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Provisions on Natural Radiation in the new Basic Safety Standards Directive

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PROVISION ON NATURAL RADIATION IN THE NEW BASIC SAFETY STANDARDS DIRECTIVE

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ABSTRACT

The new Basic Safety Standards Directive now also covers work activities which involve the presence of natural radiation sources. The Member States are requested to identify by means of surveys or by any measures and a system of radiological protection shall be applied where appropriate. This paper highlights some of the recommendations of the Article 31 Group of Experts in particular with regard to the control of industries processing materials containing elevated levels of naturally occurring radionuclides.

INTRODUCTION

The first BSS Directive was adopted in 1959 and it was later revised several times to reflect the development of scientific knowledge concerning radiation protection. International recommendations, especially those of the International Commission for Radiological Protection (ICRP), have always been considered in revising the BSS Directive. The previous BSS Directive of 1980 was based on basic recommendations issued by the ICRP in its Publication-26 of 1977. A new set of basic recommendations was issued in ICRP Publication-60 of 1990. Lower dose limits were recommended on the basis of the latest risk factors. The recommendations also comprised several new elements such as the distinction between practices and interventions, the use of dose constraints in optimisation of protection and the concept of potential exposures. It was also recognised that the system of radiological protection could be applied to some work activities involving exposures to natural radiation sources. The new BSS Directive[3] was adopted in May 1996 i.a. to reflect these changes in the international recommendations.

SCOPE OF THE DIRECTIVE CONCERNING NATURAL RADIATION SOURCES

Within the scope of the Directive (Article 2, see Annex) concerning exposure to natural radiation sources the directive distinguishes between:

1. Utilisation of natural radionuclides which are or have been processed in view of their radioactive, fissile or fertile properties. Such cases are considered practices and all the provisions of the directive on practices apply.

2. Work activities where the presence of natural radiation sources lead to a significant increase in the exposure of the workers or the members of the public. The term work activities is used instead of practices to highlight the distinction that a natural radiation source is present but natural radionuclides are not or have not been processed in the view of their radioactive, fissile or fertile properties. The directive applies to these work activities in accordance with Title VII.

The directive does not apply to exposure to radon in dwellings or to natural levels of radiation, i.e. to radionuclides contained in the human body, to cosmic radiation prevailing at ground level or to above ground exposure to radionuclides present in the earth's crust.

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[2] DG XI-C-1; L-2920 Luxembourg

[3] Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety for the protection of the health of workers and the general public against the dangers arising from ionising radiation.

Concerning radon in dwellings the Commission Recommendation[5] of 1990 is still valid. The reference levels established in the recommendation, 400 Bq/m^3 for remedial actions in existing dwellings and 200 Bq/m^3 as a design level for new dwellings, have been adopted in several Member States.

The provisions on work activities involving exposures to natural radiation sources are given in Title VII of the Directive. Title VII comprises Articles 40-42 which are reproduced in an Annex. The Articles 40 and 41 establish a stepwise system in which the Member States are required 1) to identify, by means of surveys or by any other appropriate means, work activities which may be of concern, 2) to set up appropriate means for monitoring exposure in the identified work activities and as necessary 3) to apply all or part of the system of radiological protection for practices or interventions, as prescribed elsewhere in the Directive.

IMPLEMENTATION OF TITLE VII IN THE MEMBER STATES

Some Member States have already included provisions on natural radiation in their national legislation but for many Member States these issues are something very new. In addition, the relative importance of natural radiation sources compared to other sources of radiation varies within the Member States. Therefore the approach of Title VII is rather general offering flexibility for the Member States to take into account national circumstances. It would, however, be advantageous if Member States would adopt similar approaches in identifying the relevant work activities, in taking corrective measures and in applying the system of radiological protection in occupational and in public exposure. Harmonisation of approaches is almost essential in internationally operated activities, especially in aircraft operation. Also the economic implications of controls imposed on industries processing raw materials, e.g. the phosphate industry, may be such as to require a harmonised policy. The Group of Experts referred to in the Article 31 of the Euratom Treaty has recognised this need and has provided technical guidance and recommendations on the implementation of Title VII. Many paragraphs in this paper are direct quotes of this forthcoming publication.[6]

