



Providing Insight Onsite

TRACERCO™ NORM Monitor - IS

USER MANUAL



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Glossary

Table 1 - Glossary

NORM	Naturally Occurring Radioactive Material
cps	Radiation activity measured in counts per second
cpm	Radiation activity measured in counts per minute
NaI	Sodium Iodide – scintillation crystal
LSA	Low Specific Activity
μSv/h	Micro-sieverts per hour. SI units for effective dose rate
μR/h	Micro-roentgen per hour. Non-SI units for dose rate used in USA
EMC	Electromagnetic Compatibility
ATEX	European Directive 94/9/EC applicable to equipment used in hazardous environments. From French “ <i>Appareils destinés à être utilisés en ATmosphères Explosives</i> ”
IP rating	Level of Ingress Protection against objects and liquid
IS	Intrinsically Safe . Design concept, formally assessed and certified by a notified body, which demonstrates that the instrument can be used safely in hazardous environments.
Scintillator	Material which produces photons in response to incident radiation
Isotope	Member of an element group with the same number of protons but differing number of neutrons in its nucleus.
Nuclide	A member of the set of approx. 3100 elements and their isotopes
Background radiation	The ionising radiation constantly present in the natural environment of the Earth, emitted by natural and artificial sources
Baseefa	A notified body for ATEX approval
RPA	Radiation Protection Advisor . A qualified expert who advises on safe and compliant use of Ionising radiations according to the Ionising Radiations Regulations 1999 (IRR99)
RPS	Radiation Protection Supervisor . An individual appointed to ensure compliance with local rules and radiation regulations under IRR99
RSO	Radiation Safety Officer
Bq/cm ²	A measure of surface activity. One Becquerel is equivalent to one disintegration per second.
Alpha radiation	Radioactive decay resulting in the emission of a helium nucleus (e.g. Ra-226 → Ra222)
Beta radiation	Radioactive decay resulting in emission of an electron or positron (e.g. Pb-210 → Bi210)
Gamma radiation	Radioactive decay in which a high energy photon occurs along with the decay particle(s) (e.g. 47KeV γ Pb-210 → Bi-210)

1 Introduction and Scope

1.1 Introduction

The *Tracerco NORM Monitor-IS* is an intrinsically safe portable contamination monitor which has been developed specifically to meet the requirements of the Oil and Gas Industry; particularly the measurement of Naturally Occurring Radioactive Material (NORM).

Its principal function is to detect and quantify naturally occurring radioactive isotopes under a wide range of operational conditions.

The monitor kit provides a single instrument platform with dual probe option to deliver optimum measurement capability under the most demanding circumstances.

Although specifically designed to overcome the technical and practical challenges of measuring NORM in the field, the monitor is also able to detect a wide range of man-made isotopes.

1.2 Scope

This manual provides detailed operational and technical information for the *Tracerco NORM Monitor-IS*.

In addition, an introductory guide is presented which explains the origins, radiological nature and the challenges which arise when attempting to carry out practical measurements and radiological assessments of typical Naturally Occurring Radioactive Material (NORM) deposits.

2 Naturally Occurring Radioactivity – an overview

2.1 Introduction

Radioactivity occurs naturally in the environment due to the presence of decay products from Uranium and Thorium. These isotopes have extremely long half-lives. For example:

Uranium-235:	700 million years
Uranium-238:	4.5 billion years
Thorium-232:	14 billion years

The parent uranium and thorium isotopes decay to produce a series of other radioactive daughter isotopes of widely differing half-lives. Eventually, through the course of time, these result in a stable isotope of Lead. A schematic of the decay chains for each nuclide series is illustrated in Appendix 1 – Decay Series for Uranium and Thorium

If the radioactive parent is undisturbed for a sufficiently long period of time, a condition of equilibrium is established in which all radioactivity levels are equal. Removal of all or an amount of a nuclide from the decay scheme will disturb this equilibrium and reduce the concentration of corresponding decay products. In a situation of true

radioactive equilibrium, all nuclides will be present at the same level of radioactivity. The natural decay series are complex and, in theory, up to 48 separate radionuclides may exist in scales which have been derived from a mixture of the Uranium and Thorium decay products.

In reality the isotopes of uranium-235, uranium-238 and thorium are rarely detected in scales themselves. This is thought to reflect the low solubility of such materials in the water within the reservoir. It is more usual to detect the more soluble decay products of each series in the form of radium isotopes and their subsequent daughter products.

The result of these processes is that NORM contains many different radionuclides which emit a complex mix of alpha, beta and gamma radiations. The relative amounts of radionuclides from the uranium and thorium decay chains can also vary depending on the history of the reservoir and chemical composition; hence scales taken from different locations often exhibit variations in radioactive composition.

Many of the isotopes in the various decay chains can be seen to have relatively short half-lives (minutes or hours) and, if present in isolation, would very quickly decay and cease to generate any further radiological hazards. These isotopes would technically be described as "unsupported" but in many cases they continue to remain present with an unchanging level of radioactivity. This occurs because they are continuously being produced by other radioisotopes in the decay chain such that there is a constant balance between production and decay leading to a constant level of radioactivity; irrespective of the actual half-life. In this situation the decay scheme would be considered to be in equilibrium and the shorter lived nuclide fully "supported" by its parent nuclide.

2.2 Radioactivity in Oil and Gas Installations

Radioactive materials from natural sources may arise in a number of forms within the oil and gas industry. A common form of the material is known as Low Specific Activity or Naturally Occurring Radioactive Material (LSA/NORM) scale. It frequently arises within oil and gas installations due to a process of selective chemical deposition. Radioactive isotopes, together with a wide variety of other chemicals, may be leached from reservoir rock and become dissolved within the reservoir formation water.

In oil and gas installations, where water injection of seawater is used to promote the recovery of oil, the presence of sulphate-rich injection waters can give rise to the deposition of barium and strontium sulphate scales. These scales may incorporate radioactive isotopes derived from the presence of uranium and thorium in the formation rock and can produce significant scaling of pipework and vessels; thereby reducing the flow of liquids and affecting the efficiency of control systems.

The laydown of radioactive scale can lead to significant external radiation levels on the outside of production equipment. This raises the possibility of exposure to personnel from contamination by ingestion of radioactive material when equipment is handled or cleaned during scale removal operations. Similarly, scale and silt may be deposited in the equipment of onshore terminals where crude oil is delivered from offshore installations via marine pipelines.

An additional problem may arise in gas production and associated handling systems from the presence of radon gas generated by radium isotopes; both in formation rock or water and in LSA/NORM scales. This radioactive gas can contaminate the production gas to significant levels and will decay to particulate-forming radioisotopes such as lead-210 and polonium-210 which can also be deposited in equipment of the gas production system.

These deposits can be radiologically significant and pose potential hazards to health when equipment is opened up. It is not uncommon for significant quantities of unsupported lead-210 or polonium-210 to be transported from a reservoir in the gaseous phase. In such circumstances the availability of these radionuclides reflects their chemical and physical properties and the historical levels of the radioactivity which over time have built up in the reservoir.

3 Operational Options

The *Tracerco NORM Monitor-IS* has been designed to provide a versatile instrument which will enable the operator to confidently detect and quantify contamination arising from NORM under most environmental conditions. In order to achieve this versatility, the instrument is provided as a single data processing unit with the choice of two types of radiation detection probes.

To realise the full capability of the instrument, it is important that the operator understands the technical advantages of each probe and the circumstances under which they should be deployed.

3.1 Probe Selection

Although, in general terms, both the Geiger Müller (GM) and Scintillator-based probes will detect the presence of NORM under most environmental conditions, there can be significant variations in detection sensitivity for different scale types.

The following table provides guidance on the selection of probe for a particular NORM measurement application. The table has been compiled on the basis that environmental background radiation is comparable to that found in an offshore facility and there are no local abnormal circumstances – for example, the presence of local scale storage containers will affect the detection capability of the scintillation probe due to a higher background radiation reading.

This guidance is based on monitoring experience and the known technical characteristics of each probe. The operator should always observe local operating procedures and, where appropriate, seek confirmation from the appointed RPS or RPA.

Table 2 – Measurement options for probes

Type of measurement	Suggested probe	
	Technology	Tracerco part ref.
Radium scale with readily accessible dry surface	Geiger Müller	SA-49
Radium scale with significant water, oil or sludge deposition	Scintillator	SA-50
Radium scale contaminated tubulars < 4” diameter (100mm)	Scintillator	SA-50
Radium scale deposition using external pipe surface survey measurements	Scintillator	SA-50
Lead-210 scale with readily accessible surface (wet or dry)	Geiger Müller	SA-49

3.1.1 Geiger Müller End Window (Pancake) Probe

The Geiger Müller probe utilises a thin window detector which, although capable of detecting gamma radiation, is particularly sensitive to the surface measurement of alpha and beta radiation.

The Geiger Müller probe’s high sensitivity to alpha and beta is ideally suited to the measurement of lead-210 and polonium-210 which are commonly found in gas producing facilities where NORM is transported in the form of the gas radon-222.

Measurements may be taken in units of counts per second (cps) or - in the case where specific nuclides have been selected - Becquerels per square cm (Bq/cm^2).

- ⚠ The Bq/cm^2 measurement function is used to quantify the levels of surface activity of a particular nuclide. It is important that the users have prior knowledge of the type of nuclides present in the deposition so that the measurements can be set up and interpreted correctly.

Contact radiation.monitors@tracerco.com for further details regarding radionuclide spectrum analysis of sample materials.



Figure 1 - Geiger Müller (Pancake) Probe

The detection sensitivity of the probe for alpha and beta emissions from scale materials may be significantly reduced if the surface is wet or obscured by oily deposits.

Although in such circumstances the probe will continue to respond to any gamma ray emissions with only a limited reduction in sensitivity, the reduced contribution from the alpha and beta particle detection will result in a significant overall loss in sensitivity relative to a dry surface.

The Geiger probe has been calibrated with a number of response factors to allow measurement of Bq/cm^2 for specific nuclides. The nuclide options which are provided includes Radium-226 in the form of wet or dry scales and Lead-210, again in the form of wet or dry scales. The operator is able to select the required nuclide through the instrument's configuration menu [See section 0]

The provision of a wet and dry option reflects the absorption of alpha and, to a lesser extent, beta radiation by water and oil on the surface of the scale.

- ⚠ The response factors have been factory set under a calibration conditions where the probe is placed directly above the scale surface at a distance of 2mm.

3.1.2 Scintillation Probe

The scintillation probe utilises an inorganic scintillator crystal which is very sensitive to the detection of gamma radiation. It may also detect the higher energy beta radiation emitted by certain nuclides in the natural activity decay chain.

