NOBLE GAS BETA/GAMMA MONITORS

SCINTILLATION DETECTORS

MODEL 903
(TOTAL ENERGY ABSORPTION, BETA/GAMMA)

For the measurement of total gamma energy absorption with flat energy response. Different models have different energy ranges, available up to 2 Mev. Available scintillation crystals include plastic, NaI, CsI, BGO and other.

MODEL 8102
(SCINTILLATION COUNTER, BETA)

True activity Beta counter for the measurement of ambient beta radiation. Uses a thin plastic scintillator for gamma independent response.

MODEL 8103
(SCINTILLATION COUNTER, BETA/GAMMA)

Noble gas gamma or beta/gamma activity scintillation counter. Energy response depends on size and nature of selected scintillation crystals used.

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MODEL 903

REACTOR GAS MONITOR FOR BETA AND GAMMA RADIATION

FOR DOSE RATE ASSESSMENT OF RADIOACTIVE GASES

Specifically designed to measure the total energy absorption per unit volume due to both beta and gamma components of radioactive gases typically found in association with nuclear power plant reactors. Mixture of gases typically include ^{85}Kr, ^{41}A, and others. The instrument is designed specifically to measure **ENERGY ABSORPTION PER UNIT VOLUME PER UNIT TIME**, and can be calibrated in terms of MevBq/m^3 or MevCi/m^3.

This measurement is noted to be closely related to dose rate, which is **ENERGY ABSORPTION PER UNIT MASS PER UNIT TIME** , rather than volume. The two rates are indirectly related to each other.

INSTRUMENT CONFIGURATION

A volume of radioactive gas, as contained in a shielded chamber, is faced by a scintillation photo-multiplier detector.

The signal output of the scintillation system is processed by analog circuitry to produce an output which is accurately proportional to the beta/gamma energy per unit time.

ENERGY

The instrument response is proportional over a wide range of energies. The degree to which the proportionality is accurate is a function of the energy spectrum of the radiogases as compared to the effective size of the scintillation detector. The OTC scintillator system is configured to be accurate over the range of energies typically associated with reactor gases.

PRINCIPLES OF RADIATION ABSORPTION

A scintillator is a material which converts particle or photon energy into scintillation of light. The scintillation is converted into an electric signal and subsequently amplified by a photomultiplier tube.

If the scintillator photo pulses are to be accurately proportional to the incident energy, the scintillator has itself to be energy independent, at least over the range of energy of interest. To accomplish this, it is required to simply make the scintillator physically large and use as dense a material as possible.

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GAMMA RAY INTERACTIONS

Of the various ways gamma rays can interact with matter (the scintillator) only three interaction mechanisms have any real significance.

They are:

1. Photoelectric absorption.
2. Compton scattering, and
3. Pair production. It is to be noted that photoelectric absorption predominates for low energy gamma rays (up to several hundred kev), pair production predominates for high energy gamma rays (above 5-10 Mev). Compton scattering is the most probable process over the range of energies between these extremes.

To be specific, the photoelectric process involves the generation of an Auger electron of very short range, thus even small scintillators will suffice.

Reactor gases, mainly Krypton, Xenon and Argon, all have energies below 1.3 Mev, therefore, the pair production process is not of importance. Thus, the major key to scintillator size is the absorption process associated with Compton scattering. Full discussion of all the possible interactions associated with Compton scattering has no place in this description, but can be found in many texts on radiation detection and measurement. It is sufficient to say that to ensure even (flat) energy
response, the detector should be sufficiently large, so that the recovery of all secondary gamma radiation produced through Compton scattering be as complete as possible. This simply means making the scintillator out of a dense a material as possible, and to make it physically as large as suitable.

SHIELDING

If the instrument is to be located where gamma background is present, then shielding of the instrument is required to ensure that the external background does not add an unwanted contribution to the measurement.

ELECTRONICS

With a sufficiently large and dense scintillator, the output current of the photomultiplier tube is accurately proportional to the total energy of the incident beta and gamma radiation. The associated electronics is quite simple, a very stable high voltage power supply is required since the amplification factor of the PM tube is related to the power of the number of dynode amplifier stages (typically 10 - 14) inside the tube.

The current signal amplifier stages consist of linear d.c. amplifiers, which may be followed by a logarithmic converter, E to I converter, RS - 232 or any similar desired output.

