NOBLE GAS
BETA/GAMMA MONITORS

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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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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, RS485, or ethernet
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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