IDENTIFICATION OF WORK ACTIVITIES INVOLVING NATURAL RADIATION SOURCES

Radon in workplaces

Radon (^{222}Rn) gas is one of the products of the radioactive decay series that starts with uranium (^{238}U). All terrestrial materials contain traces of natural uranium and, therefore, radon is produced everywhere in the ground. When it enters the atmosphere it disperses efficiently and outdoor air concentrations are low. However, the concentration can build up indoors as radon gas enters a building e.g. through the floor. Indoor radon concentrations depend mostly on the characteristics of the ground beneath the building, the structural details of the building and the properties and efficiency of indoor ventilation. Therefore the variations between buildings and regions are enormous.

Similar identification shall be made for exposures to thoron (^{220}Rn) gas, which is one of the decay products of thorium (^{232}Th). However, there are only very rare cases where thoron is expected to build up significantly high indoor concentrations. This is because of its very short half life, only 55 s. The half life of radon is 3.8 days.

Separate investigations should be undertaken of the geographical variation of radon exposures in above ground workplaces (e.g. factories, shops, offices and some waterworks) and in below ground workplaces. Below ground workplaces where radon concentrations may require controls include non-uranium mines, tunnels, galleries in radon spas, subways, underground installations, catacombs, show caves and tourist

[5] Commission recommendation 90/143/Euratom of 21 February 1990 on the protection of the public against indoor exposure to radon.

[6] Recommendations for the implementation of Title VII of the European Basic Safety Standards Directive concerning significant increase of exposure due to natural radiation sources (in print, 1977)

mines, underground water treatment works and stores. Surveys of all types of underground workplace should be carried out; it is not necessarily the case that high levels of radon in below ground workplaces are found only in areas, which also have high levels in buildings.

Geological information may be a useful general guide to identifying areas where radon levels in buildings are likely to be above average. However, there is a complex relationship between geological parameters such as uranium concentrations in soil and radon levels in buildings. Nevertheless geological maps can be helpful in interpolating the results of surveys of measurements of radon in buildings.

Materials and residues

Some generally utilised raw materials contain elevated levels of natural radionuclides. Raw phosphates and zircon sands are good examples. Such materials are not generally regarded as radioactive but in some circumstances operations with them may cause significant exposure to the workers or the members of the public. The significant pathways may be external gamma radiation, inhalation of dust or sometimes radon if important masses of materials containing radionuclides of the uranium series are handled indoors.

Radionuclides may concentrate significantly in some process phases, also within industries where the raw materials contain only small amounts of natural radionuclides. Examples of such cases are precipitation of radium in pipes in oil and gas industry or volatilisation of ^{210}Po and ^{210}Pb in some thermal processes and accumulation of these nuclides into stack filters. Cleaning operations may cause significant exposure to the workers and the disposal of the generated waste may also lead to significant exposure of members of the public.

Residues of some industries may also contain enhanced levels of radionuclides. Disposal or reuse of such materials may be significant especially with regard to public exposure.

Some industrial processes, which may result in significant exposures from natural radionuclides to workers and/or members of the public, are listed in Table 1. Whenever materials contain uranium or thorium consideration should be given to the extent to which their decay products are also present. It should be noted that the degree of exposure depends not only on the activity concentration of the material involved but also on any chemical or physical processing which may increase the availability of the material. For example, grinding up raw materials may generate respirable dusts and may also make it easier for radon to escape into the air of the workplace. Processing materials rich in uranium or thorium families at high temperatures (e.g. coal combustion) could enrich airborne dust in some radionuclides of the uranium and thorium series, e.g. Po-210 and Pb-210. At very high temperatures (about 3000°C or above) other nuclides of the uranium or thorium families may also gasify, e.g., Ac-228 may gasify from welding rods doped with Th-232 during welding. Attention must be paid to the possibility that waste streams may be responsible for a more significant hazard than the main process leading to the product. Table 1 should not be taken to be comprehensive but rather as illustrating the kind of process where exposures may occur and where it may therefore be necessary to assess exposures. Conversely, the fact that a process is listed does not imply that it will always lead to significant doses. If details of the process change then a review of exposures may be desirable.

