

# Ionising Radiation at Radar Facilities

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**Abstract.** For some years contributions about radiation exposures at radar facilities or radar devices of the German armed forces were published in the German media. A lot of Soldiers or other specialised workers who dealt with these devices before 1975 claimed their diseases as been caused by the radiation. In most of the cases and the resulting reports it is not distinguished between the high frequency radiation and the ionising radiation caused by the electron tubes like Klystrons, Thyratrons or other valves.

This paper is limited to the ionising radiation. An overview about the technical basis of the emission of ionising radiation is given. The radiation is pulsed, the energy is often very low and additional in the field of high frequency radiation it is not trivial to measure the ionising radiation by the common electronic radiation measurement devices. The authors decided to use thermoluminescent dosimeters. Two selected measurements, one at a military radar system from the sixties and one at a contemporary civil airport surveillance radar system will be presented.

The presented results from the military radar system show, that there could had been large radiation exposures: in the chosen example a dose rate up to 3.5 mGy per hour. But it will also be discussed that this would lead in most cases only to a skin dose, taking the very low energy into account.

On the other side, it could be verified, that contemporary civil surveillance radar systems do not emit considerable radiation exposure for the technicians, who are working on these machines and of course not for other people which stay nearby the radar systems.

## 1. Introduction

Since about two years, there is an ongoing public discussion in Germany about the causation of cancer diseases by working at or nearby radar devices. The discussion rose when a group of former military radar technicians claimed their cancer diseases as caused by the work on the radar systems in the sixties and later. However, up to now, there is no serious epidemiological investigation showing a statistically significant increase of cancers among this group of workers.

Working on radar facilities implies the danger of being exposed through:

- high frequency radiation (microwave radiation),
- x-ray from electron tubes and valves,
- radioactive sources in electronic equipment (Tritium, etc.) and
- radioactive fluorescent colours.

The majority of experts is certain that the emitted microwave radiation from the radar facilities is not able to induce cancer diseases, but is able to cause deterministic (thermal) effects if the intensity and the exposure time are high enough. The radiation exposure from the radioactive sources and colours in most cases is playing a secondary roll compared with the x-rays. So this contribution focuses on the x-ray emission from the electron valves only.

The Thyratrons, Magnetrons, Klystrons or other electron valves, used in the radar facilities, produce unwelcome pulsed x-rays (see Figure 1). The energy of the emitted radiation depends on the high voltage switched or modulated in the valves. It varies in a wide range from below 10 kV up to about 200 kV. The most military applications are working with a voltage less than 30 kV, with belonging consequences for the organ doses. The most current civil surveillance radar systems in Germany are working with about 70 or 80 kV. In case of failure or malfunctions the technicians had to do troubleshooting sometimes on operating machines. But the total working time under operation is clear under the whole daily working time in average. This has to be taken into account for the dose assessment.

With the knowledge of the hazards, the armed forces began to implement radiation protection measures in the early seventies. It lasts up to 1985 until the last radar facility had been equipped with technical protection measures.



FIG. 1. Different kinds of electron valves, used in radar facilities

If a radar technician who suffers from cancer, claims his disease as occupational caused to an accident insurance, it has to be proved if the occupational radiation exposure was high enough to induce the disease substantially according to German laws. Therefore the dose has to be verified retrospectively. In the last two years there had been a lot of investigations on various radar systems by the military and civil laboratories. In this contribution an example is given for a system with higher dose rates. The discussion about the mentioned hazards put also civil technicians into a state of uncertainty about the safety of their work on radar facilities. Because today there are no older radar systems available for measurements in Germany, only current systems could be proved by measurements. An example for a measurement at the most spread civil surveillance radar system on German airports is given in this contribution, too.

## 2. Materials and Methods

It is not simple to measure ionising radiation in high frequency fields with electronic devices. To ensure, that there is no influence to the measurements from the high frequency radiation on the one side and the pulsed radiation on the other side, it was decided to measure with thermoluminescence dosimeter (TLD). Commercial available TLD-100 chips and rods, containing LiF:Mg,Ti, were used. At each measurement position, two chips with 3.2 mm diameter and 0.05 mm thickness as well as two rods with length 6 mm and 1 mm in diameter were arranged close to each other (see Figure 2) in a non light transmissive foil. So at each measurement position four independent values have been obtained.

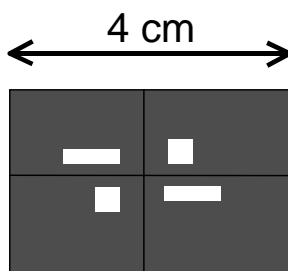


FIG. 2. Arrangement of the TLD on one measurement position

The thermoluminescence readout equipment used in the measurements was a manual planchet reader, type H3500. The TLD's and the reader were manufactured by Harshaw/Bicron, Cleveland, USA. The calibration of the TLD was done at the MPA in Dortmund using an average energy of 58 keV in the case of the civil radar facility and energy of 12 keV in the case of the military radar system, according to the suspected radiation energy.

