Measurement method not affected by dead time

of GM Dose Rate Probes Type 70 091

The Geiger-Müller counter tubes in the VacuTec dose rate probes 70 091 are operated during a specified period with constant anode voltage and pulse counting, by contrast to standard operating methods, so that the interval between the activation of the counter tube and the occurrence of the first pulse is measured. This interval depends on the event rate (dose output), and can range from minutes to microseconds, depending on the counter tube. The precision of the time measurement is 25 ns (digitalisation of time).

The probability density for the occurrence of an interval Δt between two successive events is calculated via the exponential distribution: $p(\Delta t) = \dot{n} \cdot \exp(-\dot{n} \cdot \Delta t)$, where $\dot{n}$ is the event rate related to the dose rate DL via the relationship $\dot{n} = \varepsilon \cdot DL$, ε is the dose sensitivity of the counter tube (in cps/µSv/h). With the knowledge of these circumstances and the properties of the exponential distribution, the measurement of just a moderate number of pulses allows us to determine the current event rate $\dot{n}$ with rapidly increasing precision. The precision of the current measurement result is also determined during the measurement.

Thus, this measurement method guarantees both precise calculation of the current dose output including the precision value and the automatic detection of changes in the dose rate, as early as possible, which guarantees the required reliability.

The Geiger-Müller counter tube is activated by increasing the anode voltage in the working range of the counter tube. The increase period of the voltage is approx. 50°ns. On registration of the first pulse which occurs, the time is measured and the anode voltage is lowered below the working voltage, which deactivates the Geiger-Müller counter tube. As a result, it cannot register additional events, and relaxes the charge carrier in the working gas and the field distribution to its original state. After the relaxation time ($\tau_{Relax} = 2ms$), the counter tube is activated again by raising the anode voltage. This cycle is repeated periodically, until the required statistical counting accuracy is reached.

Using this measurement concept, the otherwise standard dead time of the Geiger-Müller counter tubes ($\tau \approx 10$ bis $200\mu s$) is entirely within the relaxation phase, and therefore is entirely irrelevant for the evaluation of the measurement results. Whereas with standard pulse counting the dead time leads to a non-linear interaction between the dose rate and counter rate, which results in saturation and possibly a decrease in the counter rate at event rates $\dot{n} \approx 1/\tau$, the measurement method used here generally results in a linear event rate-dose rate relationship. In addition to this, the useful measurement range of the event rate (and thus the dose rate) is expanded to higher values by one to two decades (see diagram 1). The upper measurement range limit can be detected reliably. A decrease in the counter rate at a high dose rate, as in normal counter operation, is not possible here in principle.

While providing an appropriate relaxation phase after registration of a pulse reduces the effective measurement period, the associated decrease in the number of events registered is not significant at $\dot{n} < 1/\tau_{Relax}$. At a higher rate of $\dot{n} \geq 1/\tau_{Relax}$, the number of pulses registered per second is decreased to a preset level ($1/\tau_{Relax}$), in this case 500 pulses per second. After just a few seconds, this results in counting accuracies in the 1% range and reduces the wear on the counter tube.