A focus on gamma radiation detection sensitivity makes the scintillation probe ideal for measuring radium nuclides and the associated decay chains. The probe has been designed to provide optimum radiation collection efficiency without significantly reducing the ruggedness of the probe.

The nature of the design provides for near 360 degree collection of radiation thus providing an extremely effective monitor for pipe internals.



Figure 2 - Scintillation probe

High gamma radiation sensitivity is particularly suited to detecting NORM through pipe or vessel walls where internal monitoring is not possible and access limited to the external surfaces. In these situations the probe can be used in an end-on configuration to directly monitor against the surface of interest.

The potential problems associated with the Geiger Müller probe - where wet or oily surface contamination of scale limits detection of alpha and beta radiation - are largely overcome by the use of the scintillation based probe: gamma ray emissions from scale are relatively unaffected by the presence of small quantities of oil and water.

⚠ An exception to the above is where areas of known Pb-210 deposition exist. In this case the GM probe will be more effective.

The Scintillation Probe can measure in units of cps or dose rate. The dose rate response is calibrated against a nationally traceable caesium-137 source.

⚠ The Scintillation Probe dose rate output is designed specifically for the methods of NORM screening required by North American regulators. General dose rate surveys using the probe are not recommended.

The response of all scintillation detectors vary with radiation energy and the gamma ray energies associated with caesium-137 are significantly different to those arising from NORM.

[\[See calibration details in Section 10.3\]](#)

3.2 NORM assessment criteria

There are various measures of the radiological significance of NORM. The assessment criteria favoured by local regulators regarding NORM limits can vary from region to region.

The NORM Monitor-IS is designed so that it will accommodate all current assessment criteria.

For each assessment criteria the **NORM Monitor-IS** provides user-configurable alarms which can be set to reflect the local rule PASS/FAIL criteria.

[See section 4.8 for alarm setting options]

The range of known assessment criteria is described in the following section.

- ⚠ The operator should always seek guidance from the designated RPA, RSO or RPS when selecting an instrument for measuring NORM and observe local procedures in relation to any planned radiation monitoring operations.

3.2.1 Assessment using cps measurement

The **NORM Monitor-IS** may be operated in **cps** or **cps minus background** mode, with either the GM Probe or the Scintillator Probe.

The PASS/FAIL alarm criteria are summarised in the following table. These assessment methods are commonly used in the UK and Middle East oil and gas sectors.

Table 3 – Alarm options when using cps for NORM assessment

Operating mode	Alarm type	Description
Cps	Level	Alarm activated when total cps exceeds user-configured level
cps - background	Level	Alarm activated when cps <i>above</i> background radiation exceeds user-configured level
cps - background	Factor	Alarm activated when a multiple of background radiation is exceeded.

3.2.2 Assessment using surface activity (Bq/cm²)

Surface activity measured in Bq/cm² is less commonly used in NORM assessment but may offer the operator useful information - *provided the type of nuclide is known*.

[See also Section 3.1 Probe Selection]

The **NORM Monitor-IS** Geiger Müller probe is calibrated with response factors for lead-210 and radium-226. Selection of the appropriate nuclide for the particular NORM samples allows the user to set PASS/FAIL criteria is summarised as follows.

Table 4 – Alarm options when using Bq/cm² for NORM assessment

Operating mode	Alarm type	Description
Bq/cm ²	Level	Alarm activated when Bq/cm ² exceeds user-configured level

3.2.3 Dose rate

Legislative requirements, typically in the US, require operators to assess NORM on the basis of the direct radiation dose rate which would be experienced by a worker at the nearest “accessible” location to the contaminated item. This requirement is satisfied with the Scintillation Probe which can take measurements in units of µSv/h or µR/h.

The **NORM Monitor IS** dose rate output is calibrated by Tracerco against a traceable Cs-137 source.

[See Section 10.3]

Table 5 – Alarm options when using dose rate for NORM assessment

Operating mode	Alarm type	Description
Dose rate	Level	Alarm activated when total dose rate exceeds user-configured level
Dose rate minus background	Level	Alarm activated when dose rate <i>above</i> background dose rate exceeds user-configured level
Dose rate minus background	Factor	Alarm activated when a multiple of background dose rate is exceeded.

3.2.4 Specific activity

Specific activity in Bq/g is used as the fundamental measure of NORM activity. This measurement is performed by Tracerco in laboratory conditions using highly complex measurement instrumentation.

Contact radiation.monitors@tracerco.com for further details regarding radionuclide spectrum analysis of NORM samples.

3.3 Background Measurement

An important aspect which the operator should consider when assessing the relative sensitivities of the two probes is the background radiation level.

The Geiger Probe will only be significantly affected by very local sources of radiation and will typically display a very low and predictable background count rate - whether deployed onshore or offshore. A normal background count rate of less than 1 cps is typical.

The Scintillation Probe has a much greater environmental background count and can be significantly affected by local geology. The lowest background values can be achieved in offshore or desert environments but can rise substantially onshore depending on the precise nature of the locality. The statistical uncertainty in background must therefore always be considered when determining the sensitivity of the probe to sample radiation in any given situation.

[See Section 4.7 for details on measuring and saving background radiation levels]

4 Tracerco *NORM Monitor-IS* – Functional description

4.1 Handset monitor control keys

Indicator LEDs show when the instrument is in normal measurement mode (Rate) or if an integration measurement is in progress or complete

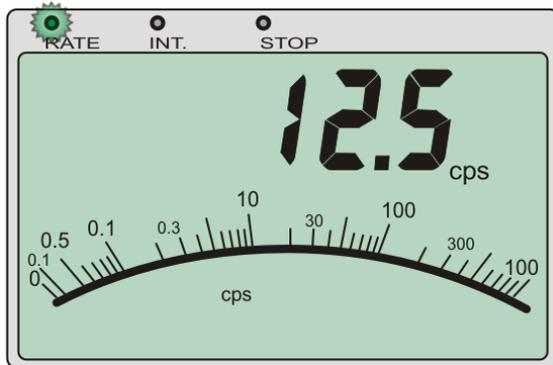
Log Background key
Press this to record the local background radiation level



Figure 3 - Tracerco *NORM Monitor-IS* – key definitions

Analogue / Digital Screen

Digital readout displays radiation levels detected by the probe in user selectable units. The LEDs provide operational status information.



Analogue dial representation provides an animated auto-ranging readout. The meter may be configured to show counts (cps or cpm), dose rate ($\mu\text{Sv/h}$ or $\mu\text{R/h}$) or Bq/cm^2 .

Instrument on/off key

Push key to turn the monitor power on or off.



Speaker / Alarm key

Press to silence audible clicking during radiation measurements. Extended press for 3 seconds provides entry to Alarm setting menu. [See Section 4.8]



The key is dual purpose and provides the means to decrease (-) the displayed value in the alarm or integration configuration menus.

Rate/Int./Stop key

This key allows the operator to select a measurement mode which gives a more statistically accurate result than that using the real-time **rate** method.

When the key is pressed, the instrument will take a measurement over a pre-configured period of time (for example

15 seconds). The user is presented with a time-averaged result on the display which gradually finds a mean value over the duration of the measurement

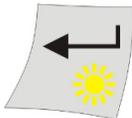
Colour-coded LEDs above the instrument's display screen indicate the current status of this measurement process.



[See Section 4.5 for more details on the integration function]

Select/Backlight key

The dual function key is used to select options from the alarm and integrate menus as well as activate the display backlight.



Following activation, the backlight will operate for 20 seconds before switching off.

Mode (+) key

The primary key function is to step through the various measurement modes of the instrument. Each key-press moves to the next unit option available for the probe attached.



The dual function key is also used to increase the alarm and integrate period parameters (+) when these menu options are selected. [See Sections 4.8 & 5 on alarm and integration period configuration]

Log Back-ground key

This key is used to record and store background radiation levels.

Following key-press, a one minute background count is initiated and the result stored in memory. The result is used in measurement modes where background compensation is factored into the value output to the display. This process overwrites any previous value of background which is stored in memory.



To use any of the background adjusted modes of operation (including Bq/cm²), the user must take a background reading for the chosen probe.

[See section 4.7 for further information on background measurement]

Probe Connection

Each probe is supplied with a flying lead terminated with an industrial specification IP68 (mated condition) coupling connector [See Section 4.2.1 – Connecting the probe]

 Note that the plug and socket are polarised. Please observe the red dot registration markings when connecting the probes.

Indicator LEDs

Three LEDs indicate the current processing stage when using the **integration** measurement mode. The integration measurement sequence is shown below.

1. Green **rate** LED – indicates that the measurement is in real-time. The display reading will fluctuate according to the random nature of the radiation source.
2. Amber **integrate** LED – indicates that the instrument is busy. The LED will continue to flash over the duration of the integration period.
During this period the display continues to show an averaged measurement with a one second refresh rate.
3. Red **stop** LED – indicates that the measurement is complete. *The display no longer updates while the red LED is flashing.*

Press the **Rate/Int./Stop**  key again and the instrument returns to **rate** mode (1). The sequence is now complete.
[See also Section 4.5 Integration Function]

4.2 Operating the instrument

4.2.1 Connecting the probes

Each probe is supplied with a flexible (“curly”) cable terminated with a polarised industrial grade plug. Connection to the hand-held monitor is made via a panel mount socket connection as shown below.



- Rotate the probe plug so that the red marker is uppermost. Align the marker with the corresponding red dot marker on the handset-mounted socket and push firmly. A successful connection is confirmed by an audible and tactile ‘click’ of the latching mechanism.

Switch the monitor on and observe that the initialisation sequence is carried out – [[See Section 4.2.3 – Switching on the instrument](#)]

4.2.2 Removing the probe

Switch the monitor off.

Hold the probe plug by the machined grip and **pull** firmly away from the handset.

4.2.3 Switching on the instrument

Pressing the power key will turn on the monitor. A self-test routine enables all LCD segments and the three indicator LEDs are illuminated in sequence.

Following the initialisation, visual acknowledgement of the selected probe type is displayed briefly as illustrated below. SA-49 indicates the GM probe is connected; SA-50 indicates the Scintillator Probe is connected.

The start-up sequence is complete once the green LED starts flashing. The monitor is now ready for use.

At this stage the unit measurement presented to the user is dependent upon the operating mode and alarm settings used when the instrument was last switched off. In the illustration below the instrument was last used in *cps mode* and no alarm was set.

