

FINNISH CENTRE FOR RADIATION AND  
NUCLEAR SAFETY - Helsinki Finland

SAFETY ASSESSMENT

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Nuclear Safety Department

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Orderer: Kosirak Oy  
Katajatie 9  
54850 KUUKANNIEMI

Equipment: MIRAKU floor/wall drier and EMI-BEAM antenna drier

Place: Turku

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## 1 GENERAL

The purpose of the measurements was to find out the level of diffuse microwave radiation of equipment designed for the drying of concrete, and to give instructions on the safety measures required to ensure nuclear safety.

There are two types of MIRAKU floor/wall driers: MIRAKU 4000 designed for the drying of floors, and MIRAKU 1350 for the drying of walls and floor corners. MIRAKU 4000 comprises of three parallel MIRAKU 1350 units, the length of whose nozzle is 1055 mm and width 260 mm. Each unit has two magnetrons with a microwave output of approximately 650 W at the frequency of 2450 Mhz. The microwave radiation of each magnetron comes out of an opening whose length is approximately 110 mm and width approximately 55 mm. The microwave output of the MIRAKU 4000 drier is approximately 4 kW. The length of its nozzle is 1055 mm and width 800 mm. The driers are placed tightly against the concrete structure to be dried, and the microwaves quickly dry the concrete also below the surface structures.

The EMI-BEAM antenna drier is made up of a generator, coaxial cable and an antenna at the end of the cable. There is one magnetron in the generator inside a metal shield, whose microwave power is approximately 650 W at the frequency of 2450 Mhz. The

microwaves are conducted through a protected cable to the antenna, which is an unprotected piece of inner conductor, about 3 cm in length. This is pushed to a hole made with a rock drill in the concrete wall. The microwaves penetrate the surrounding concrete structure and remove excess moisture, also inside the concrete.

## 2 REGULATIONS AND INSTRUCTIONS REGARDING MICROWAVE RADIATION

Regulations on equipment emitting microwave radiation have been given in the law on radiation (592/91), the statute on the supervision of nonionizing radiation (1513/91), the decision of the Ministry of Social Affairs and Health on the maximum exposure to nonionizing radiation (1474/91), as well as the law on occupational safety (299/58).

The maximum intensity directed to a person, according to the decision of the Ministry of Social Affairs and Health, is  $50 \text{ W/m}^2$  at the frequency range of 2...300 GHz. It is determined as the average of six-minute periods. The maximum value of population exposure is  $10 \text{ W/m}^2$ .

The standard IEC 519-6 of the International Electrotechnical Commission (IEC) deals with industrial microwave heating devices. According to the standard, the intensity of leakage radiation may not exceed  $50 \text{ W/m}^2$  at a distance of 5 cm from the device.

## 3 EFFECTS OF MICROWAVE RADIATION

Microwave radiation is absorbed in the tissues as heat which damages the tissues when a certain level is exceeded. Intensity below  $100 \text{ W/m}^2$  has no effect even in long-term exposure. Microwave radiation which exceeds  $300 \text{ W/m}^2$  can be felt as warmth on the skin. Continuous exposure for more than an hour at the intensity of  $1000 \text{ W/m}^2$  may cause grey cataract in the lens of the eye. The time required for the development of grey cataract gets shorter as the intensity increases, and it is 30 seconds at the intensity of  $10,000 \text{ W/m}^2$ . If microwave radiation exceeds the intensity of  $100,000 \text{ W/m}^2$ , it will cause pain and burns in the hypoderm in a few seconds.

## 4 MEASUREMENTS

#### 4.1 Measuring equipment

Microwave radiation was measured with the wide-band microwave radiation meter Narda 8616 which had an isotropic electric field measuring head 8621C. The measuring range of the measuring head extends to the intensity of 200 W/m<sup>2</sup>. The meter and the measuring head have been calibrated at the frequency of 2450 MHz with the calibrating equipment of the Finnish Centre for Radiation and Nuclear Safety. The inaccuracy of the equipment is estimated to be  $\pm 1$  dB. The calibration factor of the measuring head is 0.90, which was also used in the measuring. The estimated inaccuracy of the measurements is  $\pm 1$  dB.

#### 4.2 MIRAKU 4000 floor/wall drier

Measurements were carried out around the device to estimate the exposure of the user and those working nearby. During normal operation on the floor the greatest distance at which the intensity of 50 W/m<sup>2</sup> was exceeded was about 50 cm. Diffuse radiation was strongest by the cooling air louvres on the long side of the device. Intensity at the distance of 15 cm was approximately 100 W/m<sup>2</sup>. By other parts of the device 50 W/m<sup>2</sup> was exceeded at the distance of about 20 cm. Moving the device to another place on the floor did not significantly change diffuse radiation.

