

Development and Status Research on Dosage Development

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Abstract

As the continuous development of nuclear technology, the radioactive dose monitoring of the equipment, the individual, the environment, and the equipment is also constantly attached importance to the relevant departments. The performance of the radiation dose detection instrument directly affects the level of radiation safety management. Domestic radiation doses are developed relatively late, and many environmental radiation testing equipment is still on imports. The domestic and foreign radiation detectors mainly use the combination of the three probes or three of the three probes or the three. This paper mainly introduces the research status and development prospects of domestic and foreign dosagers.

Keywords

Scintillator; Dosage; G-M count tube.

1. Dosage Development of Domestic Research Status

1.1. Status of Mainstream Radiation Dose in the Domestic Market

In recent years, mainstream radiation doses in the domestic market are mainly environmental monitoring stage detection instruments and protective grade testing instruments, mainly with BH3103A and BH3103B of Beijing Nuclear Instrument Factory, X-gamma radiation dose meter PM1621, Xi'an Nuclear Instrument Factory. The JB4010 of Bo Ltd. The following table lists their main performance indicators:

Table 1. Various types of dose gauge performance index

Postermodel	Detectortype	Measurement	Energy response section
BH3103B	Plastic scintillator	0.01μGy/h~100μGy/h	25kev~3Mev (For 137Cs)
PM1621	Nal(Ti) scintillator	0.001μGy/h~50μGy/h	48kev~3Mev (For 137Cs)
JB4010	G-M count-tube	0.1μGy/h~0.1Gy/h	10kev~20Mev (For 137Cs)

From the above metrics data, the mainstream radiation dose gauge on the domestic market has no range from the ambient to the protective stage (0.001μGy / h ~ 0.1 Gy / h). [1] Therefore, there is a large number of dosages in the domestic market to fill the gap on the range. The research and development improvement has been carried out in terms of broadening the range of radiation dose gauges, and has been developed from stability, the humanity and communication efficiency and simultaneization of communications.

1.2. Development Research Status of Radiation Dose Rate Detector

In 1994, Yes Zhi Country of Beijing Nuclear Instrument Factory used an ionization chamber as a detector, and a BH series γ and X-ray dosage was designed. The energy response to γ photons were 0.05 ~ 2MeV range, and the error $\leq \pm 20\%$ (relative to 1.25MEV point energy), this series of radiation doses have the advantages of reading intuitive, reliable performance, simple operation, etc., but its energy response is less than the mainstream radiation dose in the market. [2]

Lu Zhixin developed a Radiometer based on the MSP430 microcontroller in 2011, which used the G-M count tube as a detecting element, and the MSP430F149 is the control platform. The dose gauge is calibrated to the GM count tube, resulting in a measurement rate and dose equivalent of the functional relationship to achieve measurement of environmental radiation intensity and radiation dose, but his design is limited, and its power consumption Higher, still in the primary stage of development. [1]

Hu Chihou, Wu Jianping and others completed hardware and software design using LabVIEW-based gamma radiation dose gauges, using GM count tubes as detectors, using DSPIC30F6014 single-chip circuit control, realizing nuclear imaging equipment on PC Monitoring of gamma radiation doses in the working environment, and further design according to PET requirements, the control of parameters such as temperature, voltage, voltage, and current can be set on the interface, and the alarm value is also available, when the measured dose value exceeds the set threshold When the alarm signal is generated, the alarm light will highlight and pass the sound alarm. Therefore, the system is better to realize human-computer interaction function.

In terms of increasing communication efficiency and simultaneousization, GPRS modules and wireless Bluetooth modules can be added to the dose gauge. In 2012, Yang Xu, Dong Lihua and others use G-M count tubes and MC35i GPRS modules to achieve hardware design based on GPRS personal dosage control system, solve the problem of dose of the staff in real-time monitoring radiation environment. The instrument can remotely monitor personal radiation doses, which has the advantage of low cost. [6] In 2017, Zhang Zhang Wen of Yunnan Radiation Environment Supervision Station designed a smartphone γ personal dose instrument of Andriod system, which used GM count tubes, ATmega8 microcontroller, FBT06 Bluetooth module, and smart phones of the Andriod system. Real-time measurement, wireless communication connection, data timing transmission and other functions. [12]

