDRC3 software "Main Menu Options" Press R for reset of Dosimeter. Dosimeter unit will bleep twice confirming a reset to dose zero.

b. In main menu options menu select option A "EDIT". Software will enter Menu "PD12i/2i EEPROM EDITINGO UTILITY" The Dosimeter will then be read by the EEPROM utility program.

c. On the left-hand side of the computer display, select Pre-set Total Dose or Dose Rate as required for the functional role required. Use the tab key to navigate around the menu. Change Dose rate and Dose alarms accordingly. Press keyboard escape key and then press enter key to write changes to the dosimeter. The Dosimeter will chirp to indicate that a change of EEPROM default has occurred.

d. Toggle through the Dosimeter LCD display using the MODE button to ensure that the required defaults have been successfully set.

5. **Setting of PD-12i/2i EEPROM Dose Management Functions test points**.

a. The PD-12i/2i internal settings and calibration test points vary depending on the operational use of the instrument as shown below. It will be necessary to alter the various settings as required during the calibration process.

Standard Test Protocol

6. All tests should be recorded for Qualified Person inspection and certificate production.

Note: The instrument should be orientated such that the LCD display faces upwards and the green/white SAIC label (dependant on model) is facing the source of radiation. The reference center for the Geiger is marked as a cross on the sidewall and the left edge of the label at the rear of instrument for the Geiger centerline.

Pre-radiation Tests, Electrical and Physical Examination.

7. The following tests must be undertaken prior to both Category 1 and 2 tests.

a. **Battery test.** Check meter battery indication and condition of battery compartment and terminations. Replace as necessary.

b. **Mechanical checks.** Check mechanical integrity of dosimeter case. Replace as necessary.

c. Check operation of all controls

Radiation Tests

8. **Category 1 Test: Test before First Use.** These tests must be undertaken on each instrument before introduction into service for the first time and also if any major repair or modification which may have altered the response of the detector is made.

Note: For Non-destructive Testing and Health Physics Protection Purposes, all source terms must be realised in terms of Personal Dose Equivalent H_p (10). The methods for realizing this dosimetric quantity are detailed in JSP 425.

a. Configure the internal settings of the PD-12i / PD-2i as follows:-
(i) Dose Alarm D-Alm as operationally required, typically 1000 µSv, H_p (10).
(ii) Dose Rate alarm D-Alm as operationally required, suggest 12 $mSv.h^{-1}$, H_p (10).
(iii) Set CHIRP Increment to I0 µSv, H_p (10).
(iv) Enable alarms.
(v) Enable Rate Mode Change.
(vi) Disable Stay Mode.

Note: For derivation of calibration source terms for 'free in air" irradiation's utilize;

^{137}Cs: 1.154 mSv Personal Dose Equivalent H_p (10) = 1.000 mGy Air KERMA

These factors are derived assuming a backscatter correction factor of 4 %. If the calibration is carried out using an appropriate phantom, then these correction factors are not required.

b. **Doserate Alarm Test**. - The instrument should be exposed to ^{137}Cs doserate of 12 mSv.h^{-1} for a minimum of 30 seconds.

(i) Acceptance / Pass criteria, the instrument should alarm (continuous intermittent beep) at the alarm level set prior to the calibration, if the unit does not alarm when this doserate is applied the unit must be failed.

c. **Accumulated Dose Test. (^{137}Cs)** Expose the instrument to a dose rate and time combination, which will allow the dose to accumulate to the values given in the table below. When each exposure has finished record the dose measurement.

Accumulated Dose Hp(10)	**^{137}Cs Permitted Range Hp(10)**
50 µSv	40 – 60µSv
500 µSv	400 – 600µSv
5000 µSv	4000 – 6000µSv

(i) Acceptance / Pass criteria is instrument response within ± 20% i.e. within the permitted ranges shown above.

d. **Dose Alarm Test**. **(^{137}Cs)** Expose the instrument to a dose rate and time combination, which will allow the dose to accumulate to 1.1 mSv.

(i) Acceptance / Pass criteria, the instrument should alarm (repeated double beep) at the alarm level set prior to the calibration, if the unit does not alarm when this dose is applied the unit must be failed.

e. **Energy Response Test (^{241}Am or 65 keV ISO X-ray Quality).** Expose the instrument to a ^{241}Am or 65 keV ISO X-ray Quality radiation field at dose rate and time combination, which will allow the dose to accumulate 50µSv.

Accumulated Dose Hp(10)	**^{241}Am Permitted Range Hp(10)**	**65 keV ISO X-ray Quality Hp(10)**
50 µSv	19.6 – 36.4 µSv	TBA

(i) Acceptance / Pass criteria is within the permitted ranges shown above.

f. **Directional Dependency at 60 keV (^{241}Am or 65 keV ISO X-ray Quality).** Reset the accumulated dose and expose the left hand side (+90$^{o)}$ instrument to a 60 keV 241Am or 65 keV ISO X-ray Quality radiation field to a dose rate and time combination which will allow the dose to accumulate to 50µSv. This test should be repeated for the right hand side (-90^{o}) of the instrument.

Note: If using a PMMA slab to achieve Personal Dose Equivalent quantity, keep the PMMA slab immobile and rotate the instrument in front of the slab.

Dose Applied/Orientation of Instrument	**^{241}Am/65 keV X-rays Permitted Range on PMMA Phantom**	**^{241}Am/65 keV X-rays Permitted Range Free in Air**
50 µSv - Left-hand Side	TBA	TBA
50 µSv - Right-hand Side	TBA	TBA

(i) Acceptance / pass criteria response should be within ±30% of type test data.

9. **Category 2: Annual Test.** Complete all Category 1 tests except Directional Dependency Test 8f.

   (i) Acceptance / pass criteria are the same as Category 1 tests.

10. **Category 3: Test Before Operational Use.** Not Required.

Certification (Qualified Person authorisation required)

11. Certificate test results as appropriate. Failed instruments must be re-tested after repair using Category 1 or Category 2 test protocols as dictated by the nature of the repair.

Standard Radiological Monitoring Instrument Statutory Test

Protocol 43 Contamination Probe Beta Type 1275C Probe

Function Beta / Gamma Contamination Monitor

Publications A: AP112G-1316-0 - Ratemeter Set Type RM10

NSN 6665-99-911-0260

Required Reference Standards

All must be emission rate calibrated except UAC1623:

Extended area ^{90}Sr/Y Type WRS 7/E Amersham code SIR 07032 or Type WRS 6/E SIR 06032;

^{36}Cl Type WRS 7/E Amersham code CIR 07032 or Type WRS 6/E CIR 06032;

^{137}Cs Type WRS 7/E Amersham code CDR 07032 or Type WRS 6/E CDR 06032;

Small area (16mm Active Diameter)

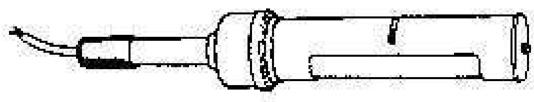
^{90}Sr/Y Type WRS 1/E Amersham code SIR 01011, SIR 01021 and SIR 01031.

Check Source ^{Nat}U Amersham code UAC 1623 NSN 6665-99-193-3906

MOD Jigs Rig SK 1407

Description

1. The 1275C beta / gamma probe and a ratemeter combination is a general purpose beta / gamma contamination monitor. The probe is fitted with a geiger-muller tube containing argon / ethyl formate gas at low pressure, this tube is fragile and care must be taken not to damage it. The probe is fitted with a shutter allowing β assessment to be carried out and has an opening of 22.1 cm^2. The beta / gamma probe is normally used in a training role.



1275C Probe

Probe Active Area: X cm^2

Controls

2. A comprehensive summary of the ratemeter functions is contained within the Publication, Reference A.

Standard Test Protocol

3. All tests should be recorded for Qualified Person inspection and certificate production. This protocol is specifically designed for dedicated probe and radiacmeter connections. Where separate testing of probe and radiacmeter is required for logistics reasons, appropriate subsidiary test should be completed, to confirm suitability of replacement probe or radiacmeter. These tests may be derived from those detailed in this protocol.

Note: This protocol should only be carried out using a calibrated ratemeter.

Pre-radiation Tests, Electrical and Physical Examination.

4. The following tests must be undertaken prior to both Category 1 and 2 tests.

   a. **Battery test.** Check meter battery indication. Replace as necessary.

   b. **Mechanical checks.** Check mechanical integrity of probe, cables, cable connections and GM tube. Replace as necessary.

   c. Check operation of all controls

Radiation Tests

5. **Category 1 Test: Test before First Use.** These tests must be undertaken on each probe before introduction into service for the first time. They must also be carried out after any repair that may have altered probe response. At least three observations of the surface contamination response should be made.

   Note: The 1275C probe and ratemeter operational voltage should be determined prior to this test, following the procedure given in publication TBA. Precise plateau characteristics will be probe and ratemeter dependent and must be determined for each combination. All measurements are undertaken unless otherwise stated with the shutter open

   a. **Light Sensitivity.** The probe should be exposed to an appropriate light source, any change in background should be observed. Record the probe's response to one of the small area sources listed in Required Reference Standards, with and without the presence of the light source.

      (i) Acceptance / pass criteria is that the background count should not be elevated and the response to the source should not be affected by the presence of the light.

   b. **Response To Beta Contamination.** The responses detailed below are for the specified reference standards, with a source to detector grille separation of 3 mm. Details of the derivation of contamination responses (cps per $Bq.cm^2$) and equivalent 2 π efficiency (%) are given in part 2 of JSP 425. Responses must be determined for all nuclides listed. Details are given below for type test responses.

   Note: Nuclide's identified by a * are desirable for category two tests only.

Nuclide	**$cps.Bq^{-1}.cm^2$ (P=2)**		**2π Efficiency %**	
	Mean Response	Permitted Range	Mean Efficiency	Permitted Range
^{36}Cl	1.79	1.25 – 2.32	16.5	11.5 – 21.4
^{90}Sr/Y	2.33	1.63 – 3.02	21.5	15 – 27.9
^{137}Cs*	1.14	0.80 – 1.48	10.7	7.5 – 13.9

   (i) Acceptance / pass criteria is instrument response within ± 30% i.e. within the permitted ranges shown above.

   c. **Check Source Response.** Place the ^{Nat}U UAC 1623 Check Source centrally 3mm below the detector with the shutter closed and the record the response on the calibration certificate. Open the shutter and record the response on the calibration certificate.

      (i) Acceptance / Pass criteria check source response should be ± 20% type test data response.

   d. **Linearity of Response.** Place the small area sources listed in Required Reference Standards centrally in turn 3mm below the detector. Record the net response (cps) for each planar disc source.

(i) Acceptance / pass criteria are that the ratio of indicated response to source emission rate should be determined for each of the three sources. Each individual ratio should agree with the mean of all three ratios to within ± 30%.

e. **Uniformity of Response.** A uniformity check is not required on this probe due to its small active area.

f. **Background Count Rate.** Remove the probe from the sources and record the monitor background count rate.

(i) Acceptance / pass criteria is 1 cps in a field of < 0.15 $\mu Sv.h^{-1}$, H*(10) from ^{137}Cs 662 keV.

6. **Category 2: Annual Test.** Complete all Category 1 tests.

(i) Acceptance / pass criteria are the same as Category 1 tests.

7. **Category 3: Test Before Operational Use.** Complete Category 1 test "Check Source Response" at paragraph 5.c.

(i) Acceptance / pass criteria check source response should be ± 20% of the response recorded at Para. 5.c.