The effect on diffuse radiation of a space between the device and the floor was studied by lifting the device on its transport wheels, in which case the space was about 1 cm. The intensity of diffuse radiation increased two-fold being 100 W/m<sup>2</sup> at the distance of 50 cm. The intensity 50 W/m<sup>2</sup> was exceeded at the distance of about 1 m.

#### 4.3 MIRAKU 1350 floor/wall drier

The device was placed at the corner of the wall and the floor at an angle of about 45 degrees with respect to the floor. A steel applicator built for the purpose was used in the installation, so there were no large gaps between the device and the concrete structure. The intensity of diffuse radiation was below 50 W/m<sup>2</sup> at the distance of 50

cm from the device. Increasing the space between the wall and the device to 1 cm did not significantly increase diffuse radiation.

Microwave radiation was also measured on the other side of the wall. The thickness of the wall was about 17 cm and moisture about 3 percent by weight. On the other side of the wall the microwave radiation had spotlike maximum points. The intensity  $200 \text{ W/m}^2$  was exceeded at the distance of about 1 m and  $100 \text{ W/m}^2$  at the distance of about 1.5 m from the wall. The intensity  $50 \text{ W/m}^2$  was exceeded at about 2.5 m from the wall. The values measured are higher than in normal use, since the wall was thinner and drier than normal. If the device is placed perpendicular to the wall, intensity behind the wall at its immediate vicinity may exceed  $1000 \text{ W/m}^2$ .

#### 4.4 EMI-BEAM antenna drier

The EMI-BEAM antenna drier was placed in a wall whose thickness was about 45 cm and moisture about 7 percent by weight. The intensity of diffuse radiation was below  $2 \text{ W/m}^2$  at the distance of 15 cm from the hole. Reducing installation depth increased leakage radiation only when the radiating cable end began to show. On the other side of the wall the intensity of diffuse radiation was below  $1 \text{ W/m}^2$  at the distance of 15 cm from the wall when the antenna drier had been placed as deep in the hole as possible.

## 5 SAFETY ASSESSMENT

The floor/wall driers do not comply with the requirement of the IEC 519-6 standard of not more than  $50 \text{ W/m}^2$  at a distance of 5 cm from the device. The maximum exposure may be exceeded, if sufficient precautions are not taken. The antenna driers complied with the leakage radiation requirement in the test situation, but do not necessary comply with it in all situations, for instance when drying a thin wall.

Use of the equipment involves the following risks: When the waveguide openings of floor/wall driers are visible, and microwave power is switched on, the intensity of radiation exceeds  $100,000 \text{ W/m}^2$  right in front of the openings and may cause burns and eye injuries in a few seconds. At the distance of 20 cm from the openings,

intensity exceeds  $10,000 \text{ W/m}^2$ , which can cause grey cataract in about one minute. When drying concrete, the intensity behind a wall, floor or ceiling may exceed  $1000 \text{ W/m}^2$ , in which case grey cataract may develop after an exposure of one hour or more. It is possible to get burns when using the antenna drier, if one touches the bare cable end when microwave power is switched on.

## 6 PRECAUTIONS

The equipment may only be used by a person well-familiar with the use of the equipment, the risks of microwave radiation as well as the precautions to be taken. The user must make sure that the maximum values of exposure are not exceeded. If necessary, the intensity of microwave radiation must be measured with a suitable meter that should be calibrated every three years.

The following precautions must be taken to ensure radiation safety during use:

- The equipment must be fitted with plates warning of microwave radiation according to the standard SFS 5424, figure 4.
- The tightness of the joints between the floor/wall driers and the applicators must be observed.
- Microwave power may not be switched on before the equipment has been properly placed in the drying position, and the microwave power must be switched off before the equipment is moved.
- It is forbidden to stay or work within one metre from an active floor/wall drier.
- When using a floor/wall drier one must make sure that nobody is working or staying on the other side of the floor, wall or ceiling. If necessary, the access of unauthorized persons to the premises during drying must be prevented by placing signs that warn of microwave radiation. It must also be noted that when the concrete dries, the intensity increases on the other side of the concrete surface.
- The equipment and its operation must be continuously monitored during use.

Inspector [Signature]  
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CC National Board of Labour Protection