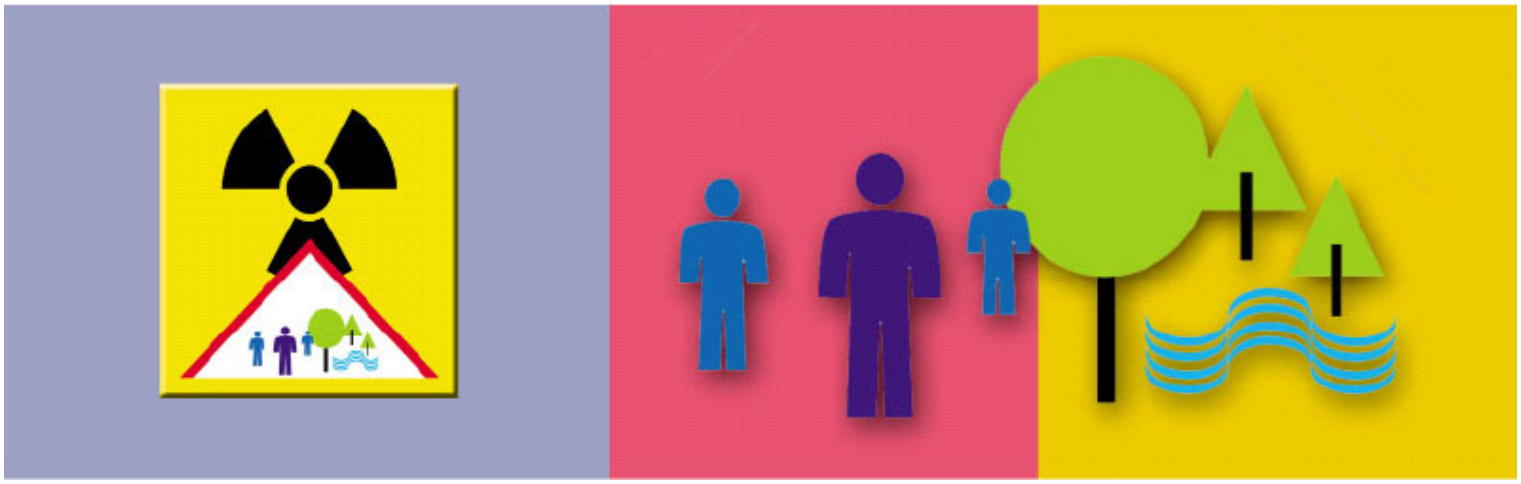
RADIATION PROTECTION



Effluent and dose control
from European Union NORM industries:

Assessment of current situation and proposal
for a harmonised Community approach

Volume 2: Appendices

Issue N° 135

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Directorate-General for Energy and Transport
Directorate H – Nuclear Safety and Safeguards
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Effluent and Dose Control from European Union NORM Industries
Assessment of Current Situation and Proposal for a Harmonised Community Approach

Volume 2: Appendices

by

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Appendix A - Title VII of Council Directive 96/29/Euratom

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 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 thoron or radon 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 had to be subject to control.

Article 41

Protection against exposure 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, IV, 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 organizing working schedules with a view to reducing the doses of highly exposed aircrew,

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

— to apply Article 10 to female air crew.

[OJ 1996 L 159, p15-16]

Appendix B - Responses to Questionnaire

Effluent and Dose Control from European Union NORM Industries. Assessment of Current Situation and Proposal for a Harmonised Approach.

Review of the regimes of prior authorisation and discharge authorisation in Member States (how it is implemented legally and in practice).

BELGIUM (Belgique/België)

Provided by: Albert van Weers (NRG)
Further comment was sought from P Smeesters of the Federal Agency for Nuclear Controls (FANC) in Belgium however no response was received during the period of the project.

Title VII of Euratom Directive

1. What are the legal provisions that enact Council Directive 96/29/Euratom Title VII into national legislation?

   Title VII implemented? *Yes*

   Legislative document:

   Koninklijk Besluit van 20 juli 2001 houdende algemeen reglement op de bescherming van de bevolking, van de werknemers en het leefmilieu tegen de gevaren van ioniserende straling. ACRONYM: ARBIS

   Translated document title:

   Royal Decision of 20 July 2001 holding the general regulation of the protection of the population, the workers and the environment against the dangers of ionising radiation.

   The provisions directly dealing with work activities are laid down in:

   Art. 1, scope

   Art. 4 Work activities involving natural radiation sources

   Art. 9 Regulatory provisions applying to work activities involving natural radiation sources

   Art. 20.3 Dose levels to be used for the application of Art. 9.3 in the framework of exposure to natural radiation sources

2. Is a definition of 'work activities' [See Title VII, Article 40 paragraph 2 of EURATOM] given in the national legislation/guidance? If so please provide the definition and describe any differences between the definitions of 'work activities ' and 'practices'.

A definition of work activities is not provided in Art. 2 'Definitions' but work activities are brought under the scope of ARBIS in Art. 1, second paragraph with the description: occupational activities (beroepsactiviteiten), not mentioned under the description of practices in the first paragraph, which involve natural radiation sources that could result in a considerable increase of exposure of persons that cannot be disregarded from the viewpoint of radiation protection.

3. What specific measures have been taken in order to identify 'work activities' in accordance with Title VII Art 40 paragraph 2 of the Council Directive 96/29/EURATOM? What, if any, industries have been identified? If identification procedure is ongoing then please provide details.

Work activities referred to in par. 2 of Art. 1 of ARBIS that already were identified are described in Art. 4. They comprise the following situations of workers exposure:

(i) with respect to work activities involving exposure to radon and its decay products (in existing or still to construct buildings, under normal work conditions or occupancy or during maintenance):

- *underground working places, including mushroom nurseries and show caves*
- *water treatment installations*
- *institutions for education, child care, health care, public buildings and, in general, all work places if they are located in a risk zone identified by the Federal Agency for Nuclear Control (FANC).*

ii) with respect to work activities involving risks of external exposure, intake of natural radionuclides by ingestion or inhalation (in existing or future establishments, under normal working conditions or normal occupancy, or during maintenance, including work activities with the residues involved):

1) production of phosphates

2) use of mineral sands

3) tin smelters

4) extraction of rare earth's

5) production of thoriated welding rods

6) any other work activity defined by FANC and included in a list published in the Belgian Government Gazette.

iii) The exploitation of airplanes.

4. What plans have been made to ensure that in the future should new industries working with NORM giving 'significant radiological risk' develop, these are identified and brought within the regulatory framework? Please detail strategies, legal provisions, work plans.

Art. 9 Regulatory system for work activities involving natural radiation sources

All work activities identified or to be identified under the provisions of Art. 4 have to be reported to FANC according to the provisions of Art. 9.1 of ARBIS.

The reporting requirement beyond administrative information on the reporting organisation extends to:

For work activities indicated in Art. 4 , point i:

- *description and purpose of the establishment*
- *details on the measuring conditions and the results of all radon analyses etc.*

For work activities indicated in Art. 4, point ii:

- *type and subject(?) (voorwerp) of the establishment;*
- *type and characteristics of the natural radiation sources being present or used;*
- *description of processes that can lead to enrichment of radionuclides present (flow chart);*
- *the number of persons involved in the work in the different sections of the establishment;*
- *protective measures implemented or recommended and, if applicable, the physical state of these natural radiation sources, their amounts, activity level, their destination, the location where they are kept, used or stored;*
- *the measures taken for their characterisation, the treatment storage and disposal of the wastes produced;*

For exploitation of air planes indicated in Art. 4 point iii:

- *the description of the methods and conditions for the measurement or to estimate the doses as a result of exposure of the aircrew to cosmic radiation*

- *the results of the measurements or the estimates of the exposure of the aircrew to cosmic radiation.*

According to Art. 9.4 FANC can impose corrective measures when the dose levels specified in Art. 20.3 for workers and members of the public are or can be exceeded. If, in spite of these corrective measures, the dose levels specified in Art. 20.3 for workers and members of the public still are or can be exceeded, FANC will impose that all or part of the regulations laid down in ARBIS for practices will apply to the establishment involved. Art. 9.3 contains also further requirements if the annual exposure of aircrew exceeds the does levels specified in Art. 3 for workers.

Art. 9.4 – Art. 9.6 explain the procedures to be followed by FANC and the operator of the establishment when some of the provisions of ARBIS are being enforced by FANC.

Art. 20.3. Dose levels to be used in the application of Art. 9.3 in relation to exposure to natural radiation sources

Work activities that give rise to exposure to natural radiation sources come according to Art. 9 totally or partly under the provisions of ARBIS that apply to practices in the following situations:

- *work activities in which workers and, when appropriate, members of the public are exposed to radon and its decay products and these workers (during their work) or these members of the public (at their work place) can receive effective doses exceeding 3 mSv per year or when their annual exposure to radon exceeds 800 kBq.m^3.h.*

- *work activities during which or as a result of which workers and/or members of the public are exposed to radiation resulting from the use or storage of materials containing natural radionuclides or as a result of the production of residues containing natural radionuclides and which can give rise to effective doses being received annually in excess of 1 mSv for workers and /or when the exposure of members of the public can lead to the dose limits specified in Art. 20.1.4 being exceeded.*

Art. 20.1.4 Dose limits for members of the public

In addition to the requirements following from Art. 20.1.2 the following dose limits for members of the public have to observed:

(a) an effective dose limit of 1 mSv per year

(b) under the condition that the requirement under a) is met:

- *an equivalent dose limit for the lens of the eye of 15 mSv per year;*

- *an equivalent dose limit for the skin of 50 mSv per year as an average for any surface area of 1 cm^2, irrespective of the total exposed surface area.*

5. What is the extent of the control of effluent discharge and waste disposal that has been introduced for the industries identified in Question 3 (see Article 41 of the Directive)? E.g. requirement for prior authorisation, monitoring, reporting etc.

From the provisions of ARBIS we tend to conclude that effluent discharges and waste disposal from work activities have not yet in practice been brought under regulatory control because of their radioactivity. However, regulatory instruments to do so are available as described in the answers to question 4. FANC envisages to commit a study to identify Belgian industries involving natural radiation. That study will aim at identifying those industries that may require some level of regulatory control because of the potential levels of exposure of workers and/or members of the public from these work activities, including the residues produced and the discharges to the environment.

Authorisations

6. Which regulatory body(ies) is responsible for regulating exposure (public and workers respectively) to NORM? Please include a hierarchy of responsibility. Which regulatory organisation is responsible for granting authorisations?

Federaal Agentschap voor Nucleaire Controle (FANC) = Federal Agency for Nuclear Control.

The Agency has been founded by the law of 15 April 1994 concerning the protection of the public and the environment against from ionising radiation and concerning the Federal Agency for Nuclear Control. The Agency is fully operational since 1 September 2001 when the Royal Decision of 20 July 2001 came into force. The general mission of the Agency is the care for the protection of the public and the environment against the dangers from ionising radiation. The main tasks of the Agency to fulfil this mission are:

- *to propose laws and regulations*
- *to control the observance of the laws and regulations*
- *to examine, propose and take decisions on applications for a variety of authorizations*
- *to ensure supervision, control and inspections on all practices and work activities involving the use of ionising radiation.*

FANC is supported in its responsibilities by a Scientific Council which provides general advise on supervision policy and, more specific, is consulted prior to the issue of authorizations or to renewal of authorizations.

7 Please provide a short summary of the legislation controlling the authorisation of NORM discharges. What sequence of action is followed when an application for authorisation for NORM discharges is submitted?

We understand that the role of FANC in making decisions on authorisation requirements, or otherwise setting limits to discharges or specifying conditions for reuse or disposal of residues, is laid down in Art. 9.4. More specifically, the recycling, reuse and disposal of radioactive residues from work activities that have brought under regulatory control according to Art. 9 fall under the provisions of Art. 18. It is not known whether any work activities have already been brought under control using the provisions of Art. 9.4 or whether the provisions of Art. 18 have as yet been applied.

8 Do national regulations or guidelines prohibit or discourage particular disposal routes for specific NORM wastes? Is, for example, disposal to public sewers permitted for any NORM wastes? To what extent do the total volumes and the chemical characteristics of NORM wastes determine acceptable disposal routes, for example, are there limits on volumes of liquid wastes that can be discharged to rivers of specific flow rates?

No answer

9 What approach or methodology is applied in setting discharge limits, for (a) gaseous and (b) liquid NORM discharges?

No answer

10 What dose constraints are applied with respect to NORM effluent discharges and do these differ from those used in relation to (i) disposal of solid NORM wastes and (ii) constraints set for the nuclear industry? Please define the meaning of 'dose constraint'.

No answer

11 What assumptions are made in the assessment of doses in relation to setting authorisations? Is there a required methodology specified in regulatory documentation or national guidelines? Are doses to critical groups calculated? To what degree are conservative assumptions made?

No answer

12 What sort of limits are used? Are there, for example, annual limits on the total discharge plus subsidiary daily limits, or limits on activity per unit volume at the discharge point? Are they generic, or industry or installation specific?

No answer

13 How is compliance with the discharge limits (and/or dose constraints) demonstrated? What kind of records should be kept, and what measurements is the operator required to make? Does the regulatory body undertake any check of measurements on the discharges? Are exposure assessments undertaken?

No answer

14 If it is required that doses to the public should be optimised how is this achieved? Is there a lower bound on doses, below which the optimisation requirement is relaxed or not required?

No answer

15 Are there any planned changes to legislation/regulation of discharges and waste disposals from work activities?

No answer

Please provide any further information that you believe is relevant to the regulation of exposure to NORM in your country.

Review of the quantities of NORM wastes discharged into the sea and into rivers or disposed of in the EU.

16 Which NORM (Naturally Occurring Radioactive Material) industries in your country identified in Question 3 are potentially radiologically significant sources of discharges and waste disposals?

For each industry please provide details of the following:

- The types of waste stream produced (i.e. gaseous/particulates (aerosol), liquid or solid) and the disposal routes (i.e. release to atmosphere, release to water bodies (rivers, lakes, coastal waters), release to sewage system, storage, landfill disposal, others? etc.).

- The radiological inventory and the range of activity concentration (or a typical activity concentration) in the waste streams (gaseous/particulates (aerosol), liquid, solid) for each radionuclide (in Bq per t_{waste} or Bq per m^3_{waste}).

- The mass or volume (in [t_{waste} or m^3_{waste}] per [$t_{product}$ or $m^3_{product}$]) of the gaseous/particulates (aerosol), liquid and solid wastes from each industry per unit production of the end product.

- The annual production rate of the end product (in $t_{product}$ per year or $m^3_{product}$ per year).

- The locations of installations that produce significant quantities of NORM and, where possible, the specific disposal routes (e.g. discharge into River Thames at grid ref…)

In the following table some industries known to discharge into air and/or water and/or producing significant amounts of residues have been listed. It should be noted that activity concentrations in effluents are not likely to be relevant parameters in relation to consequence assessments of discharges into water and of limited relevance for aerial discharges.

Provisional listing of industries with known or potentially significant discharges or NORM residue arisings

Industry	Discharges to air	Discharges to water	Solid residues
Oil and gas	Very limited, radon	^{226}Ra, ^{210}Pb, ^{228}Ra, reported	Sludges and scales, ^{210}Pb ^{226}Ra, ^{210}Pb, ^{228}Ra, ^{228}Th
Phosphoric acid	none	Potentially significant	From production and dismantling, phosphogypsum and ^{226}Ra scale
Phosphorus production	^{210}Po, ^{210}Pb	^{210}Po, ^{210}Pb	Large volume slag for reuse (^{238}U+), calcined dust significant volume (^{210}Pb)
Iron and steel production	^{210}Po, ^{210}Pb	^{210}Po, ^{210}Pb	Large volume slag for reuse, significant volume dust from off-gas treatment
TiO_2 pigment	none	Potentially significant mainly ^{226}Ra, ^{228}Ra,	Metal hydroxides (^{238}U+, ^{232}Th+), significant volumes
Cement production	^{210}Po, ^{210}Pb	Probably none	Probably none
Mineral sands	^{238}U+, ^{232}Th+	Probably low	Probably small
Fertiliser	Probably mall	Depending on process	Depending on process
Other (tin production?)	Potentially significant	?????	Potentially significant
Other (rare earth extraction?)	Potentially significant	?????	Potentially significant
Other (Copper)	Potentially significant	?????	Potentially significant

Benchmark Example:

In order to fairly and simply compare the approaches of different EU Member States it is our hope to analyse the responses States would take to a sample situation. Thus could you consider the following and describe the appropriate course of action according to regulations in your country:

- Operator of a non-nuclear installation in your country annually discharges some 100 million cubic metres of radioactively contaminated effluent offshore into the marine environment.

- Concentrations of the most significant radionuclides are as follows:

^{226}Ra and ^{228}Ra – 10 Bq/l; ^{210}Pb – 1 Bq/l

- Total annual discharges:

^{226}Ra and ^{228}Ra – 1 TBq; ^{210}Pb – 100 GBq

Please answer and justify the following questions:

1. Do you believe that the operation of this installation will fall under Title VII of the BSS?

2. Will the operator be subjected to one or combination of the following:

   a. Annual discharges exempted from any regulatory control

   b. Annual discharge limits be imposed. If yes, please provide the basis for these limits (e.g. dose constraint, etc…)

   c. Reporting of annual discharges will be required for the total activity or by categories and for specific radionuclides.

   d. The operator will be required to demonstrate that his operations meet the Best Practicable Environmental Option criterion.

   e. An alternative option. Please give details

No answer

June 2002

DENMARK (Danmark)

Provided by: Carsten Israelson, Specialist in Natural Radiation at the National Institute of Radiation Hygiene (NIRH)

Title VII of Euratom Directive

1 What are the legal provisions that enact Council Directive 96/29/Euratom Title VII into national legislation?

A new Order No. 192 of April 2nd, 2002 from the Danish Ministry of the Interior and Health on exemption levels from law on the use of radioactive substances came into force May 1st, 2002. The order list exemption levels identical to clearance levels in RP 122 Part II, "Application of the Concepts of Exemption and Clearance to Natural Radiation Sources".

We do believe that Title VII has been enacted into Danish legislation with Order 192. However, it is not yet clear how a licence to work with NORM will be formulated since we have not yet issued one.

2 Is a definition of 'work activities' [See Title VII, Article 40 paragraph 2 of EURATOM] given in the national legislation/guidance? If so please provide the definition and describe any differences between the definitions of 'work activities ' and 'practices'.

No. Work activities are not defined in Order 192. And this is the latest legislation however we are not clear on how we will implement the order with regard to the off shore industry or what the exact content of a licence will look like.

3 What specific measures have been taken in order to identify 'work activities' in accordance with Title VII Art 40 paragraph 2 of the Council Directive 96/29/EURATOM? What, if any, industries have been identified? If identification procedure is ongoing then please provide details.

National Institute of Radiation Hygiene (NIRH) is in cooperation with the oil-gas industry, refractory industry and coal and bio fuel-fired power plans. Procedures for identification of relevant work activities are still on going and NIRH is currently measuring samples and calculating doses for work activities in those industries.

4 What plans have been made to ensure that in the future should new industries working with NORM giving 'significant radiological risk' develop, these are identified and brought within the regulatory framework? Please detail strategies, legal provisions, work plans.

For the oil and gas industry a detail written instruction for working with NORM have been constructed. The instruction list exemption levels for major natural occurring radionuclides and describes working activities where 'significant radiological risk' may occur. The instructions regulatory framework is the new order on exemption levels from law on the use of radioactive substances mentioned in pt.1. Other NORM industries have so far not an instruction specifically written for that industry.

5 What is the extent of the control of effluent discharge and waste disposal that has been introduced for the industries identified in Question 3 (see Article 41 of the Directive)? E.g. requirement for prior authorisation, monitoring, reporting etc.

For the oil and gas industry, companies working with NORM are required to monitor the level of radiation in all products and waste streams and report the results to NIRH. Prior authorisation is required for any disposal of NORM with a radiological content higher than described in the order on exemption levels.

Authorisations

6 Which regulatory body(ies) is responsible for regulating exposure (public and workers respectively) to NORM? Please include a hierarchy of responsibility. Which regulatory organisation is responsible for granting authorisations?

National Institute of Radiation Hygiene. Decisions can be appealed to the Danish Ministry of the Interior and Health.

7 Please provide a short summary of the legislation controlling the authorisation of NORM discharges. What sequence of action is followed when an application for authorisation for NORM discharges is submitted?

At the present, no standard procedure has been applied. NIRH had been dealing with discharges on a case-to-case basis in the relative few cases that have been dealt with.

8 Do national regulations or guidelines prohibit or discourage particular disposal routes for specific NORM wastes? Is, for example, disposal to public sewers permitted for any NORM wastes? To what extent do the total volumes and the chemical characteristics of NORM wastes determine acceptable disposal routes, for example, are there limits on volumes of liquid wastes that can be discharged to rivers of specific flow rates?

As mentioned in Qu. 7, the number of cases involving disposal of NORM has so far been relatively limited in Denmark. Disposal to public sewers is at the present not permitted for any NORM waste. There have not been any cases, where authorisation to disposal of NORM waste to rivers has been given.

9 What approach or methodology is applied in setting discharge limits, for (a) gaseous and (b) liquid NORM discharges?

There is at present no fixed methodology for setting discharge limits for gaseous and liquid NORM discharge.

10 What dose constraints are applied with respect to NORM effluent discharges and do these differ from those used in relation to (i) disposal of solid NORM wastes and (ii) constraints set for the nuclear industry? Please define the meaning of 'dose constraint'.

A dose constraint of 0.3 mSv/y effective dose for members of the public for exemption is mentioned in 'Bilag 3'. This can be regarded as a Danish dose constraint for a single discharge, although discharge is not specified in the text.

11 What assumptions are made in the assessment of doses in relation to setting authorisations? Is there a required methodology specified in regulatory documentation or national guidelines? Are doses to critical groups calculated? To what degree are conservative assumptions made?

Doses to critical groups are calculated in some cases and calculations are to a large extent based on conservative assumptions.

12 What sort of limits are used? Are there, for example, annual limits on the total discharge plus subsidiary daily limits, or limits on activity per unit volume at the discharge point? Are they generic, or industry or installation specific?

At the present NIRH are only using limits as activity concentrations in Bq/g. Annual or daily limits for discharge or industry and installations specific limits have not been used.

13 How is compliance with the discharge limits (and/or dose constraints) demonstrated? What kind of records should be kept, and what measurements is the operator required to make? Does the regulatory body undertake any check of measurements on the discharges? Are exposure assessments undertaken?

For the oil and gas industry the detail written instruction for working with NORM dictates that the company working with NORM keeps records of all analysis for radioactivity in samples. The analytical results musts at all times be available for NIRH and every year in January a report containing these results must be submitted to NIRH.

NIRH perform regular measurements of different kind of NORM material and waste to determine regulatory aspects and doses assessments.

Detailed rules do so far only exist for the oil and gas industry. However, exposure assessments have been made for a company from the refractory industry.

14 If it is required that doses to the public should be optimised how is this achieved? Is there a lower bound on doses, below which the optimisation requirement is relaxed or not required?

It is as for all other work activities with radioactive material required in Danish law that doses to the public should be optimised. NIRH does not work with a lower dose boundary below which optimisation requirement is not required.

15 Are there any planned changes to legislation/regulation of discharges and waste disposals from work activities?

As mentioned in Qu. 1, a new order from the Danish Ministry of the Interior and Health on exemption levels from law on the use of radioactive substances will come into force May 1st, 2002.

Please provide any further information that you believe is relevant to the regulation of exposure to NORM in your country.

Review of the quantities of NORM wastes discharged into the sea and into rivers or disposed of in the EU.

16 Which NORM (Naturally Occurring Radioactive Material) industries in your country identified in Question 3 are potentially radiologically significant sources of discharges and waste disposals?

For each industry please provide details of the following:

- The types of waste stream produced (i.e. gaseous/particulates (aerosol), liquid or solid) and the disposal routes (i.e. release to atmosphere, release to water bodies (rivers, lakes, coastal waters), release to sewage system, storage, landfill disposal, others? etc.).

- The radiological inventory and the range of activity concentration (or a typical activity concentration) in the waste streams (gaseous/particulates (aerosol), liquid, solid) for each radionuclide (in Bq per t_{waste} or Bq per m^3_{waste}).

- The mass or volume (in [t_{waste} or m^3_{waste}] per [$t_{product}$ or $m^3_{product}$]) of the gaseous/particulates (aerosol), liquid and solid wastes from each industry per unit production of the end product[1].

- The annual production rate of the end product (in $t_{product}$ per year or $m^3_{product}$ per year).

- The locations of installations that produce significant quantities of NORM and, where possible, the specific disposal routes (e.g. discharge into River Thames at grid ref…)

[1] Please describe the method used to derive the data.

Significant sources of radiological discharges and waste disposals in Denmark originate only from the oil and gas industry. All production platforms are located in the Danish sector of the North Sea.

- *The industry produces water and solids. Produced waters are either re-injected into the reservoir or discharged into the sea after some pre-treatment/cleaning. Solids are collected and sent to landfills for disposal or for storage at Risø waste treatment plant.*

- *Relatively little data exists on the concentration of radionuclides in the waste. The data available consists mostly of ^{226}Ra concentrations. ^{226}Ra is believed to be the radiologically most significant natural occurring radionuclide in waste from oil and gas production.*

- *The total amount of solid waste from the industry is not known. The total volume of water discharge is monitored for all off shore installations by the Danish Energy Agency. The total discharge of produced water was in 2001 about 15 x 10^9 1. Four analyses of the concentration of ^{226}Ra in produced water showed concentrations between 1 and 10 Bq/l with an average about 5 Bq/l. This gives a total discharge of ^{226}Ra to the North Sea in the order of 75 GBq in 2001.*

Benchmark Example:

In order to fairly and simply compare the approaches of different EU Member States it is our hope to analyse the responses States would take to a sample situation. Thus could you consider the following and describe the appropriate course of action according to regulations in your country:

- Operator of a non-nuclear installation in your country annually discharges some 100 million cubic metres of radioactively contaminated effluent offshore into the marine environment.
- Concentrations of the most significant radionuclides are as follows:

Ra-226 and Ra-228 – 10 Bq/l; Pb –210 – 1 Bq/l.

- Total annual discharges:

Ra-226 and Ra-228 – 1 TBq; Pb-210 – 100 GBq

Please answer and justify the following questions:

1. Do you believe that the operation of this installation will fall under Title VII of the BSS?

2. Will the operator be subjected to one or combination of the following:
   a. Annual discharges exempted from any regulatory control
   b. Annual discharge limits be imposed. If yes, please provide the basis for these limits (e.g. dose constraint, etc…)
   c. Reporting of annual discharges will be required for the total activity or by categories and for specific radionuclides.
   d. The operator will be required to demonstrate that his operations meet the Best Practicable Environmental Option criterion.
   e. An alternative option. Please give details

Yes, I believe that the operation will fall under title VII of the BSS.

The operation will probably firstly fall under b., and the producer will have to report annual discharges (c.). The discharge limits would be based on a dose constraint to the public of 0.3 mSv/y.

That is, if the waste has already been produced and it is not possible to store or treat it in any way. The operator would also be required to demonstrate that it is not possible to change the production methods (d.) so that the contents of radionuclides is lowered.

June 2002

GERMANY (Deutschland)

Provided by: Albert van Weers (NRG)
Further comment was sought from Dr Landfermann of the BMU, Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU) in Germany however no comment was received during the period of the project.

Title VII of Euratom Directive

1. What are the legal provisions that enact Council Directive 96/29/Euratom Title VII into national legislation?

   Strahlenschutzverordnung (vom 20. Juli 2001, BGBI. I Nr. 38 S. 1714). (Hereafter referred to as Radiation Protection Ordinance, RPO).

   Atomgesetz (vom 3. Mai 2000, BGBI. I S. 636, ber. S. 1350)

2. Is a definition of 'work activities' [See Title VII, Article 40 paragraph 2 of EURATOM] given in the national legislation/guidance? If so please provide the definition and describe any differences between the definitions of 'work activities ' and 'practices'.

   Work activities *are defined in Par. 3, Definitions, No 2 as:*

   Operations, which are not practices, involving the presence of natural radioactivity that can a increase radiation exposure or radioactive contamination:

   A *in relation with exploration, extraction, production, storage, processing, application or other use of materials*

   B *as far as they involve materials, that are produced as a result of industrial activities, and not fall under the provisions of point A*

   C *as a result of the use or disposal of materials that are produced as a result of activities falling under point A or B,*

   D *as a result of the natural radiation sources involved, in particular Rn-222 and radon decay products, as far as these activities do not fall under the provisions of point A to C and are not carried out for one of the purposes mentioned in point A*

   E *in relation to aircraft operations*

   Agriculture, forestry or mechanical processing of the earth crust, as far as these operations are not performed with the aim to dispose of contamination, are not considered work activities in the sense as meant in the radiation protection ordinance.

***Practices** are defined in Par. 3, Definitions, point 1 as:*

(a) the operation of equipment emitting ionising radiation

(b) the addition of radioactive material during the fabrication of certain products or the activation of these products.

(c) All other actions, which can lead to an increase of radiation exposure or radioactive contamination

(aa) because they involve the use of artificial radiation sources or

(bb) the use of natural radiation sources in those cases where natural radionuclides are or have been processed in view of their radioactive, fissile or fertile properties.

In summary the German definitions of practices and work activities describe practices as involving the intended use of radioactive material or other radiation sources, while work activities are operations involving the (unintended) presence or increase of natural radiation sources leading to a significant increase in radiation exposure or radioactive contamination. These definitions are consistent with the Directive.

3. What specific measures have been taken in order to identify 'work activities' in accordance with Title VII Art 40 paragraph 2 of the Council Directive 96/29/EURATOM? What, if any, industries have been identified? If identification procedure is ongoing then please provide details.

The development of appropriate criteria for the new German Radiation Protection Ordinance are in the area of radiation protection at workplaces based on a number of national and international investigations, carried out during the last ten years, and on recommendation of the German Radiation Protection Commission (SSK), summarizing the results of these studies and giving specific guidance as to which workplaces should be considered in the new regulations. For the area of residues with enhanced natural radioactivity, systematic investigations were performed taking into consideration the types and amounts of materials arising, their typical radioactivity content, relevant options for their recycling or disposal, and radiation exposure resulting from these activities. Relevant NORM (or TENORM) residues were identified and the radiation exposure arising from their recycling and disposal for the public and for workers which were not subject to the specific regulations for workplaces with known elevated exposures to natural radioactivity was estimated.

These studies include:

- *Berichte der Strahlenschutzkommission (SSK) des Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit. Strahlenexposition an Arbeitsplätzen durch natürliche Radionuklide, Heft 10, 1997. Gustav Fischer Verlag, Stuttgart Jena Lübeck Ulm, 1997.*

- *Barthel, R., Goldammer, W., Kistinger, S., Kugeler, E., Nüsser, A, Thierfeldt, S. Ableitung von Überwachungsgrenzen für Reststoffe mit erhöhten Konzentrationen näturlicher Radioaktivität. Brenk Systemplanung GmbH, Aachen, 31.05.1999.*

- *Barthel, R., Goldammer, Hake, W., Kugeler, E. Eingrenzung und Bewertung der von den vorgesehenen NORM-Regelungen der Novelle StrlSchV betroffenen Bereiche. Brenk Systemplanung GmbH, Aachen, Januar 2000.*

Part 3 of the RPO deals with the protection of humans and the environment against natural radiation sources at work places. Chapter 1 of Part 3 (Par. 93 and 94) lays down principle responsibilities, Chapter 2 (Par. 95 and 96) deals protection of workers and Chapter 3 (Par. 97 – 102) pertains to protection of the public and Chapter 4 (Par. 103) deals with protection against cosmic radiation.

Dose limitation for work activities

Par. 93 and 94 refer to Chapter 2 and 4 of Part 3 for the dose limits that apply to workers involved in work activities and to the general responsibility of those responsible for these work activities to keep radiation exposures as low as possible under all circumstances of individual cases.

Identification of work activities in which radiation exposures of workers to natural terrestrial radiation sources can be significantly increased.

Par. 95 refers to Annex XI, Part A and B of the RPO that specify the type of work activities (Arbeitsfelder) that have been identified in accordance with Title VII Art 40 paragraph 2 as work activities that potentially involve significantly increased exposures of workers.

The industries identified are:

Annex XI, Part A: workplaces with enhanced radon (^{222}Rn) concentration.

- *Underground mines, tunnels and caves, including show caves*

- *Radon cure baths and radon cure caves*

- *Installations for the production, purification and distribution of water.*

Annex XI, Part B: Operations with enhanced exposure due to the presence of uranium and thorium and their decay products, excluding radon:

- *Grinding of and welding with thoriated welding rods*

- *Handling and storage of thorium coated incandescent mantles,*

- *Use of natural thorium (^{232}Th) and natural uranium (^{238}Usec and ^{235}Usec) for analytical chemical or chemical preparation purposes,*

- Handling, in particular assembling, dismantling, processing and examination of products containing thorium alloys,

- *Mining, use and processing of pyrochlore ores,*

- *Use and processing of slag from smelting of copper shale's (der Verhüttung von Kupferschiefererzen).*

Par.95 also specifies obligations of those responsible for the work activities indicated. They include assessments of exposures and reporting the results to the competent authorities within three months if the exposures can exceed 6 mSv effective dose in a calendar year. The reporting requirements comprises details as to type of work activity, the number of persons involved and protective measures to reduce exposures as required by Par. 94.

The effective dose limit for workers in work activities requiring reporting is set at 20 mSv in a calendar year and 400 mSv over all worker calendar years. Further dose limitations, monitoring requirements and dose registration are specified in Par.95.

4. What plans have been made to ensure that in the future should new industries working with NORM giving 'significant radiological risk' develop, these are identified and brought within the regulatory framework? Please detail strategies, legal provisions, work plans.

See answers to Question 5

5. What is the extent of the control of effluent discharge and waste disposal that has been introduced for the industries identified in Question 3 (see Article 41 of the Directive)? E.g. requirement for prior authorisation, monitoring, reporting etc.

Waste disposal, or better, the regulations regarding residues (Rückstände) from NORM industries is dealt with in Par. 97 to 102 of Chapter 3: "Protection of the public when naturally radioactive materials are involved". The paragraphs refer to various parts (A-D) of Annex XII "Processing and disposal of residues requiring control".

Par. 97 specifies the conditions when these residues require control (überwachungsbedürftige Rückstände),

Par. 98 specifies conditions for release of residues from control,

Par. 99 deals with reporting requirements for residues remaining under control by the responsible operator,

Par. 100 deals with reporting requirements if in a work activity arises more than 2000 tonnes annually of residues of the type indicated in annex XII,

Par. 101 describes the obligations for "clean up" of the soil from the premises where work activities have been carried out involving residues requiring control.

Par. 97, Residues requiring control

In the following situations the residues from work activities will require control:

Those who are responsible for own work activities or work activities carried out by others from which residues arise that require control has to take measures to protect members of the public when the processing or disposal of these residues could result in the reference effective dose (Richtwert) of 1 mSv in a calendar year being exceeded.

1. *Control is required for those residues specified in Annex XII, Part A unless it is guaranteed that at their disposal or processing the control levels (Überwachungsgrenze) of Annex XII, Part B and the disposal and processing routes are being satisfied. Arising residues may not before their intended disposal or processing be wilfully mixed or diluted with other materials in order to satisfy the control levels of Annex XII, Part B.*

2. *Section 3 of Par. 97 gives the competent Authority the means to require prove of compliance with Annex XII, Part A and Part B.*

3. *Section 4 of Art. 97 lays responsibility on those referred to in section 1 above to protect the residues of Annex XII, Part A against getting lost or being handled by unauthorized persons. They may only transferred to other persons for the purpose of disposal or processing.*

Annex XII, part A provides a list of residues to be considered in relation to Art. 97:

1 Sludges and sediments from oil and natural gas production,

2 Impure phosphogypsum, sludges from the production as well as dust and slags from the processing of raw phosphate (phosphorite),

3 a) ore, sludge, sand, slag and dust

from the extraction and preparation of bauxite, columbite, pyrochlore, microlite, euxenite, copper shale, tin, rare earths and uranium ores

from the processing of concentrates and residues that arise during the extraction and preparation of these ores and minerals as well as

b) minerals corresponding to the above specified ores that occur with the extraction and preparation of other raw materials.

4 Dust and sludges from the off-gas cleaning from blast furnaces in raw iron and non-ferrous metal processing

Residues within the meaning of § 97 are also

a) *materials in accordance with the subpara. 1 and following, when the production of these materials is deliberate,*

b) *Castings from the materials specified in subpara. 1 and following, as well as*

c) *excavated or cleared soil and building rubble from the dismantling of buildings or other structures when these contain residues in accordance with the subparas. 1 ff. and are removed in accordance with § 101 after completion of the work activities or in accordance with § 118, para. (5) or from properties.*

The following residues No 1 to 4:above are not being regarded as falling under the provisions of Par. 97

(a) When the specific activity of each member of the decay chain of ^{238}Usec and ^{232}Thsec in the residue is lower than 0.2 Bq/g or,

(b) When they are introduced into those processes as raw materials.