Certification (Qualified Person authorisation required)

8. Certificate test results as appropriate. Failed instruments must be re-tested after repair using Category 1 or Category 2 test protocols as dictated by the nature of the repair.

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Standard Radiological Monitoring Instrument Statutory Test

Protocol 44 Contamination Probe Alpha Type 1320C

Function Alpha Surface Contamination Monitor

Publications A: AP112G-1316-0 – Ratemeter Set Type RM10

NSN 6665-99-949-1324

Required Reference Standards

All must be emission rate calibrated except UAC1623:

Extended area ^{241}Am Type WRS 7/E Amersham code AMR 07032 or Type WRS 6/E AMR 06032;

^{90}Sr/Y Type WRS 7/E Amersham code SIR 07032 or Type WRS 6/E SIR 06032;

^{238}Pu Type WRS 7/E Amersham code PPR 07032 or Type WRS 6/E PPR 06032;

^{NAT}U Type WRS 7/E Amersham code UAR 07032 or Type WRS 6/E UAR 06032.

Small area (16mm Active Diameter)

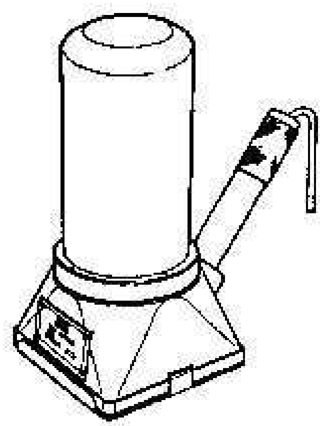
^{241}Am Type WRS 1/E Amersham code AMR 01011, AMR 01021 and AMR 01031.

Check Source ^{Nat}U Amersham code UAC 1623 NSN 6665-99-193-3906

MOD Jigs Rig SK 1407
Base plate jig
Linearity Jig

Description

1. The 1320C alpha probe and a ratemeter combination is a general purpose alpha surface contamination monitor. The probe comprises an enamel painted aluminium housing with a light tight Melinex and aluminium foil window protected by a chrome plated grille. The scintillation phosphor is a layer of silver activated zinc sulphide on a thin sheet of Perspex, giving a nominal window area of 75.7 cm^2. A photomultiplier tube and thick film resistor network are contained in the housing. The ratemeter provides high voltage, counting threshold and scaler functions. The 1320C grille provides better protection for the window of the probe.



1320C Probe

Probe Active Area: 75.7 cm^2

Controls

2. A comprehensive summary of the ratemeter is contained within the Publication, Reference A.

Standard Test Protocol

3. All tests should be recorded for Qualified Person inspection and certificate production. This protocol is specifically designed for dedicated probe and ratemeter combinations. Where separate testing of probe and ratemeter is required appropriate subsidiary tests should be completed, to confirm suitability of replacement probe or ratemeter. These tests may be derived from those detailed in this protocol.

Note: This protocol should only be carried out using a calibrated ratemeter.

Pre-radiation Tests, Electrical and Physical Examination.

4. The following tests must be undertaken prior to both Category 1 and 2 tests.

   a. **Battery test.** Check meter battery indication. Replace as necessary.

   b. **Mechanical checks.** Check mechanical integrity of the probe, cables, cable connections, and probe window. Replace as necessary.

   c. Check operation of all controls

Radiation Tests

5. **Category 1 Test: Test before First Use.** These tests must be undertaken on each probe before introduction into service for the first time. They must also be carried out after any repair that may have altered probe response. At least three observations of the surface contamination response should be made.

   Note: The 1320C alpha probe and ratemeter operational voltage should be determined prior to this test, following the procedure given in publication TBA. Precise plateau characteristics will be probe and ratemeter dependent and must be determined for each combination.

   a. **Light Sensitivity.** The probe should be exposed to an appropriate light source, any change in background should be observed. Record the probe's response to one of the small area sources listed in Required Reference Standards, with and without the presence of the light source.

      (i) Acceptance / pass criteria is that the background count should not be elevated and the response to the source should not be affected by the presence of the light.

   b. **Response To Alpha Contamination.** The responses detailed below are for the specified reference standards, with a source to detector grille separation of 3 mm. Details of the derivation of contamination responses (cps per $Bq.cm^2$) and equivalent 2 π efficiency (%) are given in part 2 of JSP 425. Responses must be determined for all nuclides listed. Details are given below for type responses.

   Note: Nuclide's identified by a * are desirable for category two tests only.

Nuclide	**$cps.Bq^{-1}.cm^2$ (P=2)**		**2π Efficiency %**	
	Mean Response	Permitted Range	Mean Efficiency	Permitted Range
^{241}Am	11.11	7.78 – 14.44	29.5	20.6 – 38.3
^{238}Pu	11.11	7.78 – 14.44	29.3	20.5 – 38.1
^{NAT}U	4.35	3.04 – 5.65	12	8.4 – 15.7

      (i) Acceptance / pass criteria is instrument response within ± 30% i.e. within the permitted ranges shown above.

   c. **Check Source Response.** Place the ^{Nat}U UAC 1623 Check Source in contact with the detector grille and the record the response on the calibration certificate.

      (i) Acceptance / Pass criteria check source response should be ± 20% type test data response.

   d. **Linearity of Response.** Place the small area sources listed in Required Reference Standards centrally in turn with a source to detector separation of 3mm. Record the net response (cps) for each planar disc source.

      (i) Acceptance / pass criteria are that the ratio of indicated response to source emission rate should be determined for each of the three sources. Each individual ratio should agree with the mean of all three ratios to within ± 30%.

e. **Uniformity of Response.** Each 10 cm^2 area of the detector window must be tested by placing one of the small area sources listed in Required Reference Standards (preferably the item with the highest activity) in turn in nine measurement positions to ensure uniformity and record the instrument response for each position.

(i) Acceptance / pass criteria is that no more than 30% of the total probe area should have a response which is less than 30% of the mean.

f. **Beta Rejection.** Place the ^{90}Sr/Y extended area reference source as listed in Required Reference Standards in the appropriate contamination response jig and record the beta.

(i) Acceptance / pass criteria is that the monitor response should be < 1% of the equivalent ^{241}Am or ^{238}Pu response, i.e. if the probe efficiency is 40% for alpha radiation it should be < 0.4% for beta radiation.

g. **Background Count Rate.** Remove the probe from the sources and record the monitor background count rate.

(i) Acceptance / pass criteria is 0.5 cps in a field of < 0.15 $\mu Sv.h^{-1}$, H*(10) from ^{241}Am 60 keV.

6. **Category 2: Annual Test.** Complete all Category 1 tests with the exception of the Uniformity of Response Test 5.e.

(i) Acceptance / pass criteria are the same as Category 1 tests.

7. **Category 3: Test Before Operational Use.** Complete Category 1 test "Check Source Response" at paragraph 5.c.

(i) Acceptance / pass criteria check source response should be ± 20% of the response recorded at Para. 5.c.

Certification (Qualified Person authorisation required)

8. Certificate test results as appropriate. Failed instruments must be re-tested after repair using Category 1 or Category 2 test protocols as dictated by the nature of the repair.

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Standard Radiological Monitoring Instrument Statutory Test

Protocol 45 Contamination Probe Alpha Type AP2/4 or AP2R/4

Function Alpha surface Contamination Monitor

Publications A: NE Technology Instruction Manual Alpha Probe AP2/4
B: NE Technology Instruction Manual Alpha Probe AP2R/4

NSN N/A

Required Reference Standards

All must be emission rate calibrated except UAC1623:

Extended area ^{241}Am Type WRS 7/E Amersham code AMR 07032 or Type WRS 6/E AMR 06032;

^{238}Pu Type WRS 7/E Amersham code PPR 07032 or Type WRS 6/E PPR 06032;

^{NAT}U Type WRS 7/E Amersham code UAR 07032 or Type WRS 6/E UAR 06032;

^{90}Sr/Y Type WRS 7/E Amersham code SIR 07032 or Type WRS 6/E SIR 06032.

Small area (16mm Active Diameter)

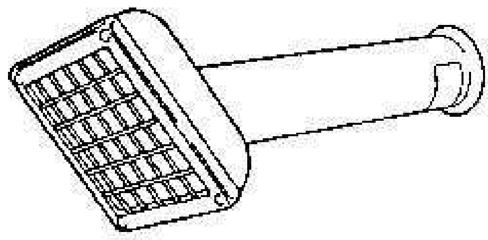
^{90}Sr/Y Type WRS 1/E Amersham code SIR 01011, SIR 01021 and SIR 01031.

Check Source ^{241}Am Mk 7 NXS check source NSN: 6665-99-736-2887

MOD Jigs		
	WRS 7/E Base Plate	Drawing Ref. AS710067
	WRS 6/E Base Plate	Drawing Ref. AS710066
	AP2/4 Support Plate	Drawing Ref. AS710071
	AP2/4 Uniformity & Linearity Insert	Drawing Ref. AS710074

Description

1. The AP2/4 or 'ruggedised' AP2R/4 alpha probes and a ratemeter combination is a general purpose alpha surface contamination monitor. The probes comprises an enamel painted aluminium housing with a light tight aluminised polycarbonate window protected by a chrome plated grille, giving a nominal window size of 49 cm^2. The scintillation phosphor is a layer of silver activated zinc sulphide on a thin sheet of Perspex. A photomultiplier tube and thick film resistor network are contained in the handle of the housing. The ratemeter provides high voltage, counting threshold and scaler functions. The AP2/4 and AP2R/4 differ only in the type of grille used. The AP2R/4 grille provides better protection for the window of the probe.



AP2R/4 Probe

Probe Active Area: 49 cm^2

Controls

2. A comprehensive summary of the ratemeter is contained within the Publications, Reference A & B.

Standard Test Protocol

3. All tests should be recorded for Qualified Person inspection and certificate production. This protocol is specifically designed for dedicated probe and ratemeter combinations. Where separate testing of probe and ratemeter is required appropriate subsidiary tests should be completed, to confirm suitability of replacement probe or ratemeter. These tests may be derived from those detailed in this protocol.

Pre-radiation Tests, Electrical and Physical Examination.

4. The following tests must be undertaken prior to both Category 1 and 2 tests.

   a. **Battery test.** Check meter battery indication. Replace as necessary.

   b. **Mechanical checks.** Check mechanical integrity of probe, cables, cable connections, and probe window. Replace as necessary

   c. Check operation of all controls

Radiation Tests

5. **Category 1 Test: Test before First Use.** These tests must be undertaken on each probe before introduction into service for the first time. They must also be carried out after any repair that may have altered probe response. At least three observations of the surface contamination response should be made.

Note: The AP2 series alpha probe and ratemeter operational voltage should be determined prior to this test, following the procedure given in publication A & B. Precise plateau characteristics will be probe and ratemeter dependent and must be determined for each combination.

   a. **Light Sensitivity.** The probe should be exposed to an appropriate light source, any change in background should be observed. Record the probe's response to one of the small area sources listed in Required Reference Standards, with and without the presence of the light source.

      (i) Acceptance / pass criteria is that the background count should not be elevated and the response to the source should not be affected by the presence of the light.

   b. **Response To Alpha Contamination.** The responses detailed below are for the specified reference standards, with a source to detector grille separation of 3 mm. Details of the derivation of contamination responses (cps per Bq.cm^2) and equivalent 2 π efficiency (%) are given in part 2 of JSP 425. Responses must be determined for all nuclides listed. Details are given below for type test responses.

Note: Nuclide's identified by a * are desirable for category two tests only.