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MODEL 903

REACTOR GAS MONITOR FOR BETA AND GAMMA RADIATION

ABRIDGED TECHNICAL SPECIFICATION

RADIATION DETECTED	Reactor gases, beta and gamma radiation
ISOTOPES	Krypton, Xenon, Argon and others
ENERGY RANGE	80 Kev to 1.5 Mev
ACCURACY	Beta: essentially 100 %
MAXIMUM RANGE OF MEASUREMENT	0 - 2 x 10^{10} MevBq/m^3 (other ranges available on request)
SCALE	6 decades over any user selected range
SENSITIVITY, STABILITY	$\pm$1 x 10^4 MevBq/$m^{3,}$ other sensitivity requirements are met by altering the desired range
SAMPLING VOLUME	1 liter, nominal, sampling volume can be removed for inspection
PHOTOMULTIPLIER TUBE	10 - 14 stage, C_sS_b photocathode for ultra stable again
SCINTILLATOR	Sodium Iodide, Bismuth Germanate, Calcium Tungstate or other
SHIELDING	The sampling volume is surrounded by lead shielding of 100 mm (4") thickness to eliminate gamma background
DISPLAY	Digital, or analog, as customer specified
SIGNAL OUTPUTS	linear, 0 - 10 V, or as option 1. logarithmic 2. 4 - 20 ma 3. RS - 232 4. IEEE - 488
ENVIRONMENTAL	temperature: 0 - 50° C humidity: 0 - 99 % R.H.
CHECK SOURCE	optional, Kr 85 micro bead, remotely controlled
ALARM FUNCTIONS	1. single set point signal alarm, 10 turn potentiometer adjustable over the full measurement scale 2. loss of high voltage malfunction alarm 3. sample flow malfunction alarm
PUMP and FLOW METER	Rotameter with needle valve, oscillating piston, or vane pump
POWER	120/240 V, 50/60 Hz

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MODEL 8102

NOBLE GAS BETA ACTIVITY SCINTILLATION COUNTER

ALL DIGITAL SCINTILLATION COUNTING SYSTEM

This scintillation counter is derived from the OTC 8100 series nuclear gages originally developed for industrial process control.

The instrument is a true digital counter, capable of counting up to 10^8 cps. It can be calibrated in Ci/m^3 or Bq/m^3.

With the exception of the output analog interface, the instrument uses ECL,TTL and CMOS digital technology throughout.

HIGH EFFICIENCY BETA RESPONSE

The 8102 series scintillation counters use thin plate plastic scintillators coupled to specially selected ultra stable photomultiplier tube amplifiers. Since the energy spectrum of beta rays forms a continuum from virtually zero up to a definite maximum, the calibration accuracy of the scintillation counter depends upon the ability to respond to and count beta particles with even the lowest energies. The 8102 systems owe their rock steady accuracy to the fact that nearly all beta particles in the measurement chamber are truly counted.

INSENSITIVE TO BACKGROUND GAMMA RADIATION

The scintillator plates used in the 8102 series instruments are just thick enough to provide total beta capture, yet are thin (less than 1 mm) and therefore have a very low gamma cross section. Thus, while the beta response is virtually 100 %, the response to external gamma fields is so low as normally to be negligible.

SYSTEM DESCRIPTION - ACTIVITY RESPONSE DETECTOR

A small (1 liter) sampling chamber faces a 2” scintillation photo multiplier which generates a digital pulse in response to virtually every beta particle which strikes the scintillator. This pulse is independent of the energy of the beta particle. Thus true activity, that is, disintegrations per unit time, is achieved. In contrast, analog scintillator systems are energy dependent, thus giving different responses to different radioisotopes even when the decay rate (Ci or Bq) is the same.

True scintillation counters, such as the OTC 8102, will produce a true activity measurement regardless which radioisotope is being measured. The exception is the case of tritium. Ultra low level tritium measurements are difficult to make with scintillators because of size limitations of the scintillator.

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RATE METER AND DISPLAY

A quartz crystal controlled time base counts the pulses over a preset period. Division of the ensuing pulse rate by a digital value corresponding to the effective size of the sampling chamber then produces a calculation of the true activity. The rate diplayed on the meter corresponds to a true gas concentration in Bequerel or Curies per unit volume (meter cubed).

CALIBRATION

Calibration controls are externally accessible in the form of front panel thumbwheel switches. Calibration of the instrument can easily be carried out using calibration gas.

LINEARITY

The 8102 series instruments are linear to very high counting rates, until 'pulse pile up" phenomena influence the counting rate. The response rate of the scintillation system and the digital signal processing is of the order of 5 nano- seconds (rise time). The Model 8102 can count at a rate up to 10^{-8} pulses per second.