4.2.4 Start-up sequence illustration

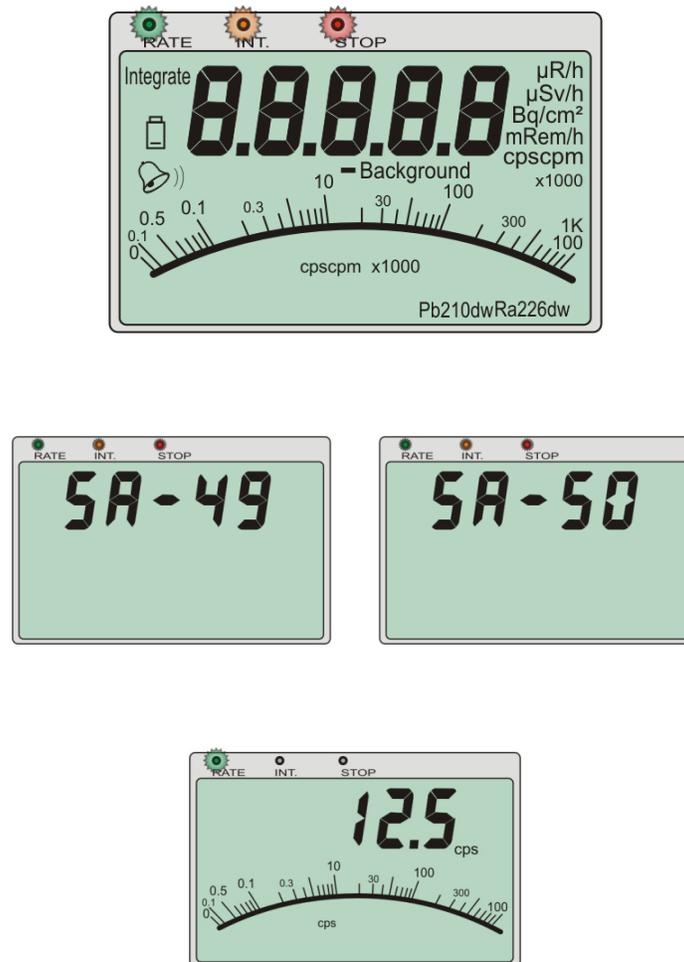


Figure 4 - Start-up sequence

4.3 Measurement Modes for the Scintillator Probe.

Following initialisation – see previous section - the user may choose to change the measurement unit mode. The various measurement modes for the scintillator probe are:

- cps count rate (or cpm)
- background subtracted cps count rate (or cpm)
- Dose rate in $\mu\text{Sv/h}$ (or $\mu\text{R/h}$)

In each case it is possible to utilise the *integration* function whereby the displayed reading is averaged over a period of time.

Note: The **NORM Monitor-IS** is capable of displaying SI units as well as non-IS units (primarily US market). **Cps** or **cpm** & **Sv/h** or **$\mu\text{R/h}$** are factory set parameters and not configurable in the field.

4.3.1 cps Mode

Press the **mode**  key until the “cps” text appears on the LCD display as shown.

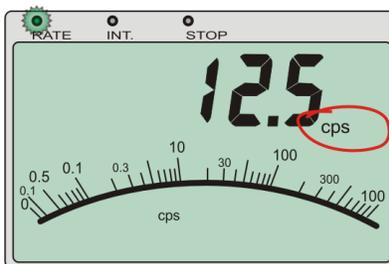


Figure 5 - cps readout screen

This screen provides a bar graph and digital display indication of the radioactivity detected by the probe in counts per second (**cps**).

In **cps** mode the value displayed indicates the total count rate detected by the probe and *includes* any contribution from environmental background radioactivity.

The green indicator LED will flash whilst the instrument is counting in this measuring mode

4.3.2 cps Minus Background Mode

Press the **Mode**  key to change the measuring units from **cps** to **cps minus background** mode. The display shows a bar graph as well as digital readout. The measurement units and mode are indicated by the “cps” and “– Background” text.

 In this mode the digital display will show the cps count rate with the last stored background count subtracted.

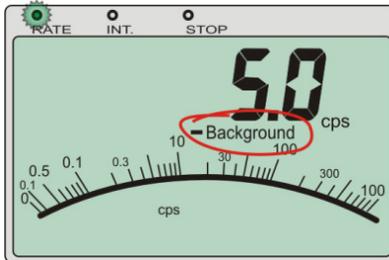


Figure 6 - Background subtracted CPS screen

The value subtracted for background **cps** will be that held in memory by the instrument. The operator may update the background value at any time. [See section 4.7]

 Stored background counts are held for each probe type. If the SA50 scintillator probe and SA49 GM probe are interchanged, the corresponding background reading for that probe type is automatically loaded and used in the background subtraction calculation.

4.3.3 Dose Rate Mode

Press the **Mode** key to change the measuring units from **cps minus background** to **Dose Rate** mode

The screen will show the analogue scale and digital display in $\mu\text{Sv/h}$ units. If the instrument has been configured for use in the USA then these units will be displayed in $\mu\text{R/h}$.

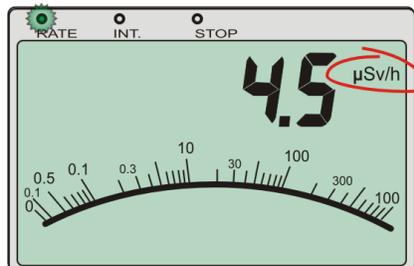


Figure 7 - Dose Rate screen with SI units

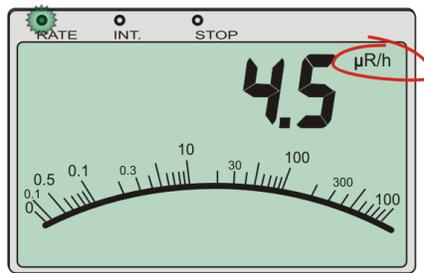


Figure 8 - Dose rate screen with US units

The green LED indicates that the instrument is recording data in real-time.

4.4 Modes of Operation for the Geiger Müller Probe.

Following initialisation – Section 4.2.4 - the user may choose to change the measurement unit mode. The various measurement modes for the Geiger Müller probe are:

- cps count rate (or cpm)
- background subtracted cps count rate (or cpm)
- Bq/cm² (background subtraction implicit in this mode)

Note: The **NORM Monitor-IS** is capable of displaying SI units as well as non-IS units (primarily US market). **Cps** and **cpm** are factory-set parameters and not configurable in the field.

In each case it is possible to select an integration mode where the readout is averaged over a period of time; thus giving the option to take a more statistically accurate measurement.

4.4.1 cps Mode

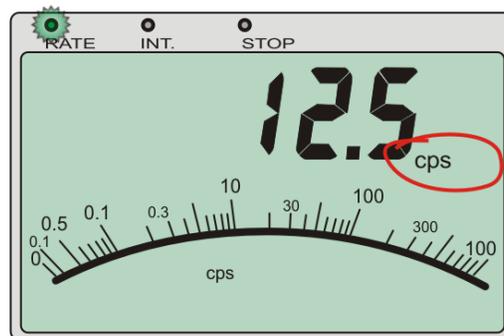


Figure 9 - cps readout screen

This screen provides a bar graph and digital display indication of the radioactivity detected by the probe in counts per second (**cps**).

In **cps** mode the value displayed indicates the total count rate detected by the probe and *includes* any contribution from environmental background radioactivity.

The green indicator LED will flash whilst the instrument is counting in this measuring mode

4.4.2 cps Minus Background Mode

Press the **Mode**  key to change the measuring units from **cps** to **cps minus background** mode. The display shows an analogue scale and digital numeral readout. The measurement units and mode are indicated by the “cps” and “- Background” text.

 In this mode the digital display will show the cps count rate with the last stored background count subtracted.

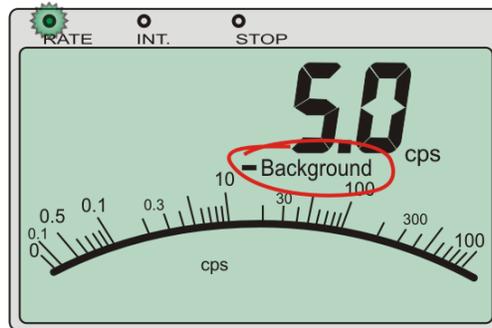


Figure 10 - Background subtracted CPS screen

The value subtracted for background **cps** will be that held in memory by the instrument. The operator may update the background value at any time. [See section 4.7]

 Stored background counts are held for each probe type. When the SA50 scintillator probe and SA49 GM probe are interchanged, then the corresponding background readings are automatically loaded.

4.4.3 Becquerels per cm squared mode (Bq/cm²)

This mode of operation uses a background-subtracted measurement along with a factory set calibration factor in order to calculate the Bq/cm² response. The user should ensure that a valid background reading has been logged prior to the target measurement.

This operating mode is intended for use where a specific nuclide is known to exist in the source of scale contamination to be measured. To carry out the measurement the user should select the Bq/cm² operating mode then select the required nuclide from the following list:

- Radium-226 wet (Ra226w)
- Radium-226 dry (Ra226 d)
- Lead-120 wet (Pb210w)
- Lead-120 dry (Pb210 d)

4.4.3.1 Selecting the radionuclide

1. Select Bq/m² mode by repeatedly pressing the **Mode** key.
2. Press the **Select** key to enter the nuclide selection menu
3. Press the **Mode** key to cycle through the radionuclide options.
4. Return to the Bq/cm² reading screen by pressing the **Select** key

