



Johnson Matthey

TRACERCO T401 Contamination Monitor USER MANUAL



Quality Assurance

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Table of Contents

1	General Description.....	5
2	Operational Safety.....	6
3	Post Delivery Checks.....	7
4	Operational Features.....	8
4.1	Switch On.....	8
4.2	Speaker.....	8
4.3	Backlight.....	8
4.4	Low Battery.....	8
4.5	Pre-Set Alarm.....	8
4.6	Detector Probe.....	9
4.7	Calibration.....	9
5	Measurement of Radiation Contamination.....	10
5.1	Procedure.....	10
5.2	Bargraph Display.....	10
5.3	Digital Numeric Display.....	10
5.4	Peak Display.....	10
5.5	Mode / Select.....	10
5.6	Nuclide Calibration Selection.....	11
5.7	Carry Out a “Background” Count.....	11
5.8	Carry Out a “Nuclide Measurement”.....	12
5.9	Nuclide Options.....	13
5.10	Operational Ranges.....	14
5.10.1	T401 Functional Diagram.....	14
5.11	Setting Alarm Trip Levels.....	15
5.11.1	Sounder Options.....	15
5.11.2	Setting the Alarm Trip Level.....	16
6	Detector Probe.....	17
6.1	Probe Retained in Monitor Yoke.....	17
6.2	Remote Probe / Yoke Assembly.....	17
6.3	Remote Probe with Telescopic Extension Kit.....	17
7	Maintenance and Calibration.....	18
7.1	Battery Replacement.....	18
7.2	General Maintenance.....	18



7.3	Repair and Calibration	19
7.3.1	Calibration Plaques	19
8	Technical Specification	20
9	Monitor Response	21
9.1	Affects of Gamma Radiation	21
10	Hints for Radiation Contamination Monitoring	22
11	Health and Safety	23
11.1	Training	23
11.2	Battery life	23
11.3	Probe	23
11.4	Radiation reading	23
11.5	Alpha radiation	23
	Revision History	25



1 General Description

The Tracerco T401 is a portable battery operated radiation contamination monitor, capable of measuring alpha, beta and gamma radiation over a wide range of energies. Radiation detection is carried out using a thin window Geiger Muller Tube located in a detachable probe adjacent to the head of the monitor.

Tracerco has extensive experience of the practical difficulties which may be encountered when attempting to carry out contamination monitoring of both man-made and naturally occurring radioactivity under hostile and restrictive environmental conditions, particularly those which relate to the Chemical, Mining, Nuclear and Oil and Gas Industries.

The Tracerco T401 has been designed to address many of these practical issues in providing a monitor which is reliable, versatile, easy to use and capable of operating in adverse environmental conditions.

A key feature of the Tracerco T401 is the capability to allow pre-programming of detection efficiency data for a wide range of radionuclides enabling recorded counts/sec to be automatically translated into more radiologically significant units of Bq/cm². There are additional design elements which are fully described in this manual and combine to make the T401 an invaluable instrument for use in radiation contamination monitoring.



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2 Operational Safety

The Tracerco T401 Contamination Monitor is a portable battery operated device which has been designed to exacting standards to operate reliably in adverse environments.

Typical battery life is around 100 hours. A 'LO BATT' warning appears on screen when the residual capacity reduces to about 4 hours. When the residual charge is exhausted, the screen clears.

A selectable backlight facility allows measurements to be made under dark or low light conditions. (Note that the extended use of this function will significantly reduce battery life).

An audible response is also available to complement visual measurements.

In the event of a GM tube failure or circuit malfunction which interrupts the radiation detection signal, the screen will indicate the following warning message "ERR1".



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3 Post Delivery Checks

All monitors supplied by Tracerco have been fully inspected, tested and calibrated prior to shipping. The monitor will be fitted with a new battery and available for immediate operation.

Each monitor is supplied in a protective overpack for transportation (customers may purchase an alternative, special transport and storage case).

All monitors should reach the customer in perfect working order.

In the unlikely occurrence of a problem, please contact Tracerco immediately (contact numbers are provided within this manual).