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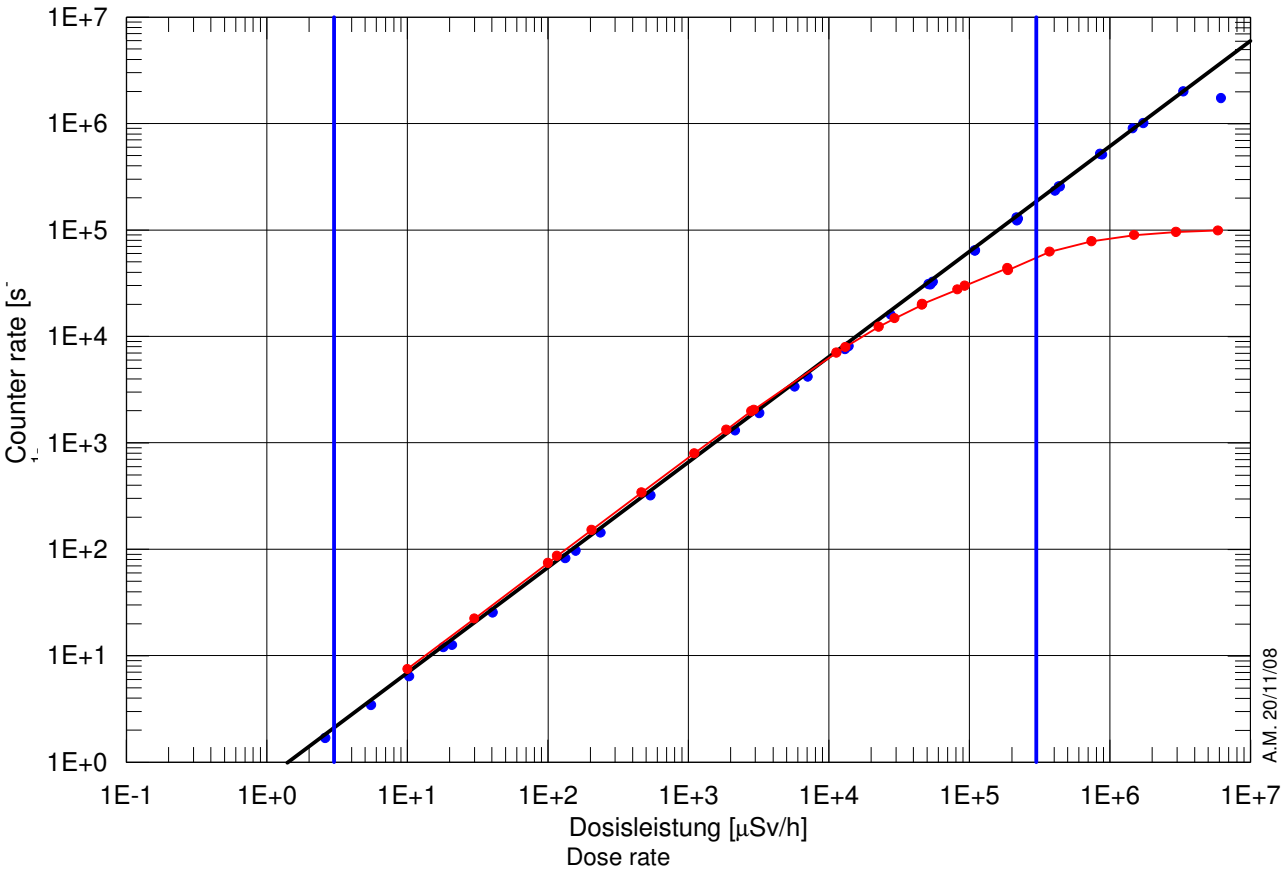

Figure 1: Counting rate from the measured pulse intervals depending on the DR for a 70017E (blue dots), standard pulse counting for this counter tube (red).

This principle for operating Geiger-Müller counter tubes was already described in the 1950s, but was technically more difficult to implement at that time than with the electronic components available today. See the literature specified for further details.
The counter tube is electronically connected such that the pulses are uniform, they do not overlap or undershoot and there is only one trigger threshold for the counter tube signal. This makes the counting technology highly stable, e.g. resistant to temperature influences.
The probe has up to four independent counter tube channels, which can also be fitted with counter tubes of different types. This allows the measuring range, measuring speed and, if necessary, the angular response of the probe to be defined. The measurements of the individual channels are combined to a final value incorporating their current precision value (statistical counting accuracy), which is available with precision data. For this reason there are no switching thresholds for selecting the measurement result from one of the individual counter channels. However, if necessary, the individual values of the individual measurement channels can also be read out.
Their modular structure means that the probes are also easy to adapt to the respective measurement task. Various housing versions made of polycarbonate or aluminium are available. The degree of protection for all housing types is IP65.
The probes have an integrated alarm system which can connect alarm signal lines directly via two independent floating contacts. These switching outputs can be configured via the probe software. Two algorithms allow alarm conditions to be detected:
Warning threshold: If a predefined limit is exceeded, an alarm is triggered. The warning limit can be set via the probe software.
Peak finder: If the dose rate increases significantly, an alarm is triggered. The greater the statistical precision of the measurement, the smaller the changes in the dose rate that can be registered (number and size of the counter tubes). The sensitivity of the peak finder can be set via the probe software.

The VacuTec dose rate probes 70 091 have an integrated clock and a data logger function in the non-volatile memory.

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