Nuclide	**cps.Bq^{-1}.cm^2 (P=2)**				**2π Efficiency %**			
	AP2/4		AP2R/4		AP2/4		AP2R/4	
	Mean Response	Permitted Range	Mean Response	Permitted Range	Mean Efficiency	Permitted Range	Mean Efficiency	Permitted Range
^{241}Am	10	7 – 13	TBA	±30%	39.54	27.68 – 51.40	TBA	±30%
^{238}Pu	10	7 – 13	TBA	±30%	39.35	27.54 – 51.15	TBA	±30%
^{NAT}U	5.26	6.84 – 3.68	TBA	±30%	22.17	15.52 – 28.82	TBA	±30%

      (i) Acceptance / pass criteria is instrument response within ± 30% i.e. within the permitted ranges shown above.

   c. **Check Source Response.** Place the ^{Nat}U UAC 1623 Check Source in contact with the detector grille and the record the response on the calibration certificate

      (i) Acceptance / Pass criteria check source response should be ± 20% type test data response.

   d. **Linearity of Response.** Place the small area sources listed in Required Reference Standards centrally in turn with a source to detector separation of 3mm. Record the net response (cps) for each planar disc source.

(i) Acceptance / pass criteria are that the ratio of indicated response to source emission rate should be determined for each of the three sources. Each individual ratio should agree with the mean of all three ratios to within ± 30%.

e. **Uniformity of Response.** Each 10 cm^2 area of the detector window must be tested by placing one of the small area sources listed in Required Reference Standards (preferably the item with the highest activity) in turn in five measurement positions and recording the instrument response.

(i) Acceptance / pass criteria is that no more than 30% of the total probe area should have a detection efficiency which is less than 30% of the mean.

f. **Beta Rejection.** Place the ^{90}Sr/Y extended area reference source as listed in Required Reference Standards in the appropriate contamination response jig and record the beta.

(i) Acceptance / pass criteria is that the monitor response should be < 1% of the equivalent ^{241}Am or ^{238}Pu response, i.e. if the probe efficiency is 40% for alpha radiation it should be < 0.4% for beta radiation.

g. **Background Count Rate.** Remove the probe from the sources and record the monitor background count rate.

(i) Acceptance / pass criteria is 0.5 cps in a field of < 0.15 $\mu Sv.h^{-1}$, H*(10) from ^{241}Am 60 keV.

6. **Category 2: Annual Test.** Complete all Category 1 tests with the exception of the Uniformity of Response Test 5.e.

(i) Acceptance / pass criteria are the same as Category 1 tests.

7. **Category 3: Test Before Operational Use.** Complete Category 1 test "Check Source Response" at paragraph 5.c.

(i) Acceptance / pass criteria check source response should be ± 20% of the response recorded at Para. 5.c.

Certification (Qualified Person authorisation required)

8. Certificate test results as appropriate. Failed instruments must be re-tested after repair using Category 1 or Category 2 test protocols as dictated by the nature of the repair.

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Standard Radiological Monitoring Instrument Statutory Test

Protocol 46 Contamination Probe Alpha Type AP3/4 or AP3R/4

Function Alpha surface Contamination Monitor

Publications A: NE Technology Instruction Manual Alpha Probe AP3/4
B: NE Technology Instruction Manual Alpha Probe AP3R/4

NSN N/A

Required Reference Standards

All must be emission rate calibrated except UAC1623:

Extended area ^{241}Am Type WRS 7/E Amersham code AMR 07032 or Type WRS 6/E AMR 06032;

^{238}Pu Type WRS 7/E Amersham code PPR 07032 or Type WRS 6/E PPR 06032;

^{NAT}U Type WRS 7/E Amersham code UAR 07032 or Type WRS 6/E UAR 06032;

^{90}Sr/Y Type WRS 7/E Amersham code SIR 07032 or Type WRS 6/E SIR 06032.

Small area (16mm Active Diameter)

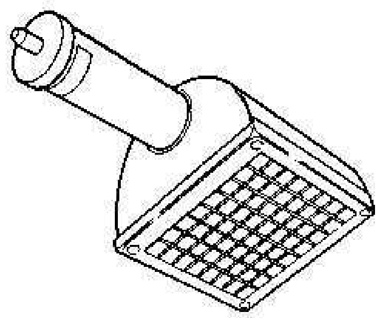
^{90}Sr/Y Type WRS 1/E Amersham code SIR 01011, SIR 01021 and SIR 01031.

Check Source ^{241}Am Mk 7 NXS check source NSN: 6665-99-736-2887

MOD Jigs	WRS 7/E Base Plate	Drawing Ref. AS710067
	WRS 6/E Base Plate	Drawing Ref. AS710066
	AP3/4 Support Plate	Drawing Ref. AS710073
	AP3/4 Uniformity & Linearity Insert	Drawing Ref. AS710068

Equipment Overview

Description and Use: The AP3/4 or 'ruggedised' AP3R/4 alpha probes and a ratemeter combination is a general purpose alpha surface contamination monitor. The scintillation phosphor is a layer of silver activated zinc sulphide on a thin sheet of Perspex. A photomultiplier tube and thick film resistor network are contained in the handle of the housing. The ratemeter provides high voltage, counting threshold and scaler functions. The AP3/4 and AP3R/4 differ only in the type of grille used. The AP3R/4 grille provides better protection for the window of the probe.
Physical Construction: The probes comprises an enamel painted aluminium housing with a light tight aluminised polycarbonate window protected by a chrome plated grille, giving a nominal window size of 100 cm^2.
Detector Type: Photomultiplier EMI type 9600H
Detector Active Area: 100 cm^2



AP3R/4 Probe

Controls

1. A comprehensive summary of the ratemeter is contained within the Publications, Reference A & B.

Standard Test Protocol

2. All tests should be recorded for Qualified Person inspection and certificate production. This protocol is specifically designed for dedicated probe and ratemeter connections. Where separate testing of probe and ratemeter is required, appropriate subsidiary test should be completed, to confirm suitability of replacement probe or ratemeter. These tests may be derived from those detailed in this protocol.

   Note: This protocol should only be carried out using a calibrated ratemeter.

Pre-radiation Tests, Electrical and Physical Examination.

3. The following tests must be undertaken prior to both Category 1 and 2 tests.

   a. **Battery test.**
   Check meter battery indication and condition of battery compartment and terminations. Replace as necessary.

   b. **Mechanical Zero.**
   Zero meter mechanical movement using meter adjustment screw. if necessary.

   c. **Mechanical checks.**
   Check mechanical integrity of probe, cables, cable connections, and probe window. Replace as necessary.

   d. Check operation of all controls

Radiation Tests

4. **Category 1 Test: Test before First Use.** These tests must be undertaken on each probe before introduction into service for the first time. They must also be carried out after any repair that may have altered probe response. At least three observations of the surface contamination response should be made.

   Note: The AP3 series alpha probe and ratemeter operational voltage should be determined prior to this test, following the procedure given in publications reference A & B. Precise plateau characteristics will be probe and ratemeter dependent and must be determined for each combination.

   a. **Background Count Rate.**
   Remove the probe from the sources and record the monitor background count rate.

      (i) Acceptance / pass criteria - 0.1 cps in a field of < 0.15 μSv.h^{-1}, H*(10) from ^{241}Am 60 keV.

   b. **Light Sensitivity.** The probe should be exposed to an appropriate light source, any change in background should be observed. Record the probe's response to one of the small area sources in Required Reference Standards with and without the presence of the light source.

      (i) Acceptance / pass criteria - The background count should not be elevated and the response to the source should not be affected by the presence of the light.

   c. **Response to Alpha Contamination.**
   The responses detailed below are for the specified reference standards, with a source to detector grille separation of 3 mm. Details of the derivation of contamination responses (cps per Bq.cm^{2}) and equivalent 2 π efficiency (%) are given in part 2 of JSP 425. Responses must be determined for all nuclides listed. Details are given below for type responses.

   Note: Nuclide's identified by a * are desirable for category two tests only.

Nuclide	$cps.Bq^{-1}.cm^2$ (P=2)				2π Efficiency %			
	AP3/4		AP3R/4		AP3/4		AP3R/4	
	Mean Response	Permitted Range	Mean Response	Permitted Range	Mean Efficiency	Permitted Range	Mean Efficiency	Permitted Range
^{241}Am	17.7	12.4 – 23.0	12.5	8.8 – 16.3	35	24.5 – 45.5	25	17.5 – 32.5
^{238}Pu	17	11.9 – 22.1	12.5	8.8 – 16.3	34	23.8 – 44.2	25	17.5 – 32.5
^{NAT}U	8	5.6 – 10.4	5.9	4.3 – 7.7	16	11.2 – 20.8	12	8.4 – 15.6

(i) Acceptance / pass criteria - Instrument response within ± 30% i.e. the expected levels shown above.

d. **Linearity of Response.** Place the small area sources listed in Required Reference Standards centrally in turn with a source to detector separation of 3mm. Record the net response (cps) for each planar disc source.

(i) Acceptance / pass criteria - The ratio of indicated response to source emission rate should be determined for each of the three sources. Each individual ratio should agree with the mean of all three ratios to within ± 30%.

e. **Uniformity of Response.**
Each 10 cm^2 area of the active detector window must be tested by placing one of the small area sources listed in Required Reference Standards (preferably the item with the highest activity) in turn in five measurement positions and recording the instrument response.

(i) Acceptance / pass criteria - No more than 30% of the total probe area should have a detection efficiency which is less than 30% of the mean.

f. **Beta Rejection.**
Place the $^{90}Sr/Y$ extended area reference source as listed in Required Reference Standards in the appropriate contamination response jigs and record the beta response.

(i) Acceptance / pass criteria - The monitor response should be < 1% of the equivalent ^{241}Am or ^{238}Pu response, i.e. if the probe efficiency is 40% for alpha radiation it should be < 0.4% for beta radiation.

g. **Check Source Response.** Place the ^{241}Am Mk 7NXS Check Source centrally in contact with the detector grille and the record the response on the calibration certificate

(i) Acceptance / Pass criteria - Check source response should be ± 20% type test data response.

5. **Category 2: Annual Test.** Complete all Category 1 tests with the exception of the Uniformity of Response Test 5.e.

(i) Acceptance / pass criteria - The same as Category 1 tests.

6. **Category 3: Test before Operational Use.** Complete Category 1 test “Check Source Response” at paragraph 5.c.

(i) Acceptance / pass criteria - Check source response should be ± 20% of the response recorded at Para 5.c.

Certification (Qualified Person authorisation required)

7. Certificate test results as appropriate. Failed instruments must be re-tested after repair using Category 1 or Category 2 test protocols as dictated by the nature of the repair.

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Standard Radiological Monitoring Instrument Statutory Test

Protocol 47 Contamination Probe Beta Type BP10

Function **Beta Contamination Monitoring Probe**

Publications A: BR 2053 (111).