PLEASE ENSURE THAT THE MONITOR RADIATION TEST AND CALIBRATION CERTIFICATE IS PRESENT IN THE PACK. (Certificates should be filed in a safe place for future reference. In the event of difficulties, duplicate certificates can be provided by Tracerco free of charge, they are also available on our webtracker.

4 Operational Features

Owners should also refer to the Main Menu Structure for Functionality

4.1 Switch On

The monitor is activated by pressing the **RED** on / off switch. This switch has a toggle action – press for **ON** and press again for **OFF**. In the absence of any significant local radiation sources the meter will register incident background radiation which will vary with geographical location. A typical background reading on the monitor would be of the order of 0.5 – 1 count per second.

Please note that there may be a slight delay of one or two seconds between physically operating the switch and the screen clearing of information.

4.2 Speaker

Pressing the **GREY** switch with the speaker symbol activates the internal speaker. The speaker provides an audible clicking sound whose rate is proportionate to the amount of radiation registered by the detector.

The speaker may be silenced by re-pressing the **GREY** switch. The speaker symbol shows on screen when the audible option has been selected. Battery life is extended with the speaker off.

4.3 Backlight

The monitor display is fitted with a backlight, which is available for use in situations of low ambient light intensity. The **GREY** switch with the sunburst symbol is pressed to activate the backlight facility. Since the backlight significantly increases the current drain on the battery, the pushbutton switch is designed for contact operation only i.e., depressing the switch activates the backlight and releasing the switch cancels the light.

4.4 Low Battery

The monitor is equipped to display a “LO BATT” message. Although it is recommended that the battery be replaced as soon as this message is activated, it might be expected that under normal conditions, the monitor is capable of operating for a further 4 hours.

4.5 Pre-Set Alarm

The monitor is equipped with an alarm function which the operator can pre-set, within prescribed limits, to any desired level of counts per second (**cps**) or **Bq/cm²**. If an alarm level is set in the **cps** mode, it will not be available when in the **Bq/cm²** mode (and vice versa). An alarm is a continuous high frequency tone whenever the measured reading exceeds the pre-set value. The alarm may be deactivated by the operator. There is no mute (accept facility) for the alarm. Alarm activation is indicated by a flashing loudspeaker icon.

4.6 Detector Probe

The T401 Contamination Monitor is equipped with a thin window Geiger Muller detector located in a special probe attached to the head of the monitor. The detector has the capability to measure alpha, beta and gamma radiation over a wide range of energies and its delicate, recessed front window is protected by an open mesh steel grille during use. (Although the mesh provides protection from a rupture of the thin window by large objects during use, the window remains delicate and vulnerable to puncture by thin sharp objects and care should be exercised at all times when carrying out monitoring operations).

The detector probe normally rests within a special yoke attached to the monitor, with the face of the probe orientated into and protected by the main body of the monitor. This orientation is recommended during storage or transportation. The probe is connected to the monitor via a flexible cable which is normally retained within the horseshoe-shaped skid attached to the monitor.

The probe is designed to be used in three possible ways during monitoring operations:-

- Probe remains attached to the monitor yoke but rotated to suit monitoring requirements.
- Probe and the yoke are decoupled from the body of the monitor for hand operation. The flexible cable allows remote operation up to 1.5-metres from the body of the monitor.
- Probe and yoke are removed from the body of the monitor and attached to the extendable arm (purchased option). The orientation of the probe is adjustable relative to the extension arm to provide maximum flexibility when monitoring. (Further information on these monitoring options is provided in section 6 describing the detector probe).

4.7 Calibration

Current UK legislation requires that all operational radiation monitors are subject to annual inspection and testing. This requirement includes for performance checks and where appropriate, recalibration of the monitor.

The calibration due date will be displayed on a label attached to the monitor. This date will indicate the 12-month anniversary of the current calibration. This can be added to appear on the monitor screen during start up if requested on purchase or when calibrating the monitor; then when switching on the contamination monitor, the next calibration check due date will register automatically on the screen for approximately 2 seconds.