Gain of the PM tube is not affected by the count rate, the overall system is therefore 99.9 % linear over the entire range.

ZERO STABILITY AND BACKGROUND

The PM tubes are specially selected for low spurious count rates. As previously mentioned, the scintillator responds primarily only to beta radiation. For very low level counting, it is possible to add extra gamma shields (lead or other).

CHECK SOURCE

A solenoid actuated check source can be incorporated into the sampling chamber. The solenoid is operated remotely.

SAMPLING CHAMBERS

The 8102 series sampling chambers are designed to suit each particular application. For environmental measurements, the sampling chambers are constructed simply from aluminum plate. For process piping, the sampling chambers are constructed from stainless steel with stainless steel windows.

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MODEL 8102

NOBLE GAS BETA ACTIVITY SCINTILLATION COUNTING SYSTEMS

ABRIDGED GENERAL TECHNICAL SPECIFICATIONS

These specifications are common to all Model 8102 instruments. Options listed below are provided upon customer request.

RANGE	0 -10^{11} Bq/m^3 with a 1 liter sampling volume (0 - 20 Ci/$m^{3)}$ Note: Range can be extended to higher values by reducing the volume of the sampling chamber
ACCURACY	1 % or better
DISPLAY	8 digit LCD counter
CALIBRATION	3 digit thumbwheel front panel controls
BACKGROUND	Less than 1 KBq/m^3, lead shielding for further reduction in background can be included
CONTAMINATION	Noble gases (or Tritium) will not contaminate the sampling chamber
SAMPLING CHAMBER	1 liter (nominal) volume coupled to the scintillator assembly housing. Light tight construction with 1/4" tube ports for the sample flow. Aluminum constructionh for the chamber.
SAMPLE FLOW SYSTEM	A high efficiency dust filter is used to prevent accretion of particulate matter on the surface of the scintillator assembly. A pump, flow meter and low flow switch (alarm) can be included.
DETECTOR	1", 2" or larger scintillation photo multiplier combination. The assembly is covered with a light tight thin aluminum or stainless steel window.
ALARMS SIGNAL	Single digitally preset high level alarm
MALFUNCTION	Alarms for loss of sample flow, electronic malfunction and loss of power supply are included. Relay closures are provided.
REMOTE SIGNAL INTERFACE	A variety of signal interface systems are available. These include: 1. linear, 0 - 10 V or 4 - 20 ma 2. logarithmic, for high resolution, 4-20 ma 3. direct digital, calibrated pulses per second to correspond to Bq/m^3
ALARM INTERFACE	Isolated relay closure, or 0 - 5 V digital signal (non isolated).
CONSTRUCTION	The sampling chamber and the scintillation detector are housed in an aluminum enclosure which may be located up to 1000 feet from the main electronics cabinet. The main electronics is generally housed in a standard 19" rack cabinet. The individual electronic circuits are in the form of plug in modules, one for the time base and calibration, one for the scaler, and one for the signal alarm and LCD read out.
POWER	115/230 V AC, 50/60 Mz, 20 W excluding pump. Pump power less than 200 W.

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MODEL 8103

NOBLE GAS BETA-GAMMA ACTIVITY SCINTILLATION COUNTER

AN ENERGY INDEPENDENT RADIOGAS ACTIVITY COUNTER

This instrument is designed to measure the activity, or counting rate of incident gamma radiation per unit volume. This instrument can be configured to measure both gamma and beta radiation simultaneously.

It is a true digital counter, capable of counting up to 10^8 cps, and can be calibrated in Ci/m^3 or Bq/m^3.

This scintillation counter is derived from the OTC 8100 series nuclear gages developed for industrial process control.

HIGH EFFICIENCY GAMMA RESPONSE

The 8103 gamma monitor uses a right circular cylindrical plastic scintillator optically coupled to specially selected ultra stable photomultiplier tubes. Since gamma photons can have energies from low to high values, the calibration accuracy of gamma counters depends on the ability of the system to respond and count all low energy photons. Low energy cut off must be stable and drift free. The 8103 systems owe their rock stable accuracy and energy independence to the fact that energy response extends below energy values corresponding to radioisotopes associated with nuclear reactors.

INSENSITIVE TO BETA RADIATION OR SENSITIVE TO BOTH BETA AND GAMMA RADIATION

The scintillator is covered with a metal shield of thickness sufficient to attenuate all incident beta particles, yet thin enough to allow transmission of essentially all photons. Removal of this beta shield will make the instrument simultaneously sensitive to both beta and gamma radiation.