NSN 6665-99-640-0349

Equipment Declared Obsolete under DCI RN 125/03

Protocol Deleted

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Standard Radiological Monitoring Instrument Statutory Test

Protocol 48 Contamination Probe Beta Type BP4, BP4/4A, BP4/4B or BP4/4C

Function Beta surface Contamination Monitor

Publications
A: NE Technology Instruction Manual Beta Probe BP4
B: NE Technology Instruction Manual Beta Probe BP4/4A
C: NE Technology Instruction Manual Beta Probe BP4/4B
D: NE Technology Instruction Manual Beta Probe BP4/4C

NSN 6665-99-765-7402

Required Reference Standards

All must be emission rate calibrated except UAC1623:

Extended area

^{14}C Type WRS 7/E Amersham code CFR 07032 or Type WRS 6/E CFR 06032;

^{36}Cl Type WRS 7/E Amersham code CIR 07032 or Type WRS 6/E CIR 06032;

^{147}Pm Type WRS 7/E Amersham code PHR 07032 or Type WRS 6/E PHR 06032;

$^{90}Sr/Y$ Type WRS 7/E Amersham code SIR 07032 or Type WRS 6/E SIR 06032;

^{60}Co Type WRS 7/E Amersham code CKR 07032 or Type WRS 6/E CKR 06032;

^{137}Cs Type WRS 7/E Amersham code CDR 07032 or Type WRS 6/E CDR 06032.

Small area (16mm Active Diameter)

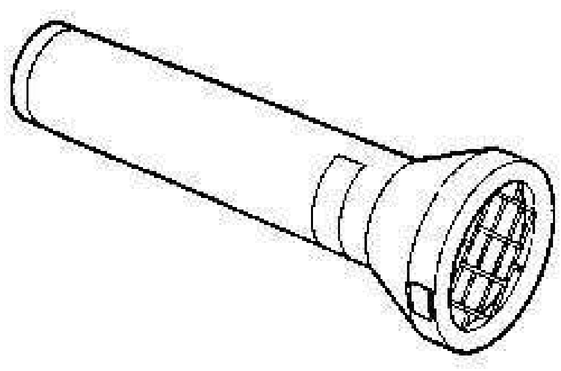
$^{90}Sr/Y$ Type WRS 1/E Amersham code SIR 01011, SIR 01021 and SIR 01031.

Check Source ^{Nat}U Amersham code UAC 1623 NSN 6665-99-193-3906

MOD Jigs	WRS 7/E Base Plate	Drawing Ref. AS710067
	WRS 6/E Base Plate	Drawing Ref. AS710066
	BP4 Support Plate	Drawing Ref. AS710069
	BP4 Uniformity & Linearity Insert	Drawing Ref. AS710074

Description

1. The BP4 series beta probes and a ratemeter combination is a general purpose beta surface contamination monitor. The BP4 series probes are comprised of an enamel painted aluminium housing with a light tight aluminised polycarbonate window protected by a chrome plated grille, giving a nominal window size of 19.6 cm^2. The scintillation phosphor is a layer of anthracene on a Perspex light guide. A photomultiplier tube and thick film resistor network are contained in the handle of the housing. The ratemeter provides high voltage, counting threshold and scaler functions. The BP4, A, B and C versions differ in the spacing between the protective grille and light tight window; these are 3, 6 and 9 mm respectively. This allows ruggedisation to be balanced against sensitivity for specific applications.



BP4 Probe

Probe Active Area: 19.6 cm^2

Controls

2. A comprehensive summary of the ratemeter functions is contained within the Publications, Reference A, B, C & D.

Standard Test Protocol

3. All tests should be recorded for Qualified Person inspection and certificate production. This protocol is specifically designed for dedicated probe and ratemeter combinations. Where separate testing of probe and ratemeter is required appropriate subsidiary test should be completed, to confirm suitability of replacement probe or ratemeter. These tests may be derived from those detailed in this protocol.

Pre-radiation Tests, Electrical and Physical Examination.

4. The following tests must be undertaken prior to both Category 1 and 2 tests.

   a. **Battery test.** Check meter battery indication. Replace as necessary.

   b. **Mechanical checks.** Check mechanical integrity of probe, cables, cable connections and probe window. Replace as necessary.

   c. Check operation of all controls

Radiation Tests

5. **Category 1 Test: Test before First Use.** These tests must be undertaken on each probe before introduction into service for the first time. They must also be carried out after any repair that may have altered probe response. At least three observations of the surface contamination response should be made.

   Note: The BP4 series beta probe and ratemeter operational voltage should be determined prior to this test, following the procedure given in publication A - D. Precise plateau characteristics will be probe and ratemeter dependent and must be determined for each combination.

   a. **Light Sensitivity.** The probe should be exposed to an appropriate light source, any change in background should be observed. Record the probe's response to one of the small area sources listed in Required Reference Standards, with and without the presence of the light source.

      (i) Acceptance / pass criteria is that the background count should not be elevated and the response to the source should not be affected by the presence of the light.

   b. **Response To Beta Contamination.** The responses detailed below are for the specified reference standards, with a source to detector grille separation of 3 mm. Details of the derivation of contamination responses (cps per Bq.cm^2) and equivalent 2 π efficiency (%) are given in part 2 of JSP 425. Responses must be determined for all nuclides listed. Details are given below for type test responses.

Note: Nuclide's identified by a * are desirable for category two tests only.

Nuclide	**$cps.Bq^{-1}.cm^2$ (P=2)** Mean Response				**2π Efficiency %** Mean Efficiency			
	BP4	BP4/4A	BP4/4B	BP4/4C	BP4	BP4/4A	BP4/4B	BP4/4C
^{14}C	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA
^{36}Cl	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA
^{147}Pm*	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA
$^{90}Sr/Y$	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA
^{60}Co	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA
^{137}Cs*	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA

(i) Acceptance / pass criteria is instrument response within ± 30% i.e. within the permitted ranges shown above.

c. **Check Source Response.** Place the ^{NAT}U UAC 1623 Check Source centrally on the probe grid and the record the response on the calibration certificate

(i) Acceptance / Pass criteria check source response should be ± 20% type test data response.

d. **Linearity of Response.** Place the small area sources listed in Required Reference Standards centrally in turn 3mm below the detector. Record the net response (cps) for each planar disc.

(i) Acceptance / pass criteria are that the ratio of indicated response to source emission rate should be determined for each of the three sources. Each individual ratio should agree with the mean of all three ratios to within ± 30%.

e. **Uniformity of Response.** A uniformity check is not required on this probe due to its small active area.

f. **Background Count Rate.** Remove the probe from the sources and record the monitor background count rate.

(i) Acceptance / pass criteria is < 6 cps in a field of < 0.15 $\mu Sv.h^{-1}$, H*(10) from ^{137}Cs 662 keV.

6. **Category 2: Annual Test.** Complete all Category 1 tests.

(i) Acceptance / pass criteria are the same as Category 1 tests.

7. **Category 3: Test Before Operational Use.** Complete Category 1 test “Check Source Response” at paragraph 5.c.

(i) Acceptance / pass criteria check source response should be ± 20% of the response recorded at Para. 5.c.

Certification (Qualified Person authorisation required)

8. Certificate test results as appropriate. Failed instruments must be re-tested after repair using Category 1 or Category 2 test protocols as dictated by the nature of the repair.

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Standard Radiological Monitoring Instrument Statutory Test

Protocol 49 Contamination Probe Beta Type BP7, BP7/4

Function Low Energy Beta surface Contamination Monitor

Publications A: NE Technology Instruction Manual Beta Probe BP7
B: NE Technology Instruction Manual Beta Probe BP7/4

NSN N/A

Required Reference Standards

All must be emission rate calibrated except ^{Nat}U Amersham code UAC 1623 Check Source:

Extended area

^{14}C Type WRS 7/E Amersham code CFR 07032 or Type WRS 6/E CFR 06032;

^{36}Cl Type WRS 7/E Amersham code CIR 07032 or Type WRS 6/E CIR 06032;

^{147}Pm Type WRS 7/E Amersham code PHR 07032 or Type WRS 6/E PHR 06032;

$^{90}Sr/Y$ Type WRS 7/E Amersham code SIR 07032 or Type WRS 6/E SIR 06032;

^{60}Co Type WRS 7/E Amersham code CKR 07032 or Type WRS 6/E CKR 06032;

^{137}Cs Type WRS 7/E Amersham code CDR 07032 or Type WRS 6/E CDR 06032.

Small area (16mm Active Diameter)

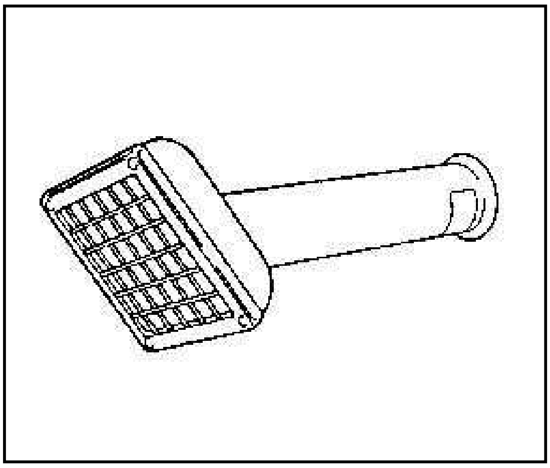
$^{90}Sr/Y$ Type WRS 1/E Amersham code SIR 01011, SIR 01021 and SIR 01031.

Check Source

^{Nat}U Amersham code UAC 1623 NSN 6665-99-193-3906

Description

1. The BP7 series beta probes and a ratemeter combination is a low energy beta surface contamination monitor. The BP7 series probes are comprised of an enamel painted aluminium housing with a light tight aluminised polycarbonate window protected by a chrome plated grille, giving a nominal window size of 49 cm^2. The scintillation phosphor is a layer of anthracene on a Perspex light guide. A photomultiplier tube and thick film resistor network are contained in the handle of the housing. The ratemeter provides high voltage, counting threshold and scaler functions.



Probe Active Area: 49 cm^2

Controls

2. A comprehensive summary of the ratemeter functions is contained within the Publications, Reference A & B.

Standard Test Protocol

3. All tests should be recorded for Qualified Person inspection and certificate production. This protocol is specifically designed for dedicated probe and ratemeter combinations. Where separate testing of probe and ratemeter is required appropriate subsidiary tests should be completed, to confirm suitability of replacement probe or ratemeter. These tests may be derived from those detailed in this protocol.

Pre-radiation Tests, Electrical and Physical Examination.

4. The following tests must be undertaken prior to both Category 1 and 2 tests.

   a. **Battery test.** Check meter battery indication. Replace as necessary.

   b. **Mechanical checks.** Check mechanical integrity of probe , cables, cable connections and probe window. Replace as necessary.

   c. Check operation of all controls

Radiation Tests

5. **Category 1 Test: Test before First Use.** These tests must be undertaken on each probe before introduction into service for the first time. They must also be carried out after any repair that may have altered probe response. At least three observations of the surface contamination response should be made.

   Note: The BP4 series of beta probe and ratemeter operational voltage should be determined prior to this test, following the procedure given in publications A - D. Precise plateau characteristics will be probe and ratemeter dependent and must be determined for each combination.

   a. **Light Sensitivity.** The probe should be exposed to an appropriate light source, any change in background should be observed. Record the probe's response to one of the small area sources listed in Required Reference Standards, with and without the presence of the light source.

      (i) Acceptance / pass criteria is that the background count should not be elevated and the response to the source should not be affected by the presence of the light.

   b. **Response To Beta Contamination.** The responses detailed below are for the specified reference standards, with a source to detector grille separation of 3 mm. Details of the derivation of contamination responses (cps per $Bq.cm^2$) and equivalent 2 π efficiency (%) are given in part 2 of JSP 425. Responses must be determined for all nuclides listed. Details are given below for type test responses.

   Note: Nuclide's identified by a * are desirable for category two tests only.

