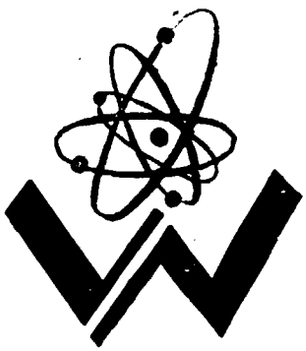
VIETNAM ATOMIC ENERGY COMMISSION



VAEC-C--024

# OVEREXPOSURE MEASUREMENT ON MICROTRON MT-17

**Dang Thanh Luong, Tran Thanh Minh**
*(Institute for Nuclear Sciences and Techniques, VINATOM)*

**1995**

Editor: Dr. Hoang Dac Luc

*ABSTRACT*

**Overexposure measurement on microtron MT-17.** Dang Thanh Luong, Tran Thanh Minh. *(Institute for Nuclear Sciences and Techniques, VINATOM).* VAEC-C-024.

On 11 November 1992, the Radiation accident happened at the channel of the high energy photon beam generated by stopping 15 MeV accelerated electron on the tungsten target of Microtron MT-17. One physicist has been exposed to the high energy photon beam. The purposes of this work are the determination of overexposure from backscatter and primary beams to estimate the whole body and hand doses received by the victim. It was found that the upper parts of his body may be received the dose from 1.0 Gy to 5.0 Gy per 4 min. of the exposure; the dose received by victim's hands is in interval of 30-50 Gy.

Vietnam Atomic Energy Commission, Hanoi, 1994

## *1. Technical data :*

1-1. TECHNICAL DATA OF MICROTRON MT-17.

All experiments were performed in the following regime of the operation :

Accelerated electron current (beam current) varied from 1μA to 3μA.

Target : W- tungsten

Collimator angle : 6 $^{o}$

The microtron MT-17 was operated without the shutter

1-2. MEASURING EQUIPMENTS:

Universal ToLeDo-TL Reader 654D, Vinten Instruments, UK.

VINATOM TLDs - $CaF_2$ - N, NRPB TLDs - LiF and NRPB film badges.

Farmer Dosimetry system 2570/1A, Ionization chambers NE 2581/675,

NE2530/598

NE water phantom : 21.5 x 21.5 x 11.5 $cm^3$

IAEA water phantom : 30 x 30 x 30 $cm^3$

## *2. Experimental*

The electron channel with the target W- Tungsten was located in the paraffin shelling box of 10 cm wall thickness and surrounded by the lead bricks of 10 cm thickness. Five experiments were arranged for determining the absorbed dose to the backscattering and primary high energy photon radiation, and another one was designed for investigating on the dependence of dose rates vs. the beam currents.

2-1. *Experiment 1: Investigation on the dependence of the dose rate vs. beam currents*

The accident occurred when the microtron MT- 17 was operated at the beam current of 6μA, and during the time of carrying out the experiments the Microtron MT-17 was able to be operated at the beam current no more than 3μA. It is necessary to investigate the dependence of dose rates upon the beam currents so that the actual dose received by the victim will be estimated.

The measurements have been done at 20 cm of water depth and source surface distance SSD = 100 cm .

The experimental data can be fitted by following formula:

$$D_w(20) = A * I + B \qquad (1)$$

$D_w$ (20) - Absorbed dose rate at 20 cm of water depth with SSD = 100 cm

- Absorbed dose rate is measured in the unit of [ Gy/h ]

I - Beam currents [ μA ]

A, B - fitting constants

$$A = ( 17.724 \pm 0.003 ) \text{ Gy/ h / } \mu A$$

$$B = ( 1.470 \pm 0.006 ) \text{ Gy /h}$$

Using the formula 1 the absorbed dose rates at 20 cm of water depth at different beam current values can be calculated ( see table 1 )

Table 1 .

| Beam current | 1 μA | 2 μA | 3 μA | 4 μA | 5 μA | 6 μA |
|---|---|---|---|---|---|---|
| $D_w$ ( 20 ) Gy/h | 19.19 | 36.29 | 54.64 | 72.37 | 90.09 | 107.81 |
| Normalized value % | 35 | 67.5 | 100 | 132.4 | 164.9 | 197.3 |

It is evident that the absorbed dose rate at beam current of 6 μA is nearly double of that at the beam current of 3 μA.