SHIELDED AGAINST EXTERNAL RADIATION

A massive lead shield surrounds the scintillation counter so that only the energy associated with the sample stream in the direct field of view of the scintillator is counted. Ambient external gamma fields are not measured, including natural radiation sources, the instrument is therefore capable of measuring to very low levels of activity.

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SYSTEM DESCRIPTION, ALL DIGITAL TRUE ACTIVITY RESPONSE DETECTOR

A small (1 liter) sampling chamber surrounds a 1" scintillation photo-multiplier which generates a digital pulse in response to virtually every incident photon. All scintillation pulses above a small threshold are counted, and thus the digital counting response is almost completely independent of the photon energy, thus, true activity, that is gamma rays per unit time are measured.

True digital scintillation counters, such as the OTC Model 8103 will provide a true activity measurement, regardless which radioisotope is being sensed. Exceptions include tritium, or other radioisotopes when photon emissions (Bremsstrahlung) is below the photomultiplier threshold setting.

RATE METER AND DISPLAY

A quartz crystal controlled time base counts the pulses over a preset period. A digital calibration system modifies the pulse rate as generated in the sampling chamber, in order to scale the digital value for the actual size of the sampling chamber. The calibration system is controlled by a front panel digital thumbwheel switch bank.

LINEARITY

The instrument is accurate to pulse counting rates well beyond 10^7 cps. Pulse pile up phenomena become apparent above such rates. Threshold voltages, or power supply variations with pulse counting rates are non existent. Digital signal processing is of the order of 5 nanoseconds, for monochromatic gamma radiation. The instrument is capable of counting to 10^8 cps.

CALIBRATION

This digital instrument has an extremely high stability..

A small gamma check source, electrically operated, can be included with the instrument, this can be used for spot checks of response.

ZERO STABILITY AND BACKGROUND

The PM tubes are specially selected for low internal spurious counting. As mentioned above, heavy lead shielding eliminates ambient external gamma fields almost completely.

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MODEL 8103

NOBLE GAS BETA-GAMMA ACTIVITY SCINTILLATION COUNTER

ABRIDGED GENERAL TECHNICAL SPECIFICATIONS

These specifications are common to all Model 8103 instruments. Options listed below are provided upon customer request.

RANGE	0 - 10^{11} Bq/m^3 with a 1 liter sampling volume (0 - 20 Ci/m^3). Note: Range can be extended to higher values by reducing the volume of the sampling chamber.
ACCURACY	1 % or better.
DISPLAY	8 digit LCD counter.
CALIBRATION	3 digit thumbwheel front panel controls.
BACKGROUND	Less than 1 cps
CONTAMINATION	Noble gases (or Tritium) will not contaminate the sampling chambers.
SAMPLING CHAMBER	1 liter (nominal) volume coupled to the scintillator assembly housing. Light tight construction with 1/4" tube ports for the sample flow. Aluminum construction for the chamber volume.
SAMPLE FLOW SYSTEM	A high efficiency dust filter is used to prevent accretion of particulate matter on the surface of the scintillator assembly. A pump, flow meter and low flow switch (alarm) can be included.
DETECTOR	1" x 1" scintillation photo multiplier combination. The assembly is housed in aluminum or stainless steel case to eliminate response to beta radiation.
CHECK SOURCE	Solenoid actuated micro bead of Kr85.
ALARMS SIGNAL	Single digitally preset high level alarm.
MALFUNCTION	Alarms for loss of sample flow, electronic malfunction and loss of power supply are included. Fail safe relay closures are provided.
REMOTE SIGNAL INTERFACE	A variety of signal interface systems are available. These include: 1. linear, 0 - 10 V or 4 - 20 ma 2. logarithmic, for high resolution, 4 - 20 ma 3. direct digital, calibrated pulses per second to correspond to Bq/m^3 or Ci/m^3
ALARM INTERFACE	Isolated relay closure, or 0 - 5 V digital signal (non isolated).
CONSTRUCTION	The sampling chamber and the scintillation detector are housed in a light tight enclosure which may be located up to 1000 feet from the main electronics cabinet. The main electronics is generally housed in a standard 19" rack cabinet. The individual electronic circuits are in the form of plug in modules, one for the time base and calibration, one for the scaler, and one for the signal alarm and LCD read out. A plug in module for malfunction and other similar interface functions can be provided.

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