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I. FEHÉR
B. SZABÓ
J. VÁGVÖLGYI
S. DEME
P.P. SZABÓ
A. CSÓKE

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FOR SPACE DOSIMETRY

Hungarian Academy of Sciences

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**I. FEHÉR, B. SZABÓ, J. VÁGVÖLGYI, S. DEME,
P.P. SZABÓ, A. CSÖKE**

**Central Research Institute for Physics
H-1525 Budapest 114, P.O.B. 49, Hungary**

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ABSTRACT

A new version of the PILLE TLD reader has recently been developed for space applications. The earlier system was small, portable and able to carry out measurements during space flight but its measuring range was limited.

A new bulb detector with easier handling has also been developed the upper limit of its linear dose signalling is 10 Gy.

This new and more versatile reader, the NA206S, has a measuring range (1 μ Gy-10 Gy) 3 orders of magnitude greater than the earlier system; it also has increased sensitivity and decreased mass. It can be used not only in space applications but also for environmental monitoring, or even in accident dosimetry. The measured dose value is shown on a four digit display with automatic range switch.

Another new variant is the NA206E which has been developed for environmental dosimetry; this is equipped with a battery and can be operated alone, on a car-battery, or from the mains.

АННОТАЦИЯ

Нами разработан новый вариант (тип NA 206S) прибора ПИЛЛЕ для оценки доз, поглощенных термолуминесцентными дозиметрами (ТЛД), созданного ранее для целей космических исследований. Прибор ПИЛЛЕ был малогабаритным, переносным, что давало возможность его использования при исследованиях в условиях космических полетов, однако, пределы измерения этого прибора были довольно ограниченными.

Разработан новый стеклянный баллон детектора, верхний предел линейности показаний которого 10 Грей.

Новый вариант прибора для оценки доз ТЛД типа NA 206S является более чувствительным, имеет на 3 порядка больший диапазон измерения (10 мкГрей - 10 Грей), меньший суммарный вес, чем предыдущий прибор, что обеспечивает возможность его более широкого и разностороннего использования. Таким образом, сохранив исполнение, разработанное для космических исследований, усовершенствованное оборудование стало пригодным также для решения задач по охране окружающей среды и аварийной дозиметрии. Измеренная доза проявляется на подключенном к ЭВМ четырехзначном дисплее с автоматическим изменением пределов измерения.

Следующий вариант прибора - тип NA 206E - пригоден как для измерений, необходимых для защиты окружающей среды, так и для решения задач аварийной дозиметрии. Этот прибор снабжен внутренним аккумулятором, поэтому его удобно использовать в полевых условиях; он может получать питание также от аккумулятора автомобиля и от обычной сети.