*2-2. Experiment 2, 3*

The idea of these experiments is the investigation on the backscattering radiation field generated from the primary high energy photon beam collided ( coming into collision ) with samples and shielding box , which the upper and abdomen parts of the victim's body may be exposed to. Backscattering radiation was measured by VINATOM TLD cassettes made from $CaF_2$ - N and NRPB TLD and film badges, that were brought here by IAEA's expert Ms. John S. Wheatley . The TLDs were attached on the surface of NE water phantom as it was showed in Fig. 1 and 2 . Besides the NRPB dosimeters both of TLD and film dosimeter were exposed in Calibration facility OB/ 6 Buchler Standard source at I - VILAS - 17 (Viet Nam standard Laboratory - 17 ) for comparison. The results of this intercomparison were showed in the table 2

Table 2.

| NRPB dosimeter | Evaluated value * | Reference value |
|---|---|---|
| TLD | 9.7 mSv | 10 mSv |
| Film | 8.1 mSv | 10 mSv |

** The data was informed by Mr. john S. Wheatley from NRPB.*

The TLDs and film badges were processed at VINATOM and NRPB independently. The result of absorbed doses from backscattering radiation measured by VINATOM's and NRPB's dosimeters were showed in table 3. All dosimeters have been exposed to radiation beam for 4 minutes and at the beam current of 3μA.

Table 3 .

| Meas. point | VINATOM - TI $K_{air}$ , Gy | NRPB's -Dosimeter $K_{air}$ , Gy |
|---|---|---|
| E | 0.48 | 0.16 * |
| G | 0.69 | 0.78 ** |
| H | 1.54 | 2.60 * |
| I | 2.62 | 2.85 ** |

* *measured by film badges*

** *measured by TLD*

*2 - 3. Experiment 4,5*

In this experiment the ionization chamber NE 2530/ 598 was used for determining the absorbed dose rates at the points, where the victim's head was approximately located. The experimental arrangement was showed in figures 3 and 4. Table 4 presents the results of measuring.

Table 4.

| Meas. point | Dose rates Gy/h | Absorbed dose for 4 min, Gy |
|---|---|---|
| A | 2.0 | |
| Bcal | 18.8 * | 1.2 * |
| C | 7.0 | 0.46 * |
| Dcal | 32.0 * | 2.13 * |

* *Calculated values*

*2- 4. Experiment 6 : Determining the dose rate of the primary high photon beam*

The experiment 6 was set up according to IAEA Technical Report No 277 [1] for determining the absorbed dose to water of the primary high energy photon beam. For measuring the absorbed dose, the shielding box was moved away, IAEA's cube water phantom and Ionization chamber NE2581 were used. The distance from the target to the surface of phantom is of 100 cm and the diameter of the field size is 10 cm.

2-4-1. Determining the photon beam quality:
SDD = 100 cm $D_{20} / D_{10} = 0.665$

2-4-2 . Determining the absorbed dose to water
According to IAEA Technical Report No 277, when $D_{20} / D_{10} \geq 0.61$. The reference depth $Z_p$ should be of 10 cm

$$D_{\underline{W}}( Z_p ) = M_u * S_{w\,air} * P_u * N_c = 1.13 \text{ Gy/min.}$$

This value of the absorbed dose rate was measured at the beam current of 3 μA so at 6 μA $D_{\underline{W}}( Z_p ) = 2.23$ Gy / min. The dose rates calculated from the later one at the different distances far from the target were presented in the table 5

Table 5

| SSD = 5 cm | SSD = 10 cm | SSD = 15 cm | SSD = 20 cm | SSD = 30 cm |
|---|---|---|---|---|
| 1075Gy/ min. | 268.6Gy/min. | 119 Gy / min. | 67 Gy / min. | 29.8 Gy/ min. |

## *3/ Discussion:*

1/ From the experiment N°1 it was found that the dose rates linearly depend upon the beam currents. The dose rate at the beam current of 6μA will be calculated from the one at the beam current of 3 μA by multiplying the factor of 1.97.

2/ The absorbed doses from the backscattering radiation around the shielding box measured by VINATOM and NRPB dosimeters are in the good agreement.

3/ Comparing the values of dose at points E & C, D & I it was found that the dose values measured by ionization chamber and TLDs are in the good agreement too.

4/ The results of the backscatering radiation measurements show that there was a very steep dose gradient at the edge of the shielding box, over which the victim was leaning. From these figures it can be suggested that the upper part of victim's body (head, face, breast, abdomen ) may be received the doses from 1.0 Gy to 5.0 Gy per 4 min. of the exposure.