Nuclide	**$Cps.Bq^{-1}.cm^2$ (P=2)**		**2π Efficiency %**	
	Mean Response	Permitted Range	Mean Efficiency	Permitted Range
^{14}C	2.54	1.78 – 3.30	11.4	8 – 14.8
^{36}Cl	8.39	5.87 – 10.91	33.6	23.5 – 43.7
^{147}Pm*	TBA	TBA	18.9	13.2 – 24.6
$^{90}Sr/Y$	9.74	6.82 – 12.66	34.5	24.2 – 44.9
^{60}Co	6.64	6.49 – 8.63	27.6	19.3 – 35.9
^{137}Cs*	8.46	5.92 – 11	32.8	23 – 42.7

      (i) Acceptance / pass criteria is instrument response within ± 30% i.e. within the permitted ranges shown above.

   c. **Check Source Response.** Place the ^{Nat}U UAC 1623 centrally on the probe grid and the record the response on the calibration certificate.

      (i) Acceptance / Pass criteria check source response should be ± 20% type test data response.

   d. **Linearity of Response.** Place the small area sources listed in Required Reference Standards centrally in turn 3mm below the detector. Record the net response (cps) for each planar disc source.

(i) Acceptance / pass criteria are that the ratio of indicated response to source emission rate should be determined for each of the three sources. Each individual ratio should agree with the mean of all three ratios to within ± 30%.

e. **Uniformity of Response.** Each 10 cm^2 area of the detector window must be tested by placing one of the small area sources listed in Required Reference Standards (preferably the item with the highest activity) in turn in five measurement positions and recording the instrument response.

(i) Acceptance / pass criteria is that no more than 30% of the total probe area should have a response which is less than 30% of the mean.

f. **Background Count Rate.** Remove the probe from the sources and record the monitor background count rate.

(i) Acceptance / pass criteria is < 6 cps in a field of < 0.15 $\mu Sv.h^{-1}$, H*(10) from ^{137}Cs 662 keV.

6. **Category 2: Annual Test.** Complete all Category 1 tests with the exception of the Uniformity of Response Test 5.e.

(i) Acceptance / pass criteria are the same as Category 1 tests.

7. **Category 3: Test Before Operational Use.** Complete Category 1 test “Check Source Response” at paragraph 5.c.

(i) Acceptance / Pass criteria check source response should be ± 20% of the response recorded at Para. 5.c.

Certification (Qualified Person authorisation required)

8. Certificate test results as appropriate. Failed instruments must be re-tested after repair using Category 1 or Category 2 test protocols as dictated by the nature of the repair.

Standard Radiological Monitoring Instrument Statutory Test

Protocol 59 710C Lead Castle + BP4 Probe

Function **Low Background Beta Contamination Monitor**

Publications
A: NE Technology Instruction Manual Beta Probe BP4
B: NE Technology Instruction Manual 710 (refers to pre-mod item)
C: Ratemeter Manual (Dependant on instrument used)

NSN 6665-99-765-7402

Required Reference Standards

All must be emission rate calibrated:

Extended area

^{14}C Amersham code CFR 05022;

^{36}Cl Amersham code CIR 05022;

$^{90}Sr/Y$ Amersham code SIR 05022;

^{60}Co Amersham code CKR 05022;

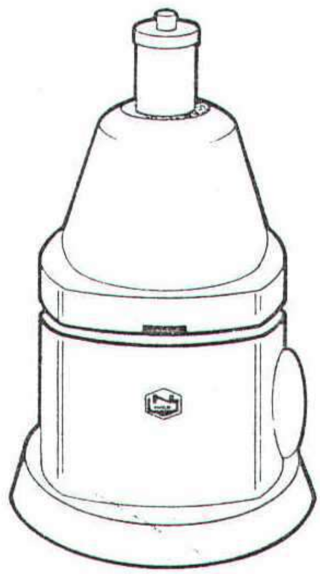
^{137}Cs Amersham code CDR 05022.

Small area (16mm Active Diameter)

$^{90}Sr/Y$ Type WRS 1/E Amersham code SIR 01011, SIR 01021 and SIR 01031.

Description

1. The 710C lead castle is a historic unit, which has been modified to accept a BP4 series beta probe by means of a hole being bored through the lid and restraining collets fitted. When connected to a compatible ratemeter the unit can be used as a low background, beta contamination monitor. The 710C lead castle weighs 52.27kg (approx.) and stands 280mm high (not including beta probe), the unit has four shelf positions. Shelf 1 sits 14.3mm below the detector, shelf 2 sits 27.0mm below the detector, shelf 3 sits 39.7mm below the detector and shelf 4 sits 52.4mm below the detector. The BP4 probe has a nominal window size of 19.6 cm^2 and uses an anthracene scintillation phosphor mounted on a Perspex light guide. The unit connects to the ratemeter via a PET100 connector.



BP4 Fitted in 710C Castle

Probe Active Area: 19.6 cm^2

Controls

2. A comprehensive summary of the unit and ratemeter functions is contained within the Publications, Reference A, B & C.

Standard Test Protocol

3. All tests should be recorded for Qualified Person inspection and certificate production. This protocol is specifically designed for dedicated probe and ratemeter combinations. Where separate testing of unit and ratemeter is required appropriate subsidiary tests should be completed, to confirm suitability of replacement probe or ratemeter. These tests may be derived from those detailed in this protocol.

Note: Owing to the nature of the unit and the shelf spacing it is necessary to calibrate the unit as a complete fixture and not just the BP4 as a single item removed from the castle.

Pre-radiation Tests, Electrical and Physical Examination.

4. The following tests must be undertaken prior to both Category 1 and 2 tests.

   a. **Battery test.** Check meter battery indication. Replace as necessary.

   b. **Mechanical checks.** Check mechanical integrity of probe, castle and ratemeter case, ensuring there is no physical damage, particular attention should be given to the door hinge assembly. Check all cables, and cable connections and probe window. Replace as necessary.

   c. Check operation of all controls

Radiation Tests

5. **Category 1 Test: Test before First Use.** These tests must be undertaken on each probe before introduction into service for the first time. They must also be carried out after any repair that may have altered probe response. At least three observations of the surface contamination response should be made.

   Note: The BP4 series of beta probe and ratemeter operational voltage should be determined prior to this test, following the procedure given in publication A. Precise plateau characteristics will be probe and ratemeter dependent and must be determined for each combination.

   a. **Light Sensitivity.** The probe should be exposed to an appropriate light source, any change in background should be observed, this is awkward but can be achieved by opening the castle door and exposing a bright light to the probe. Record the probe's response to one of the small area sources listed in Required Reference Standards, with and without the presence of the light source.

      (i) Acceptance / pass criteria is that the background count should not be elevated and the response to the source should not be affected by the presence of the light.

   b. **Response To Beta Contamination.** The responses detailed below are for the specified reference standards, with a source to detector separation determined by the shelf spacing. Details of the derivation of contamination responses (cps per Bq.cm^2) and equivalent 2 π efficiency (%) are given in part 2 of JSP 425. Responses must be determined for all nuclides listed. Details are given below for type test responses.

   Note: Nuclide's identified by a * are desirable for category two tests only.

Nuclide	**Cps.Bq^{-1}.cm^2 (P=2)**				**2π Efficiency %**			
	Mean Response				Mean Efficiency			
	Shelf 1	Shelf 2	Shelf 3	Shelf 4	Shelf 1	Shelf 2	Shelf 3	Shelf 4
^{14}C	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA
^{36}Cl	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA
^{90}Sr/Y	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA
^{60}Co	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA
^{137}Cs*	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA

      (i) Acceptance / pass criteria is instrument response within ± 30% i.e. within the permitted ranges shown above.

   c. **Check Source Response. (No check source is currently assigned to this unit**.)

   d. **Linearity of Response.** Place the small area sources listed in Required Reference Standards centrally in turn on each shelf position. Record the net response (cps) for each planar disc source.

(i) Acceptance / pass criteria are that the ratio of indicated response to source emission rate should be determined for each of the three sources. Each individual ratio should agree with the mean of all three ratios to within ± 30% for each of the shelf positions.

e. **Uniformity of Response.** A uniformity check is not required on this probe due to its small active area.

f. **Background Count Rate.** Remove any sources from the castle and record the monitor background count rate.

(i) Acceptance / pass criteria is < 5 cps in a field of < 0.15 μSv.h^{-1}, H*(10) from ^{137}Cs 662 keV.

6. **Category 2: Annual Test.** Complete all Category 1 tests.

(i) Acceptance / pass criteria are the same as Category 1 tests.

7. **Category 3: Test Before Operational Use.** Complete Category 1 test "Check Source Response" at paragraph 5.c.

(i) Acceptance / Pass criteria check source response should be ± 20% of the response recorded at Para. 5.c.

Certification (Qualified Person authorisation required)

8. Certificate test results as appropriate. Failed instruments must be re-tested after repair using Category 1 or Category 2 test protocols as dictated by the nature of the repair.

Standard Radiological Monitoring Instrument Statutory Test

Protocol 60 Doserate Meter RADIAC Type PDRM82C

Function **High Level Doserate Meter**

Publications A:

NSN 6665-99-225-4087

Description

1. The PDRM82C is a rugged, hand held, water- resistant doserate instrument scaled in cGy/hr in air, on a digital auto ranging scale. The detector is contained within a black cylindrical housing at the end of a flying lead connected via a threaded connector at the base of the instrument. The unit requires 3 C-Cells and the function of the unit is controlled by rotation of the battery compartment lid.

PDRM82C

Controls

2. The instrument is controlled via the battery compartment lid.

Position 1	BATT ACCESS, Allows removal of compartment lid on lanyard.
Position 2	OFF, with batteries inserted turning the lid clockwise whilst applying slight pressure allows unit to sit in “OFF” position.
Position 3	ON, with the unit in this position it will run through a short self-test.

Standard Test Protocol

3. All tests should be recorded for Qualified Person inspection and certificate production.

Pre-radiation Tests, Electrical and Physical Examination.

4. The following tests must be undertaken prior to both category 1 and 2 tests.

    a. Check unit for visible damage.
    b. Check battery cover and lanyard for damage including internal copper terminals.
    c. Check display.
    d. Check probe housing and cable for damage.
    e. Inspect the battery box cover seal for damage.
    f. Functional Check. Switch the unit on and a self-test routine will activate. The unit will power all segments of the LCD display followed by the word “tES.t”. On successful completion of the self-test the unit will display 0.0 with a flashing decimal point.

Radiation Tests

5. **Category 1 Test: Test before First Use.** These tests must be undertaken on each instrument before introduction into service for the first time and also if any major repair or modification, which may have altered the response of the detector is made.

    Note: The probe should be positioned to receive the radiation beam from the side.

    a. **Background Dose Rate.** Owing to the nature of the instrument range, the reading for background is zero.

(i) If a reading greater than zero is observed, the problem should be looked into.

b. **Response to High Dose Rates.** Expose the instrument to a dose rate in excess of that which it could reasonably encounter in the work place for at least 30 seconds.

(i) Acceptance / Pass criteria the instrument should maintain the reading through out the test. If the instrument reaches full-scale deflection no evidence of fold over is to be shown.

Note: Where possible, instruments should be overload tested at 10 times the maximum scale indication. It is recognised that for a number of test houses/Instruments this is impracticable. In these instances instruments should be tested at 5 or 10 times the maximum credible dose rate to which the instrument could be exposed. These instruments shall be labelled "limited calibration" and the calibration certificate shall clearly state the limits of the overload and range testing.

c. **Check Source Response.** No check source is currently assigned to the PDRM82C.

d. **Linearity of Response. (^{137}Cs)** Expose the instrument to a range of dose rates and record the observed measurements. At least three repeat measurements of the observed dose rate response should be carried out.