Underground measurements were taken into account and subtracted from the measured values. All results are values of the photon-equivalent-dose-rate. For exposure estimates, they had to be converted into organ-doses under consideration of the real working time with voltage on and the radiation energy and under taking into account the spatial distribution of the emission.

### **2.1 Civil Radar Facility Measurement**

The flight traffic on most important German Airports is controlled by an Airport Surveillance Radar ASR-2000. This type of radar facility was chosen for a measurement, done in summer 2001. The technicians had to maintain this machine from time to time nearby the opened control cabinets during operation.

The transmitting valve is a Klystron with 77 kV. The x-ray emission is pulsed. The radar facility was shut down during the positioning and de-positioning of the TLD's. The exposure-time was exactly two hours. The detection limit of the TLD-chips was 3.2  $\mu\text{Gy}$  according to a minimum detectable dose-rate of 1.6  $\mu\text{Gy/h}$  and of the TLD-rods was 2.3  $\mu\text{Gy}$  with a corresponding dose-rate of about 1.2  $\mu\text{Gy/h}$ . The TLD's had been mounted on a thin web in the front and the rear of the control cabinet in different height at that positions, the technicians normally are working at.

Additional measurements have been done at this ASR-2000 with a tissue-equivalent phantom (Alderson phantom) to verify possible organ doses in different tissues. The phantom is cut into 34 discs each with several bore-holes for taking TLD-rods (see Figure 3).



FIG. 3. Alderson Phantom with a head-disc and TLD-rods

### **2.2 Military Radar Facility Measurement**

Many types of radar devices had been in use in Germany during the last four decades. The “GRS 9 A-M” is an example for a device with higher radiation emission, which has been investigated in January 2003. There are three different electronic valves used in this system, a Magnetron, a Tetrode and a locking-Diode, all of them working at about 20 kV. The TLD's had been mounted on the surface of this device or had been mounted on a tape in the maintenance-openings (see Figure 4). The exposure-time was 20 minutes. The detection limit of the TLD's was about 4  $\mu\text{Gy}$  in this case, according to a minimum detectable dose-rate of 12  $\mu\text{Gy/h}$ .



FIG. 4. Mounting of TLD's in the greater maintenance-opening and at the control panel

At this device, there are several maintenance flaps and holes which had to be opened during maintenance and for adjustment work. Specially near the modulator was a greater opening and a smaller window for this purpose. Three measurements had been performed:

- One at the front side of the control panel, where the radar service technicians normally are working, with all maintenance-openings closed.
- One in front of the modulator, representative for the eye-dose of a technician, looking through the opened smaller window
- One in front of the modulator with the greater window opened

### **3. Results**

#### ***3.1 Civil Radar Facility***

At all positions the technicians had to work nearby, no significant value above the detection limit could be verified. Only a few TLD's at the rear side of the control cabinet showed a value just at or a little above the detection limit. But at these positions nobody is working during operation of the radar system.

It could be shown that the investigated ASR-2000 device do not emit ionising radiation, that lead to a considerable radiation exposure for the technicians who are working at these machines and fairly not for other persons, who stand nearby.

#### ***3.2 Military Radar Facility***

The results at the GRS 9 A-M show that the emission is not homogeneous into the space. There is a small angle distribution, where the emission occurs. This has been observed at all electronic valves also at other radar facilities.

In front of the control panel, there could not be verified a significant dose-rate above the underground for the technicians. For maintenance activities at the modulator with opened great window, a dose-rate of 3 mGy/h has been determined. The basis for calculation of an eye-dose – indicated by looking through the opened smaller window - is a dose-rate of about 3.5 mGy/h.

### **4. Discussion**

The problem of x-ray emission at former radar facilities is well known today, and there had been many retrospectively investigations about the emission of radiation on former military radar facilities. Some of them showed very high dose-rates. But a high dose-rate does not mean high organ doses for the technicians in all cases. It has to be taken into account that the emission occurs only in a very small spatial distribution, so it is not a whole body exposure. In most cases is the energy below 30 keV, so that first of all there could occur higher skin and eye doses. Another fact is the real working time with voltage on at the radar systems. In many cases the technicians first switch voltage off and then starts to work on the devices. Altogether these facts do not lead to greater organ doses for the radar technicians in most cases. But It should not be neglected, that in some cases at special radar facilities the circumstances could lead to really high organ-doses for the technicians.