Annex XII, part B provides limits set for the residues described under Part A:

1) For the processing or disposal of residues the representatively determined highest specific activity of any member of the decay chains of ^{238}Usec (^{238}Umax) and ^{232}Thsec (^{232}Thmax) in Bq/g must satisfy the following condition:

$$C^{238}U_{max} + C_{Th\text{-}232max} \leq C,$$

With the control limit set at C = 1 Bq/g^{-1}.

2) Contrary to 1) applies C = 0.5 Bq/g when within the area of an exploitable ground water resource more than 5000 tonnes per year is disposed,

(a) when building materials used in the building of houses contain more than 20% or when used in road construction, landscaping or waterworks contain more than 50% of the residues according to Part A.

3) Contrary to 1) applies C = 5 Bq/g for the underground application or disposal of residues.

4) If the specific activity of the radionuclide ^{210}Pb+ a factor A more than 5 higher than the specific activity of the other members of the decay chain of ^{238}Usec the following summation rule applies:

$$RC_{U238max} + C_{Th232max} \leq C$$

The factor R takes the value of 0.5 for surface application or disposal. For underground processing or disposal the factor R can be derived from the following table.

Factor A	*Factor R*
5 > A ≤10	*0,3*
10 A ≤20	*0,2*
20 < A	*0,1*

5) Contrary to 1) and 2) apply the conditions

$C_{U238max}$ + $C_{Th232max}$ ≤0,2 Bq/g and $C_{Th232max}$ ≤0,2 Bq/g when at the disposal or application in road construction or landscaping including sport and playgrounds within the drainage area of a useable aquifer an area of more than 1 hectare is being covered with waste rock. A decay chain can be neglected when the specific activity of all members of the decay chain of ^{238}Usec or ^{232}Thsec lower is than 0.2 Bq/g.

Par. 98 Release of residues from control

The conditions for release of residues of work activities from control are specified in Par. 98 1) to 4).

1) This sections lays down the requirement for formal release of controlled residues by written decision of the competent authorities when it has been established that in the particular circumstances and with the protective measures implemented the protection of the public against radiation exposure is assured. The measure for adequate radiation protection of the public is an effective dose to the public of 1 mSv per calendar year not being exceeded as a result of the disposal or processing.

2) Proof of the conditions in 1) above has to be provided on the basis of the ground rules specified in Annex XII, Part D. People occupationally involved with the application or disposal are being regarded as members of the public. When the residues are disposed together with residues or waste of different origin it can be assumed by the competent authorities that the conditions of point 1) are fulfilled when the requirements of Annex XII, Part C are met.

Annex XII, Part C specifies the conditions for release from control of residues when controlled (überwachungsbedürftige) residues are disposed of together with other residues or wastes.

This section specifies the administrative rules to be observed by the applicant for release and the competent authority with respect to the provisions of the law on the recycling industry and on waste.

Par. 99 Residues remaining under control.

This article specifies the obligations for those responsible to report details on residues kept under control including plans to process or dispose those residues that can not be released under the provisions of Par. 98, section 1, first sentence. The competent authority can impose safety measures and ways to dispose these residues.

Par. 100 Reporting obligations, residue concept and residue bookkeeping.

Those responsible for work activities involving more than 2000 tonnes of residues as specified in Annex XII, Part A has several reporting obligations to the competent authorities with respect to the preparation of a Residue Concept that provides a internal planning instrument for those residues and residue book keeping. The first Residue Concept has to be prepared before April 1 2003 for the following five years. The first residue book keeping has to be prepared before April 1 2004 and must cover the previous year.

Par. 101 Removal of radioactive contamination from soil.

This article specifies the obligation to remove soil contamination with residues requiring control within five years after a work activity has been put to an end. The criterion for adequate removal is that further use of the area by third parties is in no way limited. The measure for unlimited further use is a guidance value of 1 mSv effective dose per calendar year from the residues remaining in or on the soil.

Authorisations

6. Which regulatory body(ies) is responsible for regulating exposure (public and workers respectively) to NORM? Please include a hierarchy of responsibility. Which regulatory organisation is responsible for granting authorisations?

There are many references in RPO to competent Authorities (zuständige Behörden) without further indication of these Authorities however it is provisionally presumed that general legislation regarding the exposure of workers or members of the public is established by the Federal ministry for the environment, nature conservation and nuclear safety of the Federal Republic of Germany (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit) and that the "Länder" are responsible for the practical implementation and the granting of authorizations and control.

7. Please provide a short summary of the legislation controlling the authorisation of NORM discharges. What sequence of action is followed when an application for authorisation for NORM discharges is submitted?

No specific regulations appear in the RPO with respect to discharges of natural radionuclides from work activities to air and water. However, Par. 97 No (1) sets a limit of 1 mSv effective dose to individual members of the public resulting from the use or disposal of residues requiring control but this seems not to apply to liquid and

aerial discharges. These discharges seem not to have been brought under regulatory control.

8. Do national regulations or guidelines prohibit or discourage particular disposal routes for specific NORM wastes? Is, for example, disposal to public sewers permitted for any NORM wastes? To what extent do the total volumes and the chemical characteristics of NORM wastes determine acceptable disposal routes, for example, are there limits on volumes of liquid wastes that can be discharged to rivers of specific flow rates?

   From analyses of the RPO, in particular of Par. 97 to 101 and related Annex XII, it is clear that a German policy with respect to solid residues from work activities has been developed for materials satisfying the criteria for release (clearance) into specific routes. If the control levels of Annex XII, Part B are exceeded what policy for disposal of such material has been developed?

9. What approach or methodology is applied in setting discharge limits, for (a) gaseous and (b) liquid NORM discharges?

   No answer. See also question 7.

10. What dose constraints are applied with respect to NORM effluent discharges and do these differ from those used in relation to (i) disposal of solid NORM wastes and (ii) constraints set for the nuclear industry? Please define the meaning of 'dose constraint'.

    No answer. See also question 7.

11. What assumptions are made in the assessment of doses in relation to setting authorisations? Is there a required methodology specified in regulatory documentation or national guidelines? Are doses to critical groups calculated? To what degree are conservative assumptions made?

    No answer. See also question 7.

12. What sort of limits are used? Are there, for example, annual limits on the total discharge plus subsidiary daily limits, or limits on activity per unit volume at the discharge point? Are they generic, or industry or installation specific?

    No answer. See also question 7.

13. How is compliance with the discharge limits (and/or dose constraints) demonstrated? What kind of records should be kept, and what measurements is the operator required to make? Does the regulatory body undertake any check of measurements on the discharges? Are exposure assessments undertaken?

    No answer. See also question 7.

14. If it is required that doses to the public should be optimised how is this achieved? Is there a lower bound on doses, below which the optimisation requirement is relaxed or not required?

No answer. See also question 7.

15. Are there any planned changes to legislation/regulation of discharges and waste disposals from work activities?

No answer

Please provide any further information that you believe is relevant to the regulation of exposure to NORM in your country.

Review of the quantities of NORM wastes discharged into the sea and into rivers or disposed of in the EU.

16. Which NORM (Naturally Occurring Radioactive Material) industries in your country identified in Question 3 are potentially radiologically significant sources of discharges and waste disposals?

For each industry please provide details of the following:

a) The types of waste stream produced (i.e. gaseous/particulates (aerosol), liquid or solid) and the disposal routes (i.e. release to atmosphere, release to water bodies (rivers, lakes, coastal waters), release to sewage system, storage, landfill disposal, others? etc.).

b) The radiological inventory and the range of activity concentration (or a typical activity concentration) in the waste streams (gaseous/particulates (aerosol), liquid, solid) for each radionuclide (in Bq per t_{waste} or Bq per m^3_{waste}).

c) The mass or volume (in [t_{waste} or m^3_{waste}] per [$t_{product}$ or $m^3_{product}$]) of the gaseous/particulates (aerosol), liquid and solid wastes from each industry per unit production of the end product[1].

d) The annual production rate of the end product (in $t_{product}$ per year or $m^3_{product}$ per year).

e) The locations of installations that produce significant quantities of NORM and, where possible, the specific disposal routes (e.g. discharge into River Thames at grid ref…)

No answer

[1] Please describe the method used to derive the data.

Benchmark Example:

In order to fairly and simply compare the approaches of different EU Member States it is our hope to analyse the responses States would take to a sample situation. Thus could you consider the following and describe the appropriate course of action according to regulations in your country:

- Operator of a non-nuclear installation in your country annually discharges some 100 million cubic metres of radioactively contaminated effluent offshore into the marine environment.

- Concentrations of the most significant radionuclides are as follows:

  ^{226}Ra and ^{228}Ra – 10 Bq/l; ^{210}Pb – 1 Bq/l.

- Total annual discharges:

  ^{226}Ra and ^{228}Ra – 1 TBq; ^{210}Pb – 100 GBq

Please answer and justify the following questions:

1. Do you believe that the operation of this installation will fall under Title VII of the BSS?

2. Will the operator be subjected to one or combination of the following:

   a. Annual discharges exempted from any regulatory control

   b. Annual discharge limits be imposed. If yes, please provide the basis for these limits (e.g. dose constraint, etc…)

   c. Reporting of annual discharges will be required for the total activity or by categories and for specific radionuclides.

   d. The operator will be required to demonstrate that his operations meet the Best Practicable Environmental Option criterion.

   e. An alternative option. Please give details

   No answer.

June 2002

GREECE (Elláda)

Provided by: Dr Panagiotis Dimitriou, Greek Atomic Energy Commission (GAEC)

Title VII of Euratom Directive

1. What are the legal provisions that enact Council Directive 96/29/Euratom Title VII into national legislation?

   The legal provisions that enact Council Directive 96/29/Euratom Title VII into Greek legislation are the Radiation Protection Regulations (RPR), Joint Ministerial Order No 1014 (ΦΟΡ) 94, Official Gazette 216B, 06/03/01.

2. Is a definition of 'work activities' [See Title VII, Article 40 paragraph 2 of EURATOM] given in the national legislation/guidance? If so please provide the definition and describe any differences between the definitions of 'work activities ' and 'practices'.

   The definition of "practice" is given in the part "general definitions" (paragraph 1.9) of the RPR, and is the same as in BSS Directive. Although there is no definition of "work activities" in this part, the term is clearly mentioned in paragraph 1.2.5 of the RPR, which refers to workplaces with significant increase in exposure due to natural radiation sources.

3. What specific measures have been taken in order to identify 'work activities' in accordance with Title VII Art 40 paragraph 2 of the Council Directive 96/29/EURATOM? What, if any, industries have been identified? If identification procedure is ongoing then please provide details.

   The identification procedure is ongoing. Since the beginning of 1999, the Greek Atomic Energy Commission (GAEC) has started measuring and monitoring systematically the levels of radon concentration and gamma - dose rates at several workplaces all over Greece, such as in mines and in the Athens' Metro stations. There was no indication of increased levels of exposure to workers or members of the public, due to natural radiation sources at these places.

   According to published data for Greece (indoor radon concentrations, γ- dose rates etc.), the main work activities that may lead to a significant increase in the exposure of the workers or the members of the public are:

   (a) Mines and Quarries, (b) Thermal spas, (c) Phosphate industry, (d) Cement industries, (e) oil and gas industry and (f) Caves visited by tourists.

   Until now, GAEC has identified the following workplaces with significant increase in exposure due to natural radiation sources, in accordance with the Title VII Art 40 paragraph 2 of the 96/29/Euratom Directive:

   - *2 fertilizer production industries, located in northern Greece and,*

- *places where aero-engines constructed from Th-Mg alloy are repaired.*

Such alloys may have a ^{232}Th activity up to 160 Bq/g.

The identification procedure is ongoing. Work activities such as b, d, e and f, above are under investigation.

4. What plans have been made to ensure that in the future should new industries working with NORM giving 'significant radiological risk' develop, these are identified and brought within the regulatory framework? Please detail strategies, legal provisions, work plans.

There are preliminary plans that have not been finalised yet by GAEC, since the Regulatory Body deliberates with other relevant civil bodies such as the Ministry of the Environment and the Ministry of Labour. According to these preliminary plans, GAEC will identify categories of industries working with NORM, with potentially 'significant radiological risk' (see answer to question 3). Such new industries applying for license, have to submit to the licensing authority, a specific hazard report concerning the NORM. These reports will be sent to GAEC for evaluation. GAEC will decide if the industry will be brought within the regulatory framework or not.

According to the Greek RPR, the following criteria for NORM "work activities" have been established:

EFFECTIVE DOSE (except radon)

(para. 1.2.5.3 - 1.2.5.6 of the RPR).

- *The action levels concerning the effective dose to workers at work places due to natural radiation sources are 1 mSv per year. Work activities with corresponding dose less than 1 mSv per year are excluded from further investigation.*

- *Work activities with corresponding effective dose exceeding 1 mSv per year but less than 6 mSv/y, are characterized as supervised areas. Appropriate measures could be taken in order to minimize the dose, taking into account the effectiveness and the cost of such measures. The radiation protection measures are approved by GAEC.*

- *Work activities with corresponding effective dose exceeding 6mSv per year but less than 20 mSv/y, are characterized as controlled areas. Special authorization by GAEC is required. GAEC approves the proposed measures for radiation protection.*

- *Work activities with the corresponding effective dose exceeding 20 mSv/y, due to natural radiation sources, are prohibited.*

RADON

(para. 1.2.5.7 of the RPR).

- *The action levels concerning the effective dose to workers at work places due to radon concentration is 400 Bq/m^3 (mean yearly radon concentration corresponding to 2000 working hours per year). Work activities where mean yearly radon concentration is below 400 Bq/m^3 are excluded from further investigation.*

- *Work activities where mean yearly radon concentration exceeds 400 Bq/m^3 but is less that 1000 Bq/m^3, are characterized as supervised areas and appropriate measures must be taken in order to minimize to dose, taking into account the effectiveness and the cost of such measures.*

- *Work activities where mean yearly radon concentration exceeds 1000 Bq/m^3 but is less that 3000 Bq/m^3, are characterized as controlled areas. Special authorization by GAEC is required. GAEC approves the proposed measures for radiation protection.*

- *Work activities where the mean yearly radon concentration exceeds 3000 Bq/m^3, are prohibited.*

5. What is the extent of the control of effluent discharge and waste disposal that has been introduced for the industries identified in Question 3 (see Article 41 of the Directive)? E.g. requirement for prior authorisation, monitoring, reporting etc.

Two fertilizer industries (see answer to question No. 3), that dispose wastes and by-products (phosphogypsum), have been identified. Until recently the ways of waste disposal were the following:

- *Phosphogypsum disposal in stacks.*

- *Phosphogypsum disposal in open land.*

- *Use of phosphogypsum for agriculture purposes (saline soil improvement).*

The results of a radiological study was conducted by the GAEC concerning the two industries, lead to the issuing of an order (2001), regulating the safe management of the phosphogypsum disposal and its use for agricultural purposes in Greece, as follows:

Disposal of Phosphogypsum in the environment:

- *For the phosphogypsum disposal in the environment in the form of stacks, the industry must submit a relevant radiological study. The study must be approved by GAEC. GAEC issues the specific authorization for disposal.*

- *Phosphogypsum stacks must be covered by a soil layer.*

- *Special attention must be given to the underground water radium contamination. Radon emanation must be taken into account in case of building construction activities in areas where phosphogypsum has been disposed.*

- *For all the phosphogypsum disposal areas GAEC must keep a relevant record.*

Use of Phosphogypsum for agricultural purposes:

Phosphogypsum may be lawfully removed from a stack and commercially distributed for use in agriculture if each one of the following requirements is satisfied:

- *The industry from which phosphogypsum will be removed, shall determine annually the average ^{226}Ra concentration at the location in the stack from which the phosphogypsum will be removed. The ^{226}Ra concentration measurements must be performed by an authorized by the GAEC laboratory.*

- *The average ^{226}Ra concentration at the location in the stack from which the phosphogypsum will be removed shall not exceed the 400 Bq/kg.*

- *All phosphogypsum commercially distributed for use, shall be accompanied by a certification document.*

- *Inspections for the ^{226}Ra concentration in soil, water, underground water and agricultural products must be performed by an authorized by the GAEC laboratory, in regular basis in areas where phosphogypsum is used in agriculture.*

The methodology for the sampling and measurement of ^{226}Ra as well as details concerning the certification documents are described in details in relevant Appendixes.

Disposal of thorium engines

Many old aero-engines, such J33 (170Bq/g of ^{232}Th) and J79 (240 Bq/g ^{232}Th), are disassembled. The disposal of their components containing Th-Mg alloys, is under consideration.

Authorisation

6. Which regulatory body(ies) is responsible for regulating exposure (public and workers respectively) to NORM? Please include a hierarchy of responsibility. Which regulatory organisation is responsible for granting authorisations?

   According to the RPR, the GAEC is the regulatory body, responsible for regulating exposure (public and workers respectively) to NORM, as well as, for granting authorisations respectively.

7. Please provide a short summary of the legislation controlling the authorisation of NORM discharges. What sequence of action is followed when an application for authorisation for NORM discharges is submitted?

   The legislation controlling the phosphogypsum disposal is referred in the answer to question No.5. For other NORM wastes, the EU recommendations are applied.

   Radiation Protection 122 "Practical Use of the Concepts of Clearance and Exemption - Part II, Application of the Concepts of Exemption and Clearance to Natural Radiation Sources", EC 2001.

   For specific cases, dosimetric calculations are carried out, based on sample measurements and models (nature of the waste, quantity, place for disposal, possible exposure pathways for critical group and workers, etc).

   NORM disposal shall be authorised by GAEC.

8. Do national regulations or guidelines prohibit or discourage particular disposal routes for specific NORM wastes? Is, for example, disposal to public sewers permitted for any NORM wastes? To what extent do the total volumes and the chemical characteristics of NORM wastes determine acceptable disposal routes, for example, are there limits on volumes of liquid wastes that can be discharged to rivers of specific flow rates?

   At present, no specific regulations concerning the possible discharge of liquid or gaseous NORM waste exist. No significant liquid or gaseous NORM waste have been found to be present at the identified "work activities", so far.

9. What approach or methodology is applied in setting discharge limits, for (a) gaseous and (b) liquid NORM discharges?

   Two fertilizer production industries have been identified by GAEC so far, as "work activities" with possible liquid or gaseous discharges (see answer to question 5). However, measurements performed in air filters collected onsite and near the industry, as well as, in samples of water discharged from the industry, showed no significant increase in radium and uranium concentrations. Therefore, no specific discharge limits have been considered for these industries.

10. What dose constraints are applied with respect to NORM effluent discharges and do these differ from those used in relation to (i) disposal of solid NORM wastes and (ii) constraints set for the nuclear industry? Please define the meaning of 'dose constraint'.

The definition of dose constraint, given paragraph 1.9 of the RPR is:

Dose constraint: a restriction on the prospective doses to individuals which may result from a defined source, for use at the planning stage in radiation protection whenever optimization is involved.

There is no nuclear industry in Greece. However for effluent discharges from practices, the dose constraint is 10μSv/y (paragraph 1.1.2. of the RPR).

NORM discharges, at present, are mainly based on the EU recommendations:

Radiation Protection 122 "Practical Use of the Concepts of Clearance and Exemption - Part II, Application of the Concepts of Exemption and Clearance to Natural Radiation Sources", EC 2001.

According to this recommendation the proposed dose criterion is 300μSv/y. This criterion should be regarded as an increment to the exposure which would prevail in the absence of the work activity. This is not a restriction criterion but, according to each pathway scenario and taking in account the basic principles of ALARA and optimization the dose criterion could be much lower.

In the case of phosphogypsum disposal for agricultural purposes, the concentration of 400 Bq/kg as an upper limit, was calculated based on a dose criterion of 10μSv/y for the specific exposure pathway that corresponds to the consumption of rice produced in a phosphogypsum enriched soil. UNSCEAR 2000 values for ^{226}Ra concentration in rice from various places was taken into account as well as the public concern.

11. What assumptions are made in the assessment of doses in relation to setting authorisations? Is there a required methodology specified in regulatory documentation or national guidelines? Are doses to critical groups calculated? To what degree are conservative assumptions made?

There is no required methodology specified in regulatory documentation or national guidelines.

Concerning NORM, only phosphogypsum disposal has been under GAEC's authorization and a specific ^{226}Ra concentration limit in the case of phosphogypsum disposal for agricultural purposes (in the rice fields), has been set so far.

Dosimetric calculation was performed using the following assumptions:

- *a known quantity of phosphogypsum was dispersed in a rice field with known dimensions.*

- *The phosphogypsum deposition in the particular field was repeated every 2 years.*

- *the phosphogypsum was homogenized with a 10cm layer of soil.*

- *the critical group was the local population that consume only rice produced in this area.*

- *The quantity of rice consumed every year was taken for UNSCEAR 2000.*

- *The chosen transfer factors of ^{226}Ra from soil to grain used in this calculation was taken from the EU publication Radiation Protection 115.*

- *The dose criterion of 10 μSv/y was chosen, as a criterion due to the specific exposure pathway that corresponds to the ingestion of rice produced in a phosphogypsum enriched soil.*

12. What sort of limits are used? Are there, for example, annual limits on the total discharge plus subsidiary daily limits, or limits on activity per unit volume at the discharge point? Are they generic, or industry or installation specific?

    For the industries being authorized so far, only concentration limits, specific for the particular way of disposal were used (phosphogypsum for agriculture).

13. How is compliance with the discharge limits (and/or dose constraints) demonstrated? What kind of records should be kept, and what measurements is the operator required to make? Does the regulatory body undertake any check of measurements on the discharges? Are exposure assessments undertaken?

    The compliance with the discharge limits is verified in case of the use of phosphogypsum for agriculture, by means of gamma spectroscopy measurement of the ^{226}Ra concentration, performed by an authorized laboratory. The methodology for the sampling and measuring of ^{226}Ra are described in details in relevant Appendixes issued by GAEC. GAEC also performs measurements independently. All the GAEC recommendations are based on dosimetric assessments.

14. If it is required that doses to the public should be optimised how is this achieved? Is there a lower bound on doses, below which the optimisation requirement is relaxed or not required?

    Dose constraints provided by the RPR and mentioned above, were set within the process of optimization. No optimization requirement is provided below dose constraint levels.

15. Are there any planned changes to legislation/regulation of discharges and waste disposals from work activities?

According to the Greek RPR, GAEC has the authority to issue orders and to establish specific clearance levels for practices and work activities. This is however an on going procedure.

In case of phosphogypsum disposal for agriculture GAEC has imposed the concentration limit of 400 Bq kg^{-1}, as explained in the answer to question No.5.

Review of the quantities of NORM wastes discharged into the sea and into rivers or disposed of in the EU.

16. Which NORM (Naturally Occurring Radioactive Material) industries in your country identified in Question 3 are potentially radiologically significant sources of discharges and waste disposals?

Only those identified in answer to question 3.

For each industry please provide details of the following:

- The types of waste stream produced (i.e. gaseous/particulates (aerosol), liquid or solid) and the disposal routes (i.e. release to atmosphere, release to water bodies (rivers, lakes, coastal waters), release to sewage system, storage, landfill disposal, others? etc.).

- The radiological inventory and the range of activity concentration (or a typical activity concentration) in the waste streams (gaseous/particulates (aerosol), liquid, solid) for each radionuclide (in Bq per t_{waste} or Bq per m^3_{waste}).

- The mass or volume (in [t_{waste} or m^3_{waste}] per [$t_{product}$ or $m^3_{product}$]) of the gaseous/particulates (aerosol), liquid and solid wastes from each industry per unit production of the end product[1].

- The annual production rate of the end product (in $t_{product}$ per year or $m^3_{product}$ per year).

- The locations of installations that produce significant quantities of NORM and, where possible, the specific disposal routes (e.g. discharge into River Thames at grid ref…)

Fertilizer industries

- *The main type of waste is solid (phosphogypsum) and it is landfill disposed in the form of stacks or is used for agriculture (saline soil improvement).*

[1] Please describe the method used to derive the data.

- *200 GBq (total activity of ^{226}Ra corresponding to annual phosphogypsum production). The ^{226}Ra concentration of phosphogypsum produced, varies between 200 - 700 Bq/kg.*

- *Each industry produces about 250000 tn phosphogypsum per year.*

- *Each industry produces about 250000 tn fertilizer per year*

- *The 1st fertilizer industry is located in northern Greece near Thessaloniki. The phosphogypsum disposal is at the rice fields of Kalochori and the phosphogypsum stacks is at the industry area and the place Pentalofo.*

- *The 2nd fertilizer industry is located in Kavala (Nea Karvali) in northern Greece. The phosphogypsum disposal is a landfill disposal at the industry area.*

Benchmark Example:

In order to fairly and simply compare the approaches of different EU Member States it is our hope to analyse the responses States would take to a sample situation. Thus could you consider the following and describe the appropriate course of action according to regulations in your country:

- Operator of a non-nuclear installation in your country annually discharges some 100 million cubic metres of radioactively contaminated effluent offshore into the marine environment.
- Concentrations of the most significant radionuclides are as follows:

  ^{226}Ra and ^{228}Ra – 10 Bq/l; ^{210}Pb – 1 Bq/l.
- Total annual discharges:

  ^{226}Ra and ^{228}Ra – 1 TBq; ^{210}Pb – 100 GBq

Please answer and justify the following questions:

1. Do you believe that the operation of this installation will fall under Title VII of the BSS?

2. Will the operator be subjected to one or combination of the following:

   (a) Annual discharges exempted from any regulatory control

   (b) Annual discharge limits be imposed. If yes, please provide the basis for these limits (e.g. dose constraint, etc…)

   (c) Reporting of annual discharges will be required for the total activity or by categories and for specific radionuclides.

   (d) The operator will be required to demonstrate that his operations meet the Best Practicable Environmental Option criterion.

   (e) An alternative option. Please give details

   According to the Radiation Protection Regulations in force, the limit of daily liquid discharges via the ordinary sewer system for authorised practices is 20 kBq corresponding to 7.2 MBq/y for ^{226}Ra. These limits do not refer to NORM, for which the general clearance levels provided by the RP 122, Part II, are at present applied. Specific clearance levels are also applied by the GAEC for phosphogypsum disposal as mentioned above. The benchmark situation is not explicitly dealt in the RP122 and has not been faced yet by the regulatory body. For this case, a considerable number of assumptions must be taken under consideration concerning the receptor (open sea bay, or closed areas, selective concentration, deposition rate, etc…) in order to select the relevant scenario for evaluating the limit. Therefore no official answer can be given at present.

May 2002

SPAIN (España)

Provided by: Ignacio Lequerica, Technical Director for Radiation Protection at the Consejo de Seguridad Nuclear (CSN)

Title VII of Euratom Directive

1. What are the legal provisions that enact Council Directive 96/29/Euratom Title VII into national legislation?

   The Title VII of the Royal Decree 783/2001 on the Health Protection against Ionising Radiation enacts the Directive 96/29/Euratom in similar terms.

2. Is a definition of 'work activities' [See Title VII, Article 40 paragraph 2 of EURATOM] given in the national legislation/guidance? If so please provide the definition and describe any differences between the definitions of 'work activities ' and 'practices'.

   The article 62, Title VII, of the Royal Decree 783/2001 on the Health Protection against Ionising Radiation, establishes same candidates for "work activities" as the Directive stated. However this regulation do not defined explicitly the meaning of "work activities".

   The differences in radiological protection requirements for "work activities" and "practices" should be established by the CSN in the same terms as the provisions included in articles 41 and 42 of the Directive 96/29/Euratom.

3. What specific measures have been taken in order to identify 'work activities' in accordance with Title VII Art 40 paragraph 2 of the Council Directive 96/29/EURATOM? What, if any, industries have been identified? If identification procedure is ongoing then please provide details.

   Since the 90's the CSN and other public organisations (Carlos III Institute) have developed research programmes to identify areas and places of public concern due to the presence of significant natural radionuclides. Most of these studies were referred to the potential public impact and were focus on Radon, nevertheless there were also measurements on building materials (granite, slate, cement and concrete), phosphate industry and others.

   Recently, the CSN has been approved an Action Plan for the development of the Title VII of the Royal Decree 783/2001 on the Health Protection against Ionising Radiation. This Action Plan will be presented to representatives of the Ministry of Economy, the Ministry of Development, the Ministry of Labour and the Regional Authorities.

   There are different ways used to list the industries and companies that potentially could be affected by Title VII, inter alia, through the Chamber of Commerce register, information possessed by other Organism of Administration or Regional Authorities and Internet.

4. What plans have been made to ensure that in the future should new industries working with NORM giving 'significant radiological risk' develop, these are identified and brought within the regulatory framework? Please detail strategies, legal provisions, work plans.

At present, there are not provisions.

5. What is the extent of the control of effluent discharge and waste disposal that has been introduced for the industries identified in Question 3 (see Article 41 of the Directive)? E.g. requirement for prior authorisation, monitoring, reporting etc.

At present, there are not specific provisions rather than industrials requirements.

Authorisations

6. Which regulatory body(ies) is responsible for regulating exposure (public and workers respectively) to NORM? Please include a hierarchy of responsibility. Which regulatory organisation is responsible for granting authorisations?

The Ministry of Economy, the Ministry of Development or the Regional Authorities will be responsible for issuing these kind of authorisations, following the CSN guidance.

7. Please provide a short summary of the legislation controlling the authorisation of NORM discharges. What sequence of action is followed when an application for authorisation for NORM discharges is submitted?

At present, there are not specific legal provisions for NORM discharges.

8. Do national regulations or guidelines prohibit or discourage particular disposal routes for specific NORM wastes? Is, for example, disposal to public sewers permitted for any NORM wastes? To what extent do the total volumes and the chemical characteristics of NORM wastes determine acceptable disposal routes, for example, are there limits on volumes of liquid wastes that can be discharged to rivers of specific flow rates?

At present, there are not specific legal provisions in this concern.

9. What approach or methodology is applied in setting discharge limits, for (a) gaseous and (b) liquid NORM discharges?

At present, it has not been developed a methodology for NORM discharges limits.

10. What dose constraints are applied with respect to NORM effluent discharges and do these differ from those used in relation to (i) disposal of solid NORM wastes and (ii) constraints set for the nuclear industry? Please define the meaning of 'dose constraint'.

At present, it has not been developed a dose constraint approach for NORM discharges.

11. What assumptions are made in the assessment of doses in relation to setting authorisations? Is there a required methodology specified in regulatory documentation or national guidelines? Are doses to critical groups calculated? To what degree are conservative assumptions made?

At present, it is not established.

12. What sort of limits are used? Are there, for example, annual limits on the total discharge plus subsidiary daily limits, or limits on activity per unit volume at the discharge point? Are they generic, or industry or installation specific?

At present, it is not established.

13. How is compliance with the discharge limits (and/or dose constraints) demonstrated? What kind of records should be kept, and what measurements are the operator required to make? Does the regulatory body undertake any check of measurements on the discharges? Are exposure assessments undertaken?

At present, it is not established.

14. If it is required that doses to the public should be optimised how is this achieved? Is there a lower bound on doses, below which the optimisation requirement is relaxed or not required?

At present, it is not established.

15. Are there any planned changes to legislation/regulation of discharges and waste disposals from work activities?

The CSN is preparing a plan for developing a more coherent set of rules, regulations and safety guides on waste management, including these issues.

Review of the quantities of NORM wastes discharged into the sea and into rivers or disposed of in the EU.

16. Which NORM (Naturally Occurring Radioactive Material) industries in your country identified in Question 3 are potentially radiologically significant sources of discharges and waste disposals?

In the process of identification

Benchmark Example:

In order to fairly and simply compare the approaches of different EU Member States it is our hope to analyse the responses States would take to a sample situation. Thus could you consider the following and describe the appropriate course of action according to regulations in your country:

- Operator of a non-nuclear installation in your country annually discharges some 100 million cubic metres of radioactively contaminated effluent offshore into the marine environment.

- Concentrations of the most significant radionuclides are as follows:

  ^{226}Ra and ^{228}Ra – 10 Bq/l; ^{210}Pb – 1 Bq/l.

- Total annual discharges:

  ^{226}Ra and ^{228}Ra – 1 TBq; ^{210}Pb – 100 GBq

Please answer and justify the following questions:

1. Do you believe that the operation of this installation will fall under Title VII of the BSS?

2. Will the operator be subjected to one or combination of the following:

   (a) Annual discharges exempted from any regulatory control

   (b) Annual discharge limits be imposed. If yes, please provide the basis for these limits (e.g. dose constraint, etc…)

   (c) Reporting of annual discharges will be required for the total activity or by categories and for specific radionuclides.

   (d) The operator will be required to demonstrate that his operations meet the Best Practicable Environmental Option criterion.

   (e) An alternative option. Please give details

   As far as we are in the process of identification the "working activities" that fall under Title VII and to establish a regulatory strategy for these issues, we are not in a position to answer this benchmark example.

March 2002

FRANCE

Provided by: Mr Jean-Luc Godet, Assistant Director of the DGSNR.

At present there is neither existing inventory in France of professional activities using NORM, nor data concerning the quantities of NORM handled, processed or temporarily stored or disposed in the landfill, with potential radioactive discharges into the atmosphere or ground water. However, an inter-Ministry group, composed of Ministry representatives and experts in radiation protection in industrial and health fields has produced a synthesis document which served as a basis for the French transposition of the EURATOM Directive (Bri, 1998).

Title VII of Euratom Directive

1 What are the legal provisions that enact Council Directive 96/29/Euratom Title VII into national legislation?

Some parts of the 96/29 EURATOM Directive have already been transposed into the French regulation by an Ordinance and the corresponding State Council Decree. A second Decree will be published by the ministers in charge of health, environment and work and is expected before the end of 2002.

2001-270 Ordinance

The Title VII of the 96/29 EURATOM Directive has been transposed on 28th March 2001 by the 2001-270 Ordinance (FR 2001) that forces manufacturers to take into account exposures to natural radiations that fall within the scope of "work activities".

The L 1333-10 article of the 2001-270 ordinance (FR 2001) specifies that "The head of an establishment that uses materials containing natural radionuclides not used for their radioactive, fissile or fertile properties will implement measures for exposure monitoring, when this latter is likely to undermine health. The same obligation falls to the owners or to operators of places open to the public when this last is subjected to an exposure to the natural radiations likely to undermine its health."

The L.1333-17 article of that ordinance states that the application terms of these articles will be determined by a State Council Decree, " and notably:

(...)
(9) "The nature of activities concerned by the L.1333-10 article as well as the characteristics of natural exposure sources that must be taken into account, because of their harmfulness and if necessary, measures to be implemented in order to ensure the protection of people, taking into account the importance of the incurred risk."

Moreover, the L.1333-17 article of that ordinance specifies that " Is punished by six months of imprisonment and a fine of 7 500 Euros the fact:

(...)

(3) Not to implement, within the time limit set by a formal notice notified by the authority in charge of control, the monitoring measures envisaged with the article L 1333-10;"

2002-460 Decree

A State Council Decree (FR 2002), issued on the 4th April 2002, gives more details on industries which will be concerned by this new legislation

The 4th April 2002 State Decree (FR 2002) specifies, in its R. 43-8 article, that: "For any occupation whose characteristics answer one of the conditions defined below, it must be proceeded, in accordance with the provisions of the article L 1333-10, to a monitoring of the exposure to the ionizing radiations of natural origin and to an estimate of the doses to which the people mentioned by article R. 43-4-I are likely to be subjected because of the aforementioned activity.

Are concerned:

1 the occupations during which these people are subjected to an internal or external exposure implying the elements of the natural families of uranium and thorium;

2 occupations comprising the use or the storage of materials, not used because of their radioactive properties, but containing radionuclides naturally;

3 occupations involving the production of residues containing radionuclides naturally

"1- the occupations during which these people are subjected to an internal or external exposure implying the elements of the natural families of uranium and thorium;

2 - occupations comprising the use or the storage of materials, not used because of their radioactive properties, but containing radionuclides naturally;

3 - occupations involving the production of residues containing radionuclides naturally

A decree of the ministers in charge of health, environment and work defines the categories of occupations concerned with the provisions of this article, taking into account the quantities of radionuclides held or the levels of exposures likely to be measured.

For the occupations concerned with the categories 2 and 3 above, the estimate of the doses concerns the population close to the installations as well as all the people mentioned with article R. 43-4-I when these activities produce consumer goods or products of construction.

The preliminary studies necessary to the measurement of the exposures to the ionising radiations of natural origin and to the estimate of the doses must be carried out

within two years following the publication of the above mentioned decree. They also comprise a study of the actions to carry out to reduce, if necessary, the exposure of the people.

In view of the results, the ministers in charge of health and work fix, by decree and category of activities, the protection measures against the ionising radiations to set up. These measures cannot go beyond those imposed on the nuclear activities pursuant to the present code and of the fair labour standards act."

