Summary

A IONISING RADIATION

On 1st August 2001, the amendment to the Radiation Protection Ordinance (StrlSchV) has come into force (BGBl. I, p.1714). As a result of this the requirements of the Directive 96/29/EURATOM on the basic safety standards and the Medical Exposure Directive 97/43/EURATOMwere implemented into German legislation. They have, among others, direct consequences on the dose calculations in natural radiation exposure from radon daughter products (Part I, 2), in the case of exposure from nuclear facilities (Part II), in the occupational exposure to air crews from cosmic radiation (Part III, 1), and in incorporation monitoring (Part III, 2).

Since 1958, all data on environmental radioactivity from measurements performed by authorised laboratories have been published in quarterly reports and, since 1968, in annual reports. In addition to the results from environmental monitoring these reports include data on the population exposure from natural and man-made radiation sources. Data are shown below on exposures due to

- natural radiation sources
- technologically enhanced natural radioactivity
- medical applications
- nuclear installations
- the handling of radioactive substances
- occupational exposure
- nuclear weapons tests
- radiation accidents or other emergencies
- effects from the Chernobyl reactor accident.

The mean radiation exposure to the population in the Federal Republic of Germany during the year 2001 is shown in the following table and classified by various radiation sources. Compared to prior years, the mean effective dose remained, for most areas, unchanged.

MEAN EFFECTIVE DOSE TO THE POPULATION IN THE FEDERAL REPUBLIC OF GERMANY DURING THE YEAR 2001

		Mean effective dose mSv/year	
1.	**Exposure from natural radiation sources**		
1.1	cosmic radiation (at sea level)	approx. 0.3	
1.2	external terrestrial radiation	approx. 0.4	
	outdoors (5 h/d)		approx. 0.1
	indoors (19 h/d)		approx. 0.3
1.3	inhalation of radon and its progeny	approx. 1.1	
	outdoors (5 h/d)		approx. 0.2
	in dwellings (19 h/d)		approx. 0.9
1.4	ingestion of natural radioactive substances	approx. 0.3	
Total natural radiation exposure		**approx. 2.1**	
2.	**Exposure from man-made radiation sources**		
2.1	nuclear installations	< 0.01	
2.2	use of radioactive substances and ionising radiation in medicine	approx. 2	
2.3	use of radioactive substances and ionising radiation in research, technology and the home environment (excluding 2.4)	< 0.01	
	2.3.1 industrial products		< 0.01
	2.3.2 industrial radiation sources		< 0.01
	2.3.3 stray radiation		< 0.01
2.4	occupational radiation exposure (contribution to mean population exposure)	< 0.01	
2.5	radiological emergencies	0	
2.6	fallout from nuclear weapons tests	< 0.01	
	2.6.1 external outdoor exposure		< 0.01
	2.6.2 incorporated radioactive substances		< 0.01
2.7	exposure due to the accident in the Chernobyl nuclear power plant	< 0.015	
Total exposure from man-made sources		**approx. 2**	

Natural radiation sources and technologically enhanced natural radioactivity

Exposure from natural radiation sources consists of both an external and an internal component due to natural radioactive substances in the environment. A major source of external radiation exposure consists of both cosmic and terrestrial radiation from the natural radioisotope potassium-40 together with the radionuclides of the natural decay series of uranium-238 and thorium-232. The internal component of radiation exposure is largely caused by the inhalation of the natural noble gas radon and its daughter nuclides, and partially also by the intake of natural radioactive substances with drinking water and food. Typically, natural radiation sources contribute to the effective dose to the level of 1 to 6 millisievert per year. The nominal mean value is 2.1 millisievert, resulting in particular from exposure to radon in buildings. All individual contributions to the annual mean effective dose are listed in the above table.

Measurements performed during recent years have shown considerable regional variations in natural radiation exposure, due mainly to the significantly different concentrations of natural radioactive substances in soil and air. The construction of houses on land containing increased amounts of uranium and radium, and to a lesser extent, the use of building materials containing increased amounts of radioactive substances are assumed to be responsible for the increase in population exposure from the radioactive decay products of these radionuclides. National and international epidemiological studies are currently underway to further limit the risk to the health of the population from increased exposures to radon daughters.

A mining-related increased concentration of radon in air close to ground level is seen only in the immediate vicinity of mining facilities; the concentration decreases with increasing distance from such facilities. The overall results of the measurements show the occurrence of above-average radon concentrations in mining regions of uranium and copper slate mining but, since such concentrations occur also in geologically comparable regions, these are assumed to be partly of natural origin. The discharge of uranium and radium and their respective decay products from mining facilities into large drainage areas of the mining regions does not cause an appreciable change in the natural level of these radionuclides.