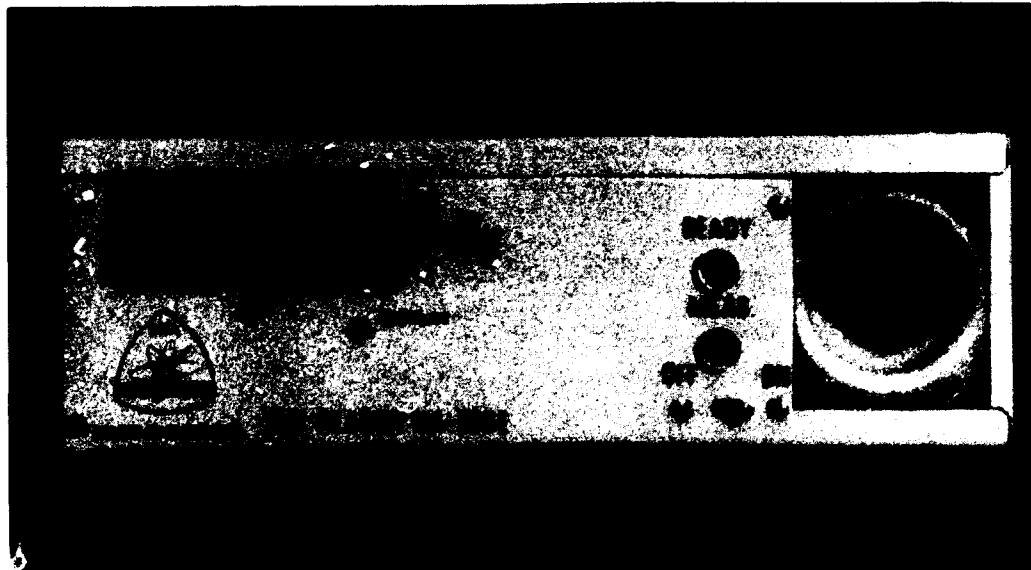
KIVONAT

Az űrutatásban alkalmazott PILLE elnevezésű TLD kiértékelő készülék egy újabb változatát fejlesztettük ki. A korábbi PILLE készülék kisméretű, hordozható és űrutatási feladatokra igen jól alkalmazható volt mérési tartománya azonban meglehetősen korlátozott.

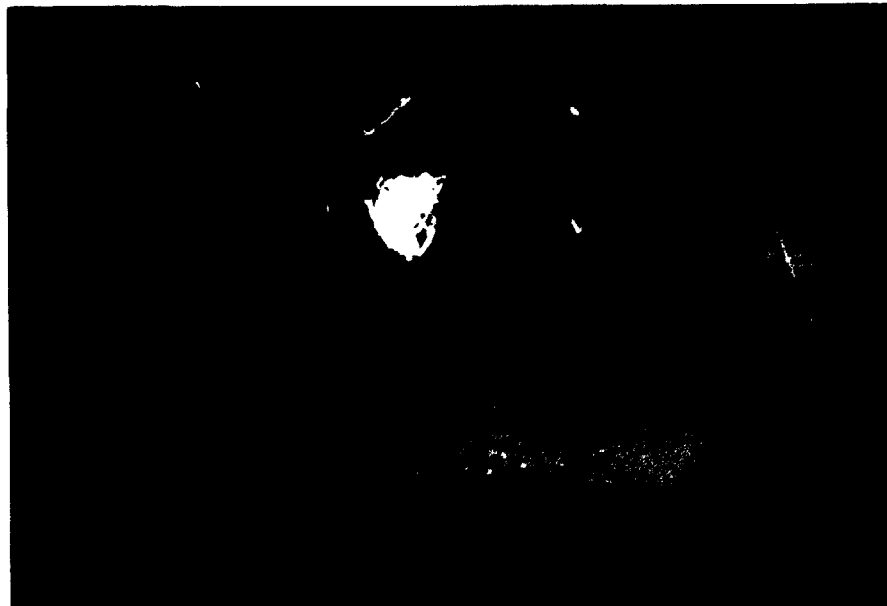
Új bura-detektort fejlesztettünk ki, melynek lineáris dózis-jelzés felső határa 10 Gy, valamint kezelése sokkal egyszerűbb.

Az új, sokoldalúbb felhasználásra alkalmas NA206S típusú kiértékelő készülék érzékenysége nagyobb, összömege kisebb és mérési tartománya (1 μ Gy-10 Gy) 3 nagyságrenddel nagyobb mint a korábbi PILLE készüléké. Így az űrutatásra alkalmas kivitel megtartása mellett a készülék környezetellenőrzési és baleset dozimetriai feladatok megoldására is alkalmas lett. A mérési eredményt négy számjegyű kijelző mutatja automatikus méréshatár váltással.

Egy további új változatot is kifejlesztettünk, az NA206E TLD kiértékelő készüléket, amely dózismérési feladatok megoldására alkalmas. Ez a készülék belső akkumulátorral rendelkezik, ezért igen jól alkalmazható terepen, továbbá táplálható autó-akkumulátorról vagy hálózati feszültségről is.