Health, Environment and Work Ministry draft Decree

A draft version of the above-mentioned Health, Environment and Work Ministry Decree describes the information that the preliminary study should contain and states that: "the preliminary study allowing to estimate the doses of the people (...) comprises following information

1 The location of the site(s) where the work activity is taking place,

2 The physical, chemical and radiological characteristics of the raw materials or substances available on the site and potentially containing natural radionuclides,

3 A description of the processes using these raw materials or substances,

4 The radiological characteristics of intermediate and final products at the various stages of fabrication, including those of produced wastes,

5 The chemical and radiological characteristics of liquid and gaseous effluents produced during the fabrication process, and if need be, a description of the treatment processes and temporary storage before their disposal,

6 The modalities of storage of the final product before its trading,

7 The retained outlets for the disposal of wastes and effluents,

8 An estimation of the doses of people to ionising radiations, together with the identification of the groups of population considered for this estimation and, if need be, the results from the implemented dosimetric monitoring,

9 The corrective actions implemented or envisaged to reduce exposures."

The draft version of the Health, Environment and Work Ministry Decree presents also a list of specific industries concerned by the 2001-270 Ordinance and 2002-460 Decree (see below answer to question 3)

The French Ministry of Health is responsible for the preparation of the Decree remaining to be published. Its official publication is not yet definitely planned, but should result from the following timetable:

Preliminarily, the Decree proposal will be sent to the Professional Trade-Union Bodies (Chambres Syndicales Professionnelles). These latter are expected to provide their comments and to inform the authorities of any dose survey that might has been (or is being) performed in the industries which are planned to fall in the scope of the Decree (See below the list provided in Annex I of the draft Decree).

In a second step, the Decree will be finalised, taking into account the responses from the above mentioned professional bodies. This could lead for example to the withdrawal of certain categories of industries from the scope of the Decree, if appropriate justifications have been provided.

In a third step, after the official publication of the Decree and within two years, all concerned industries will have to perform the preliminary study on dose survey and radioactive gaseous and liquid discharges evaluation mentioned in the Decree, and to transmit this study to the General Directorate for Nuclear Safety and Radioprotection (Direction Générale de la Sûreté Nucléaire et de la Radioprotection (DGSNR)).

2 Is a definition of 'work activities' [See Title VII, Article 40 paragraph 2 of EURATOM] given in the national legislation/guidance? If so please provide the definition and describe any differences between the definitions of 'work activities ' and 'practices'.

Work activities are implicitly defined in the L 1333-10 article of the 2001-270 ordinance (FR 2001) by requiring for these activities that "The head of an establishment that uses materials containing natural radionuclides not used for their radioactive, fissile or fertile properties will implement measures for exposure monitoring, when this latter is likely to undermine health. The same obligation falls to the owners or to operators of places open to the public when this last is subjected to an exposure to the natural radiations likely to undermine its health."

They are further defined in the R. 43-8 article of the 4th April 2002 State Decree (FR 2002) as being:

"1- the occupations during which these people are subjected to an internal or external exposure implying the elements of the natural families of uranium and thorium;
2 - occupations comprising the use or the storage of materials, not used because of their radioactive properties, but containing radionuclides naturally;
3 - occupations involving the production of residues containing radionuclides naturally

In addition, this same article further specifies that:

A decree of the ministers in charge of health, environment and work defines the categories of occupations concerned with the provisions of this article, taking into account the quantities of radionuclides held or the levels of exposures likely to be measured."

3 What specific measures have been taken in order to identify 'work activities' in accordance with Title VII Art 40 paragraph 2 of the Council Directive 96/29/EURATOM? What, if any, industries have been identified? If identification procedure is ongoing then please provide details.

The draft version of the Health, Environment and Work Ministry Decree presents the following list of specific industries concerned by the 2001-270 Ordinance and 2002-460 Decree:

"I Work activities where are handled and used natural radioactive substances (...) are concerned the work activities below when they imply the use or the storage of materials, not used because of their radioactive properties, but which naturally contain descendants of uranium and thorium.

I.1 Oil extraction industries

I.2. Coal extraction industries

I.3. Industrial installations for coal combustion

I.4. Metal smelting industries involving tin and bauxite ores, rutile and colombite

I.5. Metal smelting industries involving monazite sands

I.6. Smelting industries for magnesium and thorium alloys manufacturing

I.7. Transformation industries involving materials containing uranium, thorium and radium

I.8. Zircon industries

I.9. Phosphate extraction industries

I.10. Installations for phosphatic fertilizers manufacturing

I*.11. Colouring pigment industries, especially those using titanium oxide*

I.12. Industries processing rare earths, including monazite

I.13. Optical glass industries using rare earths based materials, including cerium

II. Other work activities

Are concerned the places where the work activities are practiced below ground when they imply, in particular, an exposure to radon coming from the subsoil

II.1. Extraction industries falling in the scope of the General Regulation of Extractive Industries (Règlement Général des Industries Extractives (RGIE))

II.2. Spas

II.3. Other underground places not open to the public such as mushroom beds."

4 What plans have been made to ensure that in the future should new industries working with NORM giving 'significant radiological risk' develop, these are identified and brought within the regulatory framework? Please detail strategies, legal provisions, work plans.

No answer

5 What is the extent of the control of effluent discharge and waste disposal that has been introduced for the industries identified in Question 3 (see Article 41 of the Directive)? E.g. requirement for prior authorisation, monitoring, reporting etc.

No answer

Authorisations

6 Which regulatory body(ies) is responsible for regulating exposure (public and workers respectively) to NORM? Please include a hierarchy of responsibility. Which regulatory organisation is responsible for granting authorisations?

No answer

7 Please provide a short summary of the legislation controlling the authorisation of NORM discharges. What sequence of action is followed when an application for authorisation for NORM discharges is submitted?

No answer

8 Do national regulations or guidelines prohibit or discourage particular disposal routes for specific NORM wastes? Is, for example, disposal to public sewers permitted for any NORM wastes? To what extent do the total volumes and the chemical characteristics of NORM wastes determine acceptable disposal routes, for example, are there limits on volumes of liquid wastes that can be discharged to rivers of specific flow rates?

No answer

9 What approach or methodology is applied in setting discharge limits, for (a) gaseous and (b) liquid NORM discharges?

No answer

10 What dose constraints are applied with respect to NORM effluent discharges and do these differ from those used in relation to (i) disposal of solid NORM wastes and (ii) constraints set for the nuclear industry? Please define the meaning of 'dose constraint'.

No answer

11 What assumptions are made in the assessment of doses in relation to setting authorisations? Is there a required methodology specified in regulatory documentation or national guidelines? Are doses to critical groups calculated? To what degree are conservative assumptions made?

No answer

12 What sort of limits are used? Are there, for example, annual limits on the total discharge plus subsidiary daily limits, or limits on activity per unit volume at the discharge point? Are they generic, or industry or installation specific?

No answer

13 How is compliance with the discharge limits (and/or dose constraints) demonstrated? What kind of records should be kept, and what measurements is the operator required to make? Does the regulatory body undertake any check of measurements on the discharges? Are exposure assessments undertaken?

No answer

14 If it is required that doses to the public should be optimised how is this achieved? Is there a lower bound on doses, below which the optimisation requirement is relaxed or not required?

No answer

15 Are there any planned changes to legislation/regulation of discharges and waste disposals from work activities?

No answer

Review of the quantities of NORM wastes discharged into the sea and into rivers or disposed of in the EU.

16. Which NORM (Naturally Occurring Radioactive Material) industries in your country identified in Question 3 are potentially radiologically significant sources of discharges and waste disposals?

No answer. However see information on phosphate and rare earth industries in France prepared by CEPN at end of questionnaire.

Benchmark Example:

In order to fairly and simply compare the approaches of different EU Member States it is our hope to analyse the responses States would take to a sample situation. Thus could you consider the following and describe the appropriate course of action according to regulations in your country:

- Operator of a non-nuclear installation in your country annually discharges some 100 million cubic metres of radioactively contaminated effluent offshore into the marine environment.

- Concentrations of the most significant radionuclides are as follows:

  ^{226}Ra and ^{228}Ra – 10 Bq/l; ^{210}Pb – 1 Bq/l.

- Total annual discharges:

  ^{226}Ra and ^{228}Ra – 1 TBq; ^{210}Pb – 100 GBq

Please answer and justify the following questions:

1. Do you believe that the operation of this installation will fall under Title VII of the BSS?

2. Will the operator be subjected to one or combination of the following:

   (f) Annual discharges exempted from any regulatory control

   (g) Annual discharge limits be imposed. If yes, please provide the basis for these limits (e.g. dose constraint, etc…)

   (h) Reporting of annual discharges will be required for the total activity or by categories and for specific radionuclides.

   (i) The operator will be required to demonstrate that his operations meet the Best Practicable Environmental Option criterion.

   (j) An alternative option. Please give details

   No answer.

May 2002

References:

(FR 2001) Ordonnance n° 2001-270 du 28 mars 2001 relative à la transposition de directives communautaires dans le domaine de la protection contre les rayonnements ionisants, 2001. http://www.hosmat.com/ordonnance/ord2001-270.htm

(FR 2002) Décret N°2002-460 du 4 avril 2002 relatif à la protection générale des personnes contre les dangers des rayonnements ionisants, 2002.
http://www.sante.gouv.fr/adm/dagpb/bo/2002/02-14/a0141332.htm

Brillanceau F., Hubert P., Rapport du groupe d'experts sur l'exposition naturelle renforcée aux rayonnements ionisants auprès du Comité Interministériel de Transposition, Juillet (1998).

The phosphate industry in France

The phosphate industry in France is one of the largest in Europe and only one major site remains in activity, so more detail has been sought on this specific site in this Member State.

La Grande Paroisse– Grand Quevilly

General description of the site (SFC, 2002a):

The Grande Paroisse site of Grand Quevilly is Europe's largest integrated fertiliser production plant of ATOFINA (third largest producer of fertiliser in Europe) and produces not only phosphoric acid and fertilisers (phosphate fertiliser, complex granulated fertilisers, ammonium nitrate fertilisers) but also ammonia, nitric and sulphuric acids, nitrate and sodium fluorosilicate and carbon dioxide.

During the eighties, the total French production of phosphogypsum was estimated at 6 Mt y^{-1} (about the same annual production as natural gypsum), of which 900,000 t y^{-1} was produced at each of the Grand Quevilly, Grand Couronne and Le Havre sites, in the Seine maritime region.

In order to develop this by-product, in 1978 four processing plants were operating in France. However, the cost of drying (in order to eliminate the water absorbed by the phosphogypsum following purification) soon made this production unprofitable and as a result, the Grand Quevilly gypsum block fabrication plant, built in 1975 with a 300,000 t y^{-1} nominal capacity, was closed in 1979. Every other country has stopped this kind of development except Japan, that has no natural resource of gypsum and for which the phosphogypsum development (3 Mt y^{-1}) is considered profitable.

Today, the only French fertiliser site remaining in operation along the River Seine after the closure of the NHA – Le Havre site in 1992 is the site of Grand Quevilly.

Production, Effluents, Disposed or stored materials:

Over more than 60 years the fertiliser plants in the lower part of the River Seine have directly released the phosphogypsum either into the River Seine or the Bay of Seine. Today, the phosphogypsum is no longer released but disposed of.

Until 1974, the phosphogypsum of the Grand Quevilly site was released into the River Seine. From 1974 to 1984, it was dumped offshore in the Manche Sea. Since 1984, the phosphogypsum of this site is disposed of using a 13 km long gypso-duct.

The production and disposal information, presented in Table 1, has been obtained from the local administration in charge of the site's surveillance. It corresponds to the treatment of natural phosphate ore that comes essentially, for several years, from Morocco.

Table 1 P_2O_5 and phosphogypsum production from the Grande Paroisse – Grande Quevilly plant

[DRIRE, 2002a]

	1997	1998	1999	2000	2001
Phosphoric acid annual production (t P_2O_5 y^{-1})	186,987	181,507	181,599	134,225	125,196
Phosphogypsum annual production (t y^{-1})	990,000	960,000	960,000	690,000	690,000
Phosphogypsum production per mass of phosphoric acid produced (t t^{-1})	5.3	5.3	5.3	5.1	5.5
Phosphogypsum mass activity (^{226}Ra Bq g^{-1})	0.7 – 1.7				
Radium discharged in phosphogypsum per unit mass of phosphoric acid production (^{226}Ra MBq t^{-1})	3.6 – 9.4				

It appears from Table 1 above that:

- The phosphoric acid annual production of this site, together with the associated production of phosphogypsum, has decreased by 30% since 2000.

- The ratio between the annual phosphogypsum production and the annual acid phosphoric production (tonnes of phosphogypsum per tonne of P_2O_5) varied from 5.1 to 5.5 over the period 1997 – 2001, with an average value of 5.3.

- Together with a phosphogypsum mass activity of ^{226}Ra between 0.7 and 1.7 Bq g^{-1}, these ratios lead to an activity of ^{226}Ra discharged in phosphogypsum per unit mass of phosphoric acid production varying between 3.6 and 9.4 MBq t^{-1} over the period 1997 - 2001.

According to the same source, the liquid effluents from the site originate essentially in the condensers. A quantitative analysis of these effluents, completed in 1998, has shown traces of radionuclides, as follows: Radium < 0.1 ppb[1]; Thorium < 0.1 ppb; Uranium < 0.8 ppb.

The gaseous effluents are subject to washing before their final release to the atmosphere. No data are available concerning their radionuclide content.

[1] **ppb** parts per billion (10^6) a unit of concentration.

The rare earth industry in France

The rare-earth processing industry in France is the largest in Europe and is represented by one single site, so more detail has been sought on this site in this Member State.

Rhodia Terres Rares – La Rochelle (WISE, 2002; SFC, 2002b)

General description of the site

This plant has been involved in the production of rare earths since 1947. It is located in the industrial zone of Chef de Baie at La Rochelle (Charentes-Maritime, France) at the north of the La Rochelle Bay. Rhône-Poulenc took over the production of rare earth from the Société des Terres Rares in 1975. Rhodia Terres Rares has been the operator since 1991.

The first step in the process is the separation of the rare earth from thorium, uranium and other impurities by liquid-liquid extraction. Thorium nitrate (99.9% purity) and uranium nitrate are produced as a result of this first separation. The following step in the process is the rare earths separation by solvent extraction.

Until 1994, Rhône-Poulenc used to use monazite as a raw material to separate and produce rare earths. The 5 to 6% of ^{232}Th that monazite contains generated residues which were composed, among other substances, of ^{232}Th, ^{238}U, and their daughters (including ^{226}Ra and ^{228}Ra).

Since 1994, the plant no longer uses monazite imported from Australia instead bastnaesite imported from China and United States is used, that naturally contains ten times lower levels of uranium and thorium, and is, in addition, largely purified of radioactivity before it reaches France. The residues from this production are in the form of suspended materials, which are entirely stored on-site.

Until the end of 1974, the plant released all radioactive liquids and solids directly into the sea. From 1974 to the end of 1990 residues were, at least partly, sent to the sub-surface disposal site (Centre de Stockage de la Manche, CSM) of the National Agency for Radioactive waste (ANDRA) but that became full in 1991. Since 1991, wastes are sent for temporary storage to the Cadarache site of the French Atomic Energy Commission (CEA).

Waste production

Liquid and atmospheric discharges:

Atmospheric effluents are mainly radioactive dusts, thoron and other chemical products.

Liquid effluents containing radioactive and chemical products were released by way of a large pipe on the Pont Neuf beach towards the Bay of La Rochelle.

Table 2 presents the evolution between 1988 and 1999 of the radium and thorium liquid discharges to the sea.

It can be concluded that:

- The annual activity discharges of ^{228}Ra and ^{228}Th have been drastically reduced during the last ten years, with a marked reduction between 1988 and 1995 (due to the building of a new liquid effluents processing station in 1991 and the abandonment of monazite since 1994), and average values over the period 1998-1999 of 0.33 and 0.19 GBq y^{-1} respectively for ^{228}Ra and ^{228}Th. Values of annual activity discharges of ^{212}Pb and ^{228}Ac are only available for the 1998-1999 period, with average values respectively equal to 3 10^{-4} and 9.5 10^{-4} GBq y^{-1}.

- For the annual volume of liquid discharge has remained essentially constant over the 1988-1999 period, the activity concentration of these radionuclides has followed the same profile as the one followed by the annual activity discharges, with average values of respectively 0.59 and 0.31 Bq l^{-1} for ^{228}Ra and ^{228}Th, and 4.6 10^{-4} and 1.5 10^{-3} Bq l^{-1} for ^{212}Pb and ^{228}Ac, over the 1998-1999 period.

- For the annual mass of processed ore has also remained essentially constant over the 1988-1999 period, the activity of these radionuclides discharged per unit mass of processed ore has also followed the same profile, with values of respectively 29 and 15.5 GBq t^{-1} for ^{228}Ra and ^{228}Th, and 2.3 10^{-2} and 7.3 10^{-2} GBq t^{-1} for ^{212}Pb and ^{228}Ac, over the 1998-1999 period.

Solid Residues:

On-site

Table 3 below presents the ANDRA inventory of on-site radioactive material.

Table 3 Rhodia-La Rochelle: Inventory of radioactive materials

[Andra, 2000]

Type of residue	**Quantity (t)**	**Activity (dry product) (Bq g^{-1})**		**Total**
		^{238}U	^{232}Th	
Solid residues (resulting from activities prior to 1994)	8,025 (50% humidity), containing: 1.15% Th and 0.05% U on dry product	6	48	0.22 TBq
Suspended materials (resulting from activities since 1994)	12,078 (50% humidity), containing: 0.06% Th and 0.04% U on dry product	4.7	2.6	44 GBq

Other radioactive minerals that have not been processed have been used to fill in a part of the plant site.

The ANDRA 2000 inventory states in a footnote that this table does not take into consideration some 11,000 t of thorium nitrate (mass activity 1650 Bq g^{-1}) and about 20,000 t of crude thorium hydroxide (mass activity 720 Bq g^{-1}), the 'historic' residues of the processing prior to mid-1994, because these substances are 'commercialised at present' by Rhodia Terres Rares. The thorium nitrate may be used in the manufacture of gas mantles and the hydroxide 'is a potential raw material.' Apparently these substances are stored on-site.

Off-site

Rhône-Poulenc also placed 61,000 t of waste, described by ANDRA as 'Conventional Solid Waste' (Résidu Solide Banalisé) into a waste site located near its factory and belonging to the city of La Rochelle (Port de Pallice). The residues contain in particular ^{232}Th (48 Bq g^{-1} dry product) and ^{238}U (6 Bq g^{-1} dry product), for a total of 1.65 TBq.

Tailings, containing ^{232}Th, ^{238}U, and their daughters including radium, are more radioactive than the RSB (see above), and are to be found at Cadarache and presumably also in the Bay of La Rochelle**.** They were disposed of for a time at the CSM. ANDRA refused to accept the tailings from 1990 onwards, and the prefect refused an authorization to store them on the site. Storage at the closed uranium mine, leaching and milling site of l'Ecarpière (Loire-Atlantique) was also forbidden. The Cadarache site finally agreed to store up to 8000 t of tailings. According to the original agreement, the waste at Cadarache was to be removed between September 1997 and the end of August 1999. Following a public inquiry, the duration of the storage has been extended.

Table 2 Rhodia-La Rochelle: Radium and thorium releases between 1988–1999 in liquid effluents discharged into Atlantic Ocean

[DRIRE, 2002b]

		1988	1990	1992	1994	1996	1998	1999
Annual mass of processed ore ($t\ y^{-1}$)		12,000	14,700	13,704	14,333	12,430	12,250	13,680
Annual activity discharge ($GBq\ y^{-1}$)	^{228}Ac[1]	-	-	-	-	-	$9\ 10^{-4}$	$1\ 10^{-3}$
	^{228}Ra	24,27	6.55	0.622	0.470	0.356	0.253	0.508
	^{228}Th	18.75	17.39	7.162	1.362	0.276	0.183	0.218
	^{212}Pb[2]	-	-	-.	-	-	$3\ 10^{-4}$	$3\ 10^{-4}$
Activity concentration ($Bq\ l^{-1}$)	^{228}Ac	-	-	-	-	-	$1.5\ 10^{-3}$	$1.4\ 10^{-3}$
	^{228}Ra	38.28	11.39	1.07	0.78	0.67	0.42	0.73
	^{228}Th	29.57	30.25	12.29	2.27	0.52	0.30	0.31
	^{212}Pb	-	-	-	-	-	$5.0\ 10^{-4}$	$4.3\ 10^{-4}$

[1] ^{228}Ac is the short-lived daughter of ^{228}Ra and is used to measure the mother by gamma spectrometry.
[2] ^{212}Pb is the short-lived gamma-emitting daughter of ^{228}Th with ^{224}Ra in between. It can thus be used to measure ^{228}Th.

Table 2 (cont'd)

Activity discharge per mass of processed ore (GBq t^{-1})	^{228}Ac	-	-	-	-	-	7.3 10^{-2}	7.3 10^{-2}
	^{228}Ra	2,023	446	45	33	29	21	37
	^{228}Th	1,563	1,183	523	95	22	15	16
	^{212}Pb	-	-	-	-	-	2.4 10^{-2}	2.2 10^{-2}
Annual volume of liquid discharge (m^3 y^{-1})		633,999	574,944	582,831	601,200	531,269	605,000	695,000

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IRELAND

Provided by: David Pollard, Radiation Protection Institute of Ireland

Title VII of Euratom Directive

1. What are the legal provisions that enact Council Directive 96/29/Euratom Title VII into national legislation?

   In Ireland the "Radiological Protection Act, 1991" [1] establishes the legal basis for regulations to protect the health of the general public and workers against the dangers of ionising radiation. The Act authorises the making of radiation protection regulations, establishes the Radiological Protection Institute of Ireland (RPII) and sets down the statutory functions of the RPII and other relevant agencies.

   The Act provides for the implementation of future European Union legislation in the area of radiation protection by means of Ministerial Order. On 13th May 2000 the necessary laws and regulations to comply with the revised BSS Directive were brought into force by the "Radiological Protection Act, 1991 (Ionising Radiation) Order, 2000" [2], hereafter referred to as the Order.

   [1] Radiological Protection Act, 1991. Government Publications Office. Dublin.

   [2] Radiological Protection Act, 1991 (Ionising Radiation) Order, 2000. SI No. 125 of 2000. Government Publications Office. Dublin.

2. Is a definition of 'work activities' [See Title VII, Article 40 paragraph 2 of EURATOM] given in the national legislation/guidance? If so please provide the definition and describe any differences between the definitions of 'work activities' and 'practices'.

   The distinction between practices and work activities in set out in Article 3 of the Order, which defines the scope. Article 3(1) states: "This Order applies to all practices which involve a risk from ionising radiation emanating from an artificial source or from a natural radiation source in cases where the natural radionuclides are being or have been processed in view of their radioactive, fissile of fertile properties".

   Article 3(2) states that" Save where otherwise indicated in this Order, this Order also applies to work activities not referred to in paragraph (1) which –

   (a) take place in workplaces having radon concentrations in excess of 400 Bq m^{-3}, averaged over a minimum period of 3 months, or

   (b) involve natural radiation sources, other than radon, which result in an effective dose to workers or members of the public in excess of 1 mSv in a period of 12 months.

3. What specific measures have been taken in order to identify 'work activities' in accordance with Title VII Art 40 paragraph 2 of the Council Directive 96/29/EURATOM? What, if any, industries have been identified? If identification procedure is ongoing then please provide details.

A national programme has been initiated to introduce controls on work activities in accordance with Title VII Art 40 paragraph 2. This programme is focused on four areas:

- *radon in underground workplaces,*
- *radon in above ground workplaces in High Radon Areas,*
- *work activities involving exposure to natural terrestrial sources other than radon*
- *and exposure of aircrew to cosmic radiation in the operation of aircraft.*

Specifically in relation to NORM the RPII, following the introduction of the Order, commenced a programme to identify work activities liable to result in significant exposure to naturally occurring terrestrial radiation sources other than radon. In the first instance, types of industries were identified, which are currently active in Ireland and which on the basis of the literature are considered liable to involve exposure to NORM sources. Companies actively involved in each of these industry types have been identified using a variety of sources including Integrated Pollution Control licences and commercial databases such as Kompass. The list of industry types identified is presented in Table below.

Industries active in Ireland liable to involve NORM

NORM Category	*Industry*
Discrete sources	*use of thoriated products (TIG welding, etc)*
	metal recycling
Diffuse sources	*oil and gas extraction*
	power industry – peat combustion/ flyash
	power industry – handling of coal flyash
	bauxite processing
	the use of Titanium dioxide in the pigment industry
	cement production
	bulk handling/ use of zircon sands
	Handling of fertiliser

The RPII has initiated a programme to investigate the extent of exposure for each of the industry types identified. Because there are wide differences in the nature of the industrial processes involved, it is necessary to adopt sector specific approaches to risk assessment and this is reflected in the RPII programme.

4. What plans have been made to ensure that in the future should new industries working with NORM giving 'significant radiological risk' develop, these are identified and brought within the regulatory framework? Please detail strategies, legal provisions, work plans.

Article 7 of the Order requires that for work activities, which fall within the scope of the Order, the undertaking must notify the RPII forthwith after the commencement of the work activity.

5. What is the extent of the control of effluent discharge and waste disposal that has been introduced for the industries identified in Question 3 (see Article 41 of the Directive)? E.g. requirement for prior authorisation, monitoring, reporting etc.

As stated in the answer to question 3 the RPII is currently investigating the extent of exposure in a number of identified industrial sectors. This investigation will also look at the extent of potential releases and discharges. When this investigation is complete the existing controls on discharges of NORM material will be reviewed.

NORM discharges are likely to fall within the scope of (non radioactive) pollution control regulations. The Environmental Protection Agency Act, 1992, enacted on the 23 April 1992, establishes an institutional framework for the control of environmental pollution in Ireland. The Environmental Protection Agency (EPA) is responsible for the Integrated Pollution Control (IPC) licensing of large or complex activities with significant polluting potential that are listed in the First Schedule to the EPA Act, 1992. Local authorities are responsible for the licensing and control of activities that do not come within the scope of IPC licensing.

Authorisations

6. Which regulatory body(ies) is responsible for regulating exposure (public and workers respectively) to NORM? Please include a hierarchy of responsibility. Which regulatory organisation is responsible for granting authorisations?

The Radiological Protection Institute of Ireland (RPII) is the national agency with regulatory responsibility for ionising radiation. The RPII is responsible for regulating both public and occupational exposure.

IPC licensing is the responsibility of the EPA. Local authorities are responsible for the licensing and control of discharges that do not come within the scope of IPC licensing.

7. Please provide a short summary of the legislation controlling the authorisation of NORM discharges. What sequence of action is followed when an application for authorisation for NORM discharges is submitted?

There is no specific legislation controlling the authorisation of NORM discharges. As per question 5 such discharges would generally fall within the scope of regulations to control environmental pollution.

8. Do national regulations or guidelines prohibit or discourage particular disposal routes for specific NORM wastes? Is, for example, disposal to public sewers permitted for any NORM wastes? To what extent do the total volumes and the chemical characteristics of NORM wastes determine acceptable disposal routes, for example, are there limits on volumes of liquid wastes that can be discharged to rivers of specific flow rates?

No regulations specific to NORM waste

9. What approach or methodology is applied in setting discharge limits, for (a) gaseous and (b) liquid NORM discharges?

No regulations specific to NORM waste

10. What dose constraints are applied with respect to NORM effluent discharges and do these differ from those used in relation to (i) disposal of solid NORM wastes and (ii) constraints set for the nuclear industry? Please define the meaning of 'dose constraint'.

No regulations specific to NORM waste

11. What assumptions are made in the assessment of doses in relation to setting authorisations? Is there a required methodology specified in regulatory documentation or national guidelines? Are doses to critical groups calculated? To what degree are conservative assumptions made?

No regulations specific to NORM waste

12. What sort of limits are used? Are there, for example, annual limits on the total discharge plus subsidiary daily limits, or limits on activity per unit volume at the discharge point? Are they generic, or industry or installation specific?

No regulations specific to NORM waste

13. How is compliance with the discharge limits (and/or dose constraints) demonstrated? What kind of records should be kept, and what measurements is the operator required to make? Does the regulatory body undertake any check of measurements on the discharges? Are exposure assessments undertaken?

No regulations specific to NORM waste

14. If it is required that doses to the public should be optimised how is this achieved? Is there a lower bound on doses, below which the optimisation requirement is relaxed or not required?

No regulations specific to NORM waste

15. Are there any planned changes to legislation/regulation of discharges and waste disposals from work activities?

No

Review of the quantities of NORM wastes discharged into the sea and into rivers or disposed of in the EU.

16. Which NORM (Naturally Occurring Radioactive Material) industries in your country identified in Question 3 are potentially radiologically significant sources of discharges and waste disposals?

For each industry please provide details of the following:

a. The types of waste stream produced (i.e. gaseous/particulates (aerosol), liquid or solid) and the disposal routes (i.e. release to atmosphere, release to water bodies (rivers, lakes, coastal waters), release to sewage system, storage, landfill disposal, others? etc.).

b. The radiological inventory and the range of activity concentration (or a typical activity concentration) in the waste streams (gaseous/particulates (aerosol), liquid, solid) for each radionuclide (in Bq per t_{waste} or Bq per m^3_{waste}).

c. The mass or volume (in [t_{waste} or m^3_{waste}] per [$t_{product}$ or $m^3_{product}$]) of the gaseous/particulates (aerosol), liquid and solid wastes from each industry per unit production of the end product[1].

d. The annual production rate of the end product (in $t_{product}$ per year or $m^3_{product}$ per year).

e. The locations of installations that produce significant quantities of NORM and, where possible, the specific disposal routes (e.g. discharge into River Thames at grid ref…)

Discharge and waste issues will be investigated in relation to all of the sources listed in the answer to question 3.

No data available at this time.

[1] Please describe the method used to derive the data.

Benchmark Example:

In order to fairly and simply compare the approaches of different EU Member States it is our hope to analyse the responses States would take to a sample situation. Thus could you consider the following and describe the appropriate course of action according to regulations in your country:

- Operator of a non-nuclear installation in your country annually discharges some 100 million cubic metres of radioactively contaminated effluent offshore into the marine environment.

- Concentrations of the most significant radionuclides are as follows:

  ^{226}Ra and ^{228}Ra – 10 Bq/l; ^{210}Pb – 1 Bq/l.

- Total annual discharges:

  ^{226}Ra and ^{228}Ra – 1 TBq; ^{210}Pb – 100 GBq

Please answer and justify the following questions:

1. Do you believe that the operation of this installation will fall under Title VII of the BSS?

2. Will the operator be subjected to one or combination of the following:

   (a) Annual discharges exempted from any regulatory control

   (b) Annual discharge limits be imposed. If yes, please provide the basis for these limits (e.g. dose constraint, etc…)

   (c) Reporting of annual discharges will be required for the total activity or by categories and for specific radionuclides.

   (d) The operator will be required to demonstrate that his operations meet the Best Practicable Environmental Option criterion.

   (e) An alternative option. Please give details

   With respect to the benchmark example I have attempted below to answer the related questions. I must stress that the relevant legislation in Ireland is new and has not been tested with respect to NORM discharges and so I can only give fairly circumspect answers.

   1 The BSS is implemented into Irish Law in by means of the Radiological Protection Act, 1991 (Ionising Radiation) Order, 2000. The Order distinguishes between practices and work activities. Practices fall within the scope of the Order if they "involve a risk from ionising radiation emanating from an artificial source or from a natural source where the natural

radionuclides are being or have been processed in view of their radioactive, fissile or fertile properties". Work activities fall within the scope of the Order if they involve a significant increase in exposure to workers or the public due to natural radiation sources. Activities covered under Title VII of the BSS are, therefore, generally considered as work activities under Irish law.

It seems, therefore, that the installation described in the benchmark example would be classified under Irish Law as a work activity and not a practice. This being the case the installation would not fall within the scope of Irish Regulations unless the dose to a worker or member of the public exceeds 1 mSv/year.

2.a *Unless the dose exceeds 1 mSv the installation would not fall within the scope of the regulations and therefore by definition could not be exempted. If it were considered as a practice then the activity concentrations would be below the exemption values specified for practices. Clearly, however, the total activities would be likely to be licensable.*

2b *There are no specific provisions under the Order to limit discharges arising from work activities. There is of course a general requirement that the dose to members of the public should not exceed 1 mSv.*

2c *With respect to work activities there are no specific regulations required reporting of annual discharges. In the case of practices the RPII may direct an undertaking to assess and report population doses.*

2d/e *Depending on the class of activity, the installation may fall within the scope of the Environmental Protection Agency Act, 1992. In this case it would be required to implement best available technology not entailing excessive costs to limit, abate or reduce an emission from the activity.*

May 2002

ITALY (Italia)

Provided by: Mr Luciano Bologna of ANPA in Italy (Title VII implementation)
Mr Flavio Trotti of ARPA Veneto in Italy (Review of NORM wastes quantities)

At present in Italy there is neither information on the radiological exposures of workers at workplaces in industries using NORM, nor an estimation of the quantities of NORM handled and associated radioactive releases into the environment. This is mainly because most of the new Italian radiation protection legislation (into which the 96/29/EURATOM Directive was transposed) came into force on January 1st 2001 and surveys of work activities which may be of concern won't start until after September 1st 2003.

Title VII of Euratom Directive

1 What are the legal provisions that enact Council Directive 96/29/Euratom Title VII into national legislation?

The provisions laid down in Title VII of Directive 96/29/EURATOM were implemented into Italian legislation (IT 2002) by the Legislative Decree no. 241 of 26th May 2000 (IT 2000); this piece of legislation modified the Legislative Decree no. 230 of 17th March 1995 (IT 1995) in order to transpose the whole of the said Directive. The Legislative Decree no. 230, that already implemented the Euratom Directives 80/836, 84/467, 89/618, 90/641 and 92/3, is the main piece of legislation laying down radiation protection requirements for workers and the public and, as modified by the Legislative Decree no. 241, now contains thirteen Technical Annexes and constitutes the new Italian radiation protection legislation which entered into force on January 1st 2001.

In particular, the provisions laid down in Title VII of the Council Directive 96/29/Euratom were implemented into Italian legislation by the introduction into the Legislative Decree no. 230 of a new Title III-bis (concerning exposures to natural radiation sources) and an Annex I-bis (which deals with relevant action levels and identifies the list of activities deemed to be worthy of concern). As far as work activities with NORMs are concerned, the Legislative Decree no. 241 established that surveys of work activities which may be of concern will start on September 1st 2003.

Subsequently, the Legislative Decree no. 257 (IT 2001) was issued on May 9th, 2001, in order to modify certain details in Legislative Decree no. 241 concerning requirements for notification and authorisation of non nuclear installations where ionising radiation is used for industrial, research and medical purposes.

As far as natural radiation sources are concerned, the transposition of the Directive 96/29/EURATOM changes the Italian radiation protection legislation, following the recommendations and technical guidance issued by European Commission (RP88), (RP 95), (RP 107).

The Legislative Decree no. 241 was prepared in a series of official meetings involving representatives of various ministries and radiation protection experts from institutes and agencies involved (Risica, 2002).

2 Is a definition of 'work activities' [See Title VII, Article 40 paragraph 2 of EURATOM] given in the national legislation/guidance? If so please provide the definition and describe any difference between the definitions of 'work activities' and 'practices'.

Definition of work activities

Work activities are implicitly defined in the new Chapter III bis, Article 10bis of the Legislative Decree no. 230, introduced by the Legislative Decree no. 241:

"EXPOSURES FROM WORKING ACTIVITIES WITH PARTICULAR SOURCES OF NATURAL RADIATION.

Field of application

1 The dispositions of the present chapter apply to work activities in which the presence of natural radiation source lead to a significant increase of the exposure of the workers or persons of the public, than can not be neglected from the point of view of the radioprotection.

Such activities comprise:

(a) work activities during which the workers and, eventually, persons of the public are exposed to the decay products of radon or thoron or to gamma radiation or any other exposure in particular workplaces such as tunnel, underground passages("sottovie"), catacombs, caves and in all other underground workplaces;

(b) work activities during which the workers and, eventually, persons of the public are exposed to decay products of radon or thoron, or to gamma radiation or any other exposure in workplaces, different from those described in a), well identified or with specific characteristics;

(c) work activities implying the use or the storage of materials not usually considered as radioactive, but that contain natural radionuclides and provoke a significant increase of the exposure of the workers and, eventually, of persons of the public;

(d) work activities that involve the production of residues not usually considered as radioactive, but that contain natural radionuclides and provoke a meaningful increase of the exposure of persons of the public and, eventually, of the workers;

(e) work activities in spas or activities not covered by chapter IV; " (mining activities)

(f) work activities on airplane as far as the navigating staff is concerned

2 The workers referred by chapter VIII are concerned by the dispositions of the above 1 paragraph.(Le attivita' lavorative di cui al comma 1 sono quelle cui siano addetti i lavoratori di cui al capo VIII)"

Differences between "work activities" and "practices"

This legislation defines work activities as activities dealing with natural radiation sources (pursuant to Title VII of directive 96/29/EURATOM) that are not considered as practices (and thus in which natural radionuclides are not or have not been processed in view of their radioactive, fissile or fertile properties), and in which the presence of natural radiation source lead to a significant increase of the exposure of the workers or persons of the public than can not be neglected from the point of view of the radioprotection distinct

Action levels

Action Levels (defined as "values of activity concentration of radon in air or effective dose whose overcoming demands the adoption of remediation actions that reduce such quantities to levels lower than the fixed value") are laid down in the legislation (Legislative Decree no. 230, Annex 1 bis) as follows:

(a) for work activities in underground environments (a) and radon prone areas (b) 500 Bq/m^3 of radon gas as an annual radon concentration average (or 3 mSv/y if the occupancy time is lower than 2000 h/y), except for nurseries, schools, kindergartens, primary and secondary schools where the 500 Bq/m^3 action level is set, regardless of occupancy time;

(b) for work activities with naturally occurring radioactive materials (c and d), 1 mSv/y for workers and 0.3 mSv/y for members of the public.