Man-made sources of radiation

Medical applications

The largest part of the mean effective population dose from man-made exposure sources is due to the use of ionising radiation and radioactive substances in medicine. The dose attributable to medical radiation exposure is estimated to be about 2 millisievert per year.

Surveys performed by the Federal Office for Radiation Protection (BfS) on exposures in diagnostic radiology, with these representing by far the largest contribution, yielded a considerable range of dose value scattering for individual examinations over more than two orders of magnitude, which is caused by the different conditions for each individual patient and the different technical standards applied. Surveys performed indicate a further slight increase in the frequency of application of examinations in spite of the broad use of alternative examination techniques (i.e. ultrasound, endoscopy and magnetic resonance tomography techniques), above all for the dose-intensive examination procedures computer tomography and angiography and including interventional radiology applications. The value for the mean effective dose may well increase over the coming few years - due to the increasingly successful quality assurance and control measures applied in diagnostic radiology and nuclear medicine, only slightly however. Surveys of the levels of radiation exposure per examination reveal a reduction in dose per individual examination. This type of survey for the updating of the data for frequency and dose has been performed continuously at the Federal Office for Radiation Protection since 1991, with the support of the health service organisations.

In radiotherapy, the use of newly developed irradiation techniques and improved irradiation planning enables the optimisation of the required therapeutic dose to be administered to the treated body region (tumour dose), while simultaneously limiting the level of radiation exposure to the remaining parts of the body. Increased efforts are needed in the area of follow up for tumour treatment.

In diagnostic nuclear medicine, scintigrams of the thyroid and the skeleton are the most frequently applied methods of examination. Of increasing importance is the use of radioactively labelled monoclonal antibodies, within the framework of the diagnosis of inflammatory processes and tumours and in tumour therapy. An ever increasingly important role is also played by Positron Emissions Tomography (PET) applied as a nuclear medicine procedure.

The new Radiation Protection Ordinance, which has come into force on 1st August of the reported year, has additional effects within the field of medical practice, particularly due to regulations on the justifying indication, on persons authorised to make applications, on the qualified competence in radiation protection, and on medical physics experts. The BfS will be involved in new tasks, such as the establishment and publication of diagnostic reference values, and the granting of licenses for the use of radioactive substances or ionising radiation in man in the scope of medical research.

Nuclear technology

The emission of radioactive substances from nuclear power facilities and from the former Morsleben repository for low and intermediate-level radioactive waste (ERAM) contributes only insignificantly to radiation exposure to the population. The radionuclides identified in the scope of environmental monitoring of the Asse mining facility are of natural origin or, in the case of strontium-90, a consequence of the natural fallout. The upper values for exposures to individuals, calculated in accordance with the "General Administrative Guideline relating to § 45 of the Radiation Protection Ordinance" of 21-2-1990 are clearly below the limits indicated in the Radiation Protection Ordinance. In general, the calculated radiation exposure values show no essential differences to those reported for 2000. The annual contribution from domestic nuclear installations and other installations located close to the borders of Germany to the mean effective dose to the population of the Federal Republic of Germany remained below 0.01 millisievert, also in the year 2001 (Table p. 18 - 2.1).

The handling of radioactive substances in research, technology and the home environment

The use of ionising radiation and radioactive substances for technological and research purposes has not changed in comparison to the preceding year. Devices representing relatively small radiation sources are in use, such as television sets, monitors, smoke alarm systems and anti-static equipment. The radiation exposure to individuals and the population as a whole from mechanical devices is limited by the stipulations of the X-Ray Ordinance and the Radiation Protection Ordinance and this is kept as low as reasonably achievable. The mean contribution to population exposure from the handling of radioactive substances in research, technology and the home environment is less than 0.01 millisievert per year.

Occupational radiation exposure

The mean effective dose from external radiation for all persons (approx. 316 000) controlled using personal dosemeters was about 0.15 millisievert in the year 2001. The effective dose of 0 millisievert was assessed, over the entire year, in about 86% of all controlled persons. In all other cases with an annual dose of 0.1 millisievert or more (approx. 45 000) a mean individual dose of 1.0 millisievert resulted. The contribution to the total mean effective population dose from occupational exposure is therefore less than 0.01 millisievert in 2001.

Nuclear weapons testing

In the year 2001, no nuclear weapons tests were carried out. The long-lived radioactive substances detectable in the atmosphere and in foodstuffs mainly originate from the above-ground nuclear weapons tests performed during the 1960s. The radionuclides emitted during this period contributed in the year 2001 to a level of less than 0.01 millisievert to the mean effective dose to the population in Germany.