Air craft operation

Member States are requested to make arrangements for undertakings operating aircraft to identify those members of the crew who are liable to receive an effective dose of more than 1 mSv per year due to elevated levels of cosmic radiation during flight. This topic is not further elaborated in this paper.

IMPLEMENTATION OF A SYSTEM OF PROTECTION

Depending on the nature of the work activity and the monitoring results it shall be required, as necessary, to apply all or part of the system of radiological protection for interventions or for practices, as prescribed elsewhere in the Directive. In the latter case the dose limits for practices also apply.

Action Levels and Reference Levels

Radon

For each identified work activity the Member State shall require to set up appropriate means for monitoring the exposures. Concerning radon exposure it is assumed on the basis of the conventional dose conversion factor proposed by ICRP (Publication 65), and for standard exposure conditions, that 100 Bq/m^3 at a work place causes an annual effective dose of about 0.6 mSv.

A radon Action Level is a concentration of radon gas above which National Authorities require (or in the case of domestic exposure, possibly recommend) that action is taken. The choice of action level will, in part, be determined by practical consideration in view of the national circumstances. However, the levels chosen for domestic and occupational circumstances should be compatible from the radiological protection point of view (see ICRP Publication 65, paragraph 85). ICRP, in Publication 65, derives a range of Action Levels for workplaces of 500-1500 Bq m^{-3} on the basis of equivalence of doses to the range for dwellings (paragraph 86). ICRP recognises that an action level can have two distinct purposes:

a) to define workplaces either in which intervention should be undertaken, or
b) to identify where the system of protection for practices should be applied.

It concludes that there are clear advantages in the adoption of the same action level for both purposes. Occupational exposures to radon above the Action Level will be subject to regulatory control. However, it is expected that the normal response to finding that radon levels in a workplace are above the Action Level will be to undertake remedial measures so that the regulations need no longer be applied. In the context of the BSS Directive, it is the regulatory purpose which is of primary interest. For this regulatory purpose, it is very desirable for the action level not to exceed the dose level at which special actions are required to protect workers involved in practices - i.e., the criterion for classifying category A workers. It is therefore recommended that, within the European Union, the Action Level for places of work should be set in the range 500-1000 Bq m^{-3} time averaged radon gas concentration, equivalent to an effective dose range of 3 to 6 mSv.

Naturally occurring radionuclides

Control of Exposure of workers

The important routes of radiation exposure of workers from the processes involving naturally occurring radionuclides are normally external gamma's and inhalation of dust. The appropriate control measures may include limitation of exposure time, attention to the arrangements for the storage of bulk material and dust control. In some cases radon or thoron may present a problem and surface contamination may also need to be considered. It is not necessarily the case that the highest doses arise when the plant is operating normally. In some circumstances, the maximum doses will be incurred during maintenance. Normal common-sense precautions should be taken to avoid all unnecessary exposures to radiation. Beyond this, assessments should be made to estimate the doses to workers from such natural radionuclides. If the doses are less than 1 mSv per year then no special precautions are required. If annual doses exceed 1 mSv then the normal scheme for controlling exposures can usually be applied. The Directive requires that, as necessary, Titles III, IV, V, and VI would apply in whole or in part. If doses exceed 6 mSv then it may, in rare cases, be appropriate to define a controlled area.

If doses exceed 1 mSv but are less than 6 mSv it would be appropriate to consider, for example, whether doses could effectively be reduced and whether there is a possibility that doses increase either over time or as the result of an accident. If doses are low and cannot effectively be reduced and if there is no realistic potential for accidents then few radiation protection measures are likely to be required beyond whatever is necessary to ensure that doses do not increase.

Control of Exposure of the public

Exposures of the public may arise from the product of a process (e.g., building materials) or from atmospheric or liquid discharges, from re-use of by-product material or from disposal of solid waste. The important routes of radiation exposure of the public are external gamma radiation, inhalation and ingestion.

The practical protection of members of the public is dealt with in Title VIII. Article 43 lays down a general duty on Member States to create the conditions for the best possible protection of the public. Article 47 stipulates that the undertaking responsible for a practice shall be responsible for achieving and maintaining an optimal level of protection for the environment and the population. The same general principles should apply to work activities involving natural radiation sources.