Specific rules are also laid down for aircrews flying above 8 km.

3 What specific measures have been taken in order to identify 'work activities' in accordance with Title VII Art 40 paragraph 2 of the Council Directive 96/29/EURATOM? What, if any, industries have been identified? If identification procedure is ongoing then please provide details.

In particular, for NORM, the Italian legislation identifies an initial list of activities deemed to be worthy of concern (see IT 1995, Annex 1 bis), which includes:

1. Industry utilising phosphate ores, warehouses for bulk distribution of fertilisers;

2. Processing of metal ores for tin extraction, ferro-niobium from pyrochlore and aluminium from bauxite;

3. *Processing of zircon sands and production of refractory materials;*

4. *Processing of rare earths;*

5. *Processing and Use of Th compounds in welding electrodes; production of Th containing lenses and optical glass and Th gas mantles;*

6. *Production of titanium dioxide pigment;*

7. *Oil and gas extraction and refining, as far as NORM presence in, and removal from, piping and storage tanks of sludge and scales are concerned.*

These work activities were chosen during the expert discussion cited earlier considering those already known by past experience in Italy, such as zircon sands, some radiation protection problems that had arisen in the past (e.g. about gas mantles), as well as those envisaged in European studies – notably (RP88), (RP95) and (RP107) reports quoted above – and having a significant radiological impact.

4 What plans have been made to ensure that in the future should new industries working with NORM giving 'significant radiological risk' develop, these are identified and brought within the regulatory framework? Please detail strategies, legal provisions, work plans.

Following (Risica, 2002), a key role in the correct implementation of the decree was assigned to a National Technical Commission on Exposure to Natural Radiation Sources, intended to deal with the scientific and technical problems specific to natural radioactivity. The Commission is to be made up of 21 experts, coming from relevant ministries, national scientific institutions and agencies and regional authorities.

As regards exposure to radioactivity of terrestrial origin, some of the main duties of this Commission are:

- *to establish criteria for identifying the possible higher exposure for workers and the population in work activities with NORM, thermal spas and mining activities not already regulated, and work out guidelines for measurement methods suitable for performing appropriate assessments;*

- *to prepare proposals for updating the legislation.*

5 What is the extent of the control of effluent discharge and waste disposal that has been introduced for the industries identified in Question 3 (see Article 41 of the Directive)? E.g. requirement for prior authorisation, monitoring, reporting etc.

A broad illustration of the application of the action levels for NORM and of some legal obligations of the operator, as requested by the Italian legislation, is presented below:

The operator whose activity is included in the previous list of relevant work activities is responsible, with the help of a qualified expert, for making measurements

according to the recommendations of the above cited National Technical Commission and assessing whether or not the exposure from its activity exceeds the Action Levels reported above. At the end of the two-year time span (following either September 1st 2003 or the start of the work activity) laid down in legislation for measurements and assessments of exposure, two cases may occur (see Legislative Decree no. 230, Chapter III bis):

(a) if exposures do not exceed the action levels of 1 mSv/y for workers and 0.3 mSv/y for reference groups of the public the operator is only required to keep its activity under control; in particular he is required to repeat such measurements and assessments every three years or to review the situation if there are significant variations in the production process; however, if 80% of the Action Levels is exceeded measurements and assessments must be repeated every year;

(b) if exposures exceed either action levels of 1 mSv/y for workers and 0.3 mSv/y for reference groups of the public, the operator is required to submit a report to the Authorities and to adopt remediation measures within a three year time limit, with a view to keeping exposures below Action Levels, taking into account the optimisation principle.

If the operator does not succeed in keeping exposures below Action Levels after adoption of such remediation measures, then legislation requires the application of the ordinary requirements for the protection of workers and the public which apply to practices.

Authorisations

6 Which regulatory body(ies) is responsible for regulating exposure (public and workers respectively) to NORM? Please include a hierarchy of responsibility. Which regulatory organisation is responsible for granting authorisations?

The regulatory oversight on these activities is the responsibility of the following local Authorities which are meant to receive the reports by the users mentioned above:

- *Regional Agencies for the Protection of the Environment;*
- *Local Health Bodies;*
- *Labour Inspectorates.*

In view of the technical difficulties involved as regards measurements and exposure assessment concerning both radon, cosmic rays and NORM legislation provides for an ad hoc Section of a Technical Commission at the national level which sits at the National Agency for Environment Protection (ANPA), charged with elaborating guidelines, technical advice, criteria and methodology for measurements and exposure assessments.

However, the National Technical Commission on Exposure to Natural Radiation Sources has not been installed yet (Risica, 2002).

7 Please provide a short summary of the legislation controlling the authorisation of NORM discharges. What sequence of action is followed when an application for authorisation for NORM discharges is submitted?

No answer

8 Do national regulations or guidelines prohibit or discourage particular disposal routes for specific NORM wastes? Is, for example, disposal to public sewers permitted for any NORM wastes? To what extent do the total volumes and the chemical characteristics of NORM wastes determine acceptable disposal routes, for example, are there limits on volumes of liquid wastes that can be discharged to rivers of specific flow rates?

No answer

9 What approach or methodology is applied in setting discharge limits, for (a) gaseous and (b) liquid NORM discharges?

No answer

10 What dose constraints are applied with respect to NORM effluent discharges and do these differ from those used in relation to (i) disposal of solid NORM wastes and (ii) constraints set for the nuclear industry? Please define the meaning of 'dose constraint'.

No answer

11 What assumptions are made in the assessment of doses in relation to setting authorisations? Is there a required methodology specified in regulatory documentation or national guidelines? Are doses to critical groups calculated? To what degree are conservative assumptions made?

No answer

12 What sort of limits are used? Are there, for example, annual limits on the total discharge plus subsidiary daily limits, or limits on activity per unit volume at the discharge point? Are they generic, or industry or installation specific?

No answer

13 How is compliance with the discharge limits (and/or dose constraints) demonstrated? What kind of records should be kept, and what measurements is the operator required to make? Does the regulatory body undertake any check of measurements on the discharges? Are exposure assessments undertaken?

No answer

14 If it is required that doses to the public should be optimised how is this achieved? Is there a lower bound on doses, below which the optimisation requirement is relaxed or not required?

No answer

15 Are there any planned changes to legislation/regulation of discharges and waste disposals from work activities?

No answer

Review of the quantities of NORM wastes discharged into the sea and into rivers or disposed of in the EU.

Almost all the following information are taken from two papers:

- *(Trotti 2001) F. Trotti et al., "Preliminary identification of work activities involving NORM in Italy", NORM III Symposium - Bruxelles, 17-21 September 2001;*

- *(Trotti 2002) F. Trotti et al., "Towards the identification of work activities involving NORM in Italy", NRE VII Symposium – Rhodes, 20-24 May 2002 (to be published).*

The survey on NORM industries already conducted does not yet concern the activities listed below:

- *Ferro-niobium, tin and aluminium industries;*

- *Processing of rare earths;*

- *Manufacture and use of Th compounds;*

- *Production of titanium dioxide pigment.*

16 Which NORM (Naturally Occurring Radioactive Material) industries in your country identified in Question 3 are potentially radiologically significant sources of discharges and waste disposals?

- *Phosphate and fertilizers industry*

- *Integrated steelworks*

- *Processing of zircon sands and production of refractory materials*

- *Oil and gas extraction*

Other industries not identified by the Italian legislation are:

- *Coal-fired power plants*

For each industry the following information is provided where possible:

1. The types of waste stream produced (i.e. gaseous/particulates (aerosol), liquid or solid) and the disposal routes (i.e. release to atmosphere, release to water bodies (rivers, lakes, coastal waters), release to sewage system, storage, landfill disposal, others? etc.).

2. The radiological inventory and the range of activity concentration (or a typical activity concentration) in the waste streams (gaseous/particulates (aerosol), liquid, solid) for each radionuclide (in Bq per t_{waste} or Bq per m^3_{waste}).

3. The mass or volume (in [t_{waste} or m^3_{waste}] per [$t_{product}$ or $m^3_{product}$]) of the gaseous/particulates (aerosol), liquid and solid wastes from each industry per unit production of the end product.

4. The annual production rate of the end product (in $t_{product}$ per year or $m^3_{product}$ per year).

5. The locations of installations that produce significant quantities of NORM and, where possible, the specific disposal routes (e.g. discharge into River Thames at grid ref…)

Phosphate and fertilizers industry

Question 1

At present, one company treats the phosphorites with nitric acid without formation of any radioactive by-product and three factories produce superphosphates by balanced reaction between phosphorites and sulphuric acid. These factories only release to atmosphere gaseous/particulates emissions (the dust filtered are recycled in the process). There are about 25 main companies that produce complex fertilizers (and simple phosphate fertilizers) mainly by granulation, mixing and compacting; overall producers including little productions or productions with a low title of phosphorus (such as organic fertilizers) are less than one hundred. In general these factories only release to atmosphere gaseous/particulates emissions, if the dust filtered are recycled in the process; if not, they can release also liquid wastes to sewage system.

Past times phosphogypsum production – from Trotti 2002, par. 2.2:

In past times several plants in Italy produced phosphoric acid through the wet process, phosphogypsum being formed as a by-product. Three phosphogypsum disposal areas (Veneto, Sicilia, Sardegna) are known, one plant in Calabria executed the process. While plants in Veneto and Sicilia produced fertilizers, those in Calabria and Sardegna operated in the field of detergents. Before the realization of phosphogypsum dumps, some plants used to discharge directly into the sea.

Information on this matter is listed in Table 1 and comes from Enichem (proprietary company) sources.

Table 1 Phosphogypsum disposal sites in Italy reported by Enichem sources

Site	*Volume (m^3)*	*Operation period of dump*	*Position*	*Reclamation*	*Notes*
Veneto (Campalto-Venezia)	*200,000-250,000*	*1965-80*	*Facing the lagoon*	*Concluded*	*Another area in the Venice Lagoon to investigate*
Veneto (Pili-Venezia)	*765,600*	*1965-80*	*Facing the lagoon*	*Programmed*	
Calabria (Crotone)	*/*	*/*	*/*	*/*	*Plant operated in 1926-1986 (discharge to sea for long time)*
Sardegna (Porto Torres)	*800,000*	*1972-82*	*Old quarry 1 km from the sea*	*Concluded*	
Sicilia (Gela)	*6,000,000*	*1981-92*	*1 km from the sea*	*Started*	

Question 2

No data on activity concentration in waste streams of present productions.

Some measurements in fertilizers and their raw materials are presented in Trotti 2001, par. 3.1.1 and Trotti 2002, par. 2.1.

Since 1998 ANPA is surveying the phosphogypsum discharge site of Campalto (Venice lagoon), with measurements of ^{226}Ra, ^{210}Pb and ^{210}Po activity concentrations in water, sediments and shellfishes around the site (M. Belli, M. Blasi, J. Guogang, S. Rosamilia, U. Sansone, Le discariche di fosfogessi nella laguna di Venezia: valutazioni preliminari dell'impatto radiologico, ANPA, Serie Stato dell'Ambiente 8/2000). There is evidence of higher level of ^{210}Pb and ^{210}Po in sediments near the dump, as a consequence of the erosion of phosphogypsum due to meteoric agents and tides, while it is not clear whether the polonium level in shellfishes is correlated to the proximity to the dump or not. The estimated effective dose by ingestion of mussels is 50-250 μSv/year.

Other measurements of activity concentration of ^{210}Pb and ^{210}Po in the Venice Lagoon biota are presented in the paper "^{210}Pb and ^{210}Po in the Venice Lagoon Biota and

their contribution to population dose" G. Jia, S. Rosamilia, M. Blasi, U. Sansone, M. Belli, D. Sepulcri, P. Bidoli – to be published in "5th International Conference on High Levels of Natural Radiation and Radon Areas: Radiation Dose and Health Effects" proceedings.

Question 3

No data, we only know the volume of phosphogypsum disposal sites (Table 1 above).

Question 4

In year 2000, the national production of fertilizers was 1,8 Mt. A similar amount is imported.

The simple phosphate fertilizers represent 5,8% of the total market of fertilizers, the complex fertilizers 30,8%.

Question 5

The fertilizers industries are mostly located in northern Italy.

The location of phosphogypsum disposal sites are shown in Table 1 above.

Integrated steelworks

Question 1

No specific information for Italian steelworks.

From literature: iron ores have moderate contents of natural radionuclides; following high temperature treatments, emissions concentrate natural radionuclides, particularly ^{210}Pb and ^{210}Po. The processes of agglomeration of ore and smelting in the blast furnace are critical from this point of view. Most of the produced dust is captured by filters and then disposed in dumps, the rest is released to air. Similar problems are caused in coke distillation; furthermore, tar, the solid residue of distillate, is reported to concentrate ^{210}Pb and ^{210}Po.

Question 2 and 3

No data

Question 4 and 5

From Trotti 2001, par. 3.2:

Italy is the 10th steel producer in the world. In 2000, 40% of the overall production (26.7 million t) has been realized in four integrated steelworks, the rest in 38 electric-arc furnace steelworks. All four integrated steelworks, located in Friuli Venezia-

Giulia, Toscana, Liguria, Puglia and holded by two different private groups (Riva and Lucchini), own coke oven batteries, and two of them also agglomeration plants.

Table 2 Information on steelworks in Italy (Federacciai – main sector association – official reports and websites of companies)

Location	*Annual production (t of steel)*	*Blast furnaces (n°)*	*Agglomeration plants (n°)*	*Coke oven plants (n° batteries)*
Genova (Liguria)	*1,200,000*	*1*	*0*	*4*
Trieste (Friuli V.G.)	*800,000*	*2*	*1*	*2*
Piombino (Toscana)	*2,400,000*	*1*	*0*	*1*
Taranto (Puglia)	*6,300,000*	*5*	*2*	*9*

Processing of zircon sands and production of refractory materials

Question 1

No specific information for Italy.

From literature: critical work activities are the sand milling for production of zircon silicate flour, the manufacture of refractory materials, that can use zircon sands as raw materials, and the manufacture of ceramic and tiles, where zircon silicate flour is generally used in enamels or in the mixture itself of a particular tile named "white porcelain stoneware". Potential environmental impact pathways are: air emissions, in particular ^{210}Pb and ^{210}Po occurring from smelting in the production of refractory materials, discharges of depuration waters and sludges, use of finished products in buildings.

Question 2

In Emilia-Romagna, a relevant investigation has been carried out about the tiles working cycle - from Trotti 2001, par. 3.3:

Activity measurements (by gamma spectrometry) of ^{238}U, ^{232}Th decay products and of 40K on an elevated number of raw materials, finished products and residues samples have been performed (Bruzzi L., Cazzoli S., Mele R., Tenaglia A., Radioattività naturale nei prodotti ceramici per l'edilizia: le piastrelle ceramiche, Cer. Acta 3 n. 3 (1991), pp. 27-36).

Table 3 ^{238}U, ^{232}Th and ^{40}K activity concentrations (Bq kg^{-1}) measured on raw materials, residues and finished products in tiles working

Samples	*^{238}U*	*^{232}Th*	*^{40}K*
Raw materials	*26-58*	*38-73*	*422-1286*
Zircon silicate (< 5 μm)	*2334*	*880*	*/*
Zircon silicate (< 45 μm)	*2084*	*858*	*/*
Sludges	*68-354*	*30-119*	*266-427*
White porcelain stoneware	*118-247*	*40-89*	*528-1000*
Red porcelain stoneware	*42*	*42*	*625*
Black porcelain stoneware	*39*	*41*	*768*
Other tiles	*27-88*	*42-69*	*544-977*

The majority of the finished products have moderate concentrations values, unlike white porcelain stoneware, that contains zircon flour in the mixture. The activity values in sludges are on average not negligible and this suggests it is necessary to keep monitored the water depuration cycle. Indoor use of the more common ceramic tiles seems not to significantly contribute to gamma irradiation or to radon gas emission; however attention should be paid to particular cases and to eventually high external beta irradiation (radionuclides from zircon sands are spread over the thin coat of enamel that covers tiles).

With regard to the refractory materials manufacture - from Trotti 2002, par. 2.3:

In Table 4, the results of activity concentrations measurements carried out in 2002 by ARPAV, by gamma spectrometry, on raw materials, residues and finished products from a refractories industry are presented. ^{226}Ra (roughly in equilibrium with ^{238}U) shows a high value in the raw material "mullite-zircon" (a semi-finished zircon silicates based component), thus giving a significant level also in the finished product based on it. Referring again to ^{226}Ra, it can be seen that the environmental impact of the sludges from roller cutting and, even more, of the dust from ventilation system is not negligible.

Table 4 ^{226}Ra, ^{232}Th and ^{40}K activity concentrations (Bq kg^{-1}) measured on raw materials, residues and finished products in refractories manufacture

Samples	*^{226}Ra**	*^{232}Th*	*^{40}K*
Mullite-zircon (raw)	*1500*	*240*	*18*
Roller with mullite-zircon (finished)	*300*	*70*	*40*
Roller without mullite-zircon (finished)	*25*	*21*	*130*
Sludges (from roller cutting stage)	*160*	*37*	*31*
Dust (from factory ventilation system)	*1000*	*170*	*36*

**Roughly in equilibrium with ^{238}U*

Question 3

No data

Question 4

Italy imports about 200,000 tons per year of zircon sands, 70% of which is used in ceramic industry.

In year 2000 the national production of tiles was 631.8 million m^2 (Italy is one of the largest tiles producers, covering 20% of total world production), the production of refractory materials was 599,000 t.

Question 5

The milling firms (ten in all) are located principally in Emilia-Romagna, Toscana and Liguria. There are about 253 tiles producers and 80% of these factories are located in the ceramic tile industry "belt", in the provinces of Modena and Reggio Emilia (Trotti 2002, Figure 2).

With regard to the refractory materials manufacture, there are in Italy 36 companies, mostly located in northern Italy (50% uses zircon sands or semi-finished components zircon silicates based in processing).

Oil and gas extraction

Question 1

The wastes are: production water, scales and sludges with high $^{226}Ra/^{210}Pb$ concentration originated inside pipework, vessels and other components. The disposal routes are: removal and storage of contaminated scales and sludges, re-injection into reservoirs of connate water after separation.

Question 2

From Trotti 2001, par. 3.4.1:

In 1992 an extensive investigation was carried out in ENI plants with measurements of gamma dose rate and of ^{238}U, ^{232}Th and ^{226}Ra activity concentration in scales and connate water (Testa C., Desideri D., Meli M. A., Roselli C., Bassignani A., Colombo G., Fresca Fantoni R., Radiation protection and radioactive scales in oil and gas production, Health Physics, Vol. 67 (1994), pp. 34-38): hundreds of wells, tens of centrals, fields and platforms for both oil and gas were monitored in Italy and in Africa. Table 5 synthesizes data on activity concentration for samples from national plants: two high values of ^{226}Ra in oil wells scales (thousands of Bq kg^{-1}) and one high value of ^{226}Ra in a "mixed" well connate water (20 Bq kg^{-1}; ^{226}Ra in Italian drinking water ranges from 2×10^{-4} to 1.2 Bq kg^{-1}) are evident.

Table 5 ^{238}U, ^{232}Th and ^{226}Ra activity concentration in scales and waters of Italian plants (Bq kg^{-1})

Sample type	*Site*	*Plant features*	*Extracted hydrocarbon*	*^{238}U*	*^{232}Th*	*^{226}Ra*
Scales	*Po valley*	*Extraction* *Extraction* *Extraction* *Collection* *Collection*	*Liquid* *Liquid* *Mixed* *Gaseous* *Gaseous*	*< 0.9* *< 0.9* *< 0.9* *23.8 ± 4.3* *53.8 ± 10.8*	*< 0.8* *< 0.8* *< 0.8* *18.9 ± 3.8* *< 0.8*	*2890 ± 578* *1126 ± 225* *120 ± 24* *30 ± 6* *< 2.7*
	South Italy	*Collection*	*Liquid*	*11.3 ± 2.3*	*< 0.8*	*110 ± 22*
Waters	*Po valley*	*Extraction* *Extraction*	*Mixed* *Liquid*	*$< 4.5\times10^{-3}$* *$1.5\times10^{-2} \pm 3.0\times10^{-3}$*	*$< 4.0\times10^{-3}$* *$< 4.0\times10^{-3}$*	*$2.0\times10^{1} \pm 4.0$* *$2.3\times10^{-1} \pm 4.6\times10^{-2}$*
	Adriatic Sea	*Offshore platform*	*Gas*	*$7.3\times10^{-3} \pm 1.5\times10^{-3}$*	*$< 4.0\times10^{-3}$*	*$6.0\times10^{-2} \pm 1.2\times10^{-2}$*

From Trotti 2002, par. 2.4:

In Table 6, updated information on radioactivity levels of the most significant waste and disposed materials in Italian ENI oil and natural gas extraction plants is given (ENI-Agip division, personal communication, 2002). To summarise the table it can be said that the peak values occurrence is rare, whilst materials typical values are fairly moderate.

Table 6 Radioactivity levels of most significant waste/disposal materials in Italian ENI oil-natural gas extraction plants

Waste/disposed material	*Quantity per year*	*Typical values*	*Peak values*	*Remarks*
Production water	*1380,000 m^3 (1999)*	*^{226}Ra* *≤0.8 Bq l^{-1}*	*^{226}Ra* *1÷2 Bq l^{-1}*	*90% re-injected into reservoirs*
Sludges	*≤2000 t (1999)*	*^{226}Ra* *20÷80 Bq kg^{-1}* *^{210}Pb* *10÷30 Bq kg^{-1}*	*^{226}Ra* *600÷1600 Bq kg^{-1}* *^{210}Pb* *140 Bq kg^{-1}*	*In phase separators, storage tanks (mostly) and vessels*
Productions tubing	*15 – 20 (presence of NORM inside)*	*≥ twice the background radiation*	*0.5 mGy h^{-1}*	*Contamination consists of scales originating inside the tubing (hundreds grams each)*

Question 3

See Trotti 2002, in Table 6 above.

Question 4

ENI (AGIP division) and Edison GAS are the main companies that extract oil and gas in Italy. The prevailing activity is the gas extraction, with a production of 13.8×10^9 m^3 and 1.4×10^9 m^3 respectively from ENI and Edison GAS in 2001. 22% of the ENI overall hydrocarbons production in 2001 is made up of oil (25.2×10^6).

Question 5

There are approximately 7000 Italian ENI wells organized in 4 districts and distributed along an important sector, the Appennini ridge (see Trotti 2001, figure 2). Edison has about 100 units: 46 concessions and 44 explorative permissions.

Coal-fired power plants

Question 1

Release to the atmosphere of fly ash (not more than 0.5% of total fly ash production); the whole of the bottom ash and the rest of fly ash are used as additive in cement or road pavements.

Question 2

Radiological assessments related to the coal-fired energy cycle have been performed several times in Italy (for instance: Borio R., Campos Venuti G., Risica S., Simula S, Radioactivity connected with coal burning, The Science of the total environment, 45 (1985), pp. 55-62).

From Trotti 2002, par. 2.6:

The Regional Agency for the Environmental Protection of Liguria (ARPAL) performs systematic monitoring on three local stations, measuring ^{40}K, ^{238}U and ^{232}Th decay products (by means of gamma spectrometry) in samples of coal and ash. Mean values for the 1998-2001 period are presented in Table 7 and Table 8 (S. Maggiolo, L. Garbarino, M. Calimero, M. Bussallino, personal communication, 2002). The mean values for coal and ashes agree with literature references; significant variations for ^{238}U and ^{232}Th in coal are observed depending on the country of origin; fly ash activity content prevails on bottom ashes one and (not reported on the table) slightly decreases since 1998 to 2001.

Table7 Mean activity concentration (Bq kg^{-1}) for coal of various origin (in brackets the measured range)

Place of origin	*N° samples*	*^{232}Th*	*^{238}U**	*^{40}K*
USA	*16*	*11.1 (5-13)*	*15.9 (7-21)*	*70.1 (48-103)*
Colombia	*34*	*3.5 (2-6)*	*5.8 (3-11)*	*38.6 (14-81)*
South Africa	*25*	*26.3 (15-38)*	*29.9 (14-42)*	*29.2 (17-70)*
Indonesia	*16*	*7.1 (4-18)*	*6.2 (3-17)*	*49.1 (10-76)*
Poland	*14*	*13.6 (9-18)*	*22.8 (14-31)*	*72.7 (37-94)*
Venezuela	*8*	*4.2 (3-5)*	*5.2 (4-6)*	*45.1 (3-58)*
China	*2*	*36.5 (36-37)*	*31.0 (31-31)*	*26.5 (23-3)*
Russia	*6*	*8.7 (7-11)*	*10.0 (8-12)*	*61.8 (42-93)*
AVERAGE	*121*	*13.8*	*15.9*	*49.1*

Table 8 Mean ash activity concentration in three ENEL coal-fired power stations (Bq kg^{-1})

Station	*Type of ash*	*N° samples*	*^{232}Th*	*^{238}U**	*^{40}K*
Genova	*Bottom*	*13*	*70*	*88*	*352*
	Fly	*13*	*89*	*115*	*460*
Vado Ligure	*Bottom*	*7*	*86*	*108*	*465*
	Fly	*12*	*93*	*135*	*489*
La Spezia	*Bottom*	*7*	*106*	*119*	*489*
	Fly	*7*	*104*	*123*	*445*
AVERAGE	*Bottom*	*27*	*87*	*105*	*435*
	Fly	*32*	*95*	*124*	*465*

**From ^{226}Ra decay products.*

Question 3

The amount of released fly ash is 0.5% of the total fly ash production (assumed standard filtering efficiency of 99,5%). Nowadays over 96% of ash is made of fly ash (many plants are provided with trituration sections that reduce the bottom ash component).

Table 9 Coal-fired power plants in Italy (from 1999 and 2000 ENEL reports and direct contacts)

	1999	*2000*	*2001*
Gross production of electricity from coal (GWh)	*23,342*	*25,902*	*30,965*
Total ash production (t)	*889,953*	*987,105*	*1,269,600**
Fly ash production (t)	*839,411*	*952,367*	
Fly ash release to atmosphere (t)	*4,197*	*4,762*	
Ash used as additive in cement or road pavements (t)	*885,756*	*982,343*	

** estimate based on the conversion factor for ash of 41g/kWh*

Questions 4 and 5

From Trotti 2002, par. 2.6:

In 2001 over 65% of electricity in Italy has been provided by societies of ENEL Group; the group account for the almost entire electricity generated from coal, that is about 12% of total energy. At the moment the Group has in all 12 coal-fired power plants (one company has been sold in late 2001): their activities in 2001 are shown in Table 10.

Table 10 Coal-fired power plants in Italy (2001)

Region	*Location*	*Company*	*Gross production of electricity from coal (GWh)*	*Use of coal (kt)*
Genova	*Liguria*	*Enel Produzione*	*2097*	*826*
La Spezia	*Liguria*	*Enel Produzione*	*1683*	*591*
Vado Ligure	*Liguria*	*Interpower*	*4202*	*1440*
Fusina	*Veneto*	*Enel Produzione*	*6038*	*2114*
Porto Marghera	*Veneto*	*Enel Produzione*	*889*	*376*
Monfalcone	*F.V. Giulia*	*Elettrogen/Endesa Italia*	*2414*	*861*
Santa Barbara	*Toscana*	*Enel Produzione*	*0*	*0*
Bastardo	*Umbria*	*Enel Produzione*	*1131*	*417*
Pietrafitta	*Umbria*	*Enel Produzione*	*0*	*0*
Brindisi Nord	*Puglia*	*Eurogen*	*1576*	*672*
Brindisi Sud	*Puglia*	*Enel Produzione*	*9300*	*3340*
Santa Gilla	*Sardegna*	*Enel Produzione*	*0*	*0*
Sulcis	*Sardegna*	*Enel Produzione*	*1635*	*649*
Total			*30965*	*11287*

May 2002

References

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(IT 2000) Decreto Legislativo 26-3-2000, n.241, Modificazione del Decreto attuativo delle direttive Euratom 80/836, 84/467, 89/618, 90/641 e 92/3, 2000. http://www.unipd.it/rpx/Legislazione/DLgs241_2000.html#

(IT 2001) Decreto Legislativo 9-5-2001, n.257, Disposizioni integrative e correttive del decreto legislativo 26 maggio 2000, n. 241, recante attuazione della direttiva 96/29/Euratom in materia di protezione sanitaria della popolazione e dei lavoratori contro i rischi derivanti dalle radiazioni ionizzanti, 2001. http://www.unipd.it/rpx/Legislazione/DLgs257_2001.pdf

(IT 2002) Italian radiological protection regulation
http://www.unipd.it/rpx/Legislazione/Lex_index.html

Risica S, Bochicchio F and Nuccetelli C, The implementation in national legislation of Title VII of the Council Directive 96/29/Euratom: some general remarks and the case of Italy, Natural Radiation Environment (NRE VII), 20-24 May 2002, Rhodes, Greece (to be published)

(Trotti 2001) F. Trotti et al., "Preliminary identification of work activities involving NORM in Italy", NORM III Symposium - Bruxelles, 17-21 September 2001;

(Trotti 2002) F. Trotti et al., "Towards the identification of work activities involving NORM in Italy", NRE VII Symposium – Rhodes, 20-24 May 2002 (to be published).

LUXEMBOURG

Provided by: Albert Van Weers (NRG)
Dr M Feider (Ministry of Health) then validated it and made additional comments.

Title VII of Euratom Directive

1 What are the legal provisions that enact Council Directive 96/29/Euratom Title VII into national legislation?

Title VII implemented: *Yes*

Règlement grand-ducal du 14 décembre 2000 concernant la protection de la population contre les dangers résultant des rayonnements ionisants (RGD).

The articles and paragraph applicable to work activities are:

Art 1.1 e) - scope.

Art 5.2 - Dose limits for workers exposed to ionizing radiation derived from natural sources.

Art 8 - Regulatory provisions applying to work activities involving natural radiation sources.

2 Is a definition of 'work activities' [See Title VII, Article 40 paragraph 2 of EURATOM] given in the national legislation/guidance? If so please provide the definition and describe any differences between the definitions of 'work activities ' and 'practices'.

No specific definition of work activities is given in the national legislation (see Annex 1 of RGD). However in art 1.1 e) a description is given for activities covering work activities:

"activities which are not covered by the activities described in subparagraph a) - d), but which involve the presence of natural radiation sources and can lead to a significant increase in the exposure of workers or members of the public, which cannot be disregarded from a radiological point of view". The use of natural radiation sources in cases where natural radionuclides are or have been used for their radioactive, fissile or fertile properties is covered by subparagraph c.

Practices involve human activities that can increase the exposure of individuals to radiation from an artificial source, or from natural radiation sources where natural radionuclides are processed for their radioactive, fissile or fertile properties, except in the case of an emergency exposure.

Work activities cover human activities, which unintentionally are confronted with the presence of natural radionuclides (e.g. water supply industries). New activities of non-nuclear industries will be considered as a practice.

3 What specific measures have been taken in order to identify 'work activities' in accordance with Title VII Art 40 paragraph 2 of the Council Directive 96/29/EURATOM? What, if any, industries have been identified? If identification procedure is ongoing then please provide details.

In 2001 Luxembourg started to identify the different industries/workplaces

Industries that might give significant exposure to radon and radon decay products:

6 water supply industries each of them covering several waterworks

1 spa

2 show-mines

1 hydro-electricity producing company with pumping stations located in caverns

Industries that might give significant exposure to cosmic radiation:

2 aviation companies

No other industries were actually identified giving rise to enhanced exposure.

Luxembourg steel and aluminium processing companies only operate electric furnaces. No ores or slag is processed in our country. Cement producing industries as well as porcelain (china bone) manufacturers use local or imported raw materials with low level natural radioactivity content.

4 What plans have been made to ensure that in the future should new industries working with NORM giving 'significant radiological risk' develop, these are identified and brought within the regulatory framework? Please detail strategies, legal provisions, work plans.

Companies having the intention to develop activities, that might give rise to pollution, are subject to a special law (Loi du 10 juin 1999 relative aux établissements classés). All industrial, commercial, manufacturing, private or public establishment, installations, activities or related activities that might give rise to any nuisance need a prior licence. These activities are ranged in classes (Reglement grand-ducal du 16 juillet 1999 portant nomenclature et classification des établissements classés) depending of the potential pollution and nuisance (the regulation covers practically all working activities). This regulation and classification is independent from the regulatory framework on radiation protection.

Every new industry needs this licensing delivered by the Ministry of Environment and by the Ministry of Labour. If these industries intend to proceed to activities including

NORM, the Ministry of Environment and the Ministry of Labour have to inform the Ministry of Health on the potential hazard associated with the new working activity. In that way, the Ministry of Health has the possibility to identify this industry and to give a judgement on the potential significant radiological risk that might be associated with this new industry and to request, if appropriate, an authorisation.

5 What is the extent of the control of effluent discharge and waste disposal that has been introduced for the industries identified in Question 3 (see Article 41 of the Directive)? E.g. requirement for prior authorisation, monitoring, reporting etc.

Discharges from work activities (from a legal point of view no difference is made between practices and work activities concerning authorisations) requiring prior authorization are regulated. Principally radioactive substances may not be released to the environment without prior authorisation (Art 2.7, paragraph 4), and the competent authority fixes the conditions for the release. Individual solutions and decisions are taken case by case. At the moment no relevant NORM industries have been identified in Luxembourg.

Authorisations

6 Which regulatory body(ies) is responsible for regulating exposure (public and workers respectively) to NORM? Please include a hierarchy of responsibility. Which regulatory organisation is responsible for granting authorisations?

The Ministry of Health is responsible for regulating the exposure of workers and members of the public and delivering authorisations.

7 Please provide a short summary of the legislation controlling the authorisation of NORM discharges. What sequence of action is followed when an application for authorisation for NORM discharges is submitted?

Industries handling or processing natural radionuclides with an activity concentration higher than 100 Bq/g require prior authorisation. The industries are identified as mentioned in point 4 and are considered as an establishment of "class III" (Art 2.1, title C).

The administrative sequence of action to be followed when an application for authorisation for NORM discharges is submitted is the same as for other class III establishments. The licensee has to indicate in his application all relevant data on the working activities (Art 2.6.2) and also all relevant data on discharges (Art 2.6.1, paragraph 10).

The competent authorities will check the impact of release and if appropriate, ask for an independent expertise and fix the conditions for the use of NORM in their authorisation.

8 Do national regulations or guidelines prohibit or discourage particular disposal routes for specific NORM wastes? Is, for example, disposal to public sewers permitted for any NORM wastes? To what extent do the total volumes and the chemical characteristics of NORM wastes determine acceptable disposal routes, for example, are there limits on volumes of liquid wastes that can be discharged to rivers of specific flow rates?

For lack of currently existing NORM industries, Luxembourg has not much experience in this specific field. Principally radioactive substances may not be released to the environment without prior authorisation (Art 2.7, paragraph 4), and the competent authority fixes the conditions for the release. Individual solutions and decisions are taken case by case.

As mentioned in the questionnaire on the evaluation of the Application of the Concepts of Exemption and Clearance for Practices According to Title III of Council Directive 96/29/Euratom, for substances or contamination exceeding the unconditional clearance level, conditional clearance is possible with a prior authorisation of the competent authorities on a case by case decision.

Principally, Luxembourg authorities would not encourage the disposal of NORM waste on public depositories or the disposal to public sewers. If in the past a problem arose, individual solutions has been looked for.

9 What approach or methodology is applied in setting discharge limits, for (a) gaseous and (b) liquid NORM discharges?

For practices no specific discharge limits are specified but dose limits for members of the public are implemented in the legislation. Only for tritium in drinking water an activity concentration limit is specified 100 Bq/l.
No specific regulations for NORM discharges exist.

10 What dose constraints are applied with respect to NORM effluent discharges and do these differ from those used in relation to (i) disposal of solid NORM wastes and (ii) constraints set for the nuclear industry? Please define the meaning of 'dose constraint'.

From a regulatory point of view the definition of the dose constraint is the same as in Council Directive 96/29/Euratom.