Radiation accidents and radiological emergencies

Due to the strict regulations laid down in the Radiation Protection Act, radiological emergencies requiring persons to handle sources of ionising radiation and radioactive substances are rare events. An overview on radiological emergencies is shown in Part III 4. In particular has to be mentioned the theft of radioactively contaminated objects from the fuel reprocessing plant in Karlsruhe (WAK). During this incidence three persons were seriously contaminated from incorporation of radioactive substances. The effective dose commitment of these persons was 5.5 Sv, 0.38 Sv, and 0.18 Sv, respectively.

Reactor accident at Chernobyl

After the reactor accident at the Chernobyl nuclear power plant in 1986, all measured data available to the Federal Republic of Germany were documented and evaluated from the point of view of radiation hygiene.

Radiation exposure resulting from this accident decreased further in the year 2000; the mean effective dose from caesium-134 and caesium-137 was less than 0.015 millisievert. Thus it was clearly below one percent of the dose from natural sources of exposure and was caused to a level of about 90% by external exposure due to caesium-137 deposited on the ground. The mean effective dose from the intake of radiocaesium with foodstuffs is estimated to have been less than 0,002 millisievert in the year 2000. In Southern Germany the levels of radiation exposure may be higher by one order of magnitude.

B NON-IONISING RADIATION

The domain of non-ionising radiation (NIR) consists of low frequency electric and magnetic, and high frequency electromagnetic fields as well as optical radiation involving ultraviolet (UV) radiation. In view of the growing technical development the general public is increasingly exposed to non-ionising radiation, above all to low frequency fields of energy supply and to high frequency fields of wireless communication networks. The planned development of communication networks in Germany, particularly the introduction of UMTS technology, has evoked a public discussion about possible risks to health from new communication technologies. Today’s behaviour in leisure times with long sunbathing and the growing up-to-date wellness areas with increasing use of solariums cause additional UV exposure. Due to the decrease of the ozone layer a further increase of UV exposure to the population is feared.

General mechanism of the effects of electromagnetic fields

The effects of electric, magnetic and electromagnetic fields are manifested in powers exerted to electric charges. This causes currents which dependent on frequency and intensity, may lead to stimulation processes or rising temperatures in biological tissues. Contrary to ionising radiation, the low and high frequency radiation in the frequency field of 0 to 300 GHz has not the energy to produce deleterious radicals in biological systems due to ionising procedures, and thus the potential to permanently damage the genetic structure, i.e. the DNA, as a prerequisite to cause cancer induction, is missing.

Limit values and recommendations for limit values

Based on proved health consequences, the international radiation protection committees give recommendations to limit exposure values. These have been adopted by the Council of the European Community. The currently applied limit values for low and high frequency installations in Germany are based on these recommendations and are stipulated in the 26. BlmSchV, (26t^{h} Ordinance on the Implementation of the Federal Immission Control Act; Ordinance on electromagnetic fields, in force since 1st January 1997).

The adherence to the limit values for fixed high frequency installations, used, e.g., in mobile communications, is controlled in a notification procedure on the granting of a site certificate from the regulation office for telecommunication and postal affairs (Regulierungsbehörde für Telekommunikation und Post, RegTP) in accordance with the legal provisions of telecommunication. The RegTP declares that these limit values were not exceeded in the year 2000.

Exposure of the general public to low frequency magnetic fields emitted from fixed low frequency installations and from domestic devices lies – according to a Bavarian study – in average far below the legally stipulated limit values.

On the basis of a national and international exchange of scientific knowledge, the recommendations on limit values are continuously checked and adapted to the state-of-the-art in science and technology. This evaluation shows that from the scientific viewpoint, there exist possible risks which have to be met with precautionary measures. At the same time endeavours are made to ensure and enlarge scientific knowledge by means of specific research.

Solar UV monitoring

UV monitoring in Germany is carried out continuously in the Federal Office for Radiation Protection and in the Federal Environmental Agency with the daily registration of UV exposure. The data determined for the year of report show maximum values of the daily quantities of more than 3000 J/m^2 in the months from April to August; the minimum values in these months lie near max. 1000 J/m^2. According to the statistical evaluation of the recent measuring data, a small increase of UV radiation is assumed, however, due to many various influence factors it is not possible to prove almost certainly an effect caused by the decrease of the ozone layer.

Actual topics in the year 2001

Apart from the discussions about non-ionising radiation in general, and the concern of the general public about health effects of mobile communication in the year of report, the debate included also to which degree electromagnetic radiation caused cancer diseases in soldiers of the Federal Armed Forces, who have been engaged in the operation and maintenance of military radar devices. However, for the cancer inducing radiation exposure of the persons concerned, the X-ray type of ionising radiation is important (see Section A, Subsection III, 4. Radiation in personnel using radar devices).