Reference levels of activity concentrations

The Commission has launched a study on the "Establishment of reference levels for regulatory control of workplaces where materials are processed which contain enhanced levels of naturally occurring radionuclides". The work is intended to provide reference levels for identifying those industries for which workers' exposure should require regulatory control. The reference levels will be specified in terms of activity concentrations, and will consider both prudently realistic and unlikely situations. The exposure scenarios will be based on a review of relevant industries within EU. The work is expected to be finalised by the end of 1997. This study is limited to the exposure of workers. The exposure of members of the public and the corresponding control of radioactive effluents and management of radioactive waste cannot easily be dealt with merely on the basis of activity concentrations. There may be a need to reach consensus among Member States as to the appropriate dose constraint for such sources.

Quantitative guidance in terms of activity concentrations is an important tool to help identifying which industries are of concern. Such values should not be looked at as a set of specific exemption levels for the non-nuclear industry. In general there is no need for a reporting requirement for such industries because they would normally be operating already under specific non-nuclear licences. The schedule of administrative requirements of reporting and prior authorisation, part of Title III, may in certain cases nevertheless be found to be useful. There should be no misinterpretation however with regard to the exemption levels referred to in Article 3: these were derived for moderate scale use of artificial radionuclides and are applicable to naturally occurring radionuclides only to the extent that the sources would have been processed in view of their radioactive, fissile or fertile properties (cf. Article 2). In the same way as for artificial sources, any reference or exemption values should not be regarded as a boundary between radioactive and non-radioactive waste or substances.

CONCLUSIONS

The new Basic Safety Standards require that exposure to natural radiation sources in workplaces or arising from work activities be taken into account. Thus the need to protect workers and members of the public in specific situations is recognised. The situations of concern can be very different from one Member State to another, and they may identify very different possibilities for remedial action or for appropriate regulatory control. Thus flexibility is offered to Member States for the implementation of these

provisions. Nevertheless there is a need for harmonisation and for practical guidance to competent authorities. The Commission undertakes to assist Member States in this process.

Table 1 Examples of industries where enhanced exposure to natural sources of radiation might occur

Work activity/industry/product	Radionuclides and typical activity concentrations	Occupational exposure above 1 mSv/main pathways/particularities	Public exposure above 1 mSv/ main exposure routes/special features
Phosphate industry (fertiliser production) Phosphoric acid (detergents and food)	Feed material: 1.5 kBq kg-1 U By-product gypsum: 1 kBq kg-1 Ra-226 But high concentrations of Ra (100 kBq kg-1) may precipitate in the plant	POSSIBLE/Gamma radiation and inhaled dust at production plants/Accumulated radium-rich scales (~ 100 kBq kg-1)	POSSIBLE/Liquid discharges, re-use of by product gypsum, atmospheric discharges if thermal processing involved (Pb-210 and Po-210)
Sulphuric acid production	Pyrites: slag containing > 1 kBq kg-1	? Inhalation and external doses	?
Coal mine de-watering plants	Sludge may contain 50-100 kBq kg-1	POSSIBLE/External gamma and internal hazard during maintenance	Disposal will need attention
Coal and fly-ash	Fly-ash: typically 0.2 kBq kg-1 U, Th Levels up to 10 kBq kg-1 have been reported in special circumstances	NOT LIKELY	POSSIBLE/Re-use of fly-ash as construction material
Metal production: smelters	Tin ore: U, Th □ 1 kBq kg-1 Lead/Bismuth smelting (bismuth may contain 100 kBq kg-1 of 210Bi/210Po) Ilmenite, rutile (titanium) Bauxite, red mud (aluminium): U, Th; < 1 kBq kg-1 Pyrochlore or columbite (for ferro-niobium): 50 kBq kg-1 Th Activity may concentrate in slags and furnace dusts	POSSIBLE/Gamma radiation and inhalation of dust at production plant/Dust scales: (~ 100 kBq kg-1)	POSSIBLE/Atmospheric discharges (particularly of volatile materials such as Pb-210 and Po-210), Re-use of waste

Table 1 (Continued)