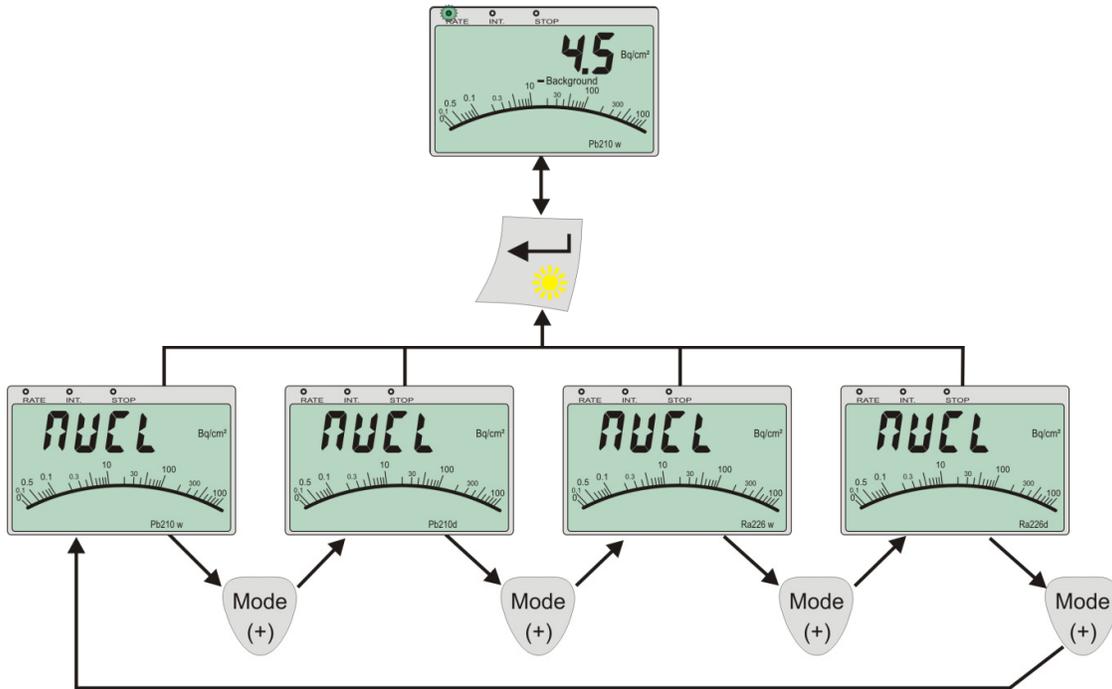


Figure 11 - Radionuclide selection in Bq/cm² mode

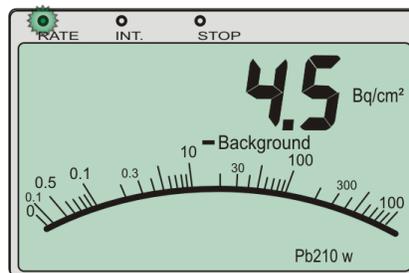


Figure 12 - Bq/cm² mode – Reading screen with Lead-210 (wet) selected

4.5 Integration Function

Each of the operating modes detailed in the above sections may utilise the integration measurement function.

4.5.1 Example – Making an integrated count measurement in *cps* mode

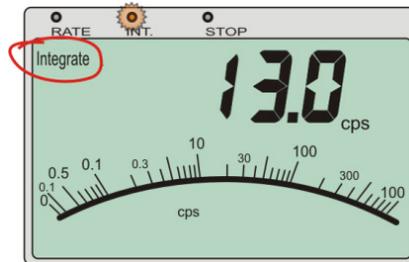


Figure 13 - *cps* integration screen

A single press of the **Rate/Int./Stop**  key starts the integrated *cps* measurement.

The period over which the measurement is recorded (the integration period) is detailed in [Section 4.5](#).

The statistical variation of this count will reduce as the accumulated count increases. The operator will see the displayed value gradually stabilise as the counting period progresses.

The operator may terminate the integration period manually by pressing the **Rate/Int./Stop**  key; whereupon the latest updated *cps* value will be displayed.

The amber **integrate** LED will flash during the measurement period. The red **Stop** LED will flash following the end of the integration period or after manual termination.



Figure 14 - Integration termination

The **stop** screen gives the opportunity for the user to log the reading before proceeding to the next operation / measurement.

Pressing the **Rate/Int./Stop**  key a final time will return the instrument to normal ("real time") measurement rate mode; visual confirmation being indicated with a flashing green **Rate** LED.

4.6 Alarm activation in integration mode

Whilst making an integrated measurement, alarm activation will not be invoked until after the integration period has expired.

If at the end of the integration period the alarm level is exceeded, then all three indicator LEDs will flash in unison and the sounder will be activated.

Moving the probe away from the source to a position where the radiation is below the alarm threshold will disable the sound but leave the LEDs flashing.

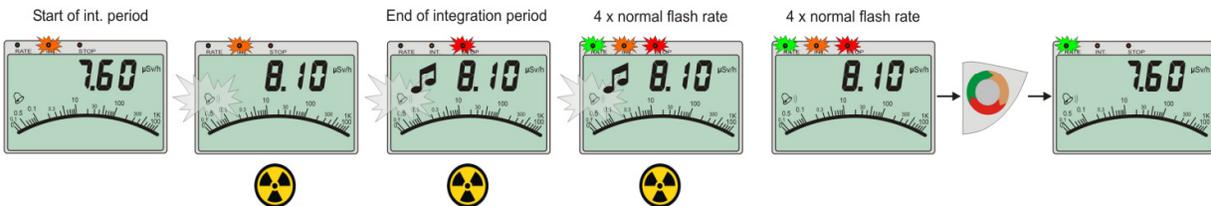
The audio and visual alarm operation is summarised in the following illustration.

[See also Section 4.8.2 Alarm notification table]

Rate Mode -
Alarm enabled
Level = 8.0µSv



Integration mode
Alarm enabled
Level = 8.0µSv



	Alarm enabled
	Alarm triggered
	Visual alarm - integration mode only
	Audible alarm

Figure 15 - Alarm operation with Integration mode

4.7 Background Measurement

It is good practice to update the background value held in the instrument at regular intervals; particularly where there has been a significant change in the environment where monitoring work is being carried out; or where the operator is uncertain of the value held in memory.

The measurement takes 60 seconds and thus provides a statistically accurate count value for use with background subtraction measurement modes.

⚠ If using more than one probe type, ensure that a background reading is taken for *each type* (ie SA50 & SA49).

Press the **Log Back-ground** key. The display will begin to flash indicating that a background measurement is in progress. The data presented represents a running average of the current measurement.

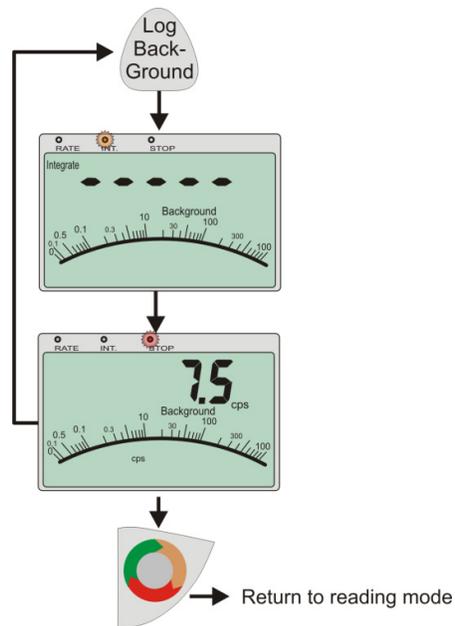


Figure 16 - Background measurement

After a period of one minute the monitor will cease counting and the new background value in *cps* (or *cpm*) will be displayed. The operator can accept this value or repeat the count by pressing the **Log Back-ground** key once more.

Press the **Rate/Int./Stop** key to accept the new reading and automatically update the value held in memory. The instrument will then return to its previous measuring mode.

4.8 Alarm Configuration

Alarm levels may be configured for each measurement mode (cps (or cpm); $\mu\text{Sv/h}$ (or $\mu\text{R/h}$); Bq/cm^2) and are retained in memory following power down or battery replacement.

The levels apply to the probe type connected. For example, the cps alarm level configured for the scintillation (SA50) probe may be given a different value to that of the corresponding cps alarm level for the GM probe.

Alarms may be enabled individually for each probe and measurement mode – as indicated by the on-screen alarm symbol .

The alarm status (enabled/disabled) is retained following power down or battery replacement.

4.8.1 Switching the alarm ON/OFF

The instrument's high pitched alarm sounder may be enabled and disabled using the configuration menu.

The comprehensive range of alarm options are either based on a single numerical value (**LEVEL**) or a multiple of the background level (**FACT** or.)

To access the Alarm settings, hold down the **alarm**  key for 3 seconds.

Note: momentary operation of the key will toggle the activity 'click' sounder on and off only.

The screen will display one of the two options shown below depending on current alarm status.

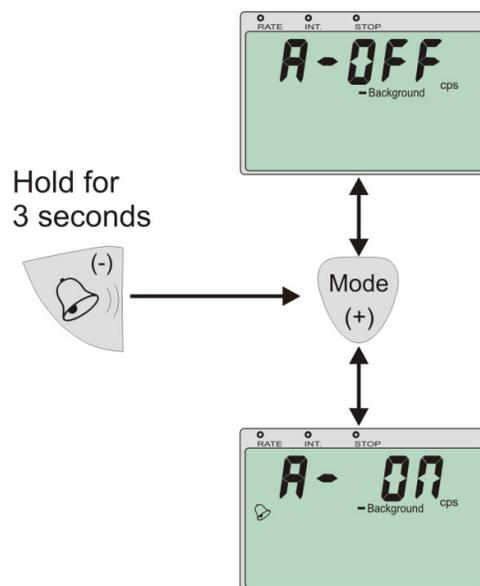


Figure 17 - Alarm ON/OFF selection

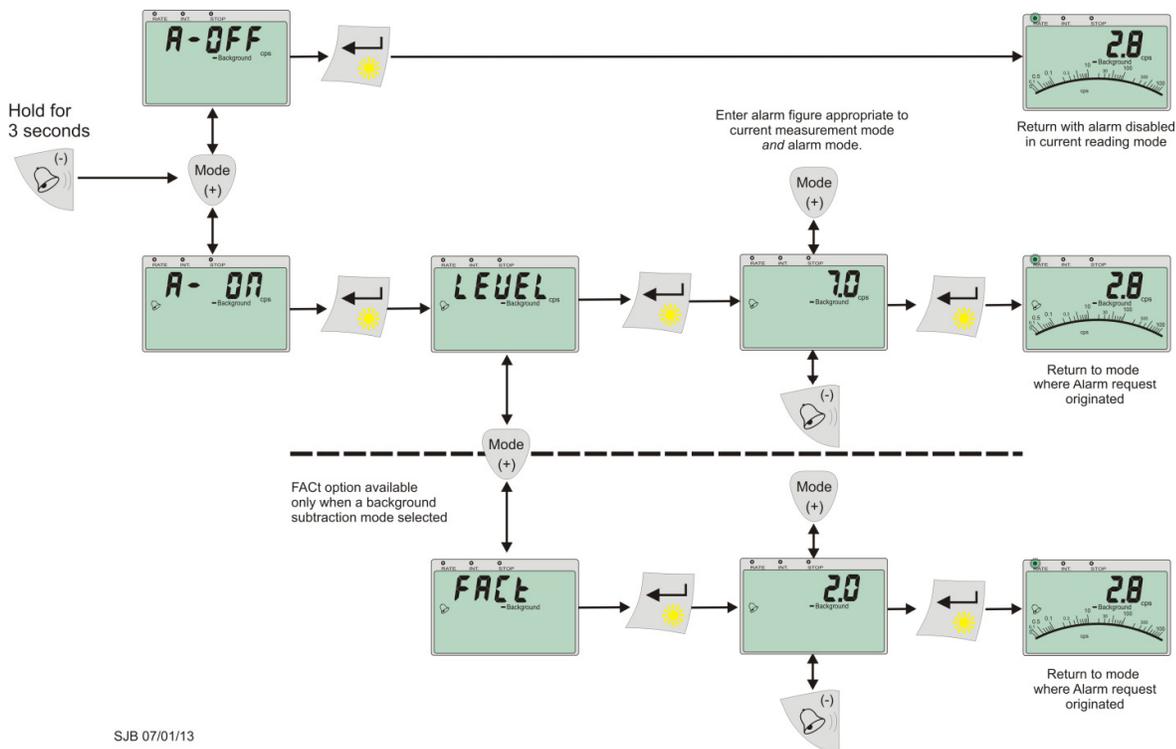
Pressing the mode key will toggle the alarm ON / OFF condition. If the screen display shows **A-OFF**, pressing the **Select** key will return the instrument to the measuring mode.