All Tracerco radiation monitors are checked and calibrated immediately prior to despatch to the customer. Following this initial procedure (or the annual inspection and calibration check), Tracerco operatives will re-set the next calibration check due date within the software of the monitor.

For further information on the calibration procedure refer to sections 7.3 and 9.

5 Measurement of Radiation Contamination

5.1 Procedure

Switching on the monitor will display all available segments for approximately 2 seconds (as shown below). A check should be performed for any missing segments.



For the following 2 seconds, the next 'Cal Due' date will show using a MM-YY format. The monitor then enters normal operation (cps mode).

5.2 Bargraph Display

This display provides a reading in the range 0cps – 1000 cps. Maximum resolution is provided in the range 0 – 10cps, which is considered to be the most critical range for routine waste characterisation purposes.

If the probe is exposed to activity levels which exceed the maximum count rate of 1000 cps, the bargraph will remain at full scale deflection until the source of radiation is removed.

5.3 Digital Numeric Display

There is a 5 digit digital display. For radiation levels below 100cps or 100 Bq/cm² the monitor will give a reading to 2 decimal places. The maximum indication is 4000 cps or its equivalent in Bq/cm²

5.4 Peak Display

The meter is capable of numerically indicating the highest radiation level to which the probe has been exposed since the instrument was switched on. Switching off will clear this reading.

Pressing the green **PEAK** button will show this reading. (During this period peak value continues to be updated). A second press of the "**PEAK**" button during this period will return monitor to normal function.

Pressing **SELECT / RESET** button whilst displaying the peak reading will reset the peak reading to zero.

5.5 Mode / Select

The yellow **MODE** and green **SELECT / RESET** buttons are required when accessing various functions associated with the monitor.

5.6 Nuclide Calibration Selection

In order to carry out a radiological assessment of the data obtained during contamination monitoring, it is necessary to know the efficiency response of the monitor for the radionuclide under investigation and to make the appropriate calculations.

The Tracerco T401 has been specially developed to provide a direct reading of the level of contamination in Bq/cm² for a number of radionuclides which the operator can pre-select.

The efficiency calibration response functions of the monitor for various radionuclides are pre-programmed into the instrument software. These functions are also checked and reset during the annual inspection and calibration process.

In order to carry out a 'statistically' effective measurement of surface activity it is necessary to accumulate counts over a reasonable timeframe and to make appropriate corrections for 'background' levels of radiation. The following procedures should be followed when carrying out a radiological measurement.

5.7 Carry Out a "Background" Count

After switch on press the yellow **MODE** button to select the background function (allow 5 seconds for the display function to normalise). The **BGnd** message will appear on the screen. Confirm this choice by pressing the **SELECT / RESET** button.

The monitor will commence a background radiation count which will continue for a period which, based on environmental levels, is sufficient to provide a statistically acceptable count. A typical count duration is 60 seconds. The unit has been pre-programmed to accumulate and terminate this count. During the count period, the display will show the real time integration of counts. After the count has been automatically terminated, the display will show the mean value of the 'Background' count in counts per second. This value will be automatically stored in memory.

Press the **SELECT / RESET** button to accept this count and move to Bq/cm² monitoring. Alternatively press the **MODE** button to repeat a background count.

The background count will remain in memory after the monitor has been turned off. This value will only be updated when the above procedure for carrying out a background count is repeated.

5.8 Carry Out a “Nuclide Measurement”

Following selection of the background count the display moves to the **Bq/cm²** screen. Confirm this choice by pressing the **SELECT / RESET** button, whereupon the message **NUCL** will appear on the screen. The previously selected radionuclide will also appear at the base of the screen. Scroll back and forth through the various nuclide options using the **MODE** and **PEAK** buttons to locate the one which is required and confirm your choice by pressing the **SELECT / RESET** button. This operation will also start the count integration.

(Note; there are 16 radionuclide options and one cps option, which, if chosen by pressing **SELECT / RESET**, will revert the monitor to a cps display. Pressing the **MODE** button will continue the scrolling operation, pressing the **PEAK** button will scroll in opposite direction). The unit will display the value of **Bq/cm²** in real time.