In 2012, Yin Xiaofang, Chengdu University of Technology, using G-M count tube, designed a new nuclear radiation dose meter, an uncertainty level of 25%, and a stability level of 15%. The instrument is characterized by low power consumption, small size, convenient carrying, real-time monitoring, time-to-time storage, width, high precision, and ability to provide strong support for nuclear radiation monitoring. However, the instrument does not realize systemic, modular, and structured, and the program is easy to run, and the positioning module is missing, and the map is not possible to make a designated radiation measurement. [7] In 2013, Hong Jun, Heilongjiang University, was very good, and he has developed a smart X-gamma ray dosage, which uses GM count tube J305 as a detection element, with PIC24F microcontroller as a control center. . The dosage enables online programming, dose storage, remote transmission function, can be used as a mobile personal alarm, and can also be used as a fixed-point alarm. [10]

In terms of special gas ionization chamber, Huangcheng, the University of Electronic Science and Technology completed a high-air pressure ionizing chamber protective dosimeter instrument in 2013. It used high air pressure ionization chamber as a detector, using STM32 single chip as a master system, completed The dose measurement is required, and its accuracy water is 0.07%, which has reached the advanced level of foreign similar products. In terms of increasing the user-friendly, this dose can automatically select the range according to the dose size, with a

dangerous dose automatic alarm function, but the instrument does not design a wireless communication module. [8]

In the new count method, in 2013, it was developed a DSP-based portable gamma dose instrument, which used the GM count tube, using TI's TMS320F2812 as the core, using the TIME-TO-COUNT measurement method, realized The measurement of the radiation dose rate, the maximum measurement error is 8%, which satisfies the error requirements. [9]

In terms of gas detectors, in 2010, Li Taoheng et al. Completed a two-ball portable neutron dose probe design, the probe used ^3He proportion to the count tube, and the chronological material was polyethylene, calculated Considering the mutual influencing problem of double balls, the energy response is less than 30% when the correction factor relationship is corrected and when neutron energy is $1.0\text{E}-9 \sim 10\text{MeV}$. Although this dose can measure the single energy neutron, it needs to be further improved in the mixing field. [4] Hong Bing completed the system development of the electronic system of the energy spectrums neutron dose instrument in 2015, using a ^3He proportion to the BF_3 proportional counter as a probe, acquired seven sets of pulse signals, using the MSP430F5348 microcontroller to control the peripheral circuit, signal Acquisition and data processing functions. The experimental results show that the instrument has a low electronics power, good performance, meets the performance design requirements of portable high energy neutron dosage. [11]

In addition to the design of radiation detection mechanism, in the process, domestic improving radiosome measuring instrument performance research is also trying to carry out, in 2004, Li Jing and others in China Radiation Protective Research Institute used the case of special metal layer in the casing inner wall. , Improve the anti-electromagnetic interference ability of the instrument. [3]

1.3. China's Radiation Dosage Instrument Development Research Status Using Scintillator Detector

In the development of radiation doses using a scintillation detector, the overall performance of the enhancement instrument was also carried out in China.

In addition, Liu Yang and Xiong Zhengming have developed a gamma scintillation dose instrument in 1983. The measurement ranges from 10 microne / hour -10 / hr, a total of 6 quantities linear changes. The dose can measure both the dose of the natural background, and also measures the size of the general accident dose. [13]

In strengthening anti-interference ability, 2010, Yang Litao, Lanzhou University, using Nai (Ti) scintillator probe and FPGA chip, designed an X- γ dosimeter based on FPGA and MC8051 IP core, the signal of its chip The maximum nonlinear distortion of treatment reached 0.01%. The experimental results verify the high precision, high speed, and strong anti-interference capability of the dose system, and is more suitable for harsh working environment and remote monitoring. [14]

In June 2012, Qiu Tiansa completed the research and development of individual radiation dose monitors using iodide detectors, which used iodide (TE activation) scintillator detector, EEPROM memory Increased detection efficiency, reducing the power consumption of the electronic module, repeatability test reaches 4.133%, and the dose equivalent error is controlled within $\pm 15\%$, and the radiation detection standard is met. [15]

In 2015, Jojohong designed to achieve β , X, gamma ray electronic personal dose gauge, which adopts silicon photoelectric multiplier SIPM to flash detector. The scintillation dose solves the problem of high-energy photon energy response and can simultaneously detect β , x, gamma rays. [16]