Note: that the alarm activation will only relate to the instrument's current measuring *mode*. i.e. *cps*, *Bq/cm²* or *Dose Rate*.

4.8.2 Selecting the alarm type

Having enabled the alarm for the current measurement mode, select the type of alarm according to the prescribed NORM assessment procedure [See Section 3.2]

Pressing the **Mode** key will toggle between the **LEVEL** and **FACT** options:



SJB 07/01/13

Figure 18 - LEVEL / FACT selection

Note: **FACT** option is only available for measurement modes which include background subtraction

In background subtraction measurement modes the value applied to **LEVEL** is the measurement *above* the background count at which the alarm is activated.

4.8.3 Setting Alarm Parameters

LEVELs

Alarm **LEVELs** are entered as a numeric value and are related directly to the value which is displayed on the instrument for the relevant measurement mode.

Having previously selected the **LEVEL/FACT** preference, press the **Select**  key and use the **Mode (+)**  or **Alarm (-)**  keys to increase or decrease the value displayed.

Confirm by pressing the **Select**  key. The instrument returns to the current measurement mode and applies the alarm parameters for that measurement mode and probe.

LEVEL setting example 1

Measuring mode: **cps**

Alarm configuration: LEVEL = 5 cps.

Result: Alarm triggered when the display indicates ≥ 5 cps.

LEVEL setting example 2

Measuring mode: **cps - background**

Alarm configuration: LEVEL = 5 cps.

Result: Alarm triggered when the display indicates ≥ 5 cps. This equates to an actual count rate of 5 + stored background count.

FACTors

The **FACT** option allows the alarm to be set as a multiple of the stored background measurement.

Having previously selected the **LEVEL/FACT** preference, press the **Select**  key and use the **Mode (+)**  or **Alarm (-)**  to increase or decrease the value.

Confirm the setting by pressing the **Select**  key. The instrument returns to the current measurement mode.

FACT setting example 1 (typ. Scintillator on-shore)

Measuring mode: **cps - background**

Alarm mode: **FACT**

Alarm parameter: **2**

Stored background count: **20 cps**

Result: Alarm triggered when displayed reading ≥ 20 cps [(2 x background) - background]

FACT setting example 2 (typ. GM probe)

Measuring mode: **cps - background**

Alarm mode: **FACT**

Alarm parameter: **3**

Stored background count: **0.5 cps**

Result: Alarm triggered when displayed reading ≥ 1 cps [(3 x background) - background]

4.8.1 Alarm options for each measurement mode

Table 6 – Complete set of alarm options

Operating mode	Alarm type	Description
Cps	Level	Alarm activated when total cps exceeds user-configured level
cps - background	Level	Alarm activated when cps <i>above</i> background radiation exceeds user-configured level
cps - background	Factor	Alarm activated when a multiple of background radiation is exceeded.
Bq/cm ²	Level	Alarm activated when Bq/cm ² exceeds user-configured level
Dose rate	Level	Alarm activated when total dose rate exceeds user-configured level
Dose rate minus background	Level	Alarm activated when dose rate <i>above</i> background dose rate exceeds user-configured level
Dose rate minus background	Factor	Alarm activated when a multiple of background dose rate is exceeded.

4.8.2 Alarm notification

The operator is alerted to an alarm condition using a combination of audio-visual indicators.

The alarm indications are summarised in the following table.

Table 7 - Alarm indications

Mode	Audible alarm	Visual Alarm – LEDs	Alarm indication on LCD display
Rate mode – green LED flashing	Continuous high pitch tone	None	Flashing symbol 
Integration in progress – amber LED flashing	None	None	Flashing symbol 
Integrated measurement complete (stop) – source of radiation still present	Continuous high pitch tone	3 x indicator LEDs high frequency flash	Flashing symbol 
Integrated measurement complete (stop) – source of radiation removed	None	3 x indicator LEDs high frequency flash	None

 Once an alarm is triggered, it may only be silenced by moving away from the source of radiation.

5 Adjusting the integration period

The versatility of the integration function is enhanced by the facility to configure the period over which the measurement is taken.

When the detected count rate is low, it may be advantageous to take a measurement over an extended period; thereby minimising the statistical error by giving an averaged count rate over the sample period. Conversely, due to the nature of on-site operations, the measurement may be subject to time restriction. The user may therefore decide to optimise the measurement period.

The following flow diagram details the integration period configuration procedure.

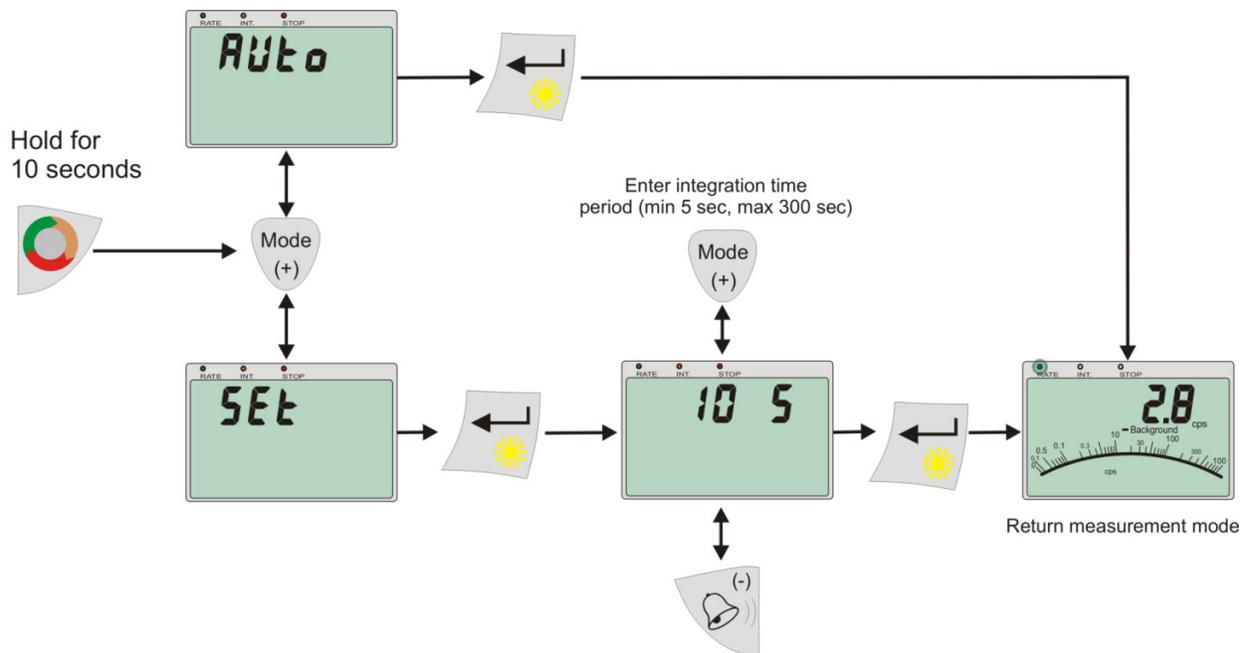


Figure 19 - Integration period configuration

Hold down the **Rate/Int/Stop** key for 10 seconds. The display will replace the current readout with either **Auto** or **Set** depending upon the previously selected integration mode.

Selecting the **Auto** mode invokes the behaviour detailed below.

- Integration maximum period/timeout = 60 seconds
- Integration ends if total count ≥ 1000

Auto is intended to provide a default measurement mode where statistical accuracy of the results could be made based on the parameters detailed above.

Selection of the **SEE** option provides the operator with a screen showing the current integration period in seconds. The +/- keys ( / ) may now be used to adjust the period within the range 0 to 600 seconds.

Note. In the unlikely event that the user wishes to disable the integration button function, then setting the integration period to "0" will render the **Rate/Int/Stop**  key non-operational.

Pressing the **Select**  key will commit the setting to memory and return the instrument to rate mode.

Mode and period parameters are retained in non-volatile memory. The instrument's configuration therefore survives power-cycle so that setup following power-on is unnecessary.

6 Locking the keypad

The operator, or supervisor, has the capability to lock the instrument keypad so that only essential functions are enabled.

A combinational key-press locks out the **Mode** and **Select** functions thus leaving the operator with a single-mode-use instrument.

Having configured the reading mode along with alarm and integration period configuration the user – or supervisor – may lock the keypad. The remaining effective key functions are:

Rate/Int./Stop*

Backlight

Log Background

Activity 'click' mute toggle

Activation / de-activation of the keypad is illustrated below.

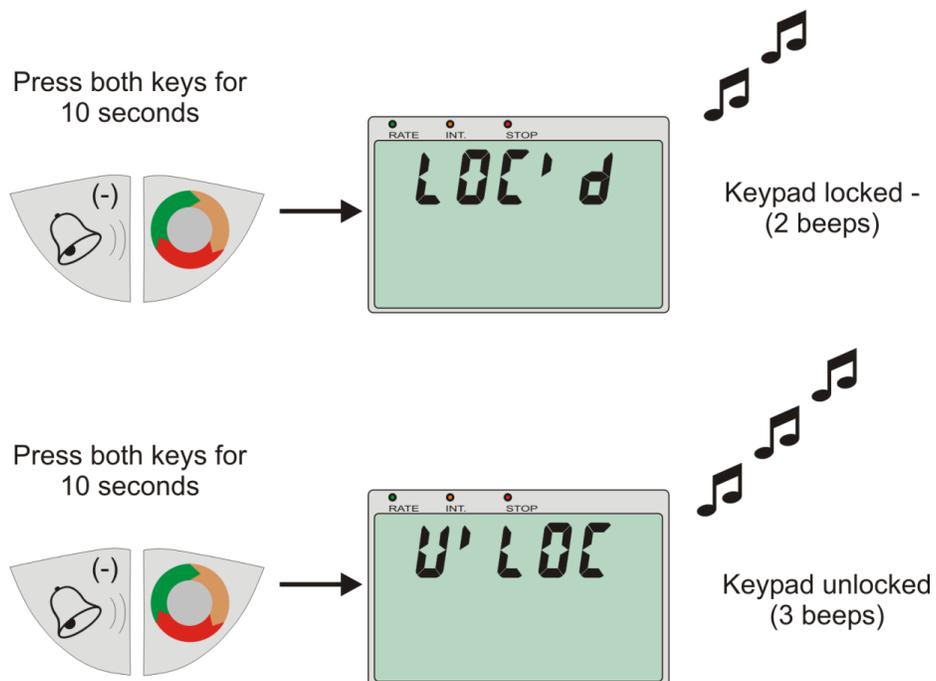


Figure 20 - Keypad lock

*Note: In the case where the **Rate/Int./Stop** function is to be disabled during keypad lock, then the integration period should be first set to zero [See Section 5]

7 Using the Instrument – taking a NORM measurement

Measurements of radioactivity at levels which are only slightly greater than background are subject to significant statistical uncertainty.