Pressing the **MODE** button whilst in **Bq/cm²** will return the digital display and associated functions to cps mode. (NB: The analogue display will always display “live” cps, irrespective of which functions are being selected in the digital display).

Each nuclide has a different response factor ie the number of counts detected by the monitor per becquerel of activity and the correct value of activity will only be displayed if the operator has selected the actual nuclide which is being measure. A mis-selection will result in either a higher or a lower value than the result, depending on the exact circumstances.



5.9 Nuclide Options

The Tracerco T401 monitor has been pre-calibrated to measure the list of nuclides given below. These nuclides have been shown to be of general interest for a wide range of environments where contamination monitoring might be required. In the event that the operator requires calibration against a range of alternative isotopes, Tracerco will endeavour to provide the appropriate functionality (subject to the availability of suitable calibration materials). These options are currently listed on the screen as Nuclide 1 to 9. The customer will be required to specify any additional nuclide calibrations at the time of purchase (Subject to Tracerco having capability to source the appropriate radionuclides in a form suitable for calibration). The identity of the radionuclides will remain on the screen as 1 to 9. It is recommended that special calibration requirements be discussed with a representative of the Tracerco monitor calibration and repair service.

Option 1	Americium-241
Option 2	Carbon-14
Option 3	Chlorine-36
Option 4	Lead-210 (d)
Option 5	Lead-210 (w)
Option 6	Radium-226 (d)
Option 7	Radium-226 (w)
Option 8	Strontium-90
Option 9	Cobalt-60
Option 10	Phosphorus-32
Option 11	Plutonium-239
Option 12	Uranium-238
Option 13	Caesium-137
Option 14	Nuclide 1
Option 15	Nuclide 2
Option 16	Nuclide 3
Option 17	Nuclide 4
Option 18	Nuclide 5
Option 19	Nuclide 6
Option 20	Nuclide 7
Option 21	Nuclide 8
Option 22	Nuclide 9