5/ From the interview with the victim, it was clear that the time of manipulating sample in the irradiation compartment ( box ) could not have been more 10-20 seconds. If some approximation is taken into account: time of exposure ≈ 15 seconds, the distance from the target to hands is of 10 -15 cm then from the dose rates presented in the table 5 the dose received by victim's hands is in the interval of 30 - 50 Gy. It was reported in [2] that the results of the examination by the Electron Spine Resonance (ESR) method was following : right cuff link of shirt, 30 ± 10 Gy ; opposite part of right cuff, 20 ± 6 Gy and the bone from the third right finger, amputated on 23 March 93, 30 Gy. In the letter [ 3 ] Mr. Philippe Vesseron have informed that the ESR results of measuring the biological samples taken from Hanoi and Paris showed that the doses of the right and left hands were of 40 - 50 Gy and 30 Gy, respectively. The good agreement between the results received by

different methods and samples confirms their credibility and corresponds to clinical manifestations. However it was regretted that the overexposure measurements were carried out too late so that the results of the above dose measurements were not able to be used for diagnosing and treating the radiation injury at the first stage.

6/ In these experiments the contribution of the beta contamination, neutron components were not taken into account. Figure 5 presents the gamma spectrum of the chicken leg has been exposed to primary high energy photon beam for 4 min. . The peak of 511 KeV was found. The similar effect was registered in the victim's hands.

***Acknowledgments:***

The authors are thankful to colleagues from the Departments of Nuclear Physics of Institute of Physics for their technical assistance and Mr. Nguyen Tien Nguyen - Director of Vietnam Atomic Energy Commission, Mr. John S. Wheatley for their information useful discussion and Mr. Pham Quang Dien for his attention to this work. Thanks also to Ms. Tran Tuyet Mai, Phan Thi Tuong Van, Nguyen Phuong Dung and Mr. Tran Ngoc Toan for their helps.

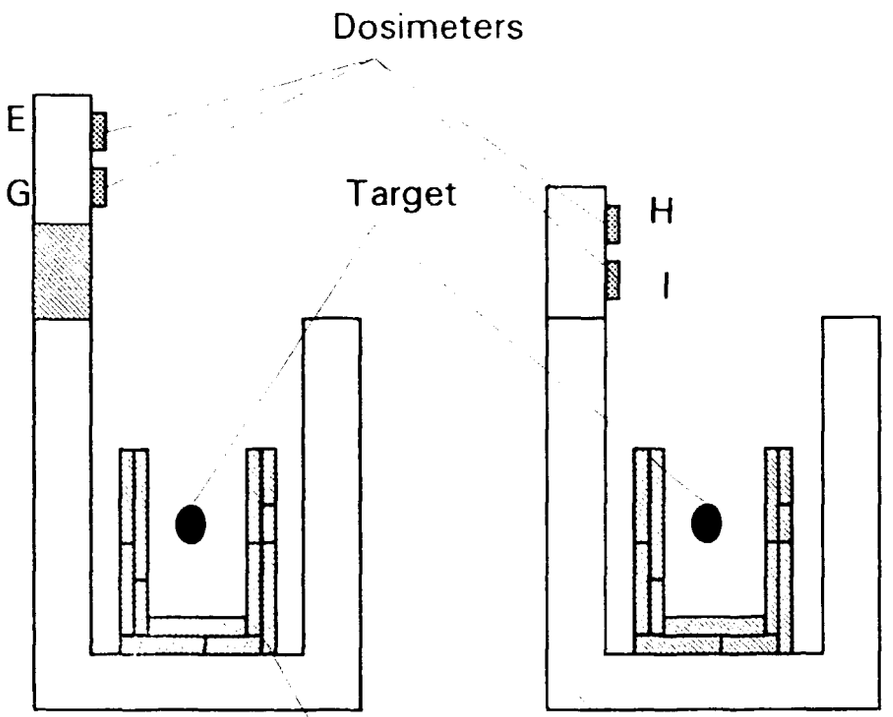
***Reference:***

[1] Absorbed Dose Determination in Photon and Electron Beam
IAEA Technical Report Series No. 277, 1987

[2] Angerika BARABANOVA
End of Mission Report on Radiation Exposure Assessment
(VIE/9/006 )
IAEA,1993