A more precise result can be achieved by using the monitor in *integration* mode which allows counts to be accumulated over a fixed time period.

The total accumulated count is then divided by the sample time to provide a statistically accurate, time averaged counts per second (or counts per minute) or dose rate.

Operation:

1. Take background reading (required if using background subtraction modes only)
 - a) Move the probe to a location which will represent the background radiation datum point for the site and not influenced by the source to be measured
 - b) Press **Log Background**  key as shown below
 - c) Wait until the red LED flashes. Press Rate/Int/Stop  to return to real-time *rate* display.

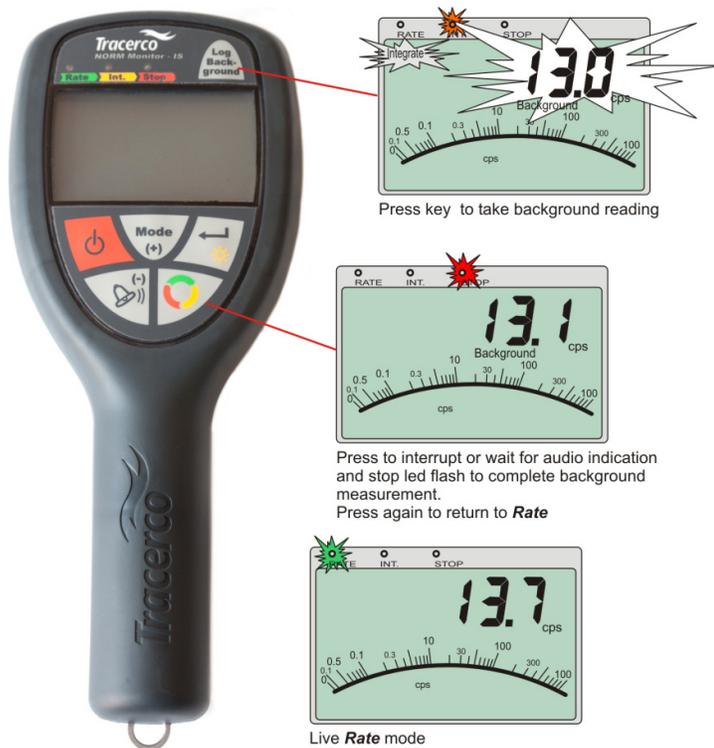


Figure 21 - Quick start guide to measurement

2. Select units.

Using the **Mode**  key, cycle through the various options associated with each probe type. For the SA-50 scintillation probe the options are:

- Cps
- Cps with background subtracted
- $\mu\text{Sv/h}$
- $\mu\text{Sv/h}$ with background subtracted

3. Press **Rate/Int./Stop**  key.

This will start the measurement as indicated by the flashing amber LED.

The instrument will complete the measurement once the pre-set integration period has elapsed [See Section 5 [Setting Integration Period.](#)]

The user may also interrupt this measurement by pressing the **Rate/Int./Stop**  key.

4. Red LED flashes. The measurement is complete.

The measurement will continue to be displayed until the user presses the **Rate/Int./Stop**  key. The instrument will now return to a live real-time display as indicated by the flashing green LED.

5. If at the end of the integration period the alarm level is exceeded, then all three indicator LEDs will flash in unison and the sounder will be activated.

Removing the source of radiation will clear the sounder but the LEDs will continue to flash until the user presses the **Rate/Int./Stop**  key to return to rate mode.

[This operation is summarised in Section 4.6 [Alarm activation in Integration Mode](#)]

Note that the alarm operation in Integration mode is different from that in rate mode in which case the alarm is activated immediately after levels are exceeded.

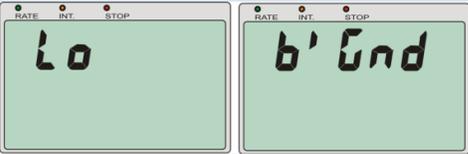
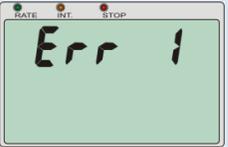
Note: the background count is stored in non-volatile memory so that the reading is retained even if the instrument is switched off.

 *The operator is responsible for ensuring the background measurement is kept current and therefore applicable to the measurement in hand. The site RPA (or deputy) will advise on frequency and location of background radiation measurements*

8 Faults /Troubleshooting

The following table shows error conditions and notification.

Table 8 – Troubleshooting

Fault	Notification	Actions
No probe detected		<ul style="list-style-type: none"> • Connect a compatible probe • Examine cable and connector for damage. In case of damage, return to Tracerco for repair.
Low count rate detected – possible failure of probe detector element or cable	<p>After 20 seconds of zero counts...</p>  <p>Further 20 seconds...</p> 	<p>⚠ Move to an area of higher activity. If error persists, return to Tracerco for diagnosis</p>
Low battery		<p>⚠ Move to non-hazardous area and change the battery.</p>
Over range		<p>⚠ Move away from source of radiation</p>

9 Display ranges – reading the screen

The following images illustrate the range of the instrument according to each measurement unit selection.

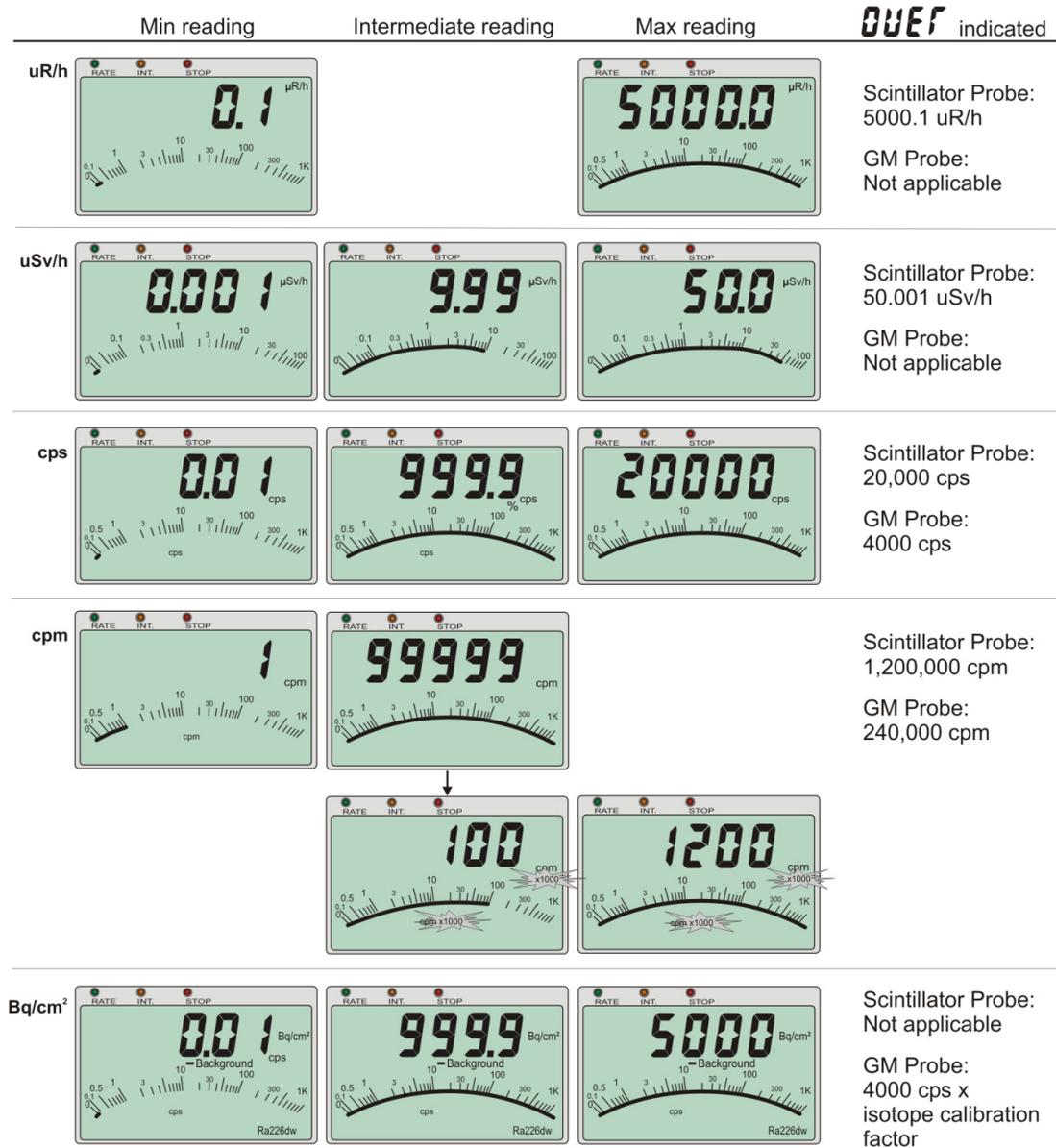


Figure 22 - Display ranges

10 Maintenance and Calibration

The **NORM Monitor-IS** has been designed for reliable operation in heavily industrialised environments and should provide many years of effective service provided attention is paid to basic operational maintenance.

10.1 Cleaning

The **NORM Monitor-IS** features a thermoplastic handset and Geiger probe housing which are manufactured from materials with excellent chemical resistance and inherent antistatic properties. The plastic cases may be cleaned by wiping with a slightly moistened cloth. A mild detergent may be used if required.

The Scintillator probe is manufactured from stainless steel and phosphor bronze. The IP67 enclosure is designed to be hosed down thereby facilitating decontamination.

⚠ Care should be taken to protect the cable termination plugs during the cleaning process.