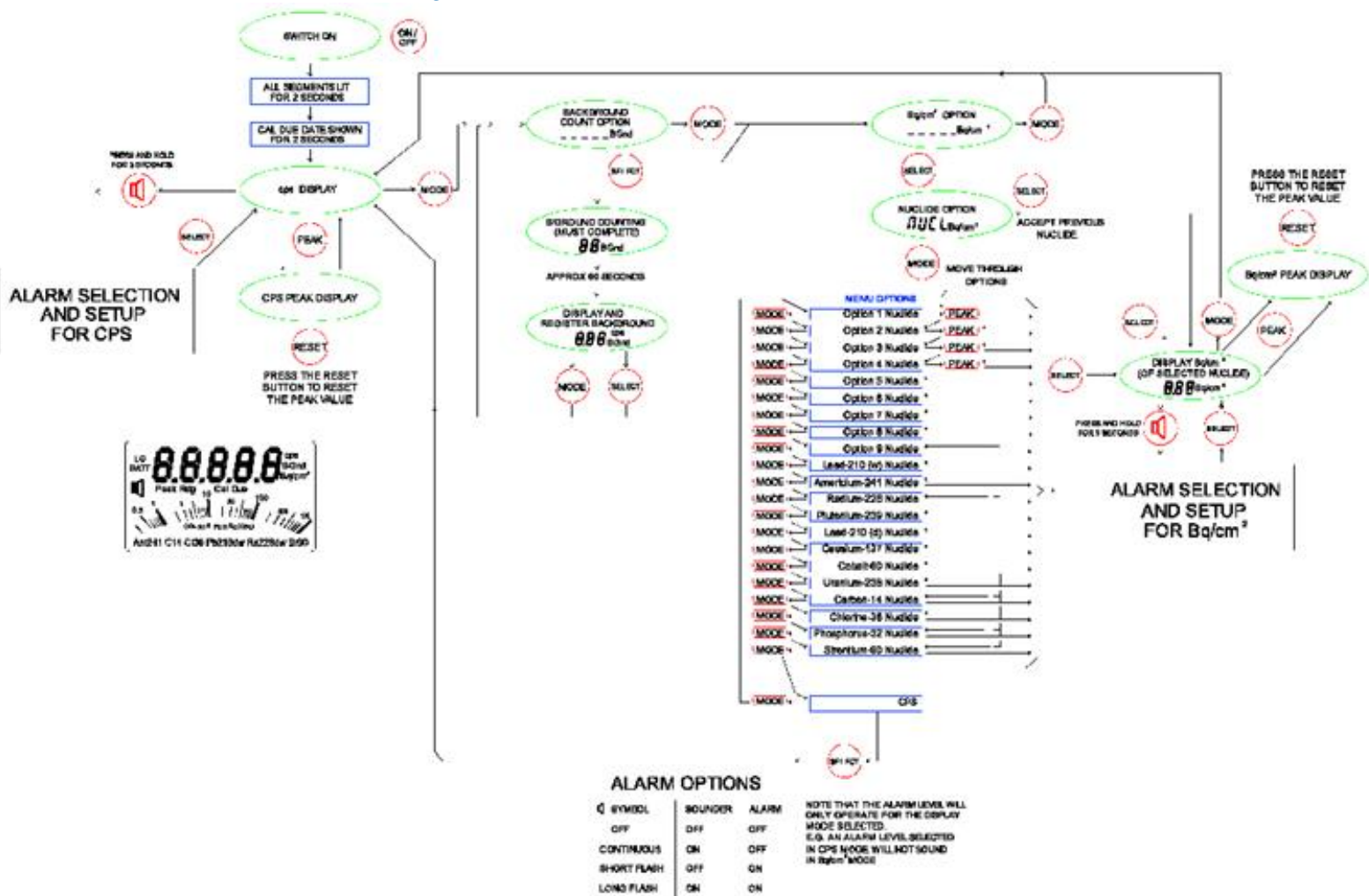
Wet and dry options (w) (d) provide alternative response coefficients to simulate the practical conditions under which naturally occurring radioactivity is monitored in the environment (particularly within the oil and gas industry). Calibration for Lead-210 assumes an equilibrium with daughter products Bismuth-210 and Polonium-210.

5.10 Operational Ranges

Bargraph scale : 0 - 1000cps.

Numeric scale : 0 - 4000cps.

5.10.1 T401 Functional Diagram



5.11 Setting Alarm Trip Levels

The Tracerco T401 is equipped with an alarm function which can be set by the operator. The alarm is a continuous high-pitched note and operates whenever the monitor reading exceeds a pre-set trip level. The alarm trip level can be set in either counts / sec or Becquerels / cm² mode.

The incremental settings for the alarms are as follows:

Range	Increment
0 . 10	1.0
10 . 50	5.0
50 . 100	10.0
100 . 1000	100
1000 . 4000	500

Maximum alarm trip level is 4000 cps.

Range (Becquerels / cm ²)	Increment
0 . 1.0	0.1
1.0 . 1.0	1.0
10 . 500	10

Maximum alarm trip level is 500 Bq / cm²

5.11.1 Sounder Options

One normal press of the speaker button will turn on the sounder which will “click” in response to radiation. In this (non-alarm) mode the speaker symbol will be on continuously.

A flashing speaker symbol indicates the alarm is set. For details, refer to page 12.