We consider dose constraints as fractions of a limiting value helping to optimise the protection against radiation related to a source, a task, a practice or an activity. They have not to be considered as a limiting value but as a tool for the optimisation of the protection of workers or for members of the public. Dose constraints may be defined by the licensee himself in the process of optimisation or by the authorities in the licensing procedure and in some way, they are a kind of common agreement between all involved stakeholders.

For that reason no generic values are fixed for dose constraints in our national legislation. Values fixed in a legal text have in our legislation always a limiting character as legal texts are related to penalties.

For the same reason, but also for reason of lack of NORM industries, no dose constraints are fixed for NORM effluent discharges and no code of practice has been issued regarding effluent discharges or solid NORM waste disposal.

11 What assumptions are made in the assessment of doses in relation to setting authorisations? Is there a required methodology specified in regulatory documentation or national guidelines? Are doses to critical groups calculated? To what degree are conservative assumptions made?

As mentioned above this would be more a case by case decision taking however into account recommendations from international bodies or legislation from neighbouring countries.

12 What sort of limits are used? Are there, for example, annual limits on the total discharge plus subsidiary daily limits, or limits on activity per unit volume at the discharge point? Are they generic, or industry or installation specific?

The same as for point 10

13 How is compliance with the discharge limits (and/or dose constraints) demonstrated? What kind of records should be kept, and what measurements is the operator required to make? Does the regulatory body undertake any check of measurements on the discharges? Are exposure assessments undertaken?

The same as for point 10

14 If it is required that doses to the public should be optimised how is this achieved? Is there a lower bound on doses, below which the optimisation requirement is relaxed or not required?

The same as for point 10

15 Are there any planned changes to legislation/regulation of discharges and waste disposals from work activities?

No

Please provide any further information that you believe is relevant to the regulation of exposure to NORM in your country.

Review of the quantities of NORM wastes discharged into the sea and into rivers or disposed of in the EU.

16 Which NORM (Naturally Occurring Radioactive Material) industries in your country identified in Question 3 are potentially radiologically significant sources of discharges and waste disposals?

None

Benchmark Example:

In order to fairly and simply compare the approaches of different EU Member States it is our hope to analyse the responses States would take to a sample situation. Thus could you consider the following and describe the appropriate course of action according to regulations in your country:

- Operator of a non-nuclear installation in your country annually discharges some 100 million cubic metres of radioactively contaminated effluent offshore into the marine environment.
- Concentrations of the most significant radionuclides are as follows:

  Ra-226 and Ra-228 – 10 Bq/l; Pb –210 – 1 Bq/l.
- Total annual discharges:

  Ra-226 and Ra-228 – 1 TBq; Pb-210 – 100 GBq

Please answer and justify the following questions:

1. Do you believe that the operation of this installation will fall under Title VII of the BSS?
2. Will the operator be subjected to one or combination of the following:
   a. Annual discharges exempted from any regulatory control
   b. Annual discharge limits be imposed. If yes, please provide the basis for these limits (e.g. dose constraint, etc…)
   c. Reporting of annual discharges will be required for the total activity or by categories and for specific radionuclides.
   d. The operator will be required to demonstrate that his operations meet the Best Practicable Environmental Option criterion.
   e. An alternative option. Please give details.

It is hypothetical for Luxembourg as we have no marine environment, but our first impression would be:

- *regarding the Luxembourg legislation, this installation would fall under Title VII of the BSS,*
- *the annual discharges would not be exempted from any regulatory control,*
- *annual discharge limits would probably be imposed,*
- *Art. 2.6.1, paragraph 10 and in particular point A (j) of paragraph 10 has to be applied. A specific evaluation of the impact of these discharges would be requested from the applicant and the outcome of the evaluation would be part of the licensing procedure. The Best Practicable Environmental Option criterion would be part of this specific evaluation.*

November 2002

THE NETHERLANDS (Nederland)

Provided by: Albert Van Weers (NRG)
Further comment was sought from Dr Zuur of the Ministry of the Environment (VROM) in the Netherlands however no response was received within the time period of the project.

Title VII of Euratom Directive

1. What are the legal provisions that enact Council Directive 96/29/Euratom Title VII into national legislation?

   Title VII implemented? *Yes*

   Legislative document:

   Koninklijk Besluit van 16 juli 2001, houdende vaststelling van het Besluit stralingsbescherming, Staatsblad 2001, 397.

   Translated document title: Royal Decision of 16 July 2001 holding the establishment of the Radiation Protection Decree.

2. Is a definition of 'work activities' [See Title VII, Article 40 paragraph 2 of EURATOM] given in the national legislation/guidance? If so please provide the definition and describe any differences between the definitions of 'work activities ' and 'practices'.

   No, but descriptions are provided in the Explanatory Notes (Toelichting) on page 160 and in further detail in section 4.7 of these notes. In par. 4.7.1 it is explained that work activities (werkzaamheden) involve natural sources that can cause radiation exposures of workers and members of the public that cannot be neglected. Natural radiation sources of terrestrial origin that require measures often comprise materials containing radionuclides from the decay chains of uranium and thorium which are not being used because of their radioactive properties or their fissile or fertile characteristics. In par. 4.72 of the Explanatory notes it is explained that work activities only involve natural radionuclides and are therefore different from practices (handelingen) with artificial sources. What is being regarded as practices is explicitly mentioned in Art. 29 of BS with respect to radioactive substances and in Par. 34 with respect to the use of apparatus.

   Work activities involving radiation exposure to natural sources also comprise exposure to cosmic radiation of aircrew.

3. What specific measures have been taken in order to identify 'work activities' in accordance with Title VII Art 40 paragraph 2 of the Council Directive 96/29/EURATOM? What, if any, industries have been identified? If identification procedure is ongoing then please provide details.

Two studies were carried out under contract with the Ministry of Social Affairs and Employment to identify current and possible future work activities in the Netherlands in which workers could be exposed to radiation doses not to be disregarded from the radiation protection point of view. These studies have been published in Dutch as Work Documents 121 and 200 in 1999 and 2001 respectively. Exposure scenarios were used to estimate annual doses in normal and unfavourable work conditions. On the basis of these studies the Ministry will publish a list of industries and occupations in which exposures can be significant and which require some form of control and/or dose registration. Those who undertake work activities of that list are also obliged to assess whether they have to report or will need authorisation according to the Art 103 (reporting and exemption from reporting on the basis of Annex 1, Table 1), Art107 (authorisation requirement on the basis of Annex 1, Table) and Art. 108 (authorisation of discharges and exemption on the basis of Annex 1, Table 2).

Our Ministers will also publish an "indicative list" of work activities involving radioactive materials with activity concentrations that may exceed the exemption and clearance levels specified in Annex 1, Table 1 of BS. Work activities with materials exceeding the weighted sum of 1 of the activity concentrations have to be reported. If the weighted sum exceeds the value of 10 authorisation is required. Those who are undertaking or intend to undertake such work activities are obliged to assess whether they have to report them or will need authorisation.

At present the two lists have not yet been published. In fact probably all of these industries have already been identified and most of them are already under radiological control.

4. What plans have been made to ensure that in the future should new industries working with NORM giving 'significant radiological risk' develop, these are identified and brought within the regulatory framework? Please detail strategies, legal provisions, work plans.

No answer

5. What is the extent of the control of effluent discharge and waste disposal that has been introduced for the industries identified in Question 3 (see Article 41 of the Directive)? E.g. requirement for prior authorisation, monitoring, reporting etc.

Waste disposal

Reporting requirements for work activities not being discharges are dealt with in Article 103 of BS. This article reads as follows:

1) Prior to the start of a work activity, not being a discharge, the employer (entrepeneur) must report the work activity in accordance with Article 40.

2) *Par. 1 does not apply when within the establishment*

a) it involves a work activity in which:

i) the activity of the radionuclides in the natural sources involved always lower is than the values provided in Annex 1, Table 1 of BS, or

ii) the activity concentration of the radionuclides in the natural sources involved lower is than the values provided in Annex 1, Table 1 of BS

b) for which on the basis of Article 107 authorization is required.

3) Article 25, par. 3 and 4 (summation rules) as well as par. 6, 7 and 8 apply equally.

4) By Ministerial regulation it can be ruled that in view of radiation protection par. 2 of Article 103 does not apply.

The exemption provisions specified in Article 103 refer to Annex 1 of BS. With respect to the numerical values in Table 1 this annex is largely identical to Annex 1, Table A of the CD for exemption of practices. However, there are principle differences pointed out below.

1) The numerical values in BS apply to both exemption and clearance.

2) They apply to artificial and natural sources, thus to practices and work activities.

3) Numerical concentration values are different from the CD for three naturally occurring radionuclides:

a) Ra-226: 1 kBq/kg in BS and 10 kBq/kg in CD

b) Ra-228: 1 kBq/kg in BS and 10 kBq/kg in CD

c) Pb-210+ and Po-210: 100 kBq/kg in BS and 10 kBq/kg in CD

4) Practices with radioactive substances exceeding the levels specified in Annex 1 Table 1 in principle will require prior authorization (as in CD) but work activities will require reporting.

5) If the weighted sum of the activity concentrations of materials within a work activity is equal to or higher than 10 that work activity will require authorization.

For work activities not exempted from reporting in Art. 103 the reporting requirements are specified in Art. 105. These requirements also apply to applications

for an authorisation of work activities according to Art.109. They include the destination of residues for reuse as material or product and disposal as waste and an estimate of the effective dose in a calendar year that people could receive as a consequence of the destination of the materials and their processing route. The more detailed administrative requirements according to Art. 105 is being laid down in a Ministerial Regulation.

Residues exceeding 10 times the reporting level (weighted sum of activity concentrations) have to be transferred to the Central Organisation for Radioactive Waste (COVRA) unless Our Ministers decide otherwise on the basis of the provisions of Art. 110.

NORM discharges

The requirement for authorization of discharges of natural sources and exemption conditions are laid down in Article 108 of BS. This article reads as follows.

1) Without authorization it is prohibited to discharge natural sources or to carry out a practice involving the discharge of natural sources.

2) Par. 1 does not apply when the activity to be discharged from the premises in a calendar year lower is than the values provided in Annex, Table 2 of BS.

3) Article 25, par. 3 and 4 (summation rules) as well as par. 6, 7 and 8 apply equally.

4) By Ministerial regulation it can be ruled that in view of radiation protection par. 2 of Article 108 does not apply.

The content of Table 2 of Annex 1 of BS is reproduced below.

<u>Clearance levels for annual discharges in water and air of radionuclides from work activities</u>

Radionuclide	*Liquid discharge GBq/a*	*Aerial discharge GBq/a*
^{210}Pb	*10*	*10*
^{210}Po	*10*	*10*
^{222}Rn	*---*	*10000*
^{223}Ra	*1000*	*---*
^{224}Ra	*1000*	*---*
^{226}Ra	*10*	*10*
^{228}Ra	*100*	*10*
^{227}Ac	*100*	*1*
^{227}Th	*1000*	*---*
^{228}Th	*1000*	*1*
^{230}Th	*100*	*1*
^{232}Th	*100*	*1*

Radionuclide	*Liquid discharge GBq/a*	*Aerial discharge GBq/a*
^{234}Th	*10000*	*---*
^{231}Pa	*10000*	*0.1*
^{234}U	*1000*	*10*
^{235}U	*1000*	*10*
^{238}U	*1000*	*10*

These clearance levels pertain to total activities (a summation rule applies) discharged annually into sewers and various types of receiving surface water and into air. They were derived on the basis of a reference dose level of 10 µSv/a and, with respect to liquid discharges, on dose assessments for discharge into a large river. Cleared levels for aerial discharge were based on a source with moderate effective stack height. Annual discharges below the clearance levels do not require prior authorisation.

Authorisations

6 Which regulatory body(ies) is responsible for regulating exposure (public and workers respectively) to NORM? Please include a hierarchy of responsibility. Which regulatory organisation is responsible for granting authorisations?

The establishment of the Radiation Protection Decree (BS) is the joint responsibility of several ministers indicated as "Our Ministers". They comprise:

1) State Secretary of the Ministry of Social Affairs and Employment (principle establisher of the regulations) also on behalf of:

2) The Minister of Housing, Spatial Planning and the Environment

3) The Minister of Public Health, Welfare and Sport

In consent with:

The Minister of Economic Affairs.

The primary responsibility for regulating public exposure to NORM lies with Minister of Housing, Spatial Planning and the Environment

The primary responsibility for regulating exposure of workers to NORM lies with the Minister of Social Affairs and Employment

The primary responsibility for regulating exposure of workers to NORM from mining operations lies with the Minister of Economic Affairs.

Art. 101 of BS specifies that with exception of Art. 27 – 34 and Chapter 6 all other provisions of BS apply unless regulated otherwise in the specific articles on work

activities. Consequently, the procedural requirements for reporting and granting authorization of work activities specified in Art. 40 – 47 in principle apply all.

The organization responsible for granting authorisations of work activities is the Minister of Social Affairs and Employment on behalf of Our Ministers with specific involvement of:

The Ministry of Economic Affairs if the work activity involves mining operations,

The Ministry of Traffic and Public works if the work activity involves discharges into surface water,

The Ministry of Agriculture, Natural Conservation and Fisheries if the work activity involves discharges into the air or surface water.

7. Please provide a short summary of the legislation controlling the authorisation of NORM discharges. What sequence of action is followed when an application for authorisation for NORM discharges is submitted?

Authorization requirements and exemptions for discharge of natural sources

The requirement for authorization of discharges of natural sources and exemption conditions are laid down in Article 108 of BS. This article reads as follows.

5) Without authorization it is prohibited to discharge natural sources or to carry out a practice involving the discharge of natural sources.

6) Par. 1 does not apply when the activity to be discharged from the premises in a calendar year lower is than the values provided in Annex, Table 2 of BS.

7) Article 25, par. 3 and 4 (summation rules) as well as par. 6, 7 and 8 apply equally.

8) By Ministerial regulation it can be ruled that in view of radiation protection par. 2 of Article 108 does not apply.

The content of Table 2 of Annex 1 of BS is reproduced below

<u>Clearance levels for annual discharges in water and air of radionuclides from work activities</u>

Radionuclide	*Liquid discharge GBq/a*	*Aerial discharge GBq/a*
^{210}Pb	*10*	*10*
^{210}Po	*10*	*10*
^{222}Rn	*---*	*10000*
^{223}Ra	*1000*	*---*
^{224}Ra	*1000*	*---*
^{226}Ra	*10*	*10*

Radionuclide	*Liquid discharge GBq/a*	*Aerial discharge GBq/a*
^{228}Ra	*100*	*10*
^{227}Ac	*100*	*1*
^{227}Th	*1000*	*---*
^{228}Th	*1000*	*1*
^{230}Th	*100*	*1*
^{232}Th	*100*	*1*
^{234}Th	*10000*	*---*

When the discharges are not cleared the operator of the work activity has to apply for authorisation according to Art. 108. To the application the provision of Art. 109 apply as well as the provisions of Art. 43. T he Ministries involved in the authorisation process have been indicated above on the basis of that article. Article 44 further specifies the information to be provided with the application. This includes the outcome of the assessment of the annual effective dose equivalent that can be received by persons at any point outside the establishment as a result of discharges from all work activities within the establishment. Art. 47 specifies that in cases of discharges into surface water those organisation responsible for quality management of the receiving water body will be involved in the authorisation process.

8. Do national regulations or guidelines prohibit or discourage particular disposal routes for specific NORM wastes? Is, for example, disposal to public sewers permitted for any NORM wastes? To what extent do the total volumes and the chemical characteristics of NORM wastes determine acceptable disposal routes, for example, are there limits on volumes of liquid wastes that can be discharged to rivers of specific flow rates?

The clearance levels for liquid discharges pertain to total activities discharged annually into sewers and various types of receiving surface water and into air. They were derived on the basis of a reference dose level of 10 µSv/a and on dose assessments for discharge into sewers and various receiving water bodies (see also question 9). So discharges into public sewers is permitted for NORM waste. However, Art. 103 par. 4 provides the Regulatory Bodies with the possibility to decide by Ministerial Regulation that exemption from authorisation requirements does not apply when, in exceptional cases, as a result of the small volume or flow rate of the receiving water body relatively high concentrations will occur that were not envisaged in setting the clearance levels.

9. What approach or methodology is applied in setting discharge limits, for (a) gaseous and (b) liquid NORM discharges?

There are no discharge limits set for NORM discharges into air and water. The clearance levels set for work activities are based of a reference dose of 10 µSv per year for individual members of the public. The corresponding nuclide specific annual activity discharges were derived on the basis of exposure scenarios applied to various discharge situations. These discharge situations included liquid discharges into a sewer, a big lake, a big river and an estuary on the North Sea coast and aerial discharges from stacks with different effective stack height as a result of factual stack

height and plume rise. The results of these assessments have been laid down in a RIVM report Nr 610 310 002 (1999) referenced in the Explanatory Notes of BS.

The exemption and clearance levels for solids to be used or disposed as waste (Annex 1, Table 1 of BS) have been based on a reference effective dose for members of the public of 0.3 mSv/a and a reference ambient dose of 1 mSv/a. On that basis and assuming various exposure scenarios for use or disposal of residues from work activities the exemption/clearance levels were derived. The Explanatory Notes refer to the reports Kema 22727-NUC 98-503, Kema 22892-NUC 09-5308 and NRG 20 293/00 31670/C

10. What dose constraints are applied with respect to NORM effluent discharges and do these differ from those used in relation to (i) disposal of solid NORM wastes and (ii) constraints set for the nuclear industry? Please define the meaning of 'dose constraint'.

The dose constraints applied to NORM discharges is 10 µSv/a effective dose to members of the public. The dose constraint for discharges from practices has been set at a much lower level of 0.1 µSv/a effective dose. The latter dose constraint is used as the basis for deriving limits expressed as "radiotoxicity equivalents" for different receiving media below which no authorisation of the discharges from practices is required (see questionnaire on clearance). How the dose constraint for discharges from practices is used for defining annual discharges not requiring authorisation is explained in the answer to question 9.

The dose constraints for use or disposal of solid residues are 0.1 mSv/a under normal conditions for workers involved in the process and 1 mSv/a under unfavourable but still realistic working conditions. The dose constraints for members of the public are set at 0.3 mSv/a effective dose and 1mSv/a ambient dose. Multiple exposure pathways were considered in deriving the relation between activity concentration and level of exposure of workers and members of the public (see references cited in the answer to question 9.

11. What assumptions are made in the assessment of doses in relation to setting authorisations? Is there a required methodology specified in regulatory documentation or national guidelines? Are doses to critical groups calculated? To what degree are conservative assumptions made?

The methodologies to be used in deriving exposures in relation to authorisations of practices, including discharges, have been laid down in a Ministerial Regulation that came into force on March 1 2002. However, this does not apply to exposure assessments for discharges from work activities.

12. What sort of limits are used? Are there, for example, annual limits on the total discharge plus subsidiary daily limits, or limits on activity per unit volume at the discharge point? Are they generic, or industry or installation specific?

No authorisations have yet been issued after enforcement of BS on March 1 2002. From the authorisations previously issued for discharges from work activities it is likely that limits will be set on total annual activity discharges irrespective of concentrations at the point of discharge. Cleared discharges are generic but authorised discharges were, and will be, installation specific.

13. How is compliance with the discharge limits (and/or dose constraints) demonstrated? What kind of records should be kept, and what measurements is the operator required to make? Does the regulatory body undertake any check of measurements on the discharges? Are exposure assessments undertaken?

Assuming that past experience will apply to future authorisations, it is likely that authorisations will require monitoring and reporting of discharges at specified frequency. None of the Dutch NORM industries has the capability to carry out the analyses required to quantify discharges. These analyses are carried out by independent research institutes and the results are reported to the Inspectorates involved. Checks on these measurements have not yet been undertaken by the regulatory bodies although they used to do so for discharges of the larger nuclear facilities.

Exposure assessments of envisaged discharges are part of the application for authorisation of the discharges. Exposures from real discharges are derived on the same basis.

In rather exceptional cases environmental monitoring is carried under responsibility of the operator of an installation.

14. If it is required that doses to the public should be optimised how is this achieved? Is there a lower bound on doses, below which the optimisation requirement is relaxed or not required?

Optimisation of radiation exposures of the public, including those from discharges is a basic requirement laid down in BS and applies to practises as well as work activities. For work activities this requirement is laid down in Art. 101 of BS. For exemption of discharges from work activities a dose criterion of 10 µSv/a effective dose has been used. This level of exposure is regarded as not requiring optimisation efforts.

It is not clear whether or not the dose criteria of 1 mSv/a ambient dose and 0.3 mSv/a effective dose for exposure of the public as a result of work activities are to be regarded as levels of exposure below which the Regulatory Authorities will not require optimisation.

15. Are there any planned changes to legislation/regulation of discharges and waste disposals from work activities?

No answer.

Please provide any further information that you believe is relevant to the regulation of exposure to NORM in your country.

Review of the quantities of NORM wastes discharged into the sea and into rivers or disposed of in the EU.

16. Which NORM (Naturally Occurring Radioactive Material) industries in your country identified in Question 3 are potentially radiologically significant sources of discharges and waste disposals?

In the following table the industries in the Netherlands known to discharge into air and/or water and producing significant amounts of residues have been listed. It should be noted that activity concentrations in effluents are not likely to be relevant parameters in relation to consequence assessments of discharges into water and of very limited relevance for aerial discharges.

Provisional listing of Dutch industries with known or potential significant discharges or NORM residue arisings

Industry	Discharges to air	Discharges to water	Solid residues
Oil and gas	Very limited, radon	Mainly offshore and some onshore (sewer), ^{226}Ra, ^{210}Pb, ^{228}Ra, reported	Sludges onshore largely ^{210}Pb Sludges offshore ^{226}Ra, ^{210}Pb, ^{228}Ra, ^{228}Th
Phosphoric acid (closed down)	none	none	From dismantling, ^{226}Ra scale
Phosphorus production	^{210}Po, ^{210}Pb, reported	^{210}Po, ^{210}Pb, reported	Large volume slag for reuse (^{238}U+), calcined dust small volume (^{210}Pb)
Iron and steel production	^{210}Po, ^{210}Pb, reported	^{210}Po, ^{210}Pb, reported	Large volume slag for reuse, significant volume dust from off-gas treatment
TiO_2 pigment	none	Mainly ^{226}Ra, ^{228}Ra, not reported	Metal hydroxides (^{238}U+, ^{232}Th+), significant volumes
Cement production	^{210}Po, ^{210}Pb (reported?0	none	none
Mineral sands	^{238}U+, ^{232}Th+ ??, reported?	Low, reported?	Very small?
Fertiliser	Small, reported?	Small, reported?	Very small?

Benchmark Example:

In order to fairly and simply compare the approaches of different EU Member States it is our hope to analyse the responses States would take to a sample situation. Thus could you consider the following and describe the appropriate course of action according to regulations in your country:

- Operator of a non-nuclear installation in your country annually discharges some 100 million cubic metres of radioactively contaminated effluent offshore into the marine environment.

- Concentrations of the most significant radionuclides are as follows:

  ^{226}Ra and ^{228}Ra – 10 Bq/l; ^{210}Pb – 1 Bq/l.

- Total annual discharges:

  ^{226}Ra and ^{228}Ra – 1 TBq; ^{210}Pb – 100 GBq

Please answer and justify the following questions:

1. Do you believe that the operation of this installation will fall under Title VII of the BSS?

   Answer: yes

2. Will the operator be subjected to one or combination of the following:

   a. Annual discharges exempted from any regulatory control

Nuclide	*Annual discharge TBq*	*Exempted annual discharge, TBq*	*Weighted contribution to sum*
^{226}Ra	*1*	*0.01*	*100*
^{228}Ra	*1*	*0.1*	*10*
^{210}Pb	*0.1*	*0.01*	*10*
Weighted sum			*120 (>1)*

   Answer: discharges not exempted from regulatory control (authorisation required)

   b. Annual discharge limits be imposed. If yes, please provide the basis for these limits (e.g. dose constraint, etc…)

   Answer: yes annual discharge limits will be imposed. Limits will be based on dose constraint of 0.3 mSv/a effective dose and implementation of ALARA to a level satisfactory to the Regulatory Authorities.

c. Reporting of annual discharges will be required for the total activity or by categories and for specific radionuclides.

Answer: Reporting will (most probably) required at a level of total annual activities of specific radionuclides.

d. The operator will be required to demonstrate that his operations meet the Best Practicable Environmental Option criterion.

Answer: Best Available Technique is more likely to be considered in the framework of ALARA.

e. An alternative option. Please give details

June 2002

AUSTRIA (Österrreich)

Provided by: Mr Johann-Klaus Hohenberg, Head of Division V/7; Radiation Protection; Federal Ministry of Agriculture, Forestry, Environment and Water-Management (BMLFUW)

Title VII of Euratom Directive

1 What are the legal provisions that enact Council Directive 96/29/Euratom Title VII into national legislation?

The draft of the new Radiation Protection Law has been sent to the relevant authorities and organisations for comment on April 22, 2002. Time for commenting is until May 20, 2002. Thereafter the comments received will be considered for possible changes and the final version of the Radiation Protection Law will be forwarded to the Parliament.

Work on the Radiation Protection Ordinance is in progress, some parts have already been drafted.

2 Is a definition of 'work activities' [See Title VII, Article 40 paragraph 2 of EURATOM] given in the national legislation/guidance? If so please provide the definition and describe any differences between the definitions of 'work activities ' and 'practices'.

"Work activities" have been defined in the paragraph "Definitions" in the Radiation Protection law in a similar way as in Title VII, Article 40 paragraph 2 of the Directive.

3 What specific measures have been taken in order to identify 'work activities' in accordance with Title VII Art 40 paragraph 2 of the Council Directive 96/29/EURATOM? What, if any, industries have been identified? If identification procedure is ongoing then please provide details.

An overview on Austrian industries, which might potentially be affected, has been made. An experimental survey including measurements is planned. Two studies have been undertaken on radon in indoor air and drinking water, which serve as indicator for potentially elevated concentrations of radon at workplaces.

4 What plans have been made to ensure that in the future should new industries working with NORM giving 'significant radiological risk' develop, these are identified and brought within the regulatory framework? Please detail strategies, legal provisions, work plans.

According to the draft of the Radiation Protection Ordinance several industries will be defined as potentially affected, leaving the possibility open, that more might be added to the list. The authorities may decide on additionally specific industries or industrial processes to be named on a case-by-case basis, if it is found that a radiological risk cannot be excluded. Industries, which fall under these categories, will have to present an expertise about the radiological risk. In case a significant radiological risk exists the authorities will prescribe that appropriate countermeasures are to be taken.

5 What is the extent of the control of effluent discharge and waste disposal that has been introduced for the industries identified in Question 3 (see Article 41 of the Directive)? E.g. requirement for prior authorisation, monitoring, reporting etc.

Control will be defined in the Radiation Protection Ordinance under development.

Authorisations

6 Which regulatory body(ies) is responsible for regulating exposure (public and workers respectively) to NORM? Please include a hierarchy of responsibility. Which regulatory organisation is responsible for granting authorisations?

The Regulatory Body responsible for regulating exposure both to workers and members of the public is the Federal Ministry of Agriculture, Forestry, Environment and Water Management, partly in collaboration with other ministries, like the Federal Ministry of Social Security and Generations. Authorisations are granted by authorities at the regional level ("Bezirksverwaltungsbehörden").

7 Please provide a short summary of the legislation controlling the authorisation of NORM discharges. What sequence of action is followed when an application for authorisation for NORM discharges is submitted?

At the time being, the authorisation of NORM discharges – as for any discharge of radionuclides – is connected to the maximum permissible discharge values defined by the old Radiation Protection Ordinance. An application for the discharge of explicitly NORM only has never been submitted, but maximum values for some NORM radionuclides are included for instance in the authorisation for discharges for the Research Centre Seibersdorf and the Atominstitute in Vienna.

The person, institute or industry applying for discharge authorisation has to submit an expertise by an authorised person, institute or company. The authorities will decide about each application separately and individually.

8 Do national regulations or guidelines prohibit or discourage particular disposal routes for specific NORM wastes? Is, for example, disposal to public sewers permitted for any NORM wastes? To what extent do the total volumes and the chemical characteristics of NORM wastes determine acceptable disposal routes, for example, are there limits on volumes of liquid wastes that can be discharged to rivers of specific flow rates?

If the maximum permissible discharge values according to the Radiation Protection Ordinance or the authorisations are not reached, any NORM waste as well as waste containing artificial radionuclides may be disposed of as non-radioactive waste. Waste exceeding these maximum values has to be treated accordingly as radioactive waste. Specific disposal routes can and most probably will be prescribed by the authorities for each case separately. The limits for discharge rates of liquid waste into rivers will be determined individually, also taking the variable flow rates of rivers into account. The chemical characteristics have to be considered separately on the basis of other laws governing the discharge of chemicals.

9 What approach or methodology is applied in setting discharge limits, for (a) gaseous and (b) liquid NORM discharges?

The basis is the potential dose to the population. The acceptable dose will be defined in the Ordinance.

10 What dose constraints are applied with respect to NORM effluent discharges and do these differ from those used in relation to (i) disposal of solid NORM wastes and (ii) constraints set for the nuclear industry? Please define the meaning of 'dose constraint'.

Dose constraints are not known in the old Radiation Protection Ordinance, but will be introduced in the new one. The concept of dose constraints is mentioned in the Radiation Protection Law, but the values will be defined in the Ordinance. There is no nuclear industry in Austria to compare with. "Dose constraint" is understood as the dose to a member of the public, which should not be exceeded as the result of exposure to one single source or by one pathway, in order to make sure, that the sum of exposure from different, independently influencing sources does not exceed the maximum permissible dose.

11 What assumptions are made in the assessment of doses in relation to setting authorisations? Is there a required methodology specified in regulatory documentation or national guidelines? Are doses to critical groups calculated? To what degree are conservative assumptions made?

Potential doses are calculated on the basis of a critical group. Dose calculations have to be done by authorized experts and are checked by the authorities. There is no methodology specified in regulatory documentation or national guidelines, but for the future it is expected that the recommendations of the EU from the "Radiation Protection" series will be closely followed. The assumptions in these recommendations are conservative.

12 What sort of limits are used? Are there, for example, annual limits on the total discharge plus subsidiary daily limits, or limits on activity per unit volume at the discharge point? Are they generic, or industry or installation specific?

The discharge limits for the Research Centre Seibersdorf and Atominstitute are both based on annual, weekly and single discharges, as well as on limits of activity per unit volume at the discharge point. All limits are installation specific, taking for instance the flow rate of the river into which the waste is discharged into account. This flow rate has to exceed a defined minimum rate to allow for discharge.

13 How is compliance with the discharge limits (and/or dose constraints) demonstrated? What kind of records should be kept, and what measurements is the operator required to make? Does the regulatory body undertake any check of measurements on the discharges? Are exposure assessments undertaken?

The installations mentioned above have to check all discharges for radionuclide concentrations and whether the limits are not exceeded. Data like date, time, volume discharged and the measurement results have to be recorded. The measurements have to be made in such a way, that compliance with the limits is demonstrated. The samples have to be stored and the regulatory body selects samples for remeasurement in a Federal Laboratory. The recorded data are controlled for plausibility. The authorities may at any time enter the installations, select and take own samples for control purposes. The installations provide an exposure assessment, but compliance with the radionuclide limits automatically implies that the maximum permissible doses have not been exceeded.

14 If it is required that doses to the public should be optimised how is this achieved? Is there a lower bound on doses, below which the optimisation requirement is relaxed or not required?

The draft of the Radiation Protection Law prescribes, that the exposure has to be kept as low as possible within the limits of the law. The goal in Austria is not the "optimisation" of doses (whatever this should be!). The exposure of single persons and the population by optimisation, which might include restriction of doses, has to be as low as possible and justified, taking economic and social factors into consideration.

15 Are there any planned changes to legislation/regulation of discharges and waste disposals from work activities?

Yes, the implementation of the EU directive will result in changes, especially since NORM was not regulated as demanded by Title VII.

Review of the quantities of NORM wastes discharged into the sea and into rivers or disposed of in the EU.

16 Which NORM (Naturally Occurring Radioactive Material) industries in your country identified in Question 3 are potentially radiologically significant sources of discharges and waste disposals?

A copy of the paper "NORM and TENORM in Austria" by Franz Schönhofer from our department is attached. This paper has been presented at NORM III in Brussels and is to be published in the conference proceedings. It deals with potentially affected industries. The actual levels of discharges and waste still have to be verified, before it can be stated, that there exists a radiologically significant source. It is not expected that many cases will be found – if any. Therefore no details can be given yet.

As sources and potential sources for elevated doses the following practices and industries in Austria were identified:

Radon exhalation from soil and accumulation in houses and working places,
radon exhalation from water and accumulation in water works,
radon in mining and excavation,
mining and milling of ores
phosphate and fertilizer industry
coal mining and burning
oil and natural gas industry
rare earths industry
zirconium industry
radium industry
thorium industry
purification of water.

Benchmark Example:

In order to fairly and simply compare the approaches of different EU Member States it is our hope to analyse the responses States would take to a sample situation. Thus could you consider the following and describe the appropriate course of action according to regulations in your country:

- Operator of a non-nuclear installation in your country annually discharges some 100 million cubic metres of radioactively contaminated effluent offshore into the marine environment.
- Concentrations of the most significant radionuclides are as follows:

  ^{226}Ra and ^{228}Ra – 10 Bq/l; ^{210}Pb– 1 Bq/l.
- Total annual discharges:

  ^{226}Ra and ^{228}Ra – 1 TBq; ^{210}Pb – 100 GBq

Please answer and justify the following questions:

1. Do you believe that the operation of this installation will fall under Title VII of the BSS?
2. Will the operator be subjected to one or combination of the following:
   a. Annual discharges exempted from any regulatory control
   b. categories and for specific radionuclides.
   c. The operator will be required to demonstrate that his operations meet the Best Practicable Environmental Option criterion.
   d. An alternative option. Please give details

   There is no marine environment in Austria, therefore no regulations exist for that case. Moreover limits for discharges of NORM for instance into lakes and rivers are to be set in the Radiation Protection Ordinance, which still is under development.

May 2002

Further developments:

The Radiation Protection Act (146 Strahlenschutz-EU-Anpassungsgesetz 2002) comes into force on the 1st January 2003. It is hoped that the Radiation Protection Ordinance (Strahlenschutzverordnung) will also come into force in January or February 2003.

November 2002

PORTUGAL

Provided by: Dr Fernando P Carvalho (in a personal capacity), Department of Radiological Protection and Nuclear Safety (DPRSN)

Approaches were made on several occasions to Dr. Délia Gazzo of the General Directorate for Health which is the public service with the responsibility to prepare projects of legislation to transpose Directive 96/29 to national legislation however no response was elicited.

Title VII of Euratom Directive

1. What are the legal provisions that enact Council Directive 96/29/Euratom Title VII into national legislation?

   None, so far.

2. Is a definition of 'work activities' [See Title VII, Article 40 paragraph 2 of EURATOM] given in the national legislation/guidance? If so please provide the definition and describe any differences between the definitions of 'work activities ' and 'practices'.

   No.

3. What specific measures have been taken in order to identify 'work activities' in accordance with Title VII Art 40 paragraph 2 of the Council Directive 96/29/EURATOM? What, if any, industries have been identified? If identification procedure is ongoing then please provide details.

   None.

4. What plans have been made to ensure that in the future should new industries working with NORM giving 'significant radiological risk' develop, these are identified and brought within the regulatory framework? Please detail strategies, legal provisions, work plans.

   None.

5. What is the extent of the control of effluent discharge and waste disposal that has been introduced for the industries identified in Question 3 (see Article 41 of the Directive)? E.g. requirement for prior authorisation, monitoring, reporting etc.

   None.

Authorisations

6. Which regulatory body(ies) is responsible for regulating exposure (public and workers respectively) to NORM? Please include a hierarchy of responsibility. Which regulatory organisation is responsible for granting authorisations?

   None.

7. Please provide a short summary of the legislation controlling the authorisation of NORM discharges. What sequence of action is followed when an application for authorisation for NORM discharges is submitted?

   N/A

8. Do national regulations or guidelines prohibit or discourage particular disposal routes for specific NORM wastes? Is, for example, disposal to public sewers permitted for any NORM wastes? To what extent do the total volumes and the chemical characteristics of NORM wastes determine acceptable disposal routes, for example, are there limits on volumes of liquid wastes that can be discharged to rivers of specific flow rates?

   No.

9. What approach or methodology is applied in setting discharge limits, for (a) gaseous and (b) liquid NORM discharges?

   N/A

10. What dose constraints are applied with respect to NORM effluent discharges and do these differ from those used in relation to (i) disposal of solid NORM wastes and (ii) constraints set for the nuclear industry? Please define the meaning of 'dose constraint'.

    N/A

11. What assumptions are made in the assessment of doses in relation to setting authorisations? Is there a required methodology specified in regulatory documentation or national guidelines? Are doses to critical groups calculated? To what degree are conservative assumptions made?

    N/A

12. What sort of limits are used? Are there, for example, annual limits on the total discharge plus subsidiary daily limits, or limits on activity per unit volume at the discharge point? Are they generic, or industry or installation specific?