[3] The Official Letter to Vietnam National Atomic Energy Commission, July 1993

*Received on 30 December 1994*
*Published on 15 January 1995*



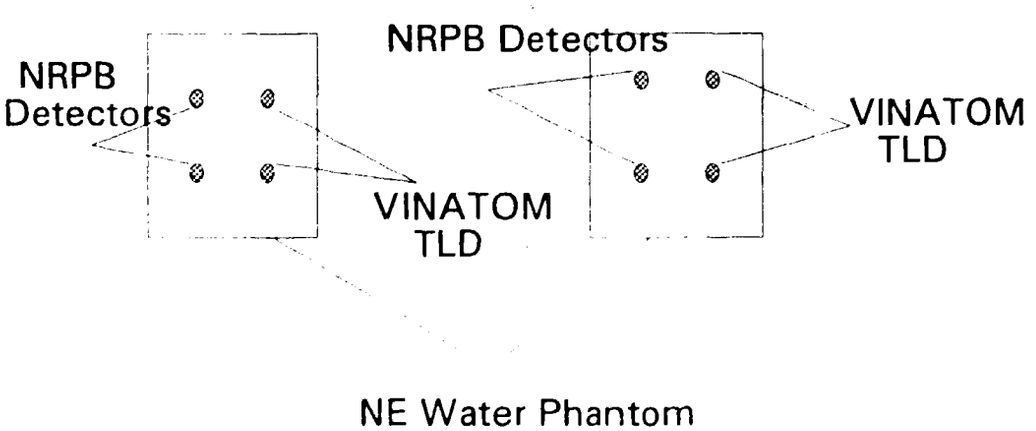




Fig.1 Experiment No1 Fig.2 Experiment No 2

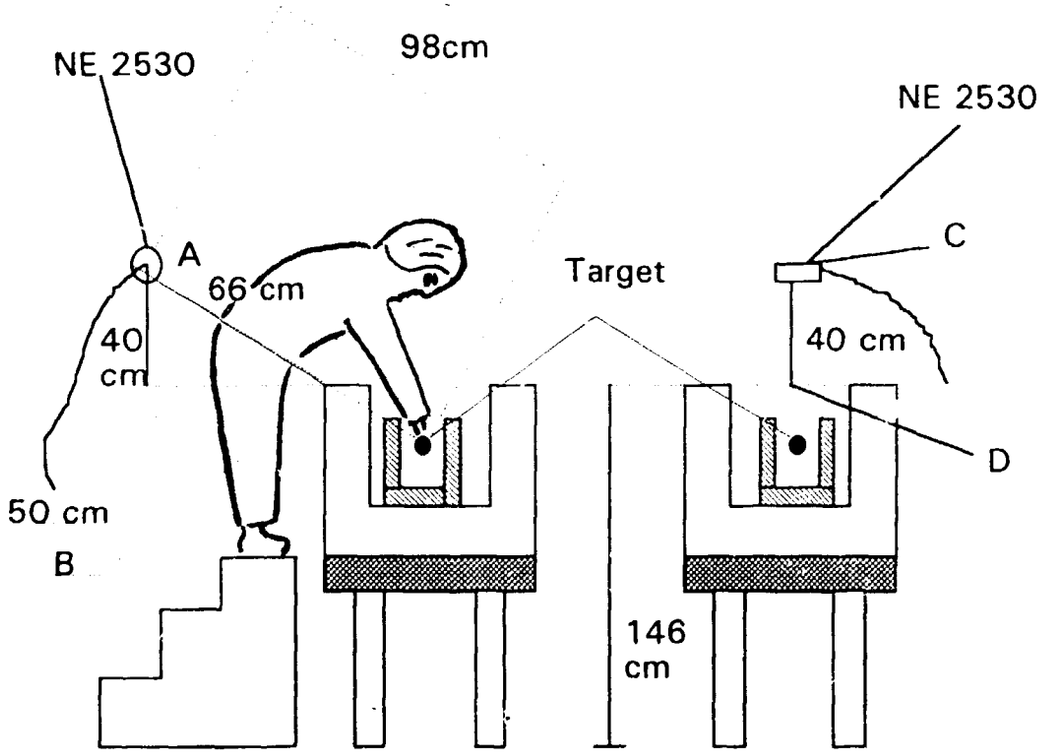



Fig. 3 Experiment No 3




Fig. 4 Experiment No 4

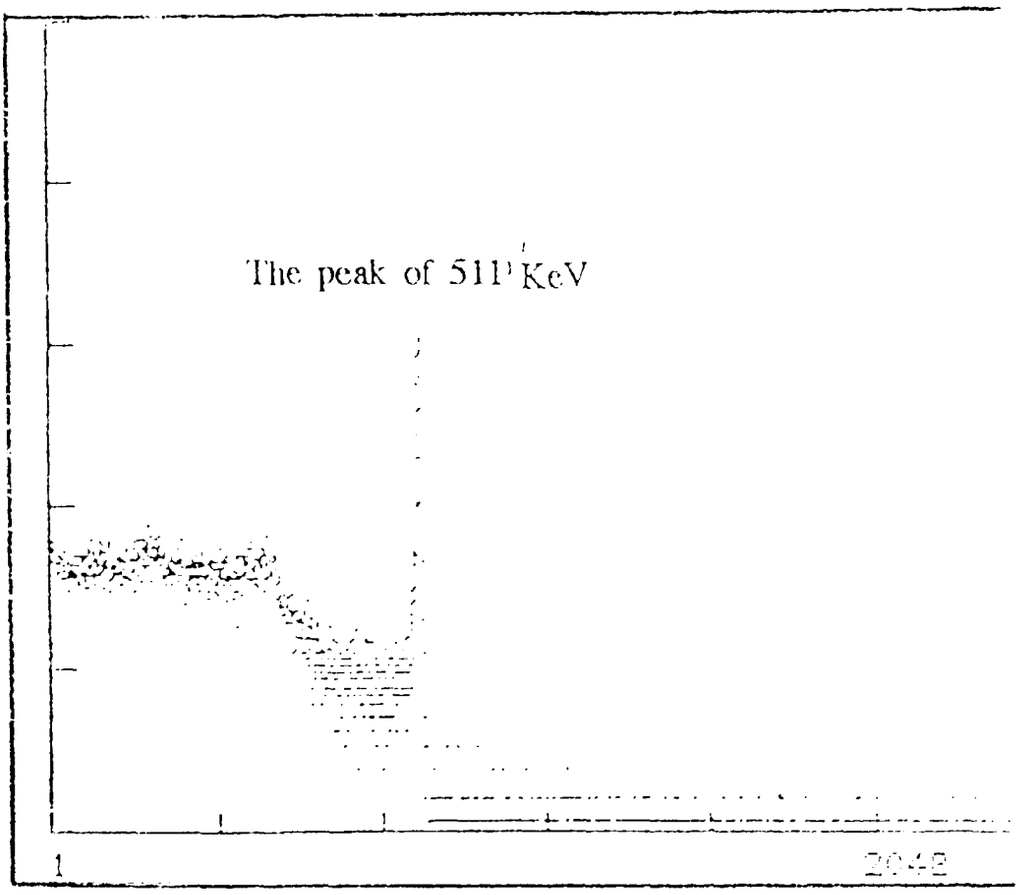



Figure 5 Gamma spectrum of The chicken leg exposed to high energy photon beam for 4 min. at beam current of 3μA

## SUBJECT CATEGORIES OF PREPRINTS OF VIETNAM NATIONAL ATOMIC ENERGY COMMISSION

| Index | Subject Categories |
|---|---|
| **A** | **Physical Science** |
| | - General Physics |
| | - High-Energy Physics |
| | - Neutron and Nuclear Physics |
| **B** | **Chemistry, Materials and Earth Science** |
| | - Chemistry |
| | - Materials |
| | - Earth Science |
| **C** | **Life Science** |
| | - All Effects and Various Aspects of External Radiation in Biology |
| | - Radioisotope Effects and Kinetics. |
| | - Applied Life Science |
| | - Health, Radiation Protection and Environment |
| | - Radiology and Nuclear Medicine. |

| Index | Subject Categories |
|---|---|

**D Isotopes, Isotope and Radiation Applications.**

- Isotopes and Radiation Sources.
- Isotope and Radiation Applications

**E Engineering and Technology**

- Engineering
- Fission Reactors (General)
- Specific Fission Reactor Types and Their Associated Plants
- Instrumentation
- Waste Management

**F Other Aspects of Nuclear Energy**

- Economics and Sociology
- Nuclear Law, Regulations
- Nuclear Documentation
- Safeguards and Inspection
- Mathematical Methods and Computer Codes
- Miscellaneous.

Printed by

**Information Centre**

**VIETNAM NATIONAL ATOMIC ENERGY COMMISSION**

59 Ly Thuong Kiet Str., Hanoi, Vietnam