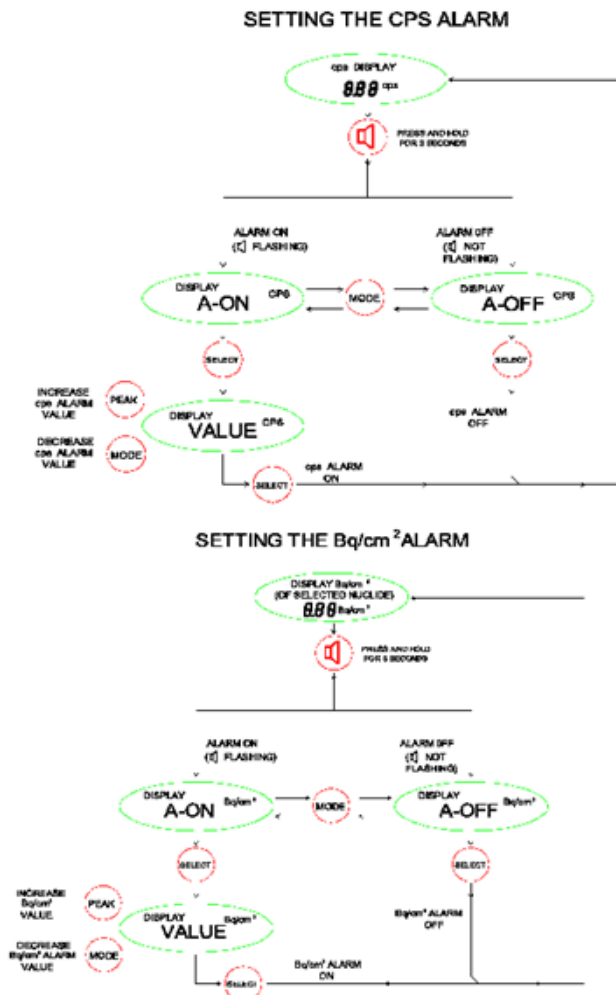
If the speaker symbol is showing an extended repeat sequence, it indicates that the alarm mode and sounder are both activated.

If the speaker symbol is absent from the screen, it indicates that both audible response and alarm setting is OFF.

It should be noted that on switching on, the monitor will retain the previous alarm trip level settings and speaker status.

5.11.2 Setting the Alarm Trip Level

The following flow chart identifies the process for setting an alarm trip level in **cps** and **Bq / cm²** mode.



Symbol	Sounder	Alarm
Off	Off	Off
Continuous	On	Off
Short Flash	Off	On
Long Flash	On	On

It should be noted that the Bq / cm² alarm will only be operative when the monitor is being used with the Bq / cm² mode selected on the digital scale. Since only a single value trip setting can be entered in Bq / cm², the operator must ensure that the selected value is consistent with the type of radionuclide being monitored.

6 Detector Probe

The Tracerco T401 utilises a thin window Geiger Muller probe for the detection of alpha, beta and gamma radiation over a wide range of energies. The probe has been designed to provide a high degree of flexibility in the manner in which it can be deployed for contamination monitoring. The following are examples of the key operational options.

6.1 Probe Retained in Monitor Yoke

During storage and transport, it is recommended that the probe is rotated to its non-operational position so that the sensitive window is protected by the body of the radiation monitor. The probe is secured in the yoke by a castellated ratchet mechanism with a positive retention pressure exerted by special o-ring seals. The probe can be rotated to various orientations within the yoke. The monitor can be operated with the probe and yoke remaining attached to the lower skid arrangement. The face of the probe should be held some 2mm from the surface being measured to ensure optimal operation and replicate the conditions under which nuclide calibrations have been carried out.

6.2 Remote Probe / Yoke Assembly

The operator may prefer to place the body of the monitor in a single location and use the probe to hand monitor irregular items of equipment or areas difficult to access with a complete monitor. The probe and attached yoke may be withdrawn from the body of the monitor by accessing the retaining lever which is located within the lower skid arrangement. The lever should be pushed sideways and the yoke withdrawn from the retention assembly.

The probe is attached to the body of the monitor by a flexible coiled cable normally fully recessed within the skid assembly. This cable will allow the probe to be operated up to a distance of 1.5-metres from the body of the monitor. The cable has been specially selected to ensure that it returns to its fully coiled resting state after use. It is recommended however, that care should be taken not to persistently overstretch the cable during use.

The probe and yoke should always be replaced in the body of the monitor before trying to re-engage the coiled cable in the skid arrangement.

6.3 Remote Probe with Telescopic Extension Kit

The base of the yoke has a threaded plug which allows it to be directly attached to an extendable arm, which can be extended to approximately 1-metre.