THE ILLUSTRATION OF THE NA-206E TLD READER



THE ILLUSTRATION OF THE PORTABLE TLD SYSTEM:
THE NA-206E READER, THE BULB DOSEMETER AND
ITS CAPSULE

INTRODUCTION

For cosmic dose measurements in space a small, portable TLD system (PILLE) was developed [1-2] and successfully used for dose measurements on board the "Salyut-6" spaceship during the flight of the Hungarian and Soviet cosmonauts. A new version of this TLD system has been developed recently which is able to measure doses in the range from 1 μGy up to 10 Gy. Here the new TLD reader, the NA206S, and its $\text{CaSO}_4:\text{Dy}$ bulbs are described.

New TLD bulb

A new TLD bulb based on $\text{CaSO}_4:\text{Dy}$ has been developed in contrast to the earlier version based on $\text{CaSO}_4:\text{Tm}$ [1]. The dose range of the whole system is wider by 3 orders of magnitude. Dy-activated CaSO_4 was selected because of its better supra-linearity beyond 1 Gy. The mechanical construction was changed so that both pins of the bulb are now on the same side in order to be able to position the bulbs more precisely. In this way only one pen-like holder is used for any number of bulbs and this has decreased the overall mass of the whole system, a paramount factor for space use. All bulbs can now be changed in the holder.

The envelope of the bulb is made of a low potassium content glass, the preliminary results show that the self dose rate from ^{40}K is about $15 \text{ nGy}\cdot\text{h}^{-1}$. The cosmic ray dose rate on board the orbital station is much higher than the self dose of the bulb. But this self dose rate must be taken into account when low dose measurements are carried out at a low dose rate level, such as in environmental monitoring applications, where the typical dose rate is around $(70-100) \text{ nGy}\cdot\text{h}^{-1}$. Thermal dissipation is small.

The linearity of the bulbs (Fig. 1) was measured in the dose range of 1 μ Gy-10 Gy. As can be seen the linearity of the bulbs is in the range of $\pm 10\%$ in the dose range of 1 mGy-10 Gy.