Note: As a minimum, 1 reading for each decade within the type test data range shown should be tested.

Dose Rate cGy/h	**^{137}Cs Permitted Range**
50 $cGy.h^{-1}$	35 – 6.5 $cGy.h^{-1}$
25 $cGy.h^{-1}$	17.5 – 32.5 $cGy.h^{-1}$
10 $cGy.h^{-1}$	7 – 13 $cGy.h^{-1}$
5 $cGy.h^{-1}$	3.5 – 6.5 $cGy.h^{-1}$
1 $cGy.h^{-1}$	0.7 – 1.3 $cGy.h^{-1}$

(ii) Acceptance / Pass criteria is instrument response within ± 30% i.e. within the permitted ranges shown above.

e. **Energy Response Test at 60 keV (60 keV ^{241}Am).** Due to the nature of the high doserate levels required for this instrument it is impractical to undertake an energy response test.

f. **Directional Dependency at 60 keV (^{241}Am or 65 keV ISO X-ray Quality.)** Due to the nature of the high doserate levels required for this instrument, it is impractical to undertake a directional dependency test.

6. **Category 2: Annual Test.** Complete all category 1 tests.

(i) Acceptance / pass criteria are the same as Category 1 tests.

7. **Category 3: Test Before Operational Use.** On power up the instrument will run though a short self test.

Certification (Qualified Person authorisation required)

8. Certificate test results as appropriate. Failed instruments must be re-tested after repair using Category 1 or Category 2 test protocols as dictated by the nature of the repair.

Standard Radiological Monitoring Instrument Statutory Test

Protocol 61 Doserate Meter RADIAC Type PDRM82D

Function **High Level Doserate meter**

Publications A:

Description

1. The PDRM82D is a rugged, hand held, water-resistant doserate instrument scaled in cGy/hr in air, on a digital auto ranging scale. The ratemeter unit is housed in a shock proof housing. The detector is contained within a green cylindrical housing at the end of a coiled lead which is hardwired at the base of the instrument. An audio sounder is supplied via an additional coiled cable and provides audible indication of the Doserate. The unit requires 3 C-Cells for operation, all unit functionality is controlled by rotation of the battery compartment lid.

PDRM82D

Controls

2. The instrument is controlled via the battery compartment lid.

Position 1 BATT ACCESS, Allows removal of compartment lid on lanyard.
Position 2 OFF, with batteries inserted turning the lid clockwise whilst applying slight pressure allows unit to sit in “OFF” position.
Position 3 ON, with the unit in this position it will run through a short self-test.

Standard Test Protocol

3. All tests should be recorded for Qualified Person inspection and certificate production.

Pre-radiation Tests, Electrical and Physical Examination.

4. These tests must be undertaken prior to both category 1 and 2 tests.

   a. Check unit for visible damage.
   b. Check battery cover and lanyard for damage including internal copper terminals.
   c. Check display.
   d. Check probe housing and cable for damage.
   e. Check Audio unit and cable for damage.
   f. Inspect the battery box cover seal for damage.
   g. Functional Check. Switch the unit on and a self-test routine will activate. The unit will power all segments of the LCD display followed by the word “tES.t”. On successful completion of the self-test the unit will display 0.0 with a flashing decimal point.

Radiation Tests

5. **Category 1 Test: Test before First Use.** These tests must be undertaken on each instrument before introduction into service for the first time and also if any major repair or modification, which may have altered the response of the detector is made.

   Note: The probe should be positioned to receive the radiation beam from the side, within the striped region.

   a. **Background Dose Rate.** Owing to the nature of the instrument range, the reading for background is zero.

      (i) If a reading greater than zero is observed, the problem should be looked into.

b. **Response to High Dose Rates.** Expose the instrument to a dose rate in excess of that which it could reasonably encounter in the work place for at least 30 seconds.

(i) Acceptance / Pass criteria the instrument should maintain the reading through out the test. If the instrument reaches full-scale deflection no evidence of fold over is to be shown.

Note: Where possible, instruments should be overload tested at 10 times the maximum scale indication. It is recognised that for a number of test houses/Instruments this is impracticable. In these instances instruments should be tested at 5 or 10 times the maximum credible dose rate to which the instrument could be exposed. These instruments shall be labelled "limited calibration" and the calibration certificate shall clearly state the limits of the overload and range testing.

c. **Check Source Response.** No check source is currently assigned to the PDRM82D.

d. **Linearity of Response. (^{137}Cs)** Expose the instrument to a range of dose rates and record the observed measurements. At least three repeat measurements of the observed dose rate response should be carried out.

Note: As a minimum, 1 reading for each decade within the type test data range shown should be tested.

Dose Rate cGy/h	**^{137}Cs Permitted Range**
5000 μGy.h^{-1}	3500 – 6500 μGy.h^{-1}
500 μGy.h^{-1}	350 – 650 μGy.h^{-1}
100 μGy.h^{-1}	70 – 130 μGy.h^{-1}
25 μGy.h^{-1}	17.5 – 32.5 μGy.h^{-1}
10 μGy.h^{-1}	7 – 13 μGy.h^{-1}
5 μGy.h^{-1}	3.5 – 6.5 μGy.h^{-1}

(iii) Acceptance / Pass criteria is instrument response within ± 30% i.e. within the permitted ranges shown above.

e. **Energy Response Test at 60 keV (60 keV ^{241}Am).** Expose the instrument to a 60 keV ^{241}Am radiation field at an air kerma rate of 25μGy.h^{-1} or 100μSv.h^{-1}.

Air Kerma Rate Gy (air)	**^{241}Am Permitted Range Gy (air)**
25μGy.h^{-1}	24.2 – 36.3 μGy.h^{-1}
100μGy.h^{-1}	± 30%

f. **Directional Dependency at 60 keV (^{241}Am or 65 keV ISO X-ray Quality).** Expose the instrument to ^{241}Am or 65 keV ISO X-ray Quality radiation field at an air kerma rate of 25μGy.h^{-1} / or 100 μSv.h^{-1} the expected polar responses are shown in Figure 1.

6. **Category 2: Annual Test.** Complete all category 1 tests.

(i) Acceptance / pass criteria are the same as Category 1 tests.

7. **Category 3: Test Before Operational Use.** On power up the instrument will run though a short self test.

Certification (Qualified Person authorisation required)

8. Certificate test results as appropriate. Failed instruments must be re-tested after repair using Category 1 or Category 2 test protocols as dictated by the nature of the repair.

Protocol 75 Thermo Electron Mini Rad 1000 RA

Function Low Level Gamma Survey Monitor

Publications A: Thermo Electron Corporation Instruction Manual, 1000 Series: Covering 1000RA, 1000RMA and 1000RLA Radiation Monitors

NSN TBA

Description

1. The Mini 1000RA is a portable, low-level, gamma survey monitor, using an internal, energy compensated, Geiger-Muller detector. The useful energy range for ambient dose equivalent H*(10) measurement, is 50keV to 1.25 MeV (±20% relative to ^{137}Cs). Dose rate is indicated on a logarithmically scaled meter, covering the range 0.1 µSv.h^{-1} to 1000 µSv.h^{-1}.

Controls

2. A comprehensive summary of the dose rate meter functions is contained within the operating manual, References A.

Standard Test Protocol

3. All tests should be recorded for Qualified Person inspection and certificate production.

Pre-radiation Tests, Electrical and Physical Examination.

4. These tests must be undertaken prior to both category 1 and 2 tests.

   a. **Battery test.** Check meter battery indication, condition of battery compartment and terminations. Replace as necessary.

   b. **Mechanical checks.** Inspect the analogue meter and face for signs of fading and damage to both glass and bezel. Ensure the handle and rotary control knob are free from damage and are securely attached to the unit. Replace defective parts as necessary.

   c. **Alarm Set Point.** Select the "set alm" position using the rotary control knob, using a flat head screw driver adjust the "adj alarm" potentiometer until the meter displays 10µSv/h.

Radiation Tests

5. **Category 1 Test: Test before First Use.** These tests must be undertaken on each instrument prior to introduction to service for the first time and also if any major repair or modification which may have altered the response of the detector is made. All radiological testing should be undertaken with the unit in the "on" position i.e. On with Audio.

   a. **Background Dose Rate.** Remove the instrument from sources and record the instrument background dose rate.

      (i) Acceptance / Pass criteria is ± 10% of known low dose rate area dose rate.

   b. **Response to High Dose Rates.** Expose the instrument to a dose rate in excess 10 mSv.h^{-1} for at least thirty seconds.

      (i) Acceptance / Pass criteria - The instrument should maintain full scale deflection throughout the test, accompanied by an audible alarm.

   c. **Check Source Response. (no check source is currently assigned to this unit)**

d. **Linearity of Response. (^{137}Cs)** Expose the instrument to a range of dose rates and record the observed measurements. At least three repeat measurements of the instrument response should be recorded.

Note: As a minimum, 1 reading of each decade within the type test data range shown should be tested.

Dose Rate H*(10)	^{137}Cs Permitted Range H*(10)
500 µSv.h^{-1}	350 – 650 µSv.h^{-1} (see note)
100 µSv.h^{-1}	70 – 130 µSv.h^{-1} (see note)
25 µSv.h^{-1}	17.5 – 32.5 µSv.h^{-1} (see note)
7.5 µSv.h^{-1}	5.25 – 9.75 µSv.h^{-1}
2.5 µSv.h^{-1}	1.75 – 3.25 µSv.h^{-1}

Note: The unit should alarm during the 25, 100 and 500µSv/h exposures.

(i) Acceptance / Pass criteria – The instrument response must be within ± 30% of the reference doserate. The unit should also issue an audible alarm on the relevant exposures.

e. **Energy Response Test at 60 keV (60 keV ^{241}Am).** Expose the instrument to a 60 keV ^{241}Am radiation field at a dose rate of H*(10) 25 µSv.h^{-1} or 100 µSv.h^{-1}.

Dose Rate H*(10)	^{241}Am Permitted Range H*(10)
25 µSv.h^{-1}	17.5 – 32.5 µSv.h^{-1}
100 µSv.h^{-1}	± 30%

(i) Acceptance / Pass criteria – The instrument response must be within the permitted ranges shown above.

f. **Directional Dependency at 60 keV (^{241}Am or 65 keV ISO X-ray Quality).** Expose the instrument to ^{241}Am or 65 keV ISO X-ray Quality radiation field at a dose rate of 25µSv.h^{-1} / or 100 µSv.h^{-1} the expected polar responses are shown in Figure 1.

Left-hand (+90°) to the direction of incident radiation (0.63 ±30%)

Normal direction of incident radiation (1.00)

Right-hand (-90°) to the direction of incident radiation (0.65 ±30%)

Figure 1 – Directional Dependency Data

6. **Category 2: Annual Test.** Complete all category 1 tests with the exception of the Directional Dependency Test reported at para 5.f.

   (i) Acceptance / pass criteria are the same as Category 1 tests.

7. **Category 3: Test Before Operational Use.** Complete Category 1 test Check Source Response at paragraph 5.c.

   (i) Acceptance / pass criteria – The instrument response should be ±30% of the values recorded for the Category 1 test.

Certification (Qualified Person authorisation required)

8. Certificate test results as appropriate. Failed instruments must be re-tested after repair using Category 1 or Category 2 test protocols as dictated by the nature of the repair.