The orientation of the probe within the yoke can be pre-set to the preferred arrangement for monitoring. The extension arm is specifically designed to assist in monitoring floors, areas above head-height and within straight pipes (the extension kit is an optional extra to the standard monitor



7 Maintenance and Calibration

The Tracerco T401 is a portable Contamination Monitor which incorporates many design features which are based on Tracerco's 40-years of global experience in the measurement of radiation in a wide range of industrial and laboratory environments.

The monitor has been designed for reliable operation in relatively hostile environments and should provide many years of effective service provided attention is paid to basic operational maintenance.

7.1 Battery Replacement

The condition of the battery is constantly monitored. Normal battery life is approximately 100-hours for continuous or intermittent operation. With about 4 hours of battery life left, a "LO BATT" warning appears on screen. When the battery power is too low for safe operation, the screen will blank.

The internal battery compartment is clearly identified but is located under the skid which holds the probe and cable. This has to be removed (3 screws) to access the battery compartment. We would recommend replacement battery of the type Duracell MX1 604 Alkaline Manganese or MN1604 Alkaline Manganese.

The battery cover can be removed by unscrewing the single retaining screw at the base. The gasket seal is attached to the inner face of the cover. Care should be exercised not to damage this seal or introduce contamination into the battery compartment.

7.2 General Maintenance

The liquid crystal display screen is sealed within the upper section of the case which provides a robust, leak-tight fitting. The bargraph display has been specially selected for reliability in the field and the case is constructed from a lightweight impact and chemical resistant polymer.

The only routine maintenance which is recommended is mild cleaning of the case and display to prevent the build-up of grease and other potential contaminants.

Do not use solvents on the window.



7.3 Repair and Calibration

The Tracerco T401 instrument incorporates special software for checking and calibrating the response of the monitor to incident radiation.

In order to comply with UK statutory regulations, the monitor must be inspected and tested on at least an annual basis. It is recommended that such inspection and testing is carried out by Tracerco or an approved organisation which has access to the appropriate testing equipment and diagnostic software.

The Tracerco T401 monitor has been designed as a sealed unit, whereby all essential operating parameters have been optimised and set at the time of manufacture and during test and calibration procedures. These controls are not accessible to the customer and should not require any adjustments during normal operation.

In addition to checking the physical condition of the monitor, Tracerco will check the response of the monitor to the displayed radionuclides using special plaques whose radioactivity content per unit area of surface is traceable to recognised national standards. Tracerco will consider modifying the list of calibration nuclides, where the operator has a specific requirement and appropriate calibration materials can be sourced.

Battery replacement will be a standard element of this annual inspection procedure.

7.3.1 Calibration Plaques

Where possible calibration data supplied for the Tracerco T401 Contamination Monitor has been measured using large surface area reference plaques. These plaques comply with the requirements for traceability to NIST specified in the 'American National Standard Traceability of Radioactive Sources to the NIST and Associated Instrument Quality Control (ANSI N42.22-1 995)'.

These plaques are constructed such that the radionuclides of interest are incorporated into the surface of an anodised aluminium foil of 0.3mm thickness. The thickness of the activated layer is approximately 6µm. In accordance with ISO8769, the calibration plaques are designated as Class 2 Reference Sources.



8 Technical Specification

Radiation detected	Alpha/Beta/Gamma Automatic direct translation to Bq/ cm ² for Cs-137, Am-241, C-14, Cl-36, Pb-210 (wet and dry), Ra-226 (wet and dry), Sr-90, Co-60, P-32, Pu-239, U-238
Detector	Single halogen thin window Geiger Muller tube
Over-range response	Bar graph display will read full scale. Digital numeric display shows 0UER (over) above 4000CPS
Variation with temperature	Less than 2%
Humidity range	0 to 95%
Ingress protection rating	Main case is sealed to IP65 sensor head sealed to IP34
Case material	Robust, chemical resistant polymers with ABS window
Weight	1 kilogram (approx.)
Display	Bar graph display (0-1000 CPS) Digital numeric display in CPS or Bq/ cm ²
Battery	Standard 9V PP3 battery
Battery life	100 hours typically with background radiation
Low battery indication	On 4 hours battery life remaining
Variation with battery voltage	Less than 15% over operating temperature range
Standard compliance	EU directives: 2004/108/EC Electromagnetic Compatibility Directive

9 Monitor Response

The response of the monitor in counts / sec to a given level of surface contamination will depend on the radiological and physical nature of the source being measured. This will include the presence of daughter products in the decay scheme, thickness of the surface layer within which the activity is deposited and the degree of backscattering which is taking place (influenced by the type of material being monitored).