10.2 Handling

Maintenance of the mechanical integrity and antistatic properties of the **NORM Monitor-IS** housing are critical for use in explosive atmospheres. While the **NORM Monitor-IS** has a tough design, unnecessary impacts, abrasions or contact with harmful chemicals should be avoided.

Tracerco recommend that the monitor and its probes are transported in a suitably robust transit case.

⚠ The user is advised not to open the **NORM Monitor-IS** or any of its associated probes.

⚠ The **NORM Monitor-IS** kit has no serviceable parts and should be returned to Tracerco in the event of damage. It is essential for safety integrity, that repair of this ATEX certified equipment is carried out by qualified personnel in accordance with the appropriate standards and regulations.

10.3 Calibration

All probes are delivered ready-calibrated; the calibration data being held in the probe itself and loaded into the handset once connected.

In surface activity (Bq/cm^2) mode the **Geiger Probe (SA49)** has been calibrated against traceable plaques of known nuclides.

The **Scintillator Probe (SA50)** in dose rate mode is calibrated against a traceable Cs-137 source.

When measuring dose rates where the source is known to contain Ra-226, the displayed rate will be in the order of 30% below that from a Cs-137 source with the same activity.

Ionising radiation legislation recommends that all operational radiation measurement devices are subjected to regular inspection and testing. This recommendation includes performance checks and where appropriate, recalibration of the monitor.

All **NORM Monitor-IS** probes are checked and calibrated immediately prior to despatch to the customer. Following this initial procedure (or the regular inspection and calibration check), Tracerco engineers will set the next calibration check due date within the probe's memory.

To assist in providing customers with a more efficient and comprehensive service, Tracerco's in-house database holds records of all monitors supplied to customers, including details of inspections, repairs, replacements and calibrations. This database provides a cradle-to-grave history for the tracking of radiation monitors.

Tracerco has several calibration and repair facilities throughout the world. Contact Tracerco customer services to find your nearest facility.

10.4 Equipment Inspection

Tracerco recommends that all portable Hazardous Area approved instruments receive an annual inspection by an appropriately trained technician. The requirement for annual inspection is consistent with EN 60079-17.

Tracerco are able to provide an appropriate inspection service and should be contacted for further details [See section **Error! Reference source not found.**]

10.5 Repair

Repair of the equipment shall be carried out by suitably trained personnel in accordance with the applicable code of practice e.g. **IEC/EN 60079-19**

All parts used in the repair of the **NORM Monitor-IS** must be supplied by Tracerco.

- ⚠ If the equipment is likely to come into contact with aggressive substances, it is the responsibility of the user to take suitable precautions to ensure the type of protection provided by the equipment is not compromised.

11 Essential Safety Information For Hazardous Areas

The **NORM Monitor-IS** handset and probes are safe for use in hazardous areas described in the equipment marking and according to the essential safety information stated below.

Marking details

ATEX Certificate number: Baseefa12ATEX0209X
IECEX Certificate number: IECExBAS12.0114X
ATEX Equipment Marking: Ex ia IIC T4 Ga (-20°C ≤ Ta ≤ +50°C)
Equipment category: II 1G

Approval standards

BS EN 60079-0:2012 – Explosive atmospheres. Equipment. General requirements
BS EN 60079-11:2012 – Explosive atmospheres. Equipment protection by intrinsic safety “i”

Limitations of hazardous area use

ATEX coding **II 1G** states that the equipment is for non-mining use (II) with highest protection (1) for gas (G) atmospheres.

Electrical coding **Ex ia IIC T4 Ga (-20°C ≤ Ta ≤ +50°C)** states that the equipment is intrinsically safe (ia) for use in zones 0, 1 and 2 and that it may be used in areas where flammable gas groups IIA, IIB, and IIC are present. T4 indicates that the equipment is suitable for use in flammable gasses with a T Class of T1, T2, T3 or T4. The ambient working temperature for the equipment is -20°C - +50°C.

Conditions of safe use (indicated by “X” extension in certification number)

- Care must be taken during transportation, removal and replacement of the scintillator from the PM Probe in the hazardous area to avoid impact with the aluminium casing of the scintillator.

Practical safety points

- Do not open the battery compartment in a hazardous area.
- Use only the Duracell MX1604 or MN1604 alkaline manganese battery.
Lock the battery compartment by the screw in the compartment lid -do not over-tighten.
- Do not use solvents on the handset monitor window.

12 Contact Us

Contact us at one of our Global Service Centres

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Email: tracerco@tracerco.com

Please visit the Tracerco website www.tracerco.com for details of other Tracerco offices and locations.

Tracerco manufacture a wide range of intrinsically safe and standard ration monitoring products.



Tracerco can provide a professional, rapid turnaround calibration and repair service as well as offering a hire service for a range of monitors.

Our experience technicians can also provide an annual Hazardous Area Equipment Inspection as described by IEC 60079-17

13 Technical Specification

13.1 Radiological Type Tests

Table 9 - Radiological type test

Instrument	Applicable standard	Description
NORM Monitor-IS with Geiger probe	BS EN 60325:2004	Radiation Protection Instrumentation – Alpha, Beta and Alpha/Beta (Beta 60keV) contamination meters and monitors
NORM Monitor-IS with Scintillation detector	BS EN 62363:2011	Radiation protection instrumentation – Portable photon contamination meters

13.2 EMC Compliance Tests

Table 10 - EMC compliance

Applicable standards	Description
BS EN 61326-1:2006	Electrical equipment for measurement, control and laboratory use.
BS EN 61000-4-2:1995+A1+A2:2001	Electrostatic Discharge
BS EN 61000-4-3:2002	Radiated Electromagnetic Field Immunity
BS EN 61000-4-8:1993	Magnetic Field Immunity
BS EN 55011:2007	Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement

13.3 Battery power

Table 11 - Battery power

Technology	Alkaline Manganese
Format	PP3 (9v)
Approved part numbers	MX1604; MN1604
Battery life (excluding backlight)	Scintillator probe: 82 hours Geiger probe: 190 hours
Low battery indication	7.8 Vd.c.

13.4 Mechanical

Table 12 - Mechanical data

Unit	Dimensions / weight
Handset meter	250 x 110 x 50mm / 500g
Scintillator probe	220 x 42mm diameter / 746g
Geiger probe	200 x 85 x 55mm / 483g
Holsters + belt	700g

13.5 Environmental

Table 13 - Environmental specification

Operating Temperature	-20 to +50 °C
Storage Temperature	-20 to +50 °C
Humidity	0 – 95%
Shock	Drop tests according to BS EN 60079-0
Ingress protection:	
Scintillator probe	IP67
Geiger probe	IP34
Handset meter	IP65

13.6 Radiological performance

13.6.1 Scintillator Probe

Table 14 - Scintillator probe specification

Radiation detected	gamma, beta
Sensor technology	Nal(Tl) scintillation crystal
Units	µSv; µRad; cps; cpm
Dose rate	0.000 – 50µSv/h (0.0 – 5,000µR/h)
Alarms	Alarm levels configurable for full range in all units Alarms configurable as defined numerical limit or as multiple factor of stored background in 0.5 increments
Overload response	OVER range displayed at 240,000 cps. Derived-units overload figure dependent upon calibration factors.
Variation with temperature	Less than ±10% over temperature range -20 to +50 °C

13.6.2 Geiger Müller Probe

Table 15 - Geiger probe specification

Radiation detected	alpha, beta, gamma
Sensor technology	Geiger Müller End Window (Pancake)
Units	cps/cpm; Bq/cm ²
Alarms	Alarm levels configurable for full range in all units Alarms configurable as defined numerical limit or as multiple factor of stored background in 0.5 increments
Overload response	OVER range displayed at 4000 cps. Derived-units overload figure dependent upon calibration factors.
Variation with temperature	Less than ±10% over temperature range -20 to +50 °C

13.7 Hazardous area approval

Table 16 - Hazardous area approval

Certification numbers	ATEX certificate reference: 12ATEX0209X IECEx certificate reference: IECExBAS12.0114X
ATEX Equipment mark	 II 1G Ex ia IIC T4 Ga (-20°C ≤ Ta ≤ +50°C)