    N/A

13. How is compliance with the discharge limits (and/or dose constraints) demonstrated? What kind of records should be kept, and what measurements is the operator required to make? Does the regulatory body undertake any check of measurements on the discharges? Are exposure assessments undertaken?

N/A

14. If it is required that doses to the public should be optimised how is this achieved? Is there a lower bound on doses, below which the optimisation requirement is relaxed or not required?

N/A

15. Are there any planned changes to legislation/regulation of discharges and waste disposals from work activities?

No

Please provide any further information that you believe is relevant to the regulation of exposure to NORM in your country.

Review of the quantities of NORM wastes discharged into the sea and into rivers or disposed of in the EU.

16. Which NORM (Naturally Occurring Radioactive Material) industries in your country identified in Question 3 are potentially radiologically significant sources of discharges and waste disposals?

For each industry please provide details of the following:

a) The types of waste stream produced (i.e. gaseous/particulates (aerosol), liquid or solid) and the disposal routes (i.e. release to atmosphere, release to water bodies (rivers, lakes, coastal waters), release to sewage system, storage, landfill disposal, others? etc.).

b) The radiological inventory and the range of activity concentration (or a typical activity concentration) in the waste streams (gaseous/particulates (aerosol), liquid, solid) for each radionuclide (in Bq per t_{waste} or Bq per m^3_{waste}).

c) The mass or volume (in [t_{waste} or m^3_{waste}] per [$t_{product}$ or $m^3_{product}$]) of the gaseous/particulates (aerosol), liquid and solid wastes from each industry per unit production of the end product[1].

d) The annual production rate of the end product (in $t_{product}$ per year or $m^3_{product}$ per year).

[1] Please describe the method used to derive the data.

e) The locations of installations that produce significant quantities of NORM and, where possible, the specific disposal routes (e.g. discharge into River Thames at grid ref…)

Phosphate industry, spas, uranium mining, coal burning. This would require appropriate investigation.

Benchmark Example:

In order to fairly and simply compare the approaches of different EU Member States it is our hope to analyse the responses States would take to a sample situation. Thus could you consider the following and describe the appropriate course of action according to regulations in your country:

- Operator of a non-nuclear installation in your country annually discharges some 100 million cubic metres of radioactively contaminated effluent offshore into the marine environment.

- Concentrations of the most significant radionuclides are as follows:

  ^{226}Ra and ^{228}Ra – 10 Bq/l; ^{210}Pb – 1 Bq/l.

- Total annual discharges:

  ^{226}Ra and ^{228}Ra – 1 TBq; ^{210}Pb – 100 GBq

Please answer and justify the following questions:

1. Do you believe that the operation of this installation will fall under Title VII of the BSS?

2. Will the operator be subjected to one or combination of the following:

   (a) Annual discharges exempted from any regulatory control

   (b) Annual discharge limits be imposed. If yes, please provide the basis for these limits (e.g. dose constraint, etc…)

   (c) Reporting of annual discharges will be required for the total activity or by categories and for specific radionuclides.

   (d) The operator will be required to demonstrate that his operations meet the Best Practicable Environmental Option criterion.

   (e) An alternative option. Please give details

   No legislation.

May 2002

FINLAND (Suomi)

Provided by: Mika Markkanen, Radiation and Nuclear Safety Authority (STUK)

Title VII of Euratom Directive

1. What are the legal provisions that enact Council Directive 96/29/Euratom Title VII into national legislation?

   The provisions are summarised in a separate memorandum "Provisions on natural radiation in Finland".

2. Is a definition of 'work activities' [See Title VII, Article 40 paragraph 2 of EURATOM] given in the national legislation/guidance? If so please provide the definition and describe any differences between the definitions of 'work activities ' and 'practices'.

   "Work activity" is not separately defined. The Radiation Act defines these operations as "practices" (Section 11). However, further provisions on natural radiation (Chapter 12, Sections 45 - 49) deal with these "practices" in very same manner as the BSS with its "work activity". So, effectively operations defined by the Radiation Act as "practices" due to exposures to natural radiation, are equivalent to the BSS's "work activity".

3. What specific measures have been taken in order to identify 'work activities' in accordance with Title VII Art 40 paragraph 2 of the Council Directive 96/29/EURATOM? What, if any, industries have been identified? If identification procedure is ongoing then please provide details.

   No separate measures (surveys etc.) have been taken to identify "work activities" in accordance to BSS since natural radiation issues have been earlier studied, and also regulated since 1992, and are thus rather well known already. Practices falling under Radiation Act, Section 11, point 2. are:

   - *Radon in workplaces (all underground workplaces, including mines, and aboveground workplaces at identified radon prone areas),*
   - *Natural radioactivity in drinking water (excluding water taken from a private well of an individual),*
   - *Natural radioactivity in building materials,*
   - *Industries listed in Guide ST 12.1 (the list is based on publication Radiation Protection Nr 88. Not many of them actually exist in Finland, however, they are mentioned in prospective manner so that attention will paid if some of these would commence in the future.)*

4. What plans have been made to ensure that in the future should new industries working with NORM giving 'significant radiological risk' develop, these are identified and brought within the regulatory framework? Please detail strategies, legal provisions, work plans.

Operators or employers have the obligation to assess whether their operations involve significant exposures to natural radiation (Article 45 of the Radiation Act, see separate memorandum on the provisions). The Radiation Decree (1512/91) sets some special obligations on notification. STUK shall be notified of the following operations before they are started up:

- *Mining operations referred to in the Mining Act (503/65)*
- *Excavation lasting longer than two months and performed mostly underground or in an enclosed place*
- *Extensive utilisation of natural resources whose uranium or thorium content exceeds 0.1 kilograms per tonne*

5. What is the extent of the control of effluent discharge and waste disposal that has been introduced for the industries identified in Question 3 (see Article 41 of the Directive)? E.g. requirement for prior authorisation, monitoring, reporting etc.

At the moment there is no such industry in operation which would require e.g. continuous monitoring of effluents. For example, in the case of TiO_2 production, radiological investigations (under Radiation Act, Section 45) have shown that effluents do not pose significant exposures and no further measures have been required. For some mining disposal sites (non-uranium mining containing elevated levels of naturals), orders have been issued e.g. regarding covering the sites with inactive soil in order to reduce external gamma and the rise of dust.

Authorisations

6. Which regulatory body(ies) is responsible for regulating exposure (public and workers respectively) to NORM? Please include a hierarchy of responsibility. Which regulatory organisation is responsible for granting authorisations?

Supreme authority in supervising compliance with the Radiation Act is the Ministry for Social Affairs and Health (Radiation Act, Section 5). Compliance with the Act and with provisions and regulations issues thereto shall be supervised by the Radiation and Nuclear Safety Authority (STUK) as an agency of the Ministry of Social Affairs and Health (Radiation Act, Section 6).

No authorisation is needed for practices involving the presence of natural radiation (i.e. work activities). However, after the investigation referred to in Article 45 of the Radiation Act (see question 3 above) has been made, STUK shall, where necessary, issue instructions on limiting the exposure to radiation (Radiation Act, Article 46). Some operations shall be notified to STUK (see Section 29 of the Radiation Decree).

7. Please provide a short summary of the legislation controlling the authorisation of NORM discharges. What sequence of action is followed when an application for authorisation for NORM discharges is submitted?

No authorisation is needed. For practices causing exposures to natural radiation (i.e. work activities), the regulatory procedure is the following:

- *Notification under Radiation Decree, Section 29, where applicable,*
- *Investigation of exposures by the operator (Radiation Act, Section 45)*
- *STUK issues, where necessary, orders on limiting the exposure to radiation (Radiation Act 46). The underlying principle in issuing these orders is that "the responsible party shall take all measures which are warranted, having regard to the investigation made and to other circumstances, in order to limit the exposure" as prescribed in Radiation Decree, Section 27 (actually Section 27 is applicable only to the occupational exposures mentioned in the said Section but the same principle is applied, in practice, also to public exposures)*
- *if reference or action levels (Guides ST 12.1, 12.2 or 12.3) are exceeded, despite of limiting measures mentioned above, STUK issues instructions on the protection of workers and the general public, as necessary*

8. Do national regulations or guidelines prohibit or discourage particular disposal routes for specific NORM wastes? Is, for example, disposal to public sewers permitted for any NORM wastes? To what extent do the total volumes and the chemical characteristics of NORM wastes determine acceptable disposal routes, for example, are there limits on volumes of liquid wastes that can be discharged to rivers of specific flow rates?

No disposal route is specifically prohibited. Any disposal route could be accepted for NORMs if it is demonstrated by the operator that exposures caused by such discharges are small (see procedure in question 7). Also disposal of small amounts of NORM waste to public sewers could be considered but as we have not had any such cases, no limits etc. for this purpose have been issued. Similarly, no limits on volumes or flow rates of liquid waste have been issued for NORMs (could be issued if needed, but have not been needed yet).

9. What approach or methodology is applied in setting discharge limits, for (a) gaseous and (b) liquid NORM discharges?

Not yet applied since there has not been a need to do so. If such a case should come up, site-specific limits would most likely be derived with appropriate modelling by considering a dose of 0.1 mSv (or 0.1 - 0.5 mSv if a site specific dose constraint would be issued) to a critical group.

10. What dose constraints are applied with respect to NORM effluent discharges and do these differ from those used in relation to (i) disposal of solid NORM wastes and (ii) constraints set for the nuclear industry? Please define the meaning of 'dose constraint'.

Dose constraint is defined in Section 7 of the Radiation Decree:

"The STUK shall, as necessary, set dose constraints which are lower than the maximum values prescribed in Sections 3–6, when these are warranted in order to implement the principle of optimisation prescribed in Section 2 of the Radiation Act and in order to allow for exposure resulting from various radiation sources."

It has been stated in Guide ST 12.1 that "In operations causing exposure to natural radiation, the population dose constraint for a specific radiation source may be 0.1 to 0.5 mSv per year". So, a source specific dose constraint within this range could be issued to both effluent discharges an/or disposal of solid waste, depending on the case.

For the nuclear industry, there is a limit (effectively a dose constraint) of 0,1 mSv for "the expected committed effective dose to a member of the public resulting from one years operation" (Council of State Decision 398/1991). This value is used for deriving the limits for discharges from a nuclear site during normal operation.

11. What assumptions are made in the assessment of doses in relation to setting authorisations? Is there a required methodology specified in regulatory documentation or national guidelines? Are doses to critical groups calculated? To what degree are conservative assumptions made?

As already said above, no authorisation is needed. Some methodologies used for dose assessment are described in the attached report STUK-B-STO 32 "Radiation Dose Assessments for Materials with Elevated Natural Radioactivity". The report provides practical information (e.g. many parameter values) needed for evaluating occupational and public exposures caused by materials containing natural radionuclides. However, the main emphasis of the report is on external gamma radiation and inhalation of dust originating from bulk amounts of materials. The discussion on waste disposal is more limited and effluent discharges are not covered at all.

12. What sort of limits are used? Are there, for example, annual limits on the total discharge plus subsidiary daily limits, or limits on activity per unit volume at the discharge point? Are they generic, or industry or installation specific?

No such limits on effluent discharges have been issued.

13. How is compliance with the discharge limits (and/or dose constraints) demonstrated? What kind of records should be kept, and what measurements is the operator required to make? Does the regulatory body undertake any check of measurements on the discharges? Are exposure assessments undertaken?

Not applicable, see question 12.

14. If it is required that doses to the public should be optimised how is this achieved? Is there a lower bound on doses, below which the optimisation requirement is relaxed or not required?

The regulatory procedure described under question 7 includes optimisation considerations (selection of actions taken to reduce doses and the selection of a site specific dose constraint).

The Guide ST 12.1 states that if doses to the public are less than 0.1 mSv per year, the practice is exempted from limitation measures laid down in Section 46 of the Radiation Act.

15. Are there any planned changes to legislation/regulation of discharges and waste disposals from work activities?

No. The existing legislation (Radiation Act) and provisions issued under it (Radiation Decree, ST Guides) give a sound legal basis for dealing with practices involving the presence of natural radiation, including discharges and waste disposal thereof. So far there has not been a need to issue more detailed guidance on effluent discharges, since such practices are rare and cases are always site specific. Therefore, the more general provisions are preferred, at least for the time being.

Please provide any further information that you believe is relevant to the regulation of exposure to NORM in your country.

It seems that all relevant information is covered by the answers given above and the attached documents.

Review of the quantities of NORM wastes discharged into the sea and into rivers or disposed of in the EU.

16. Which NORM (Naturally Occurring Radioactive Material) industries in your country identified in Question 3 are potentially radiologically significant sources of discharges and waste disposals?

Production of TiO_2 using ilmenite as raw material. Unfortunately, I do not have at my disposal (or at least not easily) such detailed information on the discharges as required below.

For each industry please provide details of the following:

a) The types of waste stream produced (i.e. gaseous/particulates (aerosol), liquid or solid) and the disposal routes (i.e. release to atmosphere, release to water bodies (rivers, lakes, coastal waters), release to sewage system, storage, landfill disposal, others? etc.).

b) The radiological inventory and the range of activity concentration (or a typical activity concentration) in the waste streams (gaseous/particulates (aerosol), liquid, solid) for each radionuclide (in Bq per t_{waste} or Bq per m^3_{waste}).

c) The mass or volume (in [t_{waste} or m^3_{waste}] per [$t_{product}$ or $m^3_{product}$]) of the gaseous/particulates (aerosol), liquid and solid wastes from each industry per unit production of the end product[1].

d) The annual production rate of the end product (in $t_{product}$ per year or $m^3_{product}$ per year).

e) The locations of installations that produce significant quantities of NORM and, where possible, the specific disposal routes (e.g. discharge into River Thames at grid ref…)

[1] Please describe the method used to derive the data.

Benchmark Example:

In order to fairly and simply compare the approaches of different EU Member States it is our hope to analyse the responses States would take to a sample situation. Thus could you consider the following and describe the appropriate course of action according to regulations in your country:

- Operator of a non-nuclear installation in your country annually discharges some 100 million cubic metres of radioactively contaminated effluent offshore into the marine environment.

- Concentrations of the most significant radionuclides are as follows:

  ^{226}Ra and ^{228}Ra – 10 Bq/l; ^{210} Pb – 1 Bq/l.

- Total annual discharges:

  ^{226}Ra and ^{228}Ra – 1 TBq; ^{210}Pb – 100 GBq

Please answer and justify the following questions:

1. *Do you believe that the operation of this installation will fall under Title VII of the BSS?*

   At least Article 40.2 would be applicable i.e. this installation would be considered "in the identification of work activities which may be of concern". However, more information (results of further investigations) on actual exposures caused by the installation would be needed before declaring that "exposure to natural radiation sources need attention and have to be subject to regulatory control". Therefore, it is impossible to say based on the given information whether or not Articles 40.3 and 41 would apply.

2. Will the operator be subjected to one or combination of the following:

   The operator would be required to investigate the radiological consequences (Radiation Act, Section 45). Any further actions would be based on the results thereof.

   a. Annual discharges exempted from any regulatory control

      Possible, if it were reliably demonstrated that the dose (committed effective dose per year) to a critical group would be less than 0.1 mSv.

   b. Annual discharge limits be imposed. If yes, please provide the basis for these limits (e.g. dose constraint, etc…)

      Possible, if the dose to a critical group would be above 0.1 mSv and it can not be reduced below this value by limitation measures laid down in Section 46 of the Radiation Act. A dose constraint could be issued within the range

0.1 - 0.5 mSv, depending on overall site specific circumstances. Annual discharge limits would most likely be derived from the dose constraint and used as a practical reference in compliance monitoring.

c. Reporting of annual discharges will be required for the total activity or by categories and for specific radionuclides.

If the point b above should apply, the reporting of the annual discharges would be required. The basic assumption would be that all nuclides important for the overall dose should be monitored and reported separately (the investigation mentioned above should identify these nuclides). However, if the operator would then demonstrate, considering e.g. actual site specific radionuclide ratios and their possible variations in the discharges, that the dose can be assessed with sufficient accuracy by some other means e.g. by monitoring some total activities, this could also be accepted.

d. The operator will be required to demonstrate that his operations meet the Best Practicable Environmental Option criterion.

Is this BPEO some UK criterion? I don't exactly know what is meant by it, but perhaps I can assume that it is related to optimisation of protection. If the point b above should apply, the operator would be obligated to "take all measures which are warranted, having regard to the investigation made and to other circumstances, in order to limit the exposure". So, these measures would take place first, and if they were not sufficient to reduce the doses to below 0.1 mSv, then the phases described under points b and c would apply.

e. An alternative option. Please give details

PROVISIONS ON NATURAL RADIATION IN FINLAND (PROVISIONS IMPLEMENTING THE BSS TITLE VII)

General structure of radiation safety legislation

The legislation comprises three levels:

– *Radiation Act (enacted by the parliament),Radiation Decree (issued by the President at the proposal of the Minister of Social Affairs and Health under the Section 49 of the Radiation Act), andST-Guides (issued by STUK under the Section 70 of the Radiation Act).*

In addition, the Ministry of Social Affairs and Health has issued a Decree on the upper limits for the radon content of indoor air (issued under Section 48 of the Radiation Act).

In the following is a summary of the provisions of the Radiation Act, Radiation Decree and ST-guides which concerns or are directly applicable to natural radiation. Also many other provisions concerning radiation practices in general may be applicable (e.g. provisions on dose monitoring, heath surveillance, arrangements at workplaces, etc.) but these are not discussed here.

Radiation Act (592/1991) as amended by several Acts including 1142/1998

Chapter 3: Definitions

Section 8

For the purposes of this Act, the term:

4) Natural radiation shall denote ionising radiation originating in outer space, or radioactive materials occurring in nature and not used as radiation sources.

Section 11

The term radiation practices shall denote:

(a) the use of radiation,

(b) operations or circumstances in which human exposure to natural radiation causes or might cause a health hazard.

Section 12

The term radiation work shall refer to work or to a task involving the use of radiation or nuclear energy, in which the worker may be exposed to radiation to such a degree that monitoring of radiation exposure must be arranged at the workplace.

Chapter 12: Natural radiation

Section 45: Reports on radiation exposure

Anyone using naturally occurring earth, stone or other materials, or materials produced as a result of using these materials, in industrial or comparable operations shall investigate the radiation exposure caused by these practices in a manner acceptable to the STUK if it is found, or there is reason to suspect, that the operations constitute radiation practices. (NOTICE: this covers e.g. operations with materials and the production of residues). The same obligation shall apply to an employer if it is found, or if there is reason to suspect, that the radiation exposure originating from natural radiation and occurring in the employer's working facilities or other workplace causes or is liable to cause detriment to health. (NOTICE: this covers e.g. radon in workplaces).

If a party required to make such an investigation fails to do so, then the STUK shall be empowered to issue an order to this effect.

Section 46: Limiting radiation exposure

When the investigation referred to in section 45 has been made, the STUK shall, where necessary, issue instructions on limiting the exposure to radiation.

Section 47: Description of organization

If the work performed at a facility referred to in section 45 constitutes radiation work as defined in Section 32, the responsible party shall furnish an account of the arrangements that have been made to ensure safety. The applicable provisions of section 18 governing the description of radiation user's organisation shall apply to this description, to the appointment of a radiation safety officer, and to qualifications thereof.

Section 48: Radon in indoor air and radioactivity in household water

The upper limits for the radon content of indoor air shall be stipulated by the Ministry of Social Affairs and Health.

Detailed provisions on the limitation and supervision of radiation exposure due to radioactive substances in household water shall be stipulated by an order of the Ministry of Social Affairs and Health.

Section 49: Authority to issue Decrees

Detailed provisions on the regulatory control of radiation exposure due to natural radiation shall be issued by Decree.

Chapter 13: Radioactive waste

Section 50: Duty of care of the responsible party

The responsible party shall take measures necessary to render harmless any radioactive waste arising from its operations.

When handling radioactive materials, the responsible party shall ensure that the release of radioactive materials into the environment is adequately restricted. If radioactive materials are released into the environment to such extent that environmental decontamination measures are required in order to avert consequent health or environmental hazards, the responsible party shall ensure that the said decontamination measures are taken.

When utilizing natural resources containing radioactive materials, the responsible party shall ensure that radioactive waste poses no hazard to health or to the environment, both during the operations and on their conclusion.

Chapter 17: Miscellaneous provisions

Section 70: More detailed provisions and instructions of the STUK

More detailed provisions on the implementation of this Act and on the division of duties and cooperation between public authorities shall be issued by Decree.

The STUK shall issue general instructions on achieving the standard of safety defined in this Act.

Radiation Decree (592/1991) as amended by several Acts including 1142/1998

Chapter 2: Maximum values for radiation exposure

Section 7: Application of maximum values and dose constraints

More detailed instructions on the application of maximum values and on the calculation of radiation doses shall be issued by the Radiation and Nuclear Safety Authority.

The Radiation and Nuclear Safety Authority shall, as necessary, set dose constraints which are lower than the maximum values prescribed in Sections 3–6, when these are warranted in order to implement the principle of optimisation prescribed in Section 2 of the Radiation Act and in order to allow for exposure resulting from various radiation sources.

Chapter 7:Natural radiation

Section 26: Reporting of monitoring data

The results of the investigation referred to in section 45 of the Radiation Act shall be submitted to STUK without delay.

Section 27: Limiting exposure to natural radiation

The responsible party shall take all measures which are warranted, having regard to the investigation made and to other circumstances, in order to limit the exposure of workers to natural radiation at work if an investigation indicates that the following are probable:

1. the annual average concentration of radon in the breathing air during working hours at a workplace where work is performed on a permanent basis exceeds 400 Bq per cubic metre, or

2. the exposure of a worker to natural radiation at work resulting from some other specific source may exceed 1 mSv per year.

The Radiation and Nuclear Safety Authority shall impose the requirements for limiting the radon concentration of breathing air in working premises in which work is performed only occasionally or for short periods.

Section 28: Monitoring of radiation exposure and medical surveillance

If, even after measures have been taken to limit exposure, it is probable that exposure of workers to natural radiation cannot reasonably be reduced below the action levels prescribed in Section 27, then the responsible party shall arrange for monitoring of the radiation exposure of the workers and for their medical surveillance in compliance with the applicable provisions of chapter 3.

Section 28 a: Protection of aircrew

If an investigation referred in Section 45 of the Radiation Act indicates that the effective dose caused by cosmic radiation to the aircrew may exceed 1 mSv per year, then the responsible party shall:

1) maintain records of employee work shifts on flights and, as necessary, plan the shifts so that exposures which considerably exceed the levels typical for aviation work may be prevented,

2) inform the employees of the health hazards of radiation, of the exposure levels typical in aviation work and of the results of exposure assessments,

3) arrange the work of a pregnant worker in accordance with the requirements of Section 5, and

4) arrange the medical surveillance of employees in accordance with the principles stipulated in the Radiation Act.

Section 29: Special duty of notification

Notification of the following operations shall be made to the Radiation and Nuclear Safety Authority before they commence:

1) Mining operations referred to in the Mining Act (No. 503 of 1965),

2) Excavation work lasting longer than two months and mainly performed underground or in a confined space, and

3) Extensive utilisation of natural resources the uranium or thorium content of which exceeds 0.1 kg per tonne, with the exception of practices supervised under the Nuclear Energy Act (No. 990 of 1987).

The notification referred to in paragraph 1 of this section shall provide the following information:

1) The nature of the operations,

2) The volume of materials planned to be handled,

3) Separate schedules for mining and excavation work performed underground or in a confined space,

4) The main types of rock to be excavated, insofar as these are known, and

5) An estimate of the number of workers and hours of work.

The notification referred to in this section shall also be made for work in underground premises in which no air conditioning has been arranged, if the working time of the worker exceeds 100 hours a year. This notification shall include the information referred to at points 1 and 5 of paragraph 2.

ST Guides

Guide ST 12.1: Radiation Safety in Practices Causing Exposure to Natural Radiation

The Guide specifies the reference levels and the maximum values to be applied for the purpose of limiting radiation exposures in practices involving the presence of natural radiation sources.

Occupational exposures

Reference levels:

Radon in workplace	*Regular work*	*400 Bq/m^3*
	Max. 600 h/a	*1000 Bq/m^3*
	Max. 300 h/a	*2000 Bq/m^3*
	Max. 100 h/a	*6000 Bq/m^3*

Other sources of natural radiation (external gamma, inhalation of dust)

1 mSv/a (radon exposure not included)

Dose limits and maximum values derived from them

Radon in workplace Regular work 3000 Bq/m^3 (corresponding 20 mSv/a)

Overall exposure to natural radiation sources (all exposure pathways considered i.e. radon, external gamma and inhalation of dust)

20 mSv/a (mean of 5 years, max 50 mSv in any year)

Application

If a reference level is exceeded, the responsible party shall take all measures which are warranted, having regard to the investigation made (section 45 of the Radiation Act) and to other circumstances, in order to limit the exposure of workers to natural radiation. If these measures are ineffective or not warranted due to sound technical or economical reasons, the protection of workers (e.g. monitoring of doses) shall be arranged as in any radiation practice. Even in this case the dose limits and maximum values given above shall not be exceeded.

Public exposures

Exemption level

An investigation referred to Section 45 of the Radiation Act is not required if the exposure, on the basis of the data given in the notification under Section 29 of the Radiation Decree, is in all probability less than 0,1 mSv per year. Also, if an investigation is made and its results show that the doses are less than 0,1 mSv per year, the practice is exempted from limitation measures laid down in Section 46 of the Radiation Act.

Dose constraints

Pursuant to Section 7 of the Radiation Decree, STUK may issue doses constraints in order to implement the principle of optimization and to control exposure from various radiation sources. In operations causing exposure to natural radiation, the population dose constraint for a specific radiation source may be 0.1 to 0.5 mSv per year.

Guide ST 12.2: The Radioactivity of Construction Materials, Fuel Peat and Peat Ash

Investigation level for Building Materials (based on the annual dose of 1 mSv due to external gamma radiation):

$$I = \frac{C_{Th}}{200\ Bq\ /\ kg} + \frac{C_{Ra}}{300\ Bq\ /\ kg} + \frac{C_K}{3000\ Bq\ /\ kg};$$

C_{Th}, C_{Ra} and C_K are activity concentrations in the material, expressed in Bq/kg

If the value of the activity index is less than 1, the material can be used without restrictions. If it exceeds 1, the responsible party is require to show specifically that the annual dose caused by the use of the material is less than 1 mSv/a.

Investigation level for materials used in Road, Playground and Related Construction (based on the annual dose of 0.1 mSv due to external gamma radiation):

$$I = \frac{C_{Th}}{500\ Bq\ /\ kg} + \frac{C_{Ra}}{700\ Bq\ /\ kg} + \frac{C_{K}}{8000\ Bq\ /\ kg} + \frac{C_{Cs}}{2000\ Bq\ /\ kg};$$

C_{Th}, C_{Ra}, C_K and C_{Cs} are activity concentrations in the material, expressed in Bq/kg

If the value of the activity index is less than 1, the material can be used without restrictions. If it exceeds 1, the responsible party is require to show specifically that the annual dose caused by the use of the material is less than 0.1 mSv/a.

Investigation level for Landfill Materials (based on the annual dose of 0.1 mSv due to external gamma radiation):

$$I = \frac{C_{Th}}{1500\ Bq\ /\ kg} + \frac{C_{Ra}}{2000\ Bq\ /\ kg} + \frac{C_{K}}{20000\ Bq\ /\ kg} + \frac{C_{Cs}}{5000\ Bq\ /\ kg};$$

C_{Th}, C_{Ra}, C_K and C_{Cs} are activity concentrations in the material, expressed in Bq/kg

If the value of the activity index is less than 1, the material can be used without restrictions. If it exceeds 1, the responsible party is require to show specifically that the annual dose caused by the use of the material is less than 0.1 mSv/a.

Investigation level for Handling Peat Ash (based on the annual dose of 1 mSv to the worker due to external gamma radiation):

$$I = \frac{C_{Th}}{3000\ Bq\ /\ kg} + \frac{C_{Ra}}{4000\ Bq\ /\ kg} + \frac{C_{K}}{50000\ Bq\ /\ kg} + \frac{C_{Cs}}{10000\ Bq\ /\ kg};$$

C_{Th}, C_{Ra}, C_K and C_{Cs} are activity concentrations in the material, expressed in Bq/kg

If the value of the activity index is less than 1, the material can be used without restrictions. If it exceeds 1, the responsible party is require to show specifically that the annual dose caused by the use of the material is less than 0.1 mSv/a.

ST-Guide 12.3: Radioactivity of Household Water

Investigation level for water intended for human consumption (based on the annual dose of 0.5 mSv):

$$I = \frac{C_{\alpha}}{Bq\ /\ l} + \frac{C_{\beta}}{Bq\ /\ l} + \frac{C_{Rn}}{300\ Bq\ /\ l};$$

where C_α, C_β and C_{Rn} are the total alpha, total beta and radon concentrations, expressed in Bq/l

If the value of the activity index is less than 1, the water can be used for human consumption without restrictions. If it exceeds 1, the responsible party is require to show specifically (nuclide specific analysis) that the annual dose caused by the use of the water is less than 0.5 mSv/a.

September 2002

SWEDEN (Sverige)

Provided by: Ann-Christin Hägg, Lars Mjönes and John-Christer Lindhé, Swedish Radiation Protection Authority (SSI)

Title VII of Euratom Directive

1. What are the legal provisions that enact Council Directive 96/29/Euratom Title VII into national legislation?

   Answer: The Radiation Protection Act (1988:220) and the Radiation Protection Ordinance (1988:293)

2. Is a definition of 'work activities' [See Title VII, Article 40 paragraph 2 of EURATOM] given in the national legislation/guidance? If so please provide the definition and describe any differences between the definitions of 'work activities' and 'practices'.

   Answer: No

3. What specific measures have been taken in order to identify 'work activities' in accordance with Title VII Art 40 paragraph 2 of the Council Directive 96/29/EURATOM? What, if any, industries have been identified? If identification procedure is ongoing then please provide details.

   Answer: The Swedish Radiation Protection Authority, SSI, has an ongoing project for identifying industries in accordance with Title VII of the BSS Directive. Radon in mines and other underground construction sites was identified as a problem in the late 1960s and has been regulated since 1972. Radon in schools and pre-schools etc. have been regulated since 1981 and radon at ordinary workplaces since 1990. A special problem that has been identified during the project is the occurrence of very high radon levels indoors at waterworks. Other activities that have been investigated are phosphoric acid production leaving waste gypsum containing elevated radium levels, foundries using zircon sand, use of thoriated welding rods, paper mills and waterworks where radium-rich scales can be formed on the inside of tubes and pumps. In waterworks, used sand filters can contain enhanced levels of radium. Burnt alum shale with enhanced radium concentrations has been deposited at about a hundred different places in Sweden. The total amount is several million tonnes. Another problem that is well known in Sweden is the building material "blue concrete". This material contains enhanced concentrations of radium and causes elevated levels of indoor radon and gamma radiation. More information can be found in the attached report "Workplaces with elevated levels of exposure to natural radiation: The situation in Sweden". This report was presented at the NORM III Symposium in Brussels, September 17-21, 2001.

4. What plans have been made to ensure that in the future should new industries working with NORM giving 'significant radiological risk' develop, these are identified and brought within the regulatory framework? Please detail strategies, legal provisions, work plans.

SSI intends to present a policy on how to treat natural radiation according to Title VII of the BSS Directive in one or two years, when regulations for future NORM industries will be considered.

5. What is the extent of the control of effluent discharge and waste disposal that has been introduced for the industries identified in Question 3 (see Article 41 of the Directive)? E.g. requirement for prior authorisation, monitoring, reporting etc.

There is one regulation SSIFS 1983:7 that is applicable on laboratories and similar work places that have special permission to handle radioactive substances. This regulation states how much of each listed nuclide that in liquid form may be disposed of into the public sewers. (It also deals with non-liquid waste.)

Authorisation

6. Which regulatory body(ies) is responsible for regulating exposure (public and workers respectively) to NORM? Please include a hierarchy of responsibility. Which regulatory organisation is responsible for granting authorisations?

The Swedish Radiation Protection Authority (SSI) is responsible for issuing specific regulations that are in accordance with the framework set forward in the Swedish Radiation Protection Act (SFS 1988:220) and in the ordinance to this law SFS 1988:293. The SSI is also responsible for issuing authorisations and for inspections and investigations on how the regulations are implemented and followed.

7. Please provide a short summary of the legislation controlling the authorisation of NORM discharges. What sequence of action is followed when an application for authorisation for NORM discharges is submitted?

The regulation SSIFS 1983:7, the ordinance SFS 1988:293 and the more general act SFS 1988:220 are the sum of the national regulation in this area. In case of an application SSI would consider dose calculations for the releases, optimisation of the radiation protection and issue necessary restrictions on the operation in order to conserve the radiation safety for the public and the workers.

8. Do national regulations or guidelines prohibit or discourage particular disposal routes for specific NORM wastes? Is, for example, disposal to public sewers permitted for any NORM wastes? To what extent do the total volumes and the chemical characteristics of NORM wastes determine acceptable disposal routes, for example, are there limits on volumes of liquid wastes that can be discharged to rivers of specific flow rates?

Except for the regulation 1983:7 there are no national regulations that specifically address the NORM issues.

9. What approach or methodology is applied in setting discharge limits, for (a) gaseous and (b) liquid NORM discharges?

The normal approach that will be used in case of an application is estimation of the presumed doses to a site and situation specific critical group that may differ depending on releases to the atmosphere or to the water.

10. What dose constraints are applied with respect to NORM effluent discharges and do these differ from those used in relation to (i) disposal of solid NORM wastes and (ii) constraints set for the nuclear industry? Please define the meaning of 'dose constraint'.

The dose constraint of 10 μSv/y to a critical group will be used. This is a standard procedure and would be similar for all other cases mentioned. The definition from EC BSS, Article 1 (p 83) is used.

11. What assumptions are made in the assessment of doses in relation to setting authorisations? Is there a required methodology specified in regulatory documentation or national guidelines? Are doses to critical groups calculated? To what degree are conservative assumptions made?

Conservative site specific assumptions are used in the estimation of annual dose to the critical group. If the result of the calculation shows that the dose might be above the dose constraint of 10 μSv/y then the calculation will be made once more but with a more realistic set of assumptions before a decision on the authorisation.

12. What sort of limits are used? Are there, for example, annual limits on the total discharge plus subsidiary daily limits, or limits on activity per unit volume at the discharge point? Are they generic, or industry or installation specific?

The regulation SSIFS 1983:7 uses a releases limit in Bq per month and a concentration limit in Bq/ml. A similar approach is anticipated for applications related to NORM in cases when this regulation is not applicable. The regulation SSIFS 1983:7 is going to be revised during 2003 and the Swedish system of regulations of NORM and other sources of radioactive waste outside of the nuclear industry will also be improved and further developed starting in 2003. This may give rise to new requirements for some industries to apply for authorisation for their operations that is not needed in the present regulations.

13. How is compliance with the discharge limits (and/or dose constraints) demonstrated? What kind of records should be kept, and what measurements is the operator required to make? Does the regulatory body undertake any check of measurements on the discharges? Are exposure assessments undertaken?

The present regulations do not stipulate monitoring or sample collection.

14. If it is required that doses to the public should be optimised how is this achieved? Is there a lower bound on doses, below which the optimisation requirement is relaxed or not required?

The present regulations do not stipulate anything in this area.

15. Are there any planned changes to legislation/regulation of discharges and waste disposals from work activities?

As already mentioned above the regulation SSIFS 1983:7 is going to be revised during 2003. There is also an ongoing investigation by a committee appointed by the Swedish government that is supposed to set forward proposals for a national system for handling radioactive waste outside the nuclear industry. A report called RAKET (in Swedish) has been produced to list all kinds of radioactive waste that will be found in Sweden, coming from activities not having requirements for authorisations in the present set of regulations. This will also be used as an input in the mentioned investigation.

Review of the quantities of NORM wastes discharged into the sea and into rivers or disposed of in the EU.

16. Which NORM (Naturally Occurring Radioactive Material) industries in your country identified in Question 3 are potentially radiologically significant sources of discharges and waste disposals?

This issue will be addressed in the ongoing investigation mentioned above.

Benchmark Example:

In order to fairly and simply compare the approaches of different EU Member States it is our hope to analyse the responses States would take to a sample situation. Thus could you consider the following and describe the appropriate course of action according to regulations in your country:

- Operator of a non-nuclear installation in your country annually discharges some 100 million cubic metres of radioactively contaminated effluent offshore into the marine environment.

- Concentrations of the most significant radionuclides are as follows:

  Ra-226 and Ra-228 - 10 Bq/l; Pb-210 - 1 Bq/l.

- Total annual discharges:

  Ra-226 and Ra-228 - 1 TBq; Pb-210 - 100 GBq

Please answer and justify the following questions:

1. Do you believe that the operation of this installation will fall under Title VII of the BSS?

   Yes

2. Will the operator be subjected to one or combination of the following:

   a. Annual discharges exempted from any regulatory control

      Probably not

   b. Annual discharge limits be imposed. If yes, please provide the basis for these limits (e.g. dose constraint, etc...)