Standard Radiological Monitoring Instrument Statutory Test

Protocol 80 Mini Monitor Series 900 Ratemeter with 42a Probe

Function Photon Surface Contamination Monitor

Publications
A: AP112G-1325-0 Mini Monitor 900 Series
B: Instrument Operating handbook Series 900 Scintillation Mini Monitor with types 41, 42A/B & 44A/B probes.

NSN TBA

Required Reference Standards

All must be emission rate calibrated except UAC 1623 Check Source:

Extended Area:

^{55}Fe Photon Reference Source Amersham code IERB 4536;

^{238}Pu Photon Reference Source Amersham code PPRB 4472;

^{129}I Photon Reference Source Amersham code ISRB 4474;

^{241}Am Photon Reference Source Amersham code AMRB4473;

^{57}Co Photon Reference Source Amersham code CTRB3504;

^{137}Cs Photon Reference Source Amersham code CDRB4475;

^{60}Co Photon Reference Source Amersham code CKRB4476;

Small area (16mm Active Diameter)

^{90}Sr/Y Type WRS 1/E Amersham code SIR 01011, SIR 01021 and SIR 01031.

Check Source

^{Nat}U Amersham code UAC 1623 NSN 6665-99-193-3906

Description

1. The Series 900 is a common rate meter, when used with the 42a probe is scaled from 0-5 kcps. The unit has a control knob on the front panel allowing the following operations, OFF, BAT, ON and ON WITH MUTED AUDIO. The battery check is displayed on the green and white band of the meter. The unit has an alarm function which is set using the SET ALARM potentiometer on the front of the unit (a source is required for this procedure). The 42a, Photon contamination probe contains an Aluminium windowed sodium iodide crystal 1mm thick, 23mm diameter coupled to a high gain photo multiplier. The housing is of spun Aluminium construction containing shielding to give greater directionality whilst in use.

Probe Active Area: X cm^2

Controls

2. A comprehensive summary of the ratemeter functions is contained within the Publications, Reference A & B.

Standard Test Protocol

3. All tests should be recorded for Qualified Person inspection and certificate production. This protocol is specifically designed for dedicated probe and ratemeter combinations. Where separate testing of probe and ratemeter is required appropriate subsidiary tests should be completed, to confirm suitability of replacement probe or ratemeter. These tests may be derived from those detailed in this protocol.

Pre-radiation Tests, Electrical and Physical Examination.

4. These tests must be undertaken prior to both category 1 and 2 tests.

   a. **Battery test.** Check meter battery indication and condition of battery compartment and terminations. Replace as necessary.

   b. **Mechanical checks.** Check mechanical integrity of ratemeter case, cables, and cable connections, probe case and window. Replace as necessary.

   c. Check operation of all controls

Radiation Tests

5. **Category 1 Test: Test before First Use.** These tests must be undertaken on each unit before introduction into service for the first time. They must also be carried out after any repair that may have altered probe response. At least three repeat measurements of surface contamination response should be recorded.

   Note: The operating voltage of the Series 900 and 42a is preset by the manufacturer and should only be altered if the unit response to ^{55}Fe is low, this operation requires the front panel to be removed and internal potentiometers adjusted.

   a. **Light Sensitivity.** The probe should be exposed to an appropriate light source, any change in background should be observed. Check the probe response to one of the small area sources listed in para 1, with and without the presence of the light source.

      (i) Acceptance / pass criteria is that the background count should not be elevated and the response to the sources should not be affected by the presence of the light.

   b. **Response To Photon Contamination.** The responses detailed below are for the specified reference standards, with a source to detector grille separation of 3 mm. Details of the derivation of contamination responses (cps per Bq.cm^2) and equivalent 2 π efficiency (%) are given in part 2 of JSP 425. Responses must be determined for all nuclides listed. Details are given below for type test responses.

      Note: Nuclide's identified by a * are desirable for category two tests only.

Nuclide	**Cps.Bq^{-1}.cm^2 (P=2)**		**2π Efficiency %**	
	Mean Response	Permitted Range	Mean Efficiency	Permitted Range
^{55}Fe	TBA	TBA	TBA	TBA
^{238}Pu	TBA	TBA	TBA	TBA
^{129}I	TBA	TBA	TBA	TBA
^{241}Am	TBA	TBA	TBA	TBA
^{57}Co	TBA	TBA	TBA	TBA
^{137}Cs*	TBA	TBA	TBA	TBA
^{60}Co	TBA	TBA	TBA	TBA

      (i) Acceptance / pass criteria is instrument response within ± 30% i.e. within the permitted ranges shown above.

c. **Check Source Response.** When the source is in its container it visibly has a thick end and a thin end. Place the probe in contact with the thin end of the Check Source (^{Nat}U Amersham code UAC 1623 NSN 6665-99-193-3906) centrally in contact with the end of the 42a probe and record the result on the calibration certificate.

d. **Linearity of Response.** Place the small area sources listed in para 1 centrally in turn 3mm below the detector. Record the net response (cps) for each planar disc source.

(i) Acceptance / pass criteria are that the ratio of indicated response to source emission rate should be determined for each of the three sources. Each individual ratio should agree with the mean of all three ratios to within ± 30%.

e. **Uniformity of Response.** A uniformity check is not required on this probe due to its small active area.

f. **Background Count Rate.** Remove the probe from the sources and record the monitor background count rate.

(i) Acceptance / pass criteria is a background level of approx. 2-8 cps in a field of < 0.15 $\mu Sv.h^{-1}$, H*(10) from ^{137}Cs 662 keV.

7. **Category 2: Annual Test.** Complete all category 1 tests with the exception of the Uniformity of Response Test 6.e.

(i) Acceptance / pass criteria are the same as Category 1 tests.

8. **Category 3: Test Before Operational Use.** Complete Category 1 test “Check Source Response” at paragraph 6.c.

(i) Acceptance / Pass criteria check source response should be ± 20% of the response recorded at Para. 6.c.

9. **Certification (Qualified Person authorisation required)**

Certificate test results as appropriate. Failed instruments must be re-tested after repair using Category 1 or Category 2 test protocols as dictated by the nature of the repair.

Standard Radiological Monitoring Instrument Statutory Test

Protocol 84 RAE 2000 – DoseRAE(P)

Function Personal Electronic Dosimeter

Publications A: DEP (Number TBA)
B: Manufactures Manual

NSN 6665-01-548-5037

Required Reference Standards

Gamma Reference Standards - All Sources shall offer traceability to national standards.

Cs-137 and Am-241*

X-radiations - All irradiations shall offer traceability to national standards.

ISO Narrow Series X – Radiation – 65 keV *

*Am-241 or 65 keV X-Radiation maybe used for energy response testing.

Equipment Overview

Description and Use: The RAE2000 offers a control dosimeter capability for real time dose assessment and provides the user with dose and dose rate alarm functions. This device is not intended to provide data for legal dose records.
Physical Construction: The unit is constructed from high impact plastic and comprises a top mounted backlit LCD display.
Detector Type: Miniature GM Tube
Dose Range: 0 μSv – 9.99 Sv
Energy Range: 55 keV – 6Mev

Controls

1. A comprehensive summary of dosimeter functionality is contained within 'Publications' A & B.

Standard Test Protocol

2. All tests should be recorded for Qualified Person inspection and certificate production.

Pre-radiation Tests, Electrical and Physical Examination.

3. The following tests must be undertaken prior to both Category 1 and 2 tests.

a. **Battery tests.**
Ensure batteries are in good order and provide the necessary voltage for operation, where a steady / flashing battery icon indicator is observed in the display the batteries should be replaced.
Replace as necessary.

b. **Mechanical checks.**
Check the mechanical integrity of instrument ensuring the case is free from cracks, the mounting clip and push buttons are fit for purpose and the LCD display is easily readable and does not show signs of segment 'bleed'.

Replace defective parts as necessary.

c. Energise the unit and check operation of all controls

Radiation Tests

4. **Category 1 Test: Test before First Use.** These tests must be undertaken on each instrument before introduction into service, the test regime must also be employed where repairs/modifications may have altered detector response.

a. **Drift Test**

Reset the unit following instructions provided in 'Publications' A & B and leave the unit under test (UUT) in a known low background environment for a period of 12 hours.

Record the instrument response after 12 hours.

(i) Acceptance / Pass criteria - Instrument response should reflect < 4μSv.

b. **Dose Linearity (^{137}Cs) – Doses should be delivered to Hp10 qualities.**

Reset the accumulated dose and configure the unit to provide a dose indication, using a PMMA phantom assembly orientate the dosimeter at the facility point of reference such that it represents operational geometry.

Using the doserates specified in the table below and a suitable exposure time, irradiate the dosimeters to the target doses.

On completion of each exposure record the observed reading on the calibration certificate.

	Reference Doserate	**Target Dose**
Low Dose	<100μSv/h	>10μSv / <100μSv
High Dose	>10mSv/h	>500μSv

(i) Acceptance / Pass criteria – Instrument responses shall reflect conformity to within ±30%of delivered reference doses.

c. **Energy Response Test - (^{241}Am or 65 keV ISO Narrow Series X-ray Quality)**

Reset the accumulated dose and expose the UUT to a doserate / time combination used during the 'Dose Linearity' testing. Record the observed reading and calculate a response ratio to the ^{137}Cs value.

(i) Acceptance / Pass criteria – The ^{137}Cs:'Tested energy' response shall indicate a ratio of 1:1.30 (±30%) when exposed to the same dose achieved using the same rate / time utilised during linearity testing, an example is provided below.

Example ^{137}Cs Response	**Example 'Tested Energy' Permitted Range**
Hp(10)	**Hp(10)**
25 μSv	22.75 – 42.25 μSv

d. **Directional Dependency - (^{241}Am or 65 keV ISO Narrow Series X-ray Quality)**

Reset the accumulated dose and expose the UUT in the -45° and +45° orientation (as shown below) to the doserate / time combination used during the 'Energy Response Testing', record the observed reading and calculate a response ratio for each angle using the frontal response as the unity value.

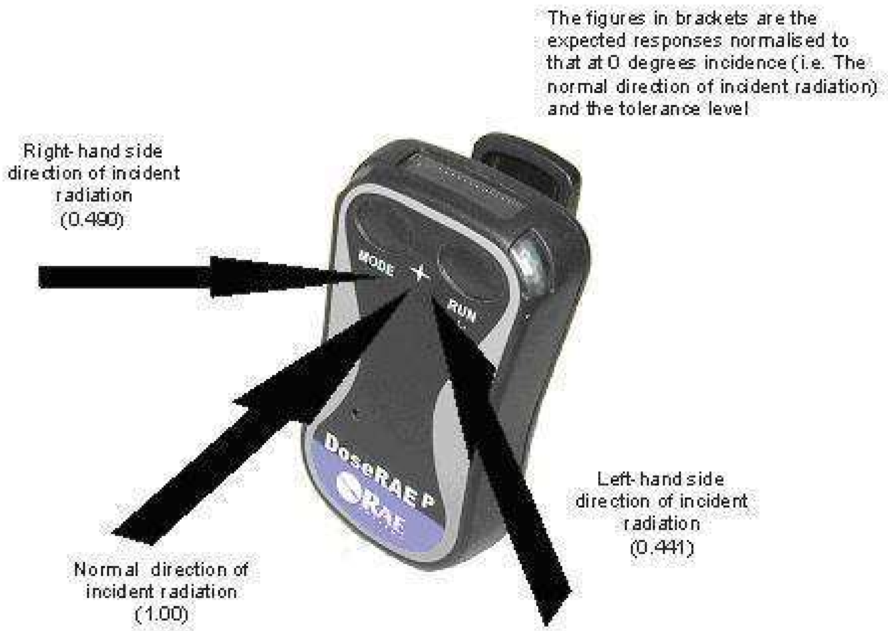


Figure 9. **Expected Directional Dependency**

(i) Acceptance / Pass criteria – The responses shall reflect the responses detailed in Figure 1.