14. Appendix 1 – Decay Series for Uranium and Thorium

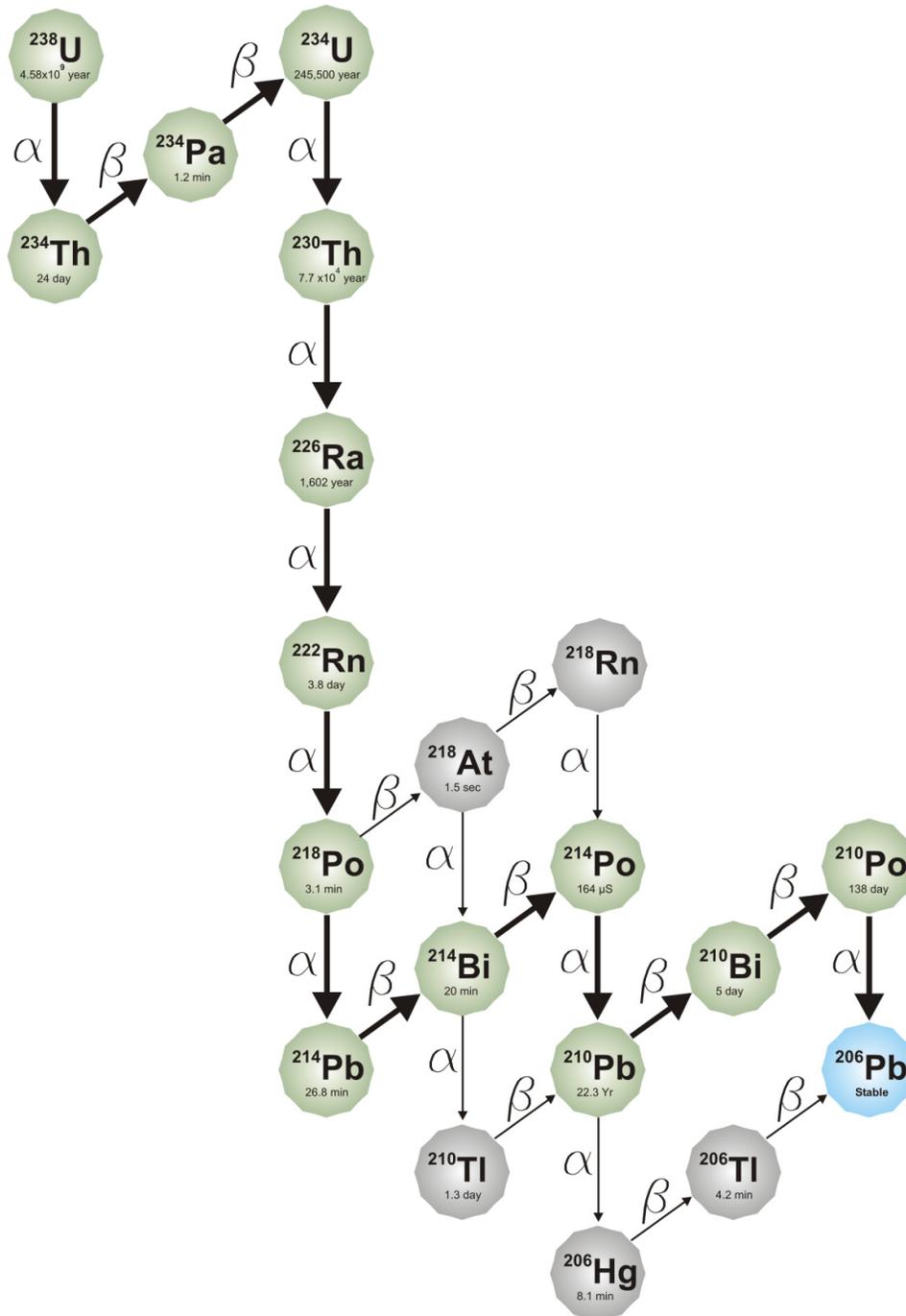


Figure 23 - U-238 Decay chain

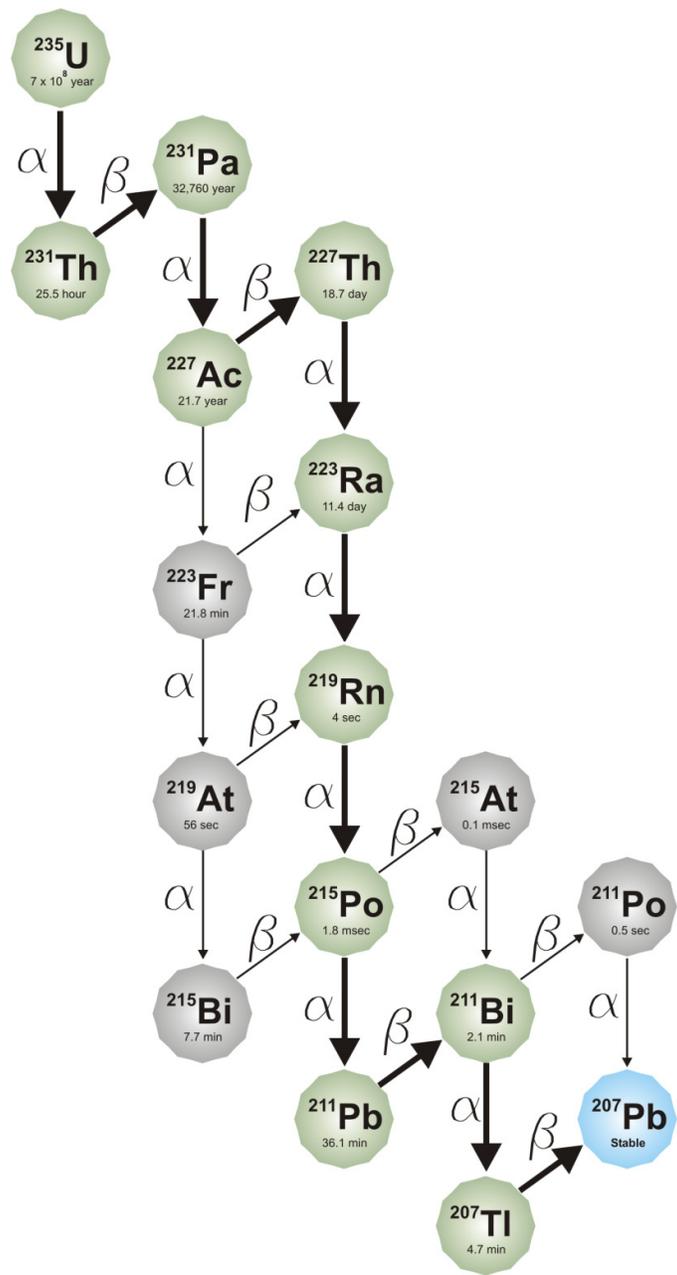


Figure 24 - U235 Decay Chain

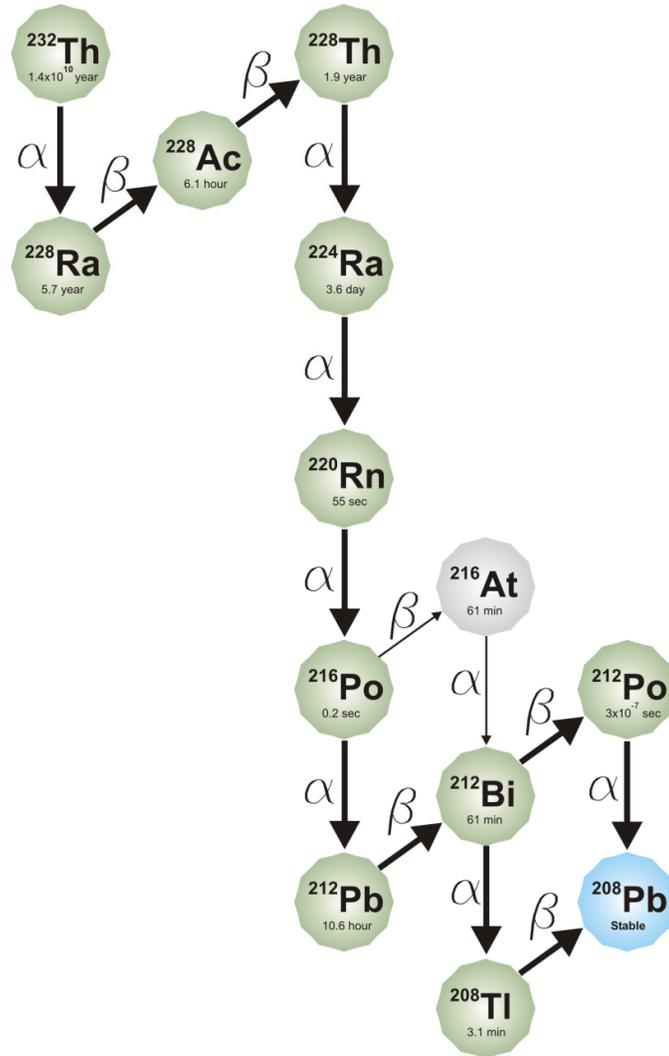


Figure 25 - Thorium-232 Decay Chain

14 Appendix 2. - Menu diagrams

14.1 Scintillator probe Menu

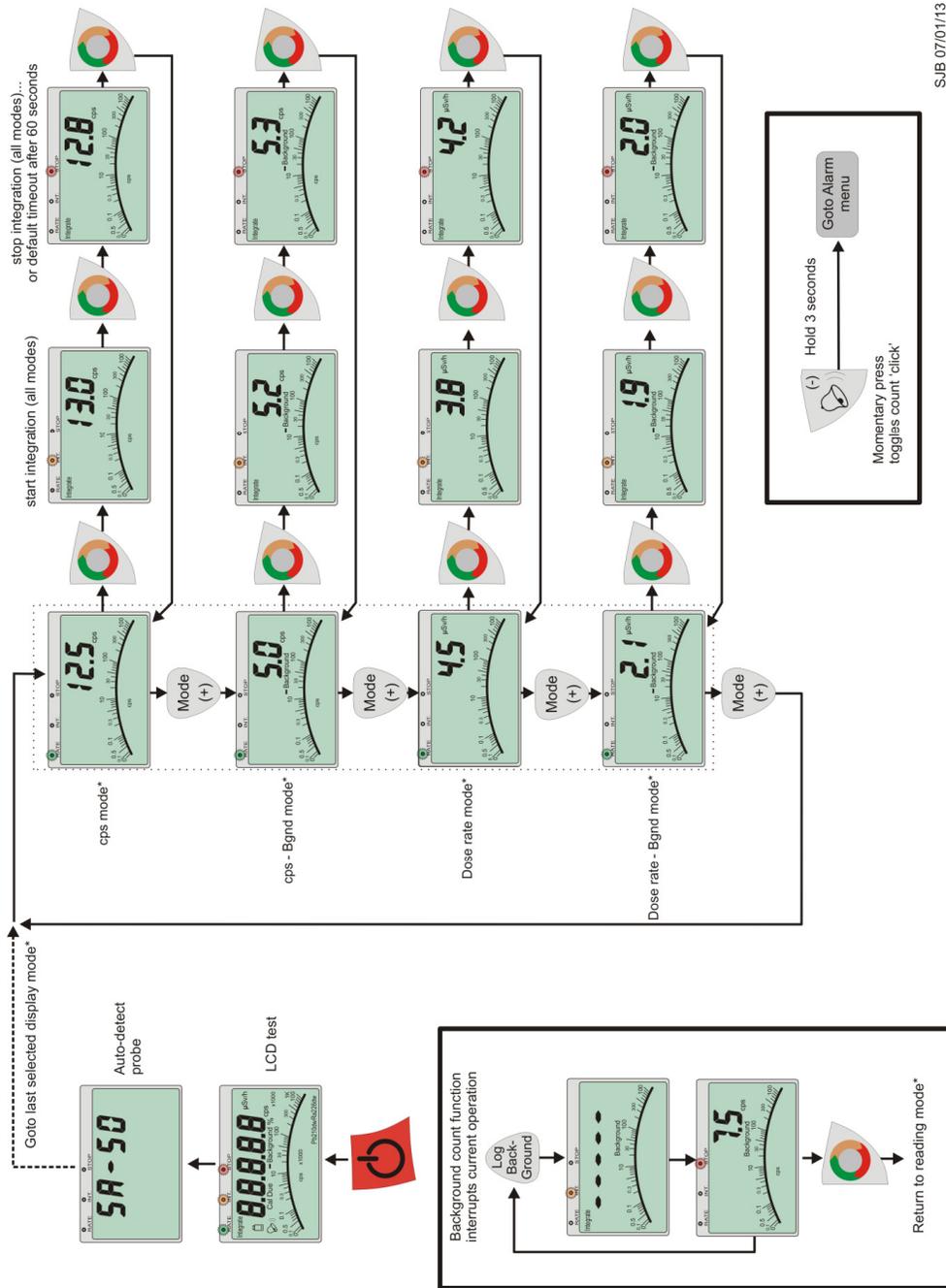


Figure 26 - Complete scintillator probe menu