      Annual release limits are likely all depending on the estimated dose to the critical group.

   c. Reporting of annual discharges will be required for the total activity or by categories and for specific radionuclides.

      Annual reporting would be a requirement.

   d. The operator will be required to demonstrate that his operations meet the Best Practicable Environmental Option criterion.

      Yes

   e. An alternative option. Please give details

December 2002

Additional Information (from papers):

The most important problem with occupational exposure from natural radiation is radon at workplaces but other areas of possible concern include:

- Foundry sands – 10 large foundries (further investigation planned)
- Oil and gas industry – 2 large refineries, scales in tubes and pumps
- Paper mills and waterworks – radium-rich scales on tubes and pumps
- Thoriated welding rods (further investigation planned) (Mjönes and Åkerblom, 2001)

Waterworks

In Sweden many waterworks especially the smaller ones use ground water from drilled wells or surface water that has been filtered through deposits of sand or gravel. In water from drilled wells, the radon concentration can be very high, up to 85,000 Bq l^{-1} has been found. The radon levels in filtered groundwater are generally lower but activity concentrations of up to 200 Bq l^{-1} are not uncommon. When water with elevated radon concentrations is processed in a waterworks, radon is released into the air. It is quite possible that employees of waterworks can receive doses exceeding 20 mSv per year. An extensive study of indoor radon at workplaces using large volumes of ground water, including public baths, the food industry, laundries and certain processing industries, such as paper mills was undertaken by SWEA (Swedish Work Environment Authority) and will be presented in 2002. (Mjönes and Åkerblom, 2002)

References

Mjönes L and Åkerblom G '*Workplaces with Elevated Levels of Exposure to Natural Radiation*': The Situation in Sweden NORM III Conference Brussels (2001)

Mjönes L and Åkerblom G '*Exposure to Natural Radiation at Workplaces in Sweden*': IBC 2nd International Conference on Natural Radiation and NORM, London 22-23 April (2002)

UNITED KINGDOM

Provided by: Shelly Mobbs (NRPB), Kathy Hillis and Bob Major (NNC).

The completed report including this questionnaire was reviewed by Chris Wilson, Head of Technical Policy Branch, Radioactive Substances (RAS), Department for Environment, Food and Rural Affairs (DEFRA), Malcolm Wakerley (DEFRA), Joe McHugh, Strategic Policy Manager at the Environment Agency for England and Wales and Robert Larmour of the Industrial Pollution & Radiochemical Inspectorate (IPRI) of the Environment & Heritage Service in Northern Ireland in the UK and their comments are included.

Representatives from the Scottish Environmental Protection Agency (SEPA) were also contacted.

Title VII of Euratom Directive

1. What are the legal provisions that enact Council Directive 96/29/Euratom Title VII into national legislation?

   Title VII implemented? *Yes*

   The BSS Directive has been implemented in UK law through the Ionising Radiations Regulations 1999, amendments to the Radioactive Substances Act 1993 and by Directions placed on the Environment Agencies. The provisions relating to occupational exposure and protecting the workers and members of the public affected by the work activities considered in Title VII are enacted largely by the Ionising Radiation Regulations 1999 (IRR99).

   The control of natural radiation exposure of aircrew is dealt with under the following legislation:

   The Air Navigation (Cosmic Radiation) Order 2000

   The Air Navigation (Cosmic Radiation) (Keeping of Records) Regulations 2000

   In addition there are the following supplementary legislation:

   Radioactive Substances (Basic Safety Standards) (England and Wales) Direction 2000, 9th May 2000. This Direction was given by the Secretary of State for the Environment, Transport and the Regions to the Environment Agency for England and Wales for the purposes of implementing the obligations of the Council Directive 96/29/Euratom. Similar provisions applying to Northern Ireland is to be found in the Radioactive Substances (Basic Safety Standards) (Northern Ireland) Regulations 2003 SR 2003 No 208.

   Under which the competent authority (for the relevant environmental protection bodies see Question 6) have been directed by Government to ensure that the dose limits of the BSS Directive and the ALARA requirement are met, when they exercise their responsibilities under RSA93.

An additional piece of legislation amending the RSA93 regarding the exemption of clocks and watches has also been issued for England and Wales, the Radioactive Substances (Clocks and Watches) (England and Wales) Regulations 2001 SI 2001 No 4005 and for Scotland in the Radioactive Substances (Basic Safety Standards) (Scotland) Regulations 2000 SI 2000 No 100, in the case of Northern Ireland these provisions are in SR 2003 No 208.

2. Is a definition of 'work activities' [See Title VII, Article 40 paragraph 2 of EURATOM] given in the national legislation/guidance? If so please provide the definition and describe any differences between the definitions of 'work activities ' and 'practices'.

Definition of work activities [See Title VII Art 40 par 2]

Work activities (i.e. work with NORM) are not defined separately in UK legislation however 'work with ionising radiation' is defined in the Ionising Radiations Regulations 1999. It is defined as: work to which these Regulations apply by virtue of regulation 3(1) and that includes work with NORM.

Reg.3 (1) States that the regulations apply to:

(a) Any practice

(b) Any work (other than a practice) carried out in an atmosphere containing Rn-222 gas at a concentration in air exceeding 400Bqm^{-3}

(c) Any work (other than work described in sub-paragraphs a and b above) with any radioactive substance containing naturally occurring radionuclides.

Practices are defined in the Ionising Radiations Regulations 1999 as work involving –

(a) the production, processing, handling, use, holding, storage, transport or disposal of radioactive substances; or

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

which can increase the exposure of individuals to radiation from an artificial source, or from a radioactive substance containing naturally occurring radionuclides which are processed for their radioactive, fissile or fertile properties.

There is therefore a distinction between practices and work activities even though the actual term 'work activities' is not used.

3. What specific measures have been taken in order to identify 'work activities' in accordance with Title VII Art 40 paragraph 2 of the Council Directive 96/29/EURATOM? What, if any, industries have been identified? If identification procedure is ongoing then please provide details.

Measures to identify 'work activities'.

Title VII implies a need for member states to identify 'work activities' that involve exposures that cannot be disregarded from the radiation protection point of view and then to set up appropriate control measures, as identified in other Titles of the Directive. UK legislation has always applied to 'work activities' and therefore a regulatory regime for these activities already existed. There was also, therefore, significant prior knowledge of the majority of the industries potentially affected, the majority of which were regulated prior to the implementation of the BSS. Therefore the majority (perhaps all) of the work activities affected have already been identified.

The Management of Health and Safety at Work Regulations 1999 require employers to undertake risk assessments of any potentially significant hazards within the workplace taking into account relevant regulations covering the hazards concerned. The Ionising Radiations Regulations relate specifically to hazards from ionising radiation. In relation to 'work activities' the UK Approved Code of Practice (UKACOP) that relates to the Ionising Radiations Regulations makes it clear that Regulation 3(1)c only applies where the work involves a 'radioactive substance'. A radioactive substance is defined in the Ionising Radiations Regulations as 'any substance which contains one or more radionuclides whose activity cannot be disregarded for the purposes of radiation protection'. The UKACOP clarifies the position regarding work with substances containing naturally occurring radionuclides that are not part of a practice as follows:

'In the special case of substances containing naturally occurring radionuclides used in work other than a practice, their activity cannot be disregarded for the purposes of radiation protection where their use is likely to lead to employees or other people receiving an effective dose of ionising radiation in excess of 1 millisievert in a year.

Thus the regulations only apply to NORM industries if an assessment indicates that doses are expected to be above 1mSv per year. If the employer's risk assessment indicates that doses are likely to be above this level, employers are required to ensure that exposure to ionising radiation of both workers and the public is in compliance with the legal requirements of IRR99, this includes ensuring that doses are ALARP.

The employer is required to consider any material whose radioactivity could not be disregarded for the purpose of radiation protection as a radioactive substance regardless of specific activity[1].

[1] This relates to radiation protection of workers and the public under Health & Safety at Work legislation. The accumulation, storage, disposal and use of radioactive material is controlled under a separate Act, the Radioactive Substances Act 1993 under which whether radioactive material comes under regulation is defined by the physical properties of material i.e. the material contains radioactivity as a result of a process of nuclear fission (i.e. practices) or natural activity above the activity concentration given in Schedule 1 of RSA93. The competent authority for the enforcement of this Act is the Environment Agency (EA) (in England and Wales),

To assist employers in the risk assessment process and therefore help identify those industries covered in Title VII the UK Health and Safety Executive (HSE) is to commission research, which aims to obtain realistic data to enable employers to carry out practical assessments of radiation doses to employees from work with NORM. The research aims are to:

- *Undertake a critical review of the current data available on the exposure to enhanced levels of NORM*

- *Conduct visits to a sample of workplaces from the affected industries and assess from air sampling in typical working atmospheres the radioactive content, the particle size and the solubility of the dust/aerosol particles; and*

- *Incorporate the data collected into Dosimetry models to set criteria/guidance to enable employers to assess radiation doses arising from work in the affected industries.*

The research is expected to be completed in 2003. NRPB and industry groups are also involved in the European Commission SMOPIE project (Strategies and methods for optimisation of internal exposures of workers from industrial natural sources).

HSE are also involved with relevant industry groups etc. to provide up to date information etc.

The National Radiological Protection Board has also undertaken work, with support from the UK Environment Agency, to identify exposures from NORM industries within the UK. Thus far coal-fired power stations, steel production plants, the oil and gas industry and the mineral sands industry have been considered (note the latter two reports are not yet complete).

Thus far within the UK the following industries have been identified where risk assessment is needed in relation to the control of workplace doses:

- *Oil and Gas Extraction*

- *China Clay extraction (Cornwell and Devon)*

- *Industries producing refractory materials (i.e. zircon processing) and ore processing (e.g. TiO_2)*

- *Industries using thoriated tungsten welding rods.*

Releases from a number of these industries and the steel industry are also currently regulated to control doses to the public under the terms of the Radioactive Substances Act 1993, or under exemption orders made under this Act.

Scottish Environmental Protection Agency (SEPA) (in Scotland) and Industrial Pollution & Radiochemical Inspectorate (IPRI) of the Environment & Heritage Service (in Northern Ireland) See Question 5.

4. What plans have been made to ensure that in the future should new industries working with NORM giving 'significant radiological risk' develop, these are identified and brought within the regulatory framework? Please detail strategies, legal provisions, work plans.

Measures to identify new work activities in the future:

As mentioned in answer to Question 3, any new industry giving rise to 'significant radiological risk' would effectively already be covered by the current legislation as the legislation is not 'industry specific'. Any new industry would, as mentioned in the answer to Question 3, require risk assessments to be undertaken to ensure protection of workers and members of the public. The difficulty with a non-industry specific regulatory approach is that the industries involved may not know the radionuclide content of the materials used or produced or be aware of the legislation relating specifically to the control of radioactive materials. The HSE's role, as mentioned above, in investigating this area and 'educating' the relevant industries is very important. The HSE regulate all health and safety issues and thus are well placed to identify new industries where NORM may be a regulatory issue. HSE works closely with the EA and SEPA and these regulatory bodies share information about NORM issues.

If the specific activities of the NORM that is used are known, the employer should complete an assessment of the likely radiation exposures that will result from its use. This is a specialist task and in the UK employers are advised to seek assistance from a radiation protection adviser[1] in this regard. In the UK there is a specific regulatory requirement for suppliers and importers to supply the 'using' employers with the specific activity of the 'feed' material however too many are avoiding their obligations.

HSE is promoting the development of protocols for characterizing NORM to this end there is an EU thorium network programme in place. In addition to the research being conducted to obtain better knowledge of personal exposures to NORM, HSE is endeavouring to raise awareness of workplace risks arising from the use of NORM.

[1] A person whose competence to give radiation protection advice meets criteria specified by HSE

5. What is the extent of the control of effluent discharge and waste disposal that has been introduced for the industries identified in Question 3 (see Article 41 of the Directive)? E.g. requirement for prior authorisation, monitoring, reporting etc.

Control of discharges and solid waste disposal

The disposal of radioactive waste is controlled and regulated under the Radioactive Substances Act 1993 (RSA93). The Act applies to both natural and artificial radioactive substances but in recognition that natural radioactivity is ubiquitous provisions were made in a Schedule (Schedule 1) for threshold levels of the activity of natural radioelements below which materials would not be treated as radioactive and would be outside the framework of control.

The [NORM] material will be subject to this Act if it contains at least one of the elements specified in Schedule 1 of said Act and the activity concentration exceeds the levels specified for that element, not individual radionuclides. Any handler of such material must be registered to hold radioactive material and authorised for the storage/disposal of radioactive waste. Discharge limits are set on a case-by-case basis, reflecting operational need and environmental imperatives, with the Environment Agency/Scottish Environmental Protection Agency who have been directed by the Government (Direction 2000) to ensure the requirements of the Euratom Basic Safety Standards Directive are met. Materials which have naturally occurring radionuclides (other than those involved in the nuclear fuel cycle) lower than the values as set out below are not considered radioactive and thus are exempt from the provisions of this Act.

The requirement of the Directive only to include work activities to the extent that a Member State has declared that they need attention contrasts with the position under RSA93 where everything is included unless it is specifically excluded or exempted.

Schedule 1 of the Act sets out concentrations of the natural radioelements of the uranium and thorium decay series in materials in solid, liquid and gas or vapour forms. Radioactive material is defined as either:

(a) A substance containing any one of the natural radioelements of the uranium and thorium decay series at a concentration exceeding the levels specified in the schedule; or

(b) A substance possessing radioactivity wholly or partly attributable to an artificial process.

SCHEDULE 1

Element	*Becquerels per gram (Bq/g^{-1})*		
	Solid	*Liquid*	*Gas or Vapour*
Actinium	*0.37*	*7.4E-2*	*2.59E-6*
Lead	*0.74*	*3.7E-3*	*1.11E-4*
Polonium	*0.37*	*2.59E-2*	*2.22E-4*
Protoactinium	*0.37*	*3.33E-2*	*1.11E-6*
Radium	*0.37*	*3.7E-4*	*3.7E-5*
Radon	*-*	*-*	*3.7E-2*
Thorium	*2.59*	*3.7E-2*	*2.22E-5*
Uranium	*11.1*	*0.74*	*7.4E-5*

The Act does not apply to ^{40}K, ^{14}C, ^{3}H or ^{7}Be unless the ^{14}C and ^{3}H are artificially formed.

It is recognised that many uses of natural radioactivity would fall within the scope of the Act at levels above those in Schedule 1. Rather than subject these to the full requirements of the Act provisions were made for exemptions by order covering the usage of NORM.

These are:

- *The Radioactive Substances (Phosphatic Substances, Rare Earths Etc) EO*

If radioactive solely because of the presence of Schedule 1 elements (naturally occurring elements) it may be exempted if:

- *solid/liquid in which activity concentration of each element doesn't exceed 14.8 Bq g^{-1}*

- *solid/liquid where the activity concentration of the substance doesn't exceed 37 Bq g^{-1} for materials composed mainly of those elements listed in the Order*

- *Alloy where the activity concentration doesn't exceed 37 Bq g^{-1}*

Radioactive waste may be exempt if the solid waste would be exempt if it wasn't a waste and is substantially insoluble in water. Liquid waste may be exempt if it consists mainly of water and suspended solid particles which if a solid would be exempt. Usually applied to waste disposal on <u>agreement</u> with EA/SEPA where the activity is above the relevant limits in RSA 93 but is below 14.8 Bq/g^{-1}.

- *The Radioactive Substances (Precipitated Phosphate) EO*

Precipitated phosphate is exempt if it is radioactive solely because of the presence of Schedule 1 elements provided that it contains no uranium other than natural uranium and natural uranium does not exceed 74 Bq/g^{-1}. Ac, Pb, Po, Pa (other than ^{234}Pa),

Ra, Rn and Th (other than ^{234}Th) do not exceed 14.8Bq/g. For ^{234}Th and ^{234}Pa the levels should not exceed what should be there by natural decay.

The exemption is only for the purposes of the fertiliser industry, and is hardly used.

- *The Radioactive Substances (Geological Specimens) EO*

Specimens of natural rocks or natural minerals containing uranium or thorium or both are exempt.

- *The Radioactive Substances (Uranium and Thorium) EO*

  Natural uranium and thorium is exempt provided it contains 4% or less by weight of natural thorium and the weight of all uranium and thorium present is less than 2 kg.

- *The Radioactive Substances (Prepared Uranium and Thorium Compounds) EO*

  Prepared thorium and prepared uranium and certain substances prepared from them in quantities appropriate to laboratory work are exempt.

- *The Radioactive Substances (Lead) EO*

  Natural lead is exempt

- *A new Exemption Order for radioactivity in natural gas and gas products came into force on the 17th May 2002.*

These Exemption Orders provide a level of control below that of full site-specific authorisations and registrations. DEFRA considers these exemption orders as representing 'generic authorisations' for the materials/wastes considered in each. The DETR has undertaken a review of all Exemption Orders and the Radioactive Substances Act 1993 to ensure that they are consistent with the requirements of the Basic Safety Standards (see Martin, 1999). The result of the review was that the currently regulatory system did indeed comply with the requirements of the BSS.

Implications of the above regulations for specific industries identified in Question 3 (in brief)

Oil and Gas Extraction – Most of the releases of scale containing wastes from offshore oil and gas facilities are covered by the Phosphatic Substances Exemption Order. However many such facilities also have authorisations under the terms of the Radioactive Substances Act 1993 for the disposal of wastes containing higher activity concentrations. These are set by the Environment Agency in England and Wales and the Scottish Environment Protection Agency in Scotland. These authorisations define limits on the total activity for disposal, stipulate the discharge conditions, require monitoring to be undertaken, characterisation by experience, sampling and

calculation are permissible alternatives, and the companies to inform the relevant Environment Agency of the quantities released each year.

Steel Industry – The activities of the feed products are below the Schedule 1 levels of the Radioactive Substances Act 1993. The majority of the materials and wastes produced also have activity concentrations below Schedule 1 limits. Some of the solid waste materials produced have higher activity concentrations but these are exempt from the provision of the Act as the activity levels are below those stipulated in the Phosphatic Substances Exemption Order. Gaseous releases from the sinter plant are above the Schedule 1 values for gases. These discharges are authorised by the Environment Agency. Authorisations under the RSA93 are in place. These set limits on the total activity to be released each year and require monitoring to be undertaken and the results of the monitoring to be provided to the Environment Agency each year.

China Clay Extraction – disposal of scale waste from this industry can come under the terms of the RSA93 and be subject to authorisations that limit total activities disposed, define disposal routes and set requirements for monitoring and informing the Environment Agency.

Industries using refractory sands – The activity concentrations in some waste streams are such that authorisations are required for their accumulation or disposal, however most operate under the Phosphatic substances EO. The authorisations require monitoring and keeping of records of the wastes involved.

Authorisations

6. Which regulatory body(ies) is responsible for regulating exposure (public and workers respectively) to NORM? Please include a hierarchy of responsibility. Which regulatory organisation is responsible for granting authorisations?

Regulatory Bodies

The Health and Safety Executive is responsible for regulating occupational exposure to workers and to the public.

The Environment Agency (EA) is the regulator for England and Wales ((the Scottish Environment Protection Agency (SEPA) regulates in Scotland and the Industrial Pollution and Radiochemical Inspectorate of the Environment and Heritage Service (EHS) is the regulator for Northern Ireland)) implementing the RSA93 and Exemption orders. These regulatory bodies are responsible for authorising radioactive discharges from all civil sources within their jurisdiction. The Department of Trade and Industry is responsible for regulating the offshore oil and gas industry.

7. Please provide a short summary of the legislation controlling the authorisation of NORM discharges. What sequence of action is followed when an application for authorisation for NORM discharges is submitted?

For details of the legislation controlling the authorisation of NORM discharges see the answer to Question 5.

Process for discharge

Environment Agency is responsible under the Radioactive Substances Act 1993 for authorisation of discharges in England and Wales (the Scottish Environment Protection Agency (SEPA) regulates in Scotland and the Industrial Pollution and Radiochemical Inspectorate of the Environment and Heritage Service (EHS) is the regulator for Northern Ireland). Discharge limits and other conditions are set on a case-by-case basis by the EA/ SEPA/EHS.

The starting point for the process is the submission by the company of a discharge/disposal application (currently form RSA3); this commonly and importantly follows pre-application discussions. This is a standard form completed by the company. This includes details of the premises from which discharges will take place, details of the proposed disposal route (e.g. drains, sea, river, atmosphere etc.) the quantities to be disposed, the activity concentrations of the material, the processes that give rise to the wastes, the physical and chemical nature of the wastes, and details of the processes used to measure (or estimate) the activity of the discharge. The company must also include a radiological impact assessment for each disposal route, this must include details of the calculations undertaken.

The relevant Environment Agency will then consider the application. The legislation sets time limits for this stage. The Environment Agency may consult with other bodies about the acceptability of the proposed discharges. For example, if the discharge is to a water body from which drinking water is extracted the local public water supply company could be contacted, similarly for disposals to the sewage system the local sewerage company may be consulted. The Environment Agency will also consider the non-radioactive characteristics of the waste (e.g. oxygen content for disposals to water bodies) (under the requirements of other environmental protection legislation). The local authority (local government) may also be consulted. For disposals from nuclear sites additional consultations with other government agencies are also standard and it is also usual for public consultation processes to be undertaken. Such public consultation exercises could also be undertaken for NORM discharges but to date this has not happened within the UK, but relevant documents are placed on 'Public Registers'.

The Environment Agency may also ask for more details from the company. If the Environment Agency considers the application adequate to allow determination it will issue an authorisation certificate (CoA). This will detail the maximum quantities to be disposed by each disposal route the requirements for monitoring and any additional conditions it sees fit to proscribe, adopting and amending a standard template where appropriate.

However the employer/controller, (undertaking), of the premises can make use of the provisions of the exemption orders highlighted in answer to question 5. Provided that the quantity of NORM is below exempted levels this material can be discharged without requiring authorisation. Few solid and liquid products are mentioned specifically in the existing EOs but many such products are covered by the exemption in the Phosphatic Substances EO for solids and liquids containing up to 14.8 Bq g^{-1} of the radioelements in Schedule 1 of RSA93. It should be noted that a facility with an authorisation could discharge wastes covered by Exemption Orders in addition to those detailed in the authorisation.

8. Do national regulations or guidelines prohibit or discourage particular disposal routes for specific NORM wastes? Is, for example, disposal to public sewers permitted for any NORM wastes? To what extent do the total volumes and the chemical characteristics of NORM wastes determine acceptable disposal routes, for example, are there limits on volumes of liquid wastes that can be discharged to rivers of specific flow rates?

Prohibition/discouragement of disposal routes

National regulations or guidelines do not prohibit or discourage particular disposal routes. The acceptability of a disposal route is judged by the relevant Environment Agency in relation to the details provided by the company in particular in relation to the radiological impact assessment and details of the chemical and physical characteristics of the waste and the knowledge of the Environment Agencies of practices and approaches in other similar industries, that is BPEO/BPM. That being said we currently know of no NORM industry that disposes of liquid waste to the sewerage system. Disposal to sewers is common for small quantities of radioactive wastes in laboratories. Liquid discharges from NORM industries tend to involve larger quantities of wastes and the approach in the UK is generally not to dispose of such industrial wastes via sewers.

Control of disposal routes for those NORM wastes which because of the quantities involved require authorisations is restricted by means of the requirement to show it is BPEO[1] and to assess doses to critical groups.

9. What approach or methodology is applied in setting discharge limits, for (a) gaseous and (b) liquid NORM discharges?

Setting discharge limits

The same general approach is used for setting discharge limits for gaseous and liquid NORM discharges.

[1] **Best Practical Environmental Option (BPEO)**: A BPEO is the outcome of a systematic consultative and decision-making procedure which emphasises the protection and conservation of the environment across land, air and water. The BPEO procedure establishes, for a given set of objectives, the option that provides the most benefit or least damage to the environment as a whole, at acceptable cost, in the long term as well in the short term (RCEP, 1988).

The appropriate Environment Agency considers the information supplied on the discharge/disposal application form. In particular they will consider the radiological impact of the proposed discharges. This they will do in the context of the applicable dose constraints. The regulator also clearly needs to ensure that the discharges are properly controlled and monitored and the radiological assessments submitted are valid. If these conditions are met then the discharge authorisation will be set at the required level. If above the threshold level the Agency will also consider optimisation issues in developing the authorisation.

In the UK strategy for radioactive discharges 2001-2020 it states "The progressive reduction of discharge limits, and of actual discharges, having regard to the application of Best Practical Means (BPM) is a central tenet of the way in which radioactive discharges should be controlled and has been a feature of UK policy since 1993" (DEFRA, July 2002).

10. What dose constraints are applied with respect to NORM effluent discharges and do these differ from those used in relation to (i) disposal of solid NORM wastes and (ii) constraints set for the nuclear industry? Please define the meaning of 'dose constraint'.

Dose constraints applied

Dose constraint – a restriction on annual dose to an individual from a single source or site such that when aggregated with doses from all sources, excluding natural background and medical procedures, the dose limit is not likely to be exceeded; the dose constraint places an upper bound on the outcome of any optimisation study and will therefore limit any inequity which might result from the economic and social judgements inherent in the optimisation process.

Constraint on dose to members of the public for a:

- *Single new source should not exceed 0.3 mSv/y*
- *Site should not exceed 0.5 mSv/y*

These constraints are applied for discharge from all industries: NORM, nuclear etc.

Dose constraints are not applied to solid radioactive wastes from NORM or other sources. The UK Environment Agencies have published principles for assessing the acceptability of purpose built disposal facilities for radioactive waste. These would be judged against a risk target of 10^{-6} y^{-1}. This relates specifically to purpose built facilities but is more generally applied to disposal sites for all types of radioactive wastes including disposal of NORM wastes to landfill. Current work led by the Scotland and Northern Ireland Forum for Environmental Research (SNIFFER) is designed to derive a method for assessment of landfills.

Where the annual dose to the critical group is less than 0.3 mSv/y expenditure to reduce the dose is unlikely to be warranted on radiological protection grounds alone.

11. What assumptions are made in the assessment of doses in relation to setting authorisations? Is there a required methodology specified in regulatory documentation or national guidelines? Are doses to critical groups calculated? To what degree are conservative assumptions made?

Dose Assessment

There is no required methodology specified in regulatory documentation, but the UK Environment Agencies have recently published interim guidance on the general principles for the assessment of public doses, (EA et al, December 2002). It will be finalised once statutory guidance to the Environment Agencies on regulation of radioactive discharges in published.

Doses to the critical group are determined for comparison with the dose constraints. Doses to the most exposed age group are assessed. All relevant exposure pathways should be included. In general a staged approach is adopted. The first stage involves making a simple and cautious assessment of the critical group dose (i.e. conservative assumptions are used to ensure the chance of actual doses being higher than predicted is very low). If the results of this indicate that the critical group dose is less than the threshold dose of 0.02 mSv/y then no further assessment would be warranted for the purpose of authorising the discharge of radioactive waste to the environment. If the dose is above 0.02 mSv/y then a detailed more site specific assessment would be required.

12. What sort of limits are used? Are there, for example, annual limits on the total discharge plus subsidiary daily limits, or limits on activity per unit volume at the discharge point? Are they generic, or industry or installation specific?

Form the limits take

Installation and discharge route specific limits are given in authorisations these can be annual, rolling annual, monthly limits on total discharge. Each authorisation is specific to that site, consistent with process operations and environmental need.

13. How is compliance with the discharge limits (and/or dose constraints) demonstrated? What kind of records should be kept, and what measurements is the operator required to make? Does the regulatory body undertake any check of measurements on the discharges? Are exposure assessments undertaken?

Demonstration of compliance

Those discharging radioactive substances are required by their authorisations to maintain records and carry out monitoring or by some other means account for their waste disposals (environmental monitoring not always required). The EA will inspect these records, (and the means of their compilation), and may take duplicate samples of the releases for independent analysis to confirm compliance. For nuclear sites the EA may undertake its own radiological assessment, and this has also recently been done for a steel works. In addition other relevant initiatives which have been

conducted include habit surveys, regional environmental sampling and analysis and 'unusual pathways' scrutiny

14. If it is required that doses to the public should be optimised how is this achieved? Is there a lower bound on doses, below which the optimisation requirement is relaxed or not required?

Optimisation requirement

The Environment Agency will consider factors such as the availability of relevant technologies etc. in assessing whether the company has applied the concept of optimisation sufficiently thus reducing doses to the required degree. Doses to the critical group are pushed down by means of the requirement to use the best practical means[1] (BPM) and not by reliance on numerical limits alone.

15. Are there any planned changes to legislation/regulation of discharges and waste disposals from work activities?

Planned changes to legislation

UK regulations for NORM discharges and waste disposal have been brought into line with the requirements of the BSS. There are currently no planned changes to legislation/regulation in this area.

Statutory guidance to the Environment Agencies on the regulation of radioactive discharges is currently under development.

The UK Government issued a consultative document on a 'UK Strategy for Radioactive Discharges 2001 – 2020' which relates to the requirements of the OSPAR strategy. This was finalised in July 2002 (DEFRA, July 2002). The UK Government is also consulting widely in relation to provision of facilities for the management (storage, disposal etc.) of solid radioactive wastes. This will include at some stage consideration of issues related to NORM wastes. These consultation exercises may ultimately result in changes to relevant legislation but the detail/nature of these is not clear at this stage.

[1] **Best Practical Means (BPM):** The BPM is that level of management and engineering control that minimises, as far as practicable, the release of radioactivity to the environment whilst taking account of a wider range of factors, including cost effectiveness, technological status, operational safety, and social and environmental factors. In determining whether a particular aspect of the proposal represents the BPM, the Inspectorates will not require the applicant to incur expenditure, whether in money, time or trouble, which is disproportionate to the benefits likely to be derived (HMSO, 1995).

Review of the quantities of NORM wastes discharged into the sea and into rivers or disposed of in the EU.

16. Which NORM (Naturally Occurring Radioactive Material) industries in your country identified in Question 3 are potentially radiologically significant sources of discharges and waste disposals?

For each industry please provide details of the following:

- The types of waste stream produced (i.e. gaseous/particulates (aerosol), liquid or solid) and the disposal routes (i.e. release to atmosphere, release to water bodies (rivers, lakes, coastal waters), release to sewage system, storage, landfill disposal, others? etc.).

- The radiological inventory and the range of activity concentration (or a typical activity concentration) in the waste streams (gaseous/particulates (aerosol), liquid, solid) for each radionuclide (in Bq per t_{waste} or Bq per m^3_{waste}).

- The mass or volume (in [t_{waste} or m^3_{waste}] per [$t_{product}$ or $m^3_{product}$]) of the gaseous/particulates (aerosol), liquid and solid wastes from each industry per unit production of the end product[1].

- The annual production rate of the end product (in $t_{product}$ per year or $m^3_{product}$ per year).

- The locations of installations that produce significant quantities of NORM and, where possible, the specific disposal routes (e.g. discharge into River Thames at grid ref…)

EXAMPLES

Mineral Sands:

In the UK in a plant processing mineral sands a furnace dust collector was installed to meet release requirements. The furnace dust with 200 Bq/g^{-1} ^{210}Pb and 600 Bq/g^{-1} ^{210}Po could go to a landfill site for hazardous waste but was rejected by the operator of the disposal site because it was classified as radioactive waste. 200 t of waste have been accumulated and a disposal route has not yet been identified.

Steel production:

Steel production in the UK is connected with an annual generation of filtered off-gas dust in the order of 10, 000 t. This waste with Pb/Po in the order of a few Bq g^{-1} is not classified as radioactive and can go to an ordinary refuse disposal. However the concentrations of ^{210}Pb and ^{210}Po in some of the gases emitted to atmosphere during steel production exceed the limits for exclusion given in Schedule 1 of the RSA93 by

[1] Please describe the method used to derive the data.

about an order of magnitude. These atmospheric releases are therefore subject to regulatory control and are authorised by the Environment Agency.

In N.Ireland there are currently no NORM industries producing potentially significant sources of radioactive waste. A source of NORM that could arise in the future would be during the reclamation of land previously occupied by fertiliser and town gas works (Robert Larmour).

The Environment Agency is engaged with SEPA and others in an initiative to collect strategic NORM intelligence with respect to the oil and gas industry. We also continues to support NRPB's NORM studies (Joe McHugh). Other examples may include:

- *Zirconium processing*
- *Descaling plant (Tyneside)*
- *Oil and Gas extraction.*

Benchmark Example:

In order to fairly and simply compare the approaches of different EU Member States it is our hope to analyse the responses States would take to a sample situation. Thus could you consider the following and describe the appropriate course of action according to regulations in your country:

- Operator of a non-nuclear installation in your country annually discharges some 100 million cubic metres of radioactively contaminated effluent offshore into the marine environment.

- Concentrations of the most significant radionuclides are as follows:

  ^{226}Ra and ^{228}Ra – 10 Bq/l; ^{210}Pb – 1 Bq/l.

- Total annual discharges:

  ^{226}Ra and ^{228}Ra – 1 TBq; ^{210}Pb – 100 GBq

Please answer and justify the following questions:

1. Do you believe that the operation of this installation will fall under Title VII of the BSS?

2. Will the operator be subjected to one or combination of the following:

   (a) Annual discharges exempted from any regulatory control

   (b) Annual discharge limits be imposed. If yes, please provide the basis for these limits (e.g. dose constraint, etc…)

   (c) Reporting of annual discharges will be required for the total activity or by categories and for specific radionuclides.

   (d) The operator will be required to demonstrate that his operations meet the Best Practicable Environmental Option criterion.

   (e) An alternative option. Please give details

   It is not clear from the question whether the waste is being discharged via a pipeline from an onshore facility or from an offshore facility such as an oil rig. In the UK the regulatory approach would be the same in both cases as the Radioactive Substances Act 1993 is applied to offshore rigs in UK waters (it does not however apply to mobile platforms). Many UK oil and gas rigs have authorisations for the disposal of radioactive wastes.

   In the specific case mentioned the activity concentration of Radium in the liquid exceeds the Schedule 1 values for liquids in RSA93 and thus on this basis an authorisation may be required.

If the liquid waste consists of water and suspended solid particles and the solid particles have an activity concentration of less than 14.8 Bq/g for each element then the wastes would be exempt from the requirements of the RSA under the terms of the Phosphatic Substances Exemption Order (this would be the case if the solid content of a litre of the liquid was about 1 g – this is the most likely scenario). In this case there would be no controls on the discharge and no requirement for monitoring or record keeping with respect to these wastes.

If this is not the case then an authorisation would have to be applied for and discharge limits would be imposed, based primarily on the predicted doses from the releases and the applicable dose constraints and optimisation considerations, and reporting of the releases and monitoring would be required (see answers to questions above for more details)

May 2002 (Reviewed May 2003)

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HMSO, *Review of Radioactive Waste Management Policy Final Conclusions,* Presented to Parliament by the Secretary of State for the Environment, the Secretary of State for Scotland and the Secretary of State for Wales by Command of Her Majesty, Command 2919, London: HMSO, July 1995.

Royal Commission on Environmental Pollution (RCEP), *Best Practicable Environmental Option*, 12th Report, Cm 310, ISBN 0 10 103102 5, HMSO, February 1988.

Martin A., *Review of compliance of Exemption Orders with requirements of the BSS Directive*, DETR/RAS/99.015, Department of the Environment, Transport and the Regions Commissioned research for Radioactive Substances Division, UK, December 1999.

Appendix C - Summary of National Regulations

Information collated in the course of the study from papers, publications and from the questionnaire relating to the regulation of work activities within Member States is summarised below on a state-by-state basis and presented in alphabetical order using the source language. The full titles of the national legislation are given in the table below (a copy of Table 32 in the main text).