Magnesium/Thorium alloys	Up to 4% Th in final alloys Typically 20% Th in the master alloy	POSSIBLE/Dusts and fumes	POSSIBLE/Disposal may need attention
Rare earths: processing of monazite sands, etc	Rare earth ores for cerium, lanthanum, etc: up to 10 kBq kg-1 U, up to 1000 kBq kg-1 Th But activities in waste streams and dusts may be very high	POSSIBLE/Gamma radiation, inhalation	POSSIBLE/Re-use of waste
Foundry sands	Zircon sands (1-5 kBq kg-1) Monazite sands (up to 1000 kBq kg-1)	POSSIBLE/inhalation of dusts, possible enrichment of Po, Pb	
Refractors, abrasives and ceramics	Zirconium minerals: 5 kBq kg-1 U, 1 kBq kg-1 Th	POSSIBLE/Gamma radiation and specially inhalation of dust at production plant	POSSIBLE/Re-use of waste
Oil/gas industry	Radium in scales (normally 1-100 kBq kg-1, but up to 4000 kBq kg-1) Possibly also Th and daughters (up to 50%) For example, in phase separation vessels on oil platforms	POSSIBLE/Gamma radiation/Radium rich scales; also inhalation in the case of (accidental) dispersion or during maintenance	LIKELY/if disposal of scales are not appropriately arranged
TiO_2 pigment industry	Feed material: ilmenite and rutile ores: 1 kBq kg-1 U, Th Waste streams up to 5 kBq kg-1	POSSIBLE/Gamma radiation and inhalation of dust at production plant	POSSIBLE/Re-use of waste
Thoriated welding rods and gas mantels	Thoriated welding rods: up to 500 kBq kg-1 Th Gas mantels: thorium oxide 95%	POSSIBLE/Inhalation of welding fumes, gamma radiation from stores/ Inhalation during grinding of rods	POSSIBLE/disposal of grinding waste or gas mantels may need attention

Table 1 (Continued)

Porcelain teeth	Up to 0.03% U	POSSIBLE/Fitting and shaping work can cause inhalation dose	?
Optical industry and glassware	Rare earth compounds (e.g., cerium) in some polishing powders: Th, U. Some glassware up to 10% of U or Th. Ophthalmic glass for eyeglasses and eyepieces: added U or Th for tinting. Some optical lenses: up to 30% of Th Some lens coating materials	POSSIBLE/Polishing, fitting and shaping work can cause inhalation dose	POSSIBLE/Gamma radiation and alpha radiation (to eye)/the dose limit of 15 mSv for the lens of the eye can be exceeded if U or Th are used for lenses in optical instruments, eyeglasses or eyepieces
Natural stone Fuel peat ash	Some granites up to about 1 kBq kg-1 of U or Th. Black shale (alum shale, other shales). Some shales up to 5 kBq kg-1 of U Up to 2 kBq kg-1 in Tuff Note: 40K may also be at ~ 1 kBq kg-1 but is unlikely to be a hazard Usually about 100 Bq kg-1 U, but some rare cases with up to few % of U has been observed. (Cs-137 from Chernobyl can be important but is outside the scope of this report.)	POSSIBLE/Gamma radiation	POSSIBLE/Use as building material (gamma and radon)

Annex

BASIC SAFETY STANDARD DIRECTIVE

TITLE I: DEFINITIONS

TITLE II: SCOPE

Article 2

1. This Directive shall apply to all practices[7] which involve a risk from ionising radiation emanating from an artificial source[8] or from a natural radiation source[9] in cases where natural radionuclides are or have been processed in view of their radioactive, fissile or fertile properties, namely:

(a) the production, processing, handling, use, holding, storage, transport, import to and export from the Community and disposal of radioactive substances;

(b) the operation of any electrical equipment emitting ionising radiation and containing components operating at a potential difference of more than 5 kV;

(c) any other practice specified by the Member State.

2. In accordance with Title VII it shall also apply to work activities, which are not covered by paragraph 1 but which involve the presence of natural radiation sources and lead to a significant increase in the exposure of workers or members of the public which cannot be disregarded from the radiation protection point of view.