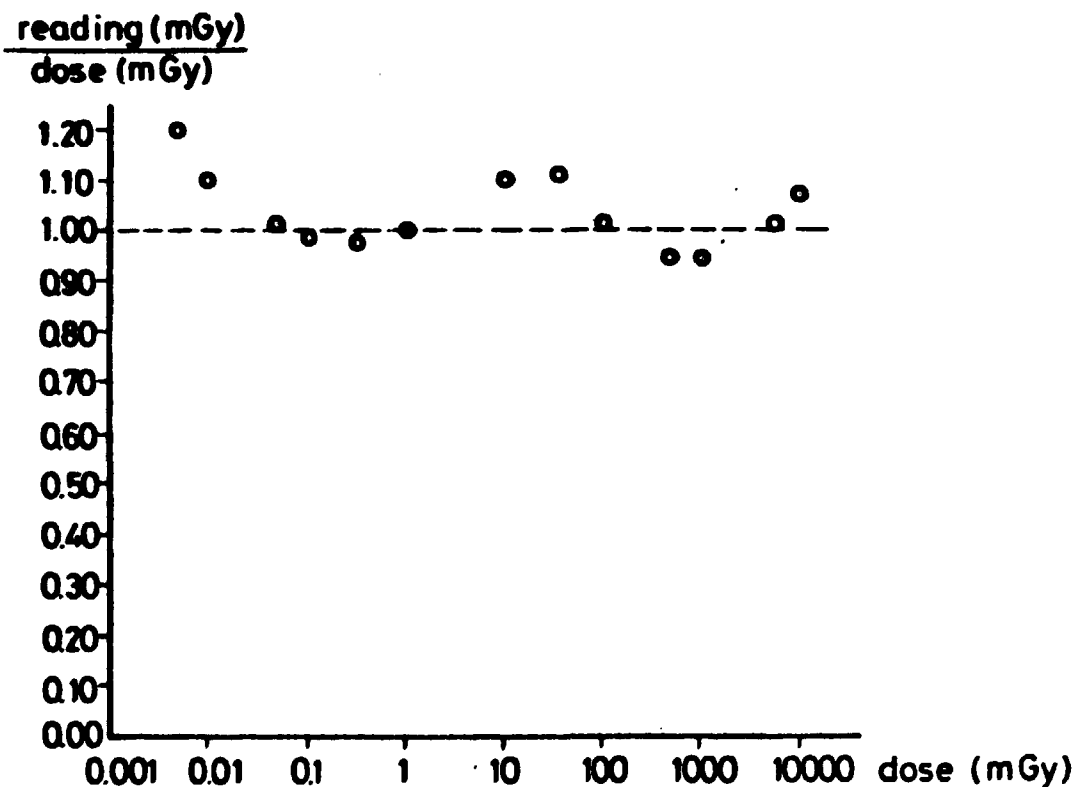


Fig. 1. Linearity of the bulbs

The residual dose is about 0.5-1%. After a large dose irradiation (beyond 1 Gy) the bulbs are annealed additionally in order to be able to use them for low dose measurements. (Additional annealing is at 300 $^{\circ}$ C for 5 hours.) After annealing the bulbs are again able to measure doses below 0.1 mGy, as the residual dose is chosen by this annealing.

The percentage of fading of the bulb dosimeters was measured by storing them at 20; 80; 100 and 120 $^{\circ}$ C for 0.25-120 hours; the storage time periods (t_{20}) for 20% fading were determined. The values measured for the new $\text{CaSO}_4 \cdot \text{Dy}$ bulbs are shown in Fig. 2. Fading is very low; 20% fading annually can be expected at 50 $^{\circ}$ C.