An ideal source would be one in which the activity is deposited in a thin layer at the surface with minimal self-absorption or backscattering taking place. In reality, surface characteristics will vary markedly and never achieve the characteristics of an “ideal” source.

In order to achieve traceability and accuracy Tracerco has calibrated the T401 for activity response using a number of specified radionuclides in the form of large surface area plaques with a precisely controlled radioactivity content. In normal use, it is unlikely that the physical characteristics of the calibration source will match precisely those of the contaminated surfaces which are under investigation. The relative impact that this will have on data interpretation will depend on the nature of the radionuclide being determined.

These limitations should be borne in mind by operators carrying out any form of radiation contamination monitoring and if there is any doubt, expert advice should be sought.

9.1 Affects of Gamma Radiation

The Tracerco T401 Contamination Monitor primarily responds to highly ionising alpha and beta radiation, although gamma radiation will be detected with a substantially reduced efficiency. A simple check may be carried out to determine whether the observed count rate is arising predominantly from alpha / beta radiation or from gamma radiation. An absorber has been provided which can be placed between the source of contamination and the sensitive volume of the detector. Any reduction in the observed counts per second reading of the instrument will be primarily be due to absorption of alpha and beta radiation. Gamma radiation, by comparison, will be relatively unaffected by the presence of the absorber.

10 Hints for Radiation Contamination Monitoring

- Hold detector probe 2mm from the surface being measured. This provides conditions which most closely reflect those used when calibrating the probe.
- Avoid contaminating the face or head of the probe during operation.
- Wherever possible, check that the monitor is working before use by placing it adjacent to a known test source.
- Alpha particles are heavily attenuated by water. Monitoring a wet surface containing alpha emitting radionuclides will dramatically reduce the observed count rate relative to dry conditions. In the worst case scenario, all alpha particles will be absorbed before being detected by the probe. A similar, though less pronounced problem may be encountered when measuring nuclides which emit weak beta particles.
- Use the optional extension arm for the detector probe when monitoring above head height or the internal surface of pipes, vessels or ventilation ducts.

11 Health and Safety

Tracerco considers that it has taken all reasonable precautions to ensure that when used as prescribed, the monitor will not endanger the health and safety of the operator. It is important, however, that the following basic guidance should be taken into account by the operator when carrying out any form of radiation contamination monitoring.

11.1 Training

Operators should receive appropriate practical training in the use of radiation contamination monitors.

11.2 Battery life

Battery life should be checked before use, particularly where work is to be carried out continuously over an extended timeframe.

11.3 Probe

The Geiger based probe contains a delicate thin window. Although some protection has been provided against accidental damage in the form of a wire mesh, care must be exercised when monitoring surfaces which may have protruding sharp objects. When the probe is not in use, it is recommended that the yoke assembly is securely replaced in the body of the monitor. The detector probe should not be placed directly onto surfaces since this may lead to contamination of the face and increase the risk of perforating the GM window.

Tracerco supply robust transport/storage cases which can provide space for a probe extension and spare battery. Details are available from www.tracerco.com/monitors.

11.4 Radiation reading

The monitor has been designed and tested (EN60325:2004) to ensure that if the probe is exposed to radiation levels well in excess of the full scale values (ie., up to 10^6 counts / second), the readings will recover and normal operation resumed once the source of radiation has been removed. The numeric display will show a OUEr when full scale has been exceeded. The bargraph display will sustain full scale deflection.

The operator should never attempt to estimate a reading when over-range has occurred.

11.5 Alpha radiation

Alpha radiation is heavily attenuated (weak beta radiation to a degree) when damp or wet surfaces are being monitored. This characteristic should be fully taken into account when monitoring outside



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