In order to realize the wireless communication function of the instrument, Li Zhong has developed a SIPM-based personal dose instrument in 2017, using Lyso: CE scintillator, SIPM

new photomultiplier, and CC2650 microcontroller. The dose gauge is non-linear 0.6%, and the points are non-linearity of 0.02%, and the energy resolution is 24.47%, and communication with mobile Bluetooth can be realized. [17]

1.4. Development Research Status of Radiation Poster Terminal Adopt Semiconductor

In order to increase the scale of the instrument, in 2005, Xu Jianyi has developed a TQ-2000 multi-channel dosage, and its probe uses a cyclic array semiconductor detector, which for photons, and the measurement range is 1.3mev ~ 25mev, For electrons, the measurement range is 5.0mev ~ 15mev, and the technical performance has reached the advanced level of foreign similar products in the same time, the measurement control and data processing have realized automation. [18]

In terms of improving the accuracy and reliability of the instrument, 2005, Liu Zhengshan et al. Completed the application study of the PIN semiconductor detector in a personal dose, select the PIN semiconductor probe as a detector, and the dose energy response is 50 ~ 1250 keV energy range. The inner phase is within 137 cs, and the error is within $\pm 30\%$. [19] Zhao Yongfu et al. Used a micro semiconductor detector. In 2010, a multi-channel radiation dose instrument was developed, and 6 groups of probes were carried with 6 measuring points. The instrument has a dose rate of 80 Gy / min, a low precision is $\pm 0.071\%$, and the worst of stability is $\pm 0.18\%$, and is rugged and reliable. The line is simple, and the performance is reliable. [20] In 2015, Ou Ming and others completed the study of semiconductor personal dose meter energy compensation. By using punching lead, tin composite filter, the semiconductor type personal dose meter energy compensation is met, which satisfies relevant standards and actual The requirements for use, that is, measurement error $\leq \pm 30\%$ of the measurement error of 53 to 662 Kev of photonic energy range. [21]

2. Foreign Research Status Developed By Dosage

Compared to domestic, foreign countries are earlier than X, γ , neutron radiation dose, and the current technology is also more advanced.

As early as the 1950s, the US military was equipped with an AN / PDR-27 contaminated inspector, but its weight reached 4.8 kg, which was very impact on the speed of march.

So the 1960s, the US radiation dose instrument was improved toward small volume and light weight. At present, the US military equipment is an AN / VDR-2 radiator, and the AN / PDR-77 radiator and AN / PDR-77 radiometer are very light and advanced, including the AN / PDR-77 radiometer not only detects α rays, β rays, but Gamma rays and X-rays, and have digital liquid crystal display, sound conversion, and alarm video functions. [22]

In the 1980s, the US General Radiometer Civilization, the thermoelectric company designed an EPDMK2 electronic personal dose, which has a high-speed infrared interface, a large-capacity storage space and low power sound alarm. [23]

DMC2000S Electronic Personal Radiation Dose Monitoring Alarm Energy Produced by France Measures the X-ray and gamma ray dose size alarm instrument, and its dose measurement accuracy is high and has waterproof functions, and the measurement results will not be in the memory chip even after removing the battery. Lost. [24]

In 2009, the United States Thermo Fisher Scientific designed an thermo EPD MK2 electronic personal dosage that uses 3 PIN silicon photodiode detectors. The output of each detector is connected to the amplifier and counting circuit, respectively, and measured soft γ , respectively. Hard γ and β rays. [25]

3. Radiosome Meter Development Trend Prediction

The current status of radiation dosage instrument inner and external national radiation instrument can be more discovered that most of the domestic radiation dose gauge uses the GM count tube in the gas detector as a probe, and the working voltage of the GM count tube is large, and the power consumption is relatively large. And the volume of the GM tube is relatively large, resulting in an inconvenient use of the entire instrument, and foreign radiation dose instrument is more functional, smaller power consumption, small volume, and more user-friendly.

We can also see that in terms of three radiation doses, in recent years, we have wanted to broaden the range, improve accuracy, reduce power consumption, strengthen anti-interference ability, and implement wireless communication, fixed-point measurement, intelligent control, instrument portability. Study exploration, increased the diversity of ray sources. Although some aspects in scale and accuracy lead foreign countries, the overall portability, intelligent and systematic research is late, and the advanced extent is behind foreign countries.

At present, due to the continuous improvement and ultra-low power consumption of radiation detectors, chip and electronic components, the radiation dose instrument is miniaturized, intelligent, width, low power consumption, humanized development trends. Therefore, the dosage development will become a research hotspot in the present and future.

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