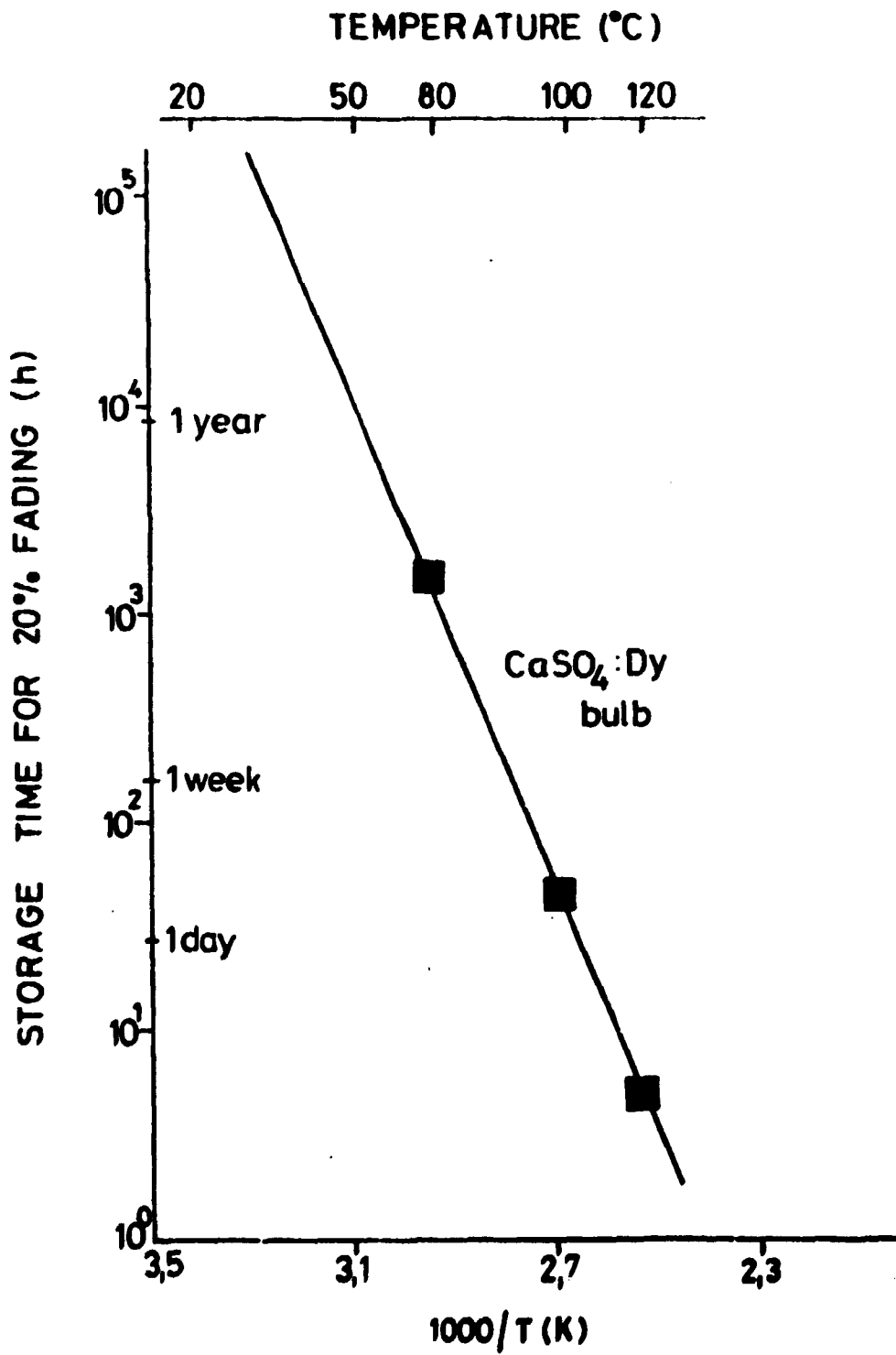


Fig. 2. Fading of the bulbs

New, portable TLD reader

The NA206S has a wider range by 3 orders of magnitude than the original PILLE and can well be used in cosmic dose measurements or in environmental monitoring where low doses at a low dose rate level are to be measured. The wider dose range of 1 μ Gy-10 Gy is reached by using an automatic range switch. The measured dose value is shown on a four digit LED display, where the brightness of the numbers displayed is automatically varied according to the ambient light intensity.

Because, now, all the bulbs have only one pen-like holder, the whole mass of the system is reduced - a highly important factor in space applications. The bulb to be evaluated is placed into this holder which is put into the NA206S TLD reader. After turning the pen-like holder in a clockwise direction the evaluation process of the bulb is automatically started. The whole readout cycle takes just one minute, including the preheating and the postannealing; this avoids the short time fading of the $\text{CaSO}_4:\text{Dy}$ bulbs.

The NA206S TLD reader is equipped with special electronic circuits to protect the device against damage due to mishandling. Its power supply is from the 27 V battery of the orbital stations. The mass of the reader is 1.2 kg, its dimensions 190x120x60 mm.

For environmental monitoring purposes, the NA206E version is used. This reader (see photos) is equipped with a battery so that it can operate without any external supply; the electrical consumption of this is so small that more than 100 measurements (bulbs) can be carried out without recharging the battery of the reader. The NA206E reader can be supplied by 220 V A.C. mains current or by a 12 V carbattery.

A TLD system such as this is built into a cross-country vehicle and is proving satisfactory in use for environmental monitoring in the vicinity of the Paks nuclear power plant, Hungary [3].

CONCLUSIONS

The new TLD system is more versatile than the previous one as its dose range covers 7 orders of magnitude, therefore it can easily be used for space measurement, for environmental monitoring [3], or for personal and accidental monitoring. The overall mass of the whole system is reduced because the bulbs can be used for dose measurements without any special pen-like holder - this being needed only during their evaluation on the TLD reader.

The other main advantage of the whole system is that dose measurements can be carried out on the spot (on board spaceships, or built into a cross-country car for environmental purposes). The dose evaluation takes only one minute.

Such TLD systems have successfully been applied in cosmic dose measurements on board "Salyut-6" and "Salyut-7"; another version of the system is now being used for environmental monitoring in the vicinity of the first Hungarian nuclear power plant.

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