5. **Category 2: Annual Test.**
   Complete all Category 1 tests except Directional Dependency Test 4.d

   (i) Acceptance / Pass criteria – Criteria reflects those noted for Category 1 tests.

Certification (Qualified Person authorisation required)

6. Certificate all test results, failed instruments must be certified with a relevant failure certificate and re-tested after repair using Category 1 or Category 2 test protocols as dictated by the nature of the repair.

Labelling

7. The DoseRAE(P) is designed to connect via capacitive transfer to a SAIC PDR-1 reader, therefore it is imperative that the frontal portion of the dosimeter is not obstructed by a calibration label. All labels should be attached to the unit using a plastic 'dog tag' assembly using a plastic lanyard or cable tie.

Leaflet 9 Annex C
List of Common Radioactive Items Which Require Leak Testing

Radioactive source type	Stores or NATO catalogue no.	Type and Original quantity of radioactive material	Leak Test Required
CBRN training source type A	0552/F12Z 6665-99-911-0015	18.5 MBq Ra-226	Yes
CBRN training source type B	0552/F12Z 6665-99-911-0016	37 MBq Co-60 (total)	Yes
CBRN training source type C	0552/F12Z 6665-99-911-0017	37 MBq Co-60	Yes
CBRN training source type D	0552/F12Z 6665-99-911-0018	185 MBq Co-60	Yes
CBRN training source type E	0552/F12Z 6665-99-911-0019	925 MBq Co-60	Yes
CBRN training source type G	0552/F12Z 6665-99-911-0098	185 MBq Co-60	Yes
CBRN training source type G Mk III	6665-99-224-7975 12Z 2247975	740 MBq Cs-137	Yes
CBRN training source type H	0552/F12Z 6665-99-911-0099	3.7 MBq Ra-226	Yes
CBRN training source type J	6665-99-911-0097	370 Bq Ra-226	Yes
* Type 1623A	K107 6665-99-193-3906	111 kBq Natural Uranium	Yes
NIS 322XA	12Z 114-8909	248 kBq Pu-239/	Yes
Check source	6Z/623-2897	43.8 kBq Am-241	
IS 610	K107 6665-99-376-2459	24 kBq Am-241	Yes
Check source	6Z/623-2897	46 kBq Am-241	Yes
Calibrator for PDRM	6665-99-628-0572	555 MBq Sr-90	Yes
Test Mk 13NJ sample	K104/0552/6665-99-733-5728	11.1 kBq Sr-90	Yes
Test Mk 16NJ sample	K104/0552/6665-99-795-2016	555 kBq Sr-90	Yes
Mk 18NJ jig and source	K104/0552/6665-99-721-2707	22 kBq Sr-90	Yes
* Test Mk 20NJ source	K104/6665-99-736-4922	37 kBq Pu-239	Yes

List of Common Radioactive Items Which Require Leak Testing (continued)

Radioactive source type	Stores or NATO catalogue no.	Type and Original quantity of radioactive material	Leak Test Required
Calibration plaque Mk 2NCS	Not patternised	222 kBq Pu-239	Yes
Calibration jig and source AERE Type 1546A test	Not patternised	185 MBq Ra-226/Be	Yes
IM 192 (APD)	0552/6665-00-691-2840	2.96 MBq Sr-90/Y-90	Yes
Source CFR 3	K107/4940-99-640-5477	37 kBq/g C-14	Yes
* Source AMR 2402	K107/4940-99-640-5476	740 Bq Am-241	Yes
L1A1 (Proban)	Z5 6665-99-224-8293	111.0 MBq Cd-109	Yes
L3A1 (HED)	Z5 6665-99-224-8294	1.2 MBq Cf-252	Yes
* L4A1 (BED)	Z5 6665-99-224-9015	370 MBq Ni-63	Yes
* L9A1 (COT) -	Z5 6665-99-967-0491 NU 6635-99-739-7235	370 MBq Ni-63 2.0 GBq Am-241/Be 370 MBq Cs-137	Yes Yes Yes
TK30	WO8 6635-99-785-5723	1.4 TBq Co-60	Yes
Source in adjusted assembly	Z8 6665-99-119-6940	12.95 MBq Sr-90	Yes
Dose meter (PDRM)	Z8 6665-99-119-8766	12.95 MBq Sr-90 40.7 MBq H-3	Yes
Leakmeter Model 61	6625-99-654-0124	370 MBq Ni-63	Yes
Chemical agent monitor	Z8 6665-99-225-3521	370 MBq Ni-63	See Leaflet 20
MCAD	6665-99-809-0326	555 MBq Ni-63	See Leaflet 20
COLPRO CAM	6665-99-609-8640	555 MBq Ni-63	See Leaflet 20
GID-3	6665-99-292-4508	740 MBq Ni-63	See Leaflet 20
Otto fuel monitor	Z8 1065-99-765-5786	370 MBq Ni-63	See Leaflet 20

List of Common Radioactive Items Which Require Leak Testing (continued)

Radioactive source type	Stores or NATO catalogue no.	Type and Original quantity of radioactive material	Leak Test Required
Meter survey radiac	Z8 6665-99-911-0123	18.5 kBq Sr-90	Yes
SIC MK10 NHA	K103/6665-99-037-0455 K103/ 6665-99-197-1894 K103/ 6665-99-917-1194	370MBq Ni-63	Yes (annual)
Mk 22NRS (SIRS) (Mk 28 NH detector)	K101/0552/6665-99-733-5339	1.1 kBq Sr-90	No
Mk22 NRS (SIRS) (Mk 29 NH detector)	K101/0552/6665-99-733-1142	2.6 MBq Sr-90	Yes
Mk 1 NRS (SIRS) (Mk 3 NH detector)	K101/0552/6665-99-462-3935	18.5 MBq Sr-90	Yes
Mk 10 NXS Th232 check source	K104/6665/01/441/0980	1.11 kBq Th-232	Yes
Gamma Alarm Monitor PNI 1248	K104/6665-99-538-9196	1.1 kBq Sr-90	Yes
Test Mk 18 NJ Source	K104/6665-99-721-2707	22.2 kBq Sr-90	Yes
*TEST MK 7NXS SAMPLE	K104/6665-99-736-2887	50 Bq Am-241	Yes
Test Source Pu-239	K107/6665-99-664-2456	220 Bq Pu-239	Yes
Check Source Set 7 Piece	K104/6665-99-361-2834	Max 3 kBqSr-90 Max 3 kBqCo-60 1 kBq Am-241 1 kBq C-14	Yes
Check Source Set 3 Piece	K104/6665-99-549-9499	1 kBq Sr-90 1 kBq Am-241	Yes
Smoke Detectors	Various	Am-241	See Leaflet 18

* Sources are fragile and could be damaged by direct leak testing. Leak tests are to therefore only be carried out on the inside of the container in which the source is stored, following the procedure described in local orders or as agreed with the RPA. There is no minimum activity for a source below which a leak test is not required on a sealed source. However, where it is indicated that a source does not require leak testing, this decision has been made on the basis that 100% ingestion of the source would not result in a dose greater than 0.1 mSv and therefore poses a trivial radiological hazard.

Leaflet 21 Annex A

Example Summary Radiation Risk Assessment

1623a Natural Uranium Check Source

1623A Natural uranium check source	
Description	 The check source is a disc of natural uranium (23.1 mm diameter, 1.12 mm thick) mounted in an aluminium container. The container lid is unscrewed to reveal the source, which is bonded to the circular aluminium base block. NOTE: These check sources have been modified with a steel ring and four screws to hold the source more securely. Please contact your RPA if your check source is not the modified version shown above.
Use	Used in the functional testing of a wide range of radiation protection instruments.
Supplier	AEA Technology QSA
NSN / part number	K107-6665-99-193-3906
DT	Chemical Biological Radiological Nuclear (CBRN)
Radionuclide	Natural uranium (Nat-U)
Ionising radiation	Alpha, beta and gamma and X-ray radiation is emitted from the source. Natural uranium contains 0.72% uranium- 235, 0.006% uranium-234 and 99.274% uranium-238.
Half life	~ 4.5x10^{9} years for uranium 238
Original activity	111 kBq
Hazard	The alpha radiation of the uranium isotopes in the source, present an internal radiation hazard on ingestion or inhalation of the natural uranium. The beta radiation of some of the decay products present in the source, together with the weak gamma radiation emitted by all nuclides, present an external radiation hazard.

Risk assessment	During the functional testing on a wide range of radiation protection instruments, the radioactive source will be exposed for a short period only and will be directed away from the body. The most significant dose rate will be to the hand of the operator and will be shielded by the source housing. In this configuration the maximum dose rate to the hand is 1.5 μSv/hr. As the check source may be used on a daily basis, and a functional test is estimated to take 30 seconds, the maximum theoretical skin dose for a working year is estimated to be 5 μSv/hr. Whole body effective dose would be very much less than this value.
Local orders	Details of the control measures taken from this leaflet are to be included in the local orders for radiation safety (Leaflet 16 refers).
Control measures during use	There is no requirement to unscrew the source lid when function testing an instrument that measures gamma radiation. The unopened source container should be placed against the radiation monitoring instrument to obtain a reading. If necessary, the lid should be unscrewed for use to check the function of particular type of instrument (e.g. alpha or beta contamination probe). In this case, the radiation monitoring instrument or detector is to be placed against the outer casing or close to (but not touching) the surface of the uranium disc to obtain a reading. This item is not to be carried on the person and handling of the item is to be kept to a minimum. The spread of contamination and the likelihood of any resultant personal contamination will be minimised where practicable by wearing disposable gloves when using the source and washing hands immediately afterwards as a precautionary measure.
Leak testing	Leak testing is required at least every 24 months.
Accounting	This item is to be accounted for on a Radioactive Source List (Leaflet 9 refers) under the supervision of an RPS or WPS (RAM). All radioactive material is to be mustered at least monthly. Any change of location is to be entered in the Source Movement Log together with any change in custodian.
EPR10/RSA93	This item is exempt from notification to the relevant environment agencies under EPR10/RSA93.
Annual Holdings Return (AHR)	This item should be included on the AHR to Dstl ESD (Leaflet 3 refers)
Storage and labelling	This item is to be stored in a dedicated area for radioactive materials (see Leaflet 9). The equipment is to have the recognised radioactive trefoil and marking on it. The storage/installed area is also to have a sign showing radioactive material within, i.e. a radiation warning trefoil including the contact name and telephone number of the RPS or WPS (RAM) and stating the nature of the radiological hazard in appropriate languages: **Items contain radioactive material. No radiation hazard from intact item. Radioactive contamination hazard if item damaged.**
Contingency plans breakage/loss/incident	If a breakage occurs the area is to be cordoned off. The RSO and the RPA are to be contacted. Reporting of loss and certain other incidents are to be carried out in accordance with the procedures described in Leaflet 14.
Transport	May be transported as an excepted package.
Disposal	Units and Establishments are to return this item, unbroken, through the Stores Organisation.

LEAFLET 21 Annex B

Example Instrument Pre-Use Functional Testing Record Sheet

Instrument Description	Serial Number	Battery Power Check	Check Source Reference Number	Instrument Response		Name of person carrying out test	Signature	Date
				Expected	Actual			