3. In accordance with Title IX it shall also apply to any intervention in cases of radiological emergencies or in cases of lasting exposure resulting from the after-effects of a radiological emergency or a past or old practice or work activity.

4. This Directive shall not apply to exposure to radon in dwellings or to the natural level of radiation, i.e. to radionuclides contained in the human body, to cosmic radiation prevailing at ground level or to aboveground exposure to radionuclides present in the undisturbed earth's crust.

TITLE III: REPORTING AND AUTHORIZATION OF PRACTICES
TITLE IV: JUSTIFICATION, OPTIMISATION AND DOSE LIMITATION FOR PRACTICES
TITLE V: ESTIMATION OF EFFECTIVE DOSE
TITLE VI: FUNDAMENTAL PRINCIPLES GOVERNING OPERATIONAL PROTECTION OF EXPOSED WORKERS, APPRENTICES AND STUDENTS FOR PRACTICES

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[7] ***Article 1*: Practice**: a human activity that can increase the exposure of individuals to radiation from an artificial source, or from a natural radiation source where natural radionuclides are processed for their radioactive, fissile or fertile properties, except in the case of an emergency exposure.

[8] ***Article 1:* Source**: an apparatus, a radioactive substance or an installation capable of emitting ionising radiation or radioactive substances.

[9] ***Article 1*: Natural radiation sources**: sources of ionising radiation from natural terrestrial or cosmic origin.

TITLE VII: SIGNIFICANT INCREASE IN EXPOSURE DUE TO NATURAL RADIATION SOURCES

Article 40

Application

1. This Title shall apply to work activities not covered by Article 2(1) within which the presence of natural radiation sources leads to a significant increase in the exposure of workers or of the members of the public which cannot be disregarded from the radiation protection point of view.

2. Each Member State shall ensure the identification, by means of surveys or by any other appropriate means, of work activities, which may be of concern. These include, in particular:

(a) work activities where workers and, where appropriate, members of the public are exposed to radon or thoron daughters or gamma radiation or any other exposure in workplaces such as spas, caves, mines, underground workplaces and aboveground workplaces in identified areas;

(b) work activities involving operations with, and storage of, materials, not usually regarded as radioactive but which contain naturally occurring radionuclides, causing a significant increase in the exposure of workers and, where appropriate, members of the public;

(c) work activities which lead to the production of residues not usually regarded as radioactive but which contain naturally occurring radionuclides, causing a significant increase in the exposure of members of the public and, where appropriate, workers;

(d) aircraft operation.

3. Articles 41 and 42 shall apply to the extent that the Member States have declared that exposure to natural radiation sources due to work activities identified in accordance with paragraph 2 of this Article needed attention and must be subject to control.

Article 41

Protection against exposures from terrestrial natural radiation sources

For each work activity declared by them to be of concern, the Member States shall require the setting-up of appropriate means for monitoring exposure and as necessary:

(a) the implementation of corrective measures to reduce exposure pursuant to all or part of Title IX.

(b) the application of radiation protection measures pursuant to all or part of Titles III, V, VI and VIII.

Article 42

Protection of air crew

Each Member State shall make arrangements for undertakings operating aircraft to take account of exposure to cosmic radiation of air crew who are liable to be subject to exposure to more than 1 mSv per year. The undertakings shall take appropriate measures, in particular:

- to assess the exposure of the crew concerned,

- to take into account the assessed exposure when organising working schedules with a view to reducing the doses of highly exposed air crew,

- to inform the workers concerned of the health risks their work involves,

- to apply Article 10 to female air crew[10]

TITLE VIII: IMPLEMENTATION OF RADIATION PROTECTION FOR THE POPULATION IN NORMAL CIRCUMSTANCES

TITLE IX: INTERVENTION

TITLE X: FINAL PROVISIONS

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[10] ***Article 10 point*** 1. As soon as a pregnant woman informs the undertaking, in accordance with national legislation and/or national practice, of her condition, the protection of the child to be born shall be comparable with that provided for the members of the public. The conditions for the pregnant women in the context of her employment shall therefore be such that the equivalent dose to the child to be born will be as low as reasonably achievable and that it will be unlikely that this dose will exceed 1 mSv during at least the remainder of the pregnancy.