Table C1 National legislation and *associated guidance*[1] relevant to NORM

Country	Document
Belgium	Royal Decision of 20th July 2001 (ARBIS)
Denmark	Radiation Law, Law No 94 31st March 1953 as modified by Law No 369 6th June 1991.
	Ministry of the Interior and Health Order No 192 of 2nd April 2002 on exemption from law on the use of radioactive substances (Order 192)
Germany	Radiation Protection Ordinance (Strahlenschutzverordnung), 20th July 2001 (RPO)
	Nuclear Law (Atomgesetz) 3rd May 2000
Greece	Radiation Protection Regulations Joint Ministerial Order No 1014 (ΦΟΡ) 94, Official Gazette No 216B, 06/03/01 (RPR).
Spain	Royal Decree 783/2001 on the Health Protection against Ionising Radiation (RD).
France	Ordinance No 2001-270 of the 28th March 2001 (FR 2001)
	Decree No 2002-460 of the 4th April 2002 (FR 2002)
Ireland	Radiological Protection Act, 1991.
	Radiological Protection Act, 1991 (Ionising Radiation) Order 2000 (S.I. No 125 of 2000)
Italy	Legislative Decree nr 230 of 17th March 1995
	Legislative Decree nr 241 of 26th May 2000 (modifying Decree nr. 230)
	Legislative Decree nr 257 of 9th May 2001 (modifying Decree nr 241)
Luxembourg	Regulations of the Grand Duchy, 14 December 2000.
Netherlands	Royal Decision of 16th July 2001 (BS).
Austria	Radiation Protection Act (BGBl. I Nr. 146, Strahlenschutz-EU-Anpassungsgesetz 2002), 20th August 2002
	Radiation Protection Ordinance (draft)
Portugal	Decree No 165/2002 of 17th July
Finland	Radiation Act (592/1991) as amended by 1142/1998
	Radiation Decree (1512/1991) as amended 1142/1998
	ST 12.1 Radiation Safety in Practices Causing Exposure to Natural Radiation
	ST 12.2 Radiation of Construction Materials, Fuel Peat and Peat Ash
	ST 12.3 Radioactivity of Household Water
Sweden	Radiation Protection Act (1988/220)
	Radiation Protection Ordinance (1988/293) as amended 1st Sept 2001
UK	The Management of Health & Safety at Work Regulations 1999 SI 1999 No 3244
	Ionising Radiation Regulations 1999 SI 1999 No 3232
	Approved Code of Practice for IRR99 L121
	Radioactive Substances Act 1993 (c12)
	Exemption Orders (18 of) (See Appendix B for details)
	Radioactive Substances (Basic Safety Standards) (England and Wales) Direction 2000, 9th May 2000
	Radioactive Substances (Basic Safety Standards) (Scotland) Regulations 2000 SI 2000 No 100
	Radioactive Substances (Clocks and Watches) (England and Wales) Regulations 2001 SI 2001 No 4005
	Radioactive Substances (Basic Safety Standards) (Northern Ireland) Regulations 2003 SR 2003 No 208

[1] Guidance given in italics in the table.

Belgium (Belgique/België)

Overview of Regulations

Title VII is implemented in Belgian Law through the provisions in Article 1, Article 4 and Article 9 of ARBIS. The main features are:

- Work activities involving natural sources are included in the scope of ARBIS (Article 1).
- The work activities brought under the scope of ARBIS for protection of workers are defined in Article 4. The work activities comprise:
    - Those with risk of exposure to radon
    - A short list of work activities, including the processing of residues and wastes, involving risks of external and internal exposure. Any other work activity than those listed can be defined by the Federal Agency FANC and included in a list to be published in the Belgian Government Gazette.
    - Exploitation of air planes
- Article 9.1 defines the reporting requirements for work activities as listed in Article 4.
- Article 9.3 refers to the dose levels laid down in Article 20.3 and above which FANC can impose corrective measures.
- Article 9.3 also states that if implementation of corrective measures does not bring the exposures below the dose levels specified in Article 20.3 FANC will impose all or part of the provisions laid down in ARBIS for practices.

Dose Constraints and Limits

The dose limits for work activities are laid down in Article 20.3 of ARBIS and are as follows.

- For exposure to radon of workers during work and for members of the public at work places: 3 mSv y^{-1} effective dose or 800 kBq m^{-3} h^{-1}.
- For exposure of workers and/or members of the public as a result of the use or storage of materials containing natural radionuclides or as a result of the production of residues containing natural radionuclides: 1 mSv y^{-1} effective dose and/or,
- Exposure of members of the public exceeding the dose limits specified in Article 20.1.4 for practices:
    - 1 mSv y^{-1} effective dose limit,
    - equivalent dose limit of 15 mSv y^{-1} for the lens of the eye,

- equivalent dose limit of 50 mSv y^{-1} for the skin averaged over 1 cm^2 of any exposed surface.

- Belgium has no specific provisions for clearance of residues or discharges from work activities but FANC (the regulator) can impose restrictions on reported work activities.

Denmark (Danmark)

Overview of Regulations

Title VII has been implemented by Order No. 192 of 2nd April 2002, which came into force on 1st May 2002. The main points being that:

- Danish legislation generally provides a step-by-step approach as opposed to a comprehensive legal framework-act covering all the different activities involving the use of radiation sources. Order No. 192 by exception does provide for an overall approach as regards exemption and clearance thus it does not define 'work activities' as the exceptions refer to levels of activity concentrations rather than to the nature of the activities involved.

- A detailed work instruction for the oil and gas industry has been produced under the framework of Order No. 192; as yet instructions for other NORM industries have not been produced. Generally with regard to NORM waste the experience to date has been limited, such that the NIRH has been dealing with discharges on a case-by-case basis as opposed to a standard procedure.

- Article 6(1) states that material containing natural radionuclides exceeding the clearance levels given in Annex 1 of the regulations cannot be marketed as building materials prior to the completion and reporting of a dose assessment to the National Board of Health. Materials on which a prior ruling has been given by the Health Board are excluded from this requirement.

- Article 7(1) allows for materials containing NORM below the exemption levels given in Annex 2 to be exempt from authorisation. The exemption and clearance levels adopted are identical to those in Radiation Protection 122 Part II. Under Article 12 prior authorisation is required for any disposal of NORM wastes above exemption levels in the Order as stated in Annex 2.

- However exemption under Article 7 does not exempt, under Article 2 of Law No 92 dated 31st March 1953 on the use etc of radioactive substances as modified by Law No 369 dated 6th June 1991, those in possession of such material from observing stated decisions on safety arrangements.

Dose Constraints and Limits

As is the case for all other work activities with radioactive materials doses to the public must be optimised. NIRH (the regulator) does not work with a lower dose boundary below which optimisation requirement is not required.

- The dose criteria for clearance/disposal (discharge is not specified in the text) of material containing natural radionuclides (as given in Annex 3(4) of Order 192) is an effective dose increment in addition to natural background of less than 0.3 mSv y^{-1} to members of the public.

- For man-made nuclides the effective dose criteria to the public is of the order of 0.01 mSv y^{-1} or less and either the collective committed effective dose per year due to the clearance is of the order of 1 manSv or an assessment shows that clearance is the optimum solution.

- To ensure compliance companies are required to keep records of all radioactive analysis and these must always be available for inspection by the Regulator who will also perform regular measurements to determine regulatory aspects and dose assessments.

Germany (Deutschland)

Overview of Regulations

Title VII of the Directive is implemented in German Law through the provisions of Part 3 of the Radiation Protection Ordinance (RPO). The main features of the legislation are:

- Radiation protection of workers in work activities is required according to Part 3, Chapter 1, par 93 and par. 94 on dose limitation and dose reduction respectively.

- Part 3, Chapter 2, par. 95 specifies the responsibilities of those engaged in or permitting engagement in work activities of the kind described in Appendix XI Part A and B. This Appendix fulfils the requirements of Article 40 of the Council Directive to identify work activities involving radiation exposure of workers which cannot be disregarded from the radiation protection point of view.

- Part A of Annex XI lists a number of work activities involving exposure to enhanced levels of ^{222}Rn and Part B provides a list of work activities with enhanced exposure to ^{238}U and ^{232}Th and their decay products excluding radon.

- Part 3, Chapter 2, par. 95 requires the assessment of the exposure of workers and requires reporting if the annual effective dose to a worker exceeds 6 mSv.

- Part 3, Chapter 3 provides measures for the protection of the public from naturally occurring radioactive materials.

- Par. 97 (1) specifies that residues require control if their use or disposal could lead to radiation exposure of members of the public exceeding 1 mSv y^{-1}.

- Par. 97 (2) defines residues requiring control by referring to the list in Appendix XII Part A but exempts from control residues with activity concentrations below the levels specified in Annex XII, Part B for different ways of use or disposal.

- Par. 98 (1) requires that residues will only be released from control when it is shown that members of the public are adequately protected from radiation exposure. The guidance level for adequate protection is 1 mSv y^{-1} and applies also to workers involved in the processing or disposal. Dose assessments have to be carried out according to the provisions of Annex XII, Part D.

- In cases of release of controlled residues for mixed disposal with other residues it can be assumed, according to Par. 98 (2) that the guidance level of dose is not being exceeded when the conditions with respect to activity concentrations specified in Annex XII, Part C are fulfilled.

Dose Constraints and Limits

- Workers exposed at work places described in Annex XI of the Radiation Protection Ordinance of the 20 July 2001 and which require reporting the limits are as follows:

    - Effective dose limit 20 mSv y^{-1} and organ dose limits of 150 mSv y^{-1} for the lens of the eye and 500 mSv y^{-1} for the skin, hands, forearms, feet and ankles.

    - Total effective dose limit for occupational exposure over all years is 400 mSv.

    - For people under 18 years the effective dose limit is 6 mSv y^{-1} and the organ dose limits 50 mSv y^{-1} for the lens of the eye and 150 mSv y^{-1} for the skin, hands forearms, feet and ankles.

    - For the unborn child the effective dose limit is a total of 1 mSv for the remaining period after the pregnancy has been reported.

- Members of the public: The dose constraint for protection of members of the public from exposure to residues from work activities is an annual effective dose of 1 mSv. Workers involved in the processing or disposal of residues are regarded as members of the public.

- Germany has included in the RPO an extensive list of residues that may require control, and can be released from control on the basis of a dose criterion of 1 mSv y^{-1} to members of the public, including workers involved in the use or disposal of the residues.

- Germany also has detailed provisions for release of residues from regulatory control including limits set for activity concentrations below which it can be assumed that the dose criterion of 1 mSv is met for specified uses or disposal conditions. These provisions can be characterised as conditional releases.

- Germany has no specific provisions for regulating discharges from work activities. It can be understood that the dose criterion of 1 mSv y^{-1} being exceeded as a result of discharges will require measures to protect the public (Article 97).

Greece (Elláda)

Overview of Regulations

The legal provisions that enact Council Directive 96/29/Euratom Title VII into Greek legislation are the Radiation Protection Regulations (RPR), Joint Ministerial Order No 1014 (ΦΟΡ) 94, Official Gazette 216B, 06/03/01.

Although there is no definition of "work activities" under definitions, the term is clearly mentioned in paragraph 1.2.5 of the RPR, which refers to workplaces with significant increase in exposure due to natural radiation sources. The regulations under para 1.1.1 lists activities covered by the regulations including '*natural sources of radiation which could result in a significant increase in exposure to workers or the public which cannot be ignored'* which is the definition of 'work activities' in the Directive. The identification of such work activities has been ongoing since 1999 and some activities have been identified including two fertiliser plants and an aeroplane engine repair facility.

According to the Greek RPR, the following criteria for NORM "work activities" have been established:

Work excluding radon (para. 1.2.5.3 - 1.2.5.6 of the RPR)

- The action levels concerning the effective dose to workers at work places due to natural radiation sources are 1 mSv per year. Work activities with corresponding dose less than 1 mSv per year are excluded from further investigation.

- Work activities with corresponding effective dose exceeding 1 mSv per year but less than 6 mSv y^{-1}, are characterized as supervised areas. Appropriate measures could be taken in order to minimize the dose, taking into account the effectiveness and the cost of such measures. The radiation protection measures are approved by GAEC.

- Work activities with corresponding effective dose exceeding 6 mSv per year but less than 20 mSv y^{-1}, are characterized as controlled areas. Special authorization by GAEC is required. GAEC approves the proposed measures for radiation protection.

- Work activities with the corresponding effective dose exceeding 20 mSv y^{-1}, due to natural radiation sources, are prohibited.

Radon (para. 1.2.5.7 of the RPR).

- The action levels concerning the effective dose to workers at work places due to radon concentration is 400 Bq m^{-3} (mean yearly radon concentration corresponding to 2000 working hours per year). Work activities where mean yearly radon concentration is below 400 Bq m^{-3} are excluded from further investigation.

- Work activities where mean yearly radon concentration exceeds 400 Bq m^{-3} but is less that 1000 Bq m^{-3}, are characterized as supervised areas and appropriate measures must be taken in order to minimize to dose, taking into account the effectiveness and the cost of such measures.

- Work activities where mean yearly radon concentration exceeds 1000 Bq m^{-3} but is less that 3000 Bq m^{-3}, are characterized as controlled areas. Special authorization by GAEC is required. GAEC approves the proposed measures for radiation protection.

- Work activities where the mean yearly radon concentration exceeds 3000 Bq m^{-3}, are prohibited.

The control of NORM wastes is relatively well developed. An Order was issued in 2001 relating to the disposal of waste from the fertiliser industry requiring prior authorisation for disposal including a radiological assessment and the disposal of Th-Mg alloy components from aircraft engines is under consideration. Greece applies EC guidance 'Radiation Protection 122 Part II' for other NORM wastes with dosimetric calculations for specific cases.

To date no significant NORM effluents or discharges have been encountered and no specific regulations relating to NORM discharges.

Dose Constraints and Limits

The following criteria for NORM 'work activities' have been established in the Radiation Protection Regulations (RPR) No 1014 (ΦΟΡ) 94.

- Effective dose to workers from activities excluding radon (para. 1.2.5.3 - 1.2.5.6):

    - The action levels concerning the effective dose to workers at work places due to natural radiation sources are 1 mSv y^{-1}. Work activities with corresponding dose less than 1 mSv y^{-1} are excluded from further investigation.

    - Work activities with corresponding effective dose exceeding 1 mSv per year but less than 6 mSv y^{-1}, are characterized as supervised areas. Appropriate measures could be taken in order to minimize the dose, taking into account the effectiveness and the cost of such measures. The radiation protection measures are approved by GAEC.

    - Work activities with corresponding effective dose exceeding 6 mSv y^{-1} but less than 20 mSv y^{-1}, are characterized as controlled areas. Special authorization by GAEC is required. GAEC approves the proposed measures for radiation protection.

    - Work activities with the corresponding effective dose exceeding 20 mSv y^{-1}, due to natural radiation sources, are prohibited.

- Effective dose to workers due to radon in the workplace (para. 1.2.5.7 of the RPR).

- The action levels concerning the effective dose to workers at work places due to radon concentration is 400 Bq m^{-3} (mean yearly radon concentration corresponding to 2000 working hours per year). Work activities where mean yearly radon concentration is below 400 Bq m^{-3} are excluded from further investigation.

- Work activities where mean yearly radon concentration exceeds 400 Bq m^{-3} but is less that 1000 Bq m^{-3}, are characterized as supervised areas and appropriate measures must be taken in order to minimize to dose, taking into account the effectiveness and the cost of such measures.

- Work activities where mean yearly radon concentration exceeds 1000 Bq m^{-3} but is less that 3000 Bq m^{-3}, are characterized as controlled areas. Special authorization by GAEC is required. GAEC approves the proposed measures for radiation protection.

- Work activities where the mean yearly radon concentration exceeds 3000 Bq m^{-3}, are prohibited.

- There is no nuclear industry in Greece however for effluent discharges from practices, the dose constraint is 10 μSv y^{-1} (para 1.1.2 of the RPR).

- At present for NORM, control in Greece is based on EC guidance namely a 300 μSv y^{-1} increment, that is an increment to the exposure which would prevail in the absence of the work activity from RP 122 Part II. Nevertheless this is not a restriction criterion but according to each pathway scenario and in taking account ALARA principles and optimisation the dose criterion could be much lower.

    - In the case of phosphogypsum disposal a dose criterion of 10 μSv y^{-1} was applied and this is the only 'work activity' to have been authorised as yet.

- Dose constraints provided by the Greek regulations were set within the process of optimization. There is no optimisation requirement below these dose constraint levels. Compliance is confirmed by sampling and measurement by authorised laboratories.

Spain (España)

Overview of Regulations

Title VII of the Council Directive 96/29/Euratom (CD) has been implemented by Title VII of the Royal Decree 783/2001 (RD) on the Health Protection against Ionising Radiation. The Directive has been transposed with only minor amendments. The main observations are that:

- Under Regulation 61 paragraph 1 the competent authority, which may be the Ministry of Economy, the Ministry of Development or the Regional Authorities, will with advice of the CSN require those operating work activities involving natural sources of radiation (but not covered within the definition of a practice) to carry out studies to determine if a

significant increase of the exposure of the workers or the members of the public exists which cannot be disregarded from the point of view of the radiological safety.

- Once complete these studies will be sent to the CSN who will determine what measures are necessary. The competent authority is then charged under Regulation 63 with enforcing these requirements upon the company carrying out the work activity.

- The CSN may require the application in full or in part the regulations relating to:

    (a) Intervention (Title VI, RD or IX, CD)

    (b) Justification, Optimisation and Dose Limitation (Title II, RD or IV, CD)

    (c) Estimation of Effective and Equivalent doses (Title III, RD or V, CD)

    (d) Fundamental Principles of Radiation Protection for workers etc (Title IV, RD or VI, CD)

    (e) Fundamental Principles of Radiation Protection for the public (Title V, RD or VIII, CD)

- Work activities have been defined in Regulation 62(1) as in the Directive. Furthermore, recently the CSN has approved an Action Plan to be presented to representatives of the Ministry of Economy, the Ministry of Development, the Ministry of Labour and the Regional Authorities in order to target/identify those work places which would be required to initiate studies as envisaged in Regulation 62. There are different ways used to locate the industries and companies that potentially could be affected by Title VII including through the Chamber of Commerce register, information possessed by other organisations of Administration or Regional Authorities and the Internet.

- Since the requirement resides with the company working with radiation to conduct studies to confirm whether they come within the regulatory framework i.e. if there is a significant increase of the exposure of the workers or the members of the public which cannot be disregarded from the point of view, future industries will be covered.

At present no particular work activities have been identified and controlled under Title VII of the Royal Decree. Thus no specific provisions for NORM have been defined or established with regard to discharges, disposal routes, and dose constraints etc. However the CSN is preparing a plan for developing a more coherent set of rules, regulations and safety guides on waste management, including these issues.

Dose Constraints and Limits

At present there are no specific discharge provisions relating to the radioactive content of NORM discharges other than normal industrial requirements. Discharge controls are to be reviewed on completion of the identification process and so no dose constraints have been set. The Consejo de Seguridad Nuclear (CSN) is in the process of preparing a plan for

developing a more coherent set of rules, regulations and safety guides on waste management, including issues relating to NORM wastes.

Under Article 64 of the Royal Decree 783/2001 the action level for airline companies to consider a program of radiological safety are doses in excess of 1 mSv per official year. A similar action level for other 'work activities' is not stated explicitly in the regulations instead it is stated in terms of *'exposure which cannot be disregarded'* Article 62 of Decree 783/2001).

France

Overview of Regulations

The Title VII of the 96/29 EURATOM Directive has been transposed on 28th March 2001 by the 2001-270 Ordinance (FR 2001) that forces manufacturers to take into account exposures to natural radiations that fall within the scope of "work activities". The corresponding State Council Decree (FR 2002), issued on the 4th April 2002, gives more details on industries which will be affected by this new legislation. A second Decree will be published by the Ministers in charge of Health, Environment and Work. This Decree will present a list of specific industries affected by the 2001-270 Ordinance and the 2002-460 Decree and will describe the information that the preliminary studies should contain.

More precisely, the main features of the legislation are as follows:

- The L 1333-10 article of the 2001-270 ordinance (FR 2001) requires the implementation of measures for exposure monitoring, when this latter is likely to undermine health, by the head of an establishment that uses materials containing natural radionuclides not used for their radioactive, fissile or fertile properties.

- The L.1333-17 article of that same ordinance states that a State Council Decree will determine the application terms of these articles, and notably the nature of activities concerned, the characteristics of natural exposure sources that must be taken into account and if necessary, the protection measures to be implemented, taking into account the importance of the risk.

- The R. 43-8 article of the 4th April 2002 State Council Decree (FR 2002):

    - specifies in general terms the main characteristics of the occupations for which the exposure to ionising radiation of a natural origin must be monitored and the doses due to the activity estimated,

    - reiterates that, for the work activities dealing with the storage of NORM or the production of NORM containing residues, the estimate of the doses concerns the population close to the installations as well as all the members of the public when these activities produce consumer goods or construction products.

- specifies that a decree by the Ministers in charge of Health, Environment and Work will:
    - define the categories of occupations affected by the provisions of this Article, taking into account the quantities of radionuclides held or the levels of exposures likely to be measured,
    - fix, by category of activities, the protection measures to be set up against the ionising radiation,
- reiterates that such protection measures cannot go beyond those imposed on the nuclear activities,
- states that the preliminary studies necessary for the measurement of exposure and to estimate the doses will have to be carried out within two years following the publication of the decree of the Ministers in charge of Health, Environment and Work, and will also comprise a study of the actions required to reduce, if necessary, the exposure of the people.

Dose Constraints and Limits

Control of work activities has not been introduced.

Ireland

Overview of Regulations

The competent authority is the Radiological Protection Institute of Ireland (RPII) and it is the Radiological Protection Act 1991 (Ionising Radiation) Order 2000 which incorporates the Council Directive 96/29/Euratom into national legislation in Ireland and in particular Part 2 Article 7 and Part 6 Articles 30 - 33.

The Order establishes national radiation protection regulations covering both practices and other work activities not considered as practices but where the presence of natural radioactivity leads to the risk of significant increase in exposure to workers or members of the public. This definition as such for work activities is given in the Scope of the Order in Article 3(2). For sources other than radon i.e. NORM radiation protection system is required where the effective dose to workers or members of the public is in excess of 1 mSv in any continuous 12-month period.

The main provisions of Title VII are implemented in Part 6 of the Order, which deals with:

- identification of work activities involving a significant increase in exposure to radon
- identification of work activities involving a significant increase in exposure to natural terrestrial radiation sources other than radon
- remedial measures in workplaces found to have significant levels of radon

- implementation of a system of protection where exposures cannot be reduced.

RPII has commenced a programme to identity work activities initially identifying the types of industries active in Ireland and which on the basis of literature are likely to be significant with regard to NORM. Companies actively involved were identified using a variety of sources including Integrated Pollution Control licences and commercial databases such as Kompass. Having identified the industry types involved a programme of investigation into the extent of exposure has been initiated with a sector specific approach being adopted.

However under Part 2 Article 7 the onus is upon the operator to notify the RPII on the commencement of a work activity as defined in 3(2) and 3(3) or as provided in 30(4) or 32(3).

When the investigation into the extent of exposure in these NORM industries which includes an investigation of potential releases and discharges, is complete the existing controls on discharges of NORM material will be reviewed. It is felt that NORM discharges are likely to fall within the scope of (non radioactive) pollution control regulations i.e. under the licensing controls of the Environmental Protection Agency and Local Authorities.

No regulations specific to NORM wastes i.e. discharge limits, assessment methodology etc have been enacted. Such discharges it was felt would generally fall within the scope of regulations to control environmental pollution.

<u>Dose Constraints and Limits</u>

- Under Article 9(1) of the Radiological Protection Act 1991 (Ionising Radiation) Order 2000 all exposures including to the population as a whole, from practices and work activities must be kept as low as reasonably achievable taking into account economic and social factors with the exception of specified medical exposures.

    - Under Article 9(5) the undertaking where appropriate shall use dose constraints in restricting exposure to ionising radiation pursuant to Article 9(1) (Optimisation). However these figures are not given for these dose constraints in the Order.

    - Dose constraints are defined under Article 2 (Interpretation) as meaning *'a restriction on the prospective dose to individuals which may result from a defined source, for use at the planning stage in radiation protection whenever optimisation is involved.'*

- Under Article 9(3) in relation to work activities the undertaking is required to undertake an assessment (acceptable to the Radiation Protection Institute) of the risks of exposure to workers and the public for the purposes of identifying the measures necessary to restrict exposure. Which could involve the application of dose constraints.

- Discharge controls are to be reviewed on completion of the identification process and so no dose constraints have been set.

- The action level for radon concentrations in workplaces is given in article 30 (2)(c) as concentrations liable to be in excess of 400 Bq m^{-3}, averaged over a minimum period of three months.

Italy (Italia)

Overview of Regulations

The Title VII of Directive 96/29/EURATOM was implemented into Italian legislation (IT 2002) by the Legislative Decree no. 241 of 26th May 2000 (IT 2000); this piece of legislation modified the Legislative Decree no. 230 of 17th March 1995 (IT 1995) in order to transpose the whole of the Directive. The Legislative Decree no. 230, as modified by the Legislative Decree no. 241, constitutes the new Italian legislation laying down radiation protection requirements for workers and the public, which entered into force on January 1st 2001.

More precisely, the main features of the legislation are as follows:

- Article 5 of the Legislative Decree no. 241 introduces the new Title III-bis in the Legislative Decree no. 230 that concerns exposure to natural radiation sources.

- Article 10-2 of this new Title III-bis defines the general characteristics of the work activities to which the dispositions of the chapter apply.

- Annex I-bis of the Legislative Decree no. 230 identifies an initial list of work activities deemed to be worthy of concern and defines the relevant Action Levels (1 mSv y^{-1} for workers and 0.3 mSv y^{-1} for reference groups of the public) for such activities.

- Article 10-7 defines the key role of a National Technical Commission on Exposure to Natural Radiation Sources, intended to deal with the scientific and technical problems specific to natural radioactivity. The Commission is to be made up of 21 experts, coming from relevant ministries, national scientific institutions, agencies and regional authorities.

- Articles 10-3 and 10-5 define the obligations of the operators (whose work activity is included in the list of relevant work activities defined in the above cited Annex I-bis) and the required actions depending on the results of the measurements.

    - the operator is responsible, before the end of the two-year time span (following either September 1st 2003 or the start of the work activity), for making measurements and assessments according to the recommendations of the above cited National Technical Commission and assessing whether or not the exposure from its activity exceeds the Annex I-bis Action Levels.

    - if exposures remain below the Action Levels, the operator is only required to repeat such measurements and assessments every three years or to review the situation if there are significant variations in the production process; if 80% of the action levels is exceeded, measurements and assessments must be repeated every year;

- if exposures exceed either Action Level, the operator must submit a report to the Authorities and adopt remediation measures within a three year time limit, with a view to keeping exposures below Action Levels, taking into account the optimisation principle;

- if the operator does not succeed in keeping exposures below Action Levels after adoption of remediation measures, the application of the ordinary requirements for the protection of workers and the public which apply to practices is required.

- if the operator does not succeed in keeping exposures below Action Levels after adoption of remediation measures, the application of the ordinary requirements for the protection of workers and the public which apply to practices is required.

Dose Constraints and Limits

Control of work activities has not been introduced.

Luxembourg

Overview of Regulations

Title VII is implemented in Luxembourg Law through the provisions in Article 1.1 e), Article 5.2 and Article 8 of the "Règlement grand-ducal du 14 decémbre 2000 concernant la protection de la population contre les dangers résultant des rayonnements ionisants" (RGD).

- Article 1.1 e) brings work activities under scope of the RGD. The same description of work activities is used as in the Council Directive.

- Article 5.2 sets dose limits for exposure of workers to natural sources.

- Article 8 specifies the regulatory provisions for work activities involving natural radiation sources.

    - Article 8.1 specifies the types of exposure in work activities considered for the provisions of Article 8:

        - work activities involving exposure of workers to radon and external radiation in water supply industries, thermal spas etc.

        - work activities involving exposure of workers as a result of the use or storage of materials normally not usually considered as radioactive but which may contain naturally occurring radionuclides that may cause a significant increase of the radiation exposure of workers and, if applicable, members of the public.

        - work activities involving the production of residues not usually considered as radioactive but which may contain naturally occurring radionuclides that may cause a significant increase of the radiation exposure of workers and, if applicable, members of the public.

- Exploitation of air planes.

- Article 8.2, par. 1 describes the operational provisions applicable to work activities. They include:
  - Chapter 2 on classification of establishments.
  - Chapter 5.2 on dose limits for practices.
  - Chapter 6 on operational radiation protection provision for practices.
  - Chapter 10 on the protection and safety of the public.
  - Chapter 11 on intervention.
- Article 8.2, par. 2 – 6 provides dose constraints for occupational exposure to cosmic radiation and specifies responsibilities of operators of establishments to evaluate the radiation exposure of the workers and to take measures to ensure their protection.

Dose Constraints and Limits

- According to Article 5.2 of the Decree of the 14th December 2000 the following dose constraints apply to the exposure of workers to natural radiation sources:
  - For workers or members of the public occupationally exposed to external radiation from natural sources: the dose limits for exposed workers specified in Article 5.1.3 apply i.e.
    - 10 mSv y^{-1} effective dose,
    - 150 mSv y^{-1} equivalent dose to the lens of the eye,
    - equivalent dose limit of 500 mSv y^{-1} for the skin averaged over 1 cm^2 of any exposed surface,
    - 500 mSv y^{-1} for the skin, hands, forearms, feet and ankles.

    These limits apply to everyone occupationally exposed in practices and work activities. Apparently the limits are set at 10 times the limits for members of the public specified in Article 5.1.2, for the total of all exposure pathways, while, in the Directive the effective dose limit for workers is set at 20 times that limit, for average exposure in a consecutive five-year period.

- The limit for workers and members of the public occupationally exposed to radon is set at 1.7 MBq m^{-3} per year, corresponding to 1000 Bq m^{-3} for 1700 hours per year.

- Persons occupationally exposed to cosmic radiation are regarded as members of the public if their exposure is below 1/10 of the limit set for workers in Article 5.1.3.

- If persons are occupationally exposed to cosmic radiation and may receive doses in excess of 1/10 of the dose limits specified in Article 5.1.3 their radiation protection should be carried out in agreement with specific international regulations.

- For the protection of members of the public it is forbidden to import, produce and sell building materials for houses or other residencies with activity concentrations exceeding:

    - 3000 Bq kg^{-1} for ^{40}K

    - 300 Bq kg^{-1} for ^{226}Ra

    - 200 Bq kg^{-1} for ^{232}Th

    If more than one radionuclide is present the weighted sum of the activity concentrations should not exceed 0.5 for materials applied in bulk and 2 for materials applied to surfaces or in small amounts only.

- Luxembourg has no specific provisions for clearance of residues or discharges from work activities but the competent authorities can impose restrictions on discharges and residues from authorised work activities on a case-by-case basis. No work activities requiring authorisation have been identified yet.

The Netherlands (Nederland)

Overview of Regulations

Title VII of the Directive is implemented in Dutch Law through the provisions of Chapter 8 in the Radiation Protection Decree. The main features of the legislation are:

- The regulatory provisions for practices are applicable also to work activities unless explicitly stated otherwise (Article 101).

- Before starting a work activity the entrepreneur is obliged to check whether that work activity has to be reported or will require authorisation (Article 102, par. 2).

- The Ministers will publish a list of work activities involving materials that probably will exceed the exemption levels specified in Annex 1, table 1 and 2 of the Decree (Article 102, par. 1).

- The list to be published is based on studies carried out according to the obligations laid down in Article 40 of Title VII of the Directive. These studies comprise studies on potential levels of exposure of workers in work activities in the Netherlands and assessments of radiation exposure of workers and members of the public as a result of reuse, recycling and disposal of residues from work activities. The list is not yet finalised and published.

- Work activities have to be reported when the activities and activity concentrations of solid material (i.e. not discharges) exceed the exemption/clearance levels specified in Annex 1, Table 1 (Article 103, par. 1 – 6).

- Work activities require prior authorisation if the total activities involved are equal to or exceed the exemption/clearance levels specified in Annex 1, Table 1 of the Decree and the activity concentration is equal to or higher than ten times the exemption/clearance levels in that Table 1 (Article 107, par. 1 – 4) (solid materials not discharges).

- Discharges of natural sources from work activities into air and water require prior authorisation when the total activities discharged annually exceed the levels specified in Annex 1, Table 2 of the Decree (Article 108, par. 1 – 4).

- The reporting requirements as specified in Article 105, par. 1 include estimates of the effective doses that could be received as a result of reuse, recycling or disposal of natural sources from work activities. A ministerial regulation with detailed reporting requirements is envisaged but not published yet.

Dose Constraints and Limits

- The dose constraints applied to natural sources, (not discharges), are not specified in the text of the Radiation Protection Decree of 16 July 2001 (BS) itself but in the section 4.7.3 of the Explanatory Notes.

- Workers
  The dose constraints (dose criterion) for workers on which exemption and clearance levels are based are effective doses of 0.1 mSv y^{-1} under normal conditions and 1 mSv y^{-1} under unfavourable but still realistic conditions. On the basis of a number of studies carried out under contract with the Dutch government it is assumed that exemption from reporting and clearance of materials on the basis of the values provided in Annex 1, Table 1 of the Decree this dose criterion will not be exceeded.

- Members of the public
  The dose constraints for members of the public are specified as 1 mSv y^{-1} ambient dose equivalent and 0.3 mSv y^{-1} effective dose. On the basis of a number of studies carried out under contract with the Dutch government it is assumed that exemption from reporting and clearance of materials on the basis of the values provided in Annex 1, Table 1 of the Decree these dose criteria will not be exceeded.

- A dose constraint of 10 μSv y^{-1} is used in the calculation of the clearance levels for discharges from work activities. It is explained that this dose criterion is based on the dose criterion recommended in the Council Directive. However, the 10 μSv y^{-1} dose criterion in the Council Directive pertains to exemption of practices from reporting and not to work activities.

- The dose constraints applied to NORM discharges is 10 μSv y^{-1} effective dose to members of the public. The dose constraint for discharges from practices has been set at

a much lower level of 0.1 μSv y^{-1} effective dose. The latter dose constraint is used as the basis for deriving limits expressed as 'radiotoxicity equivalents' for different receiving media below which no authorisation of the discharges from practices is required.

- The Netherlands has included in BS a table (Table 2 of Annex 1) providing levels of cleared annual discharges of natural sources into air and water.

- The dose constraints for use or disposal of solid residues are 0.1 mSv y^{-1} under normal conditions for workers involved in the process and 1 mSv y^{-1} under unfavourable but still realistic working conditions. The dose constraints for members of the public are set at 0.3 mSv y^{-1} effective dose and 1 mSv y^{-1} ambient dose. Multiple exposure pathways were considered in deriving the relation between activity concentration and level of exposure of workers and members of the public.

- The Netherlands have chosen to apply the same list of exemption levels (Table 1 Annex 1 of BS) to practices as well as to work activities and to clearance of residues from work activities for use or disposal. In principle these clearance levels apply to unconditional clearance.

- To ensure compliance those discharging radioactive substances are required by their authorisations to maintain records and carry out monitoring. Optimisation is not likely to be required below the dose constraint level of 10 μSv y^{-1} for discharges.

Austria (Österreich)

Overview of Regulations

Title VII is implemented by the new Radiation Protection Law which comes into force on the 1st January 2003 and defines 'work activities' in a similar way to Title VII, Article 40 paragraph 2 of the Directive. However copies of the new Law and the draft Ordinance became available too late in the study for detailed analysis of the full text.

The Regulatory Body responsible for regulating exposure both to workers and members of the public is the Federal Ministry of Agriculture, Forestry, Environment and Water Management, partly in collaboration with other ministries, like the Federal Ministry of Social Security and Generations. Authorisations are on the other hand are granted by authorities at the regional level ("Bezirksverwaltungsbehörden").

A preliminary investigation to identity the potentially relevant industries in Austria has been completed with a more detailed survey of these industries currently being planned. Austria plans to name the industries affected by the new controls with the provision to allow more industries to be added to the list on a case-by-case basis.

The control of NORM discharges is under development. Up to now no application for authorisation has been received for purely NORM waste though natural radionuclides have been included in other authorisations. However provided the maximum permissible discharge values according to the existing Radiation Protection Ordinance or the authorisations are not reached any NORM waste as well as waste containing man-made

radionuclides may be disposed of as non-radioactive waste. If the limits are exceeded case-by-case assessments of the potential dose to the population considering river flow rates, chemical characteristics etc must be undertaken.

Finally NORM is not presently regulated but the Radiation Protection Ordinance is under development to rectify this situation and it is expected that European Commission guidance from the 'Radiation Protection Series' will be applied.

Dose Constraints and Limits

Dose constraints are to be introduced in the new Radiation Protection Ordinance which is currently out to consultation. They are not contained in the present Radiation Protection Ordinance. The exposure of single persons and the population as a whole has to be as low as possible and justified, taking economic and social factors into consideration.

Compliance is assured by requirements placed upon the installations to take and retain records of measurements to demonstrate compliance. The samples are retained for random checking by the Regulator.

Portugal

Overview of Regulations

Information obtained from the Portuguese Department of Radiological Protection and Nuclear Safety (letter dated on 17th May 2002) indicates that "(…) *so far, neither has the Directive 96/29 been transposed nor does the current Law provides any definition or identification of NORMs. Consequently, there are no provisions for the follow up of radiation dose of workers in industries manipulating NORMs"*.

However since this letter was received Decree No 165/2002 of the 17 July 2002 was enacted and under the its scope in Article 2 (2) (a) '*work activities where the presence of natural sources of radiation leads to a significant increase in exposure of workers or the public, to a level that cannot be ignored from the point of view of radiation protection'* it is stated that the regulations apply equally to these activities as to practices.

Dose Constraints and Limits

At the time of writing, control of work activities had not been introduced and available information would appear to suggest there are no dose constraints currently applied to work activities.

Finland (Suomi)

Overview of Regulations

There are three levels of legislation in Finland, the Radiation Act, the Radiation Decree and ST-Guides all of which contain provisions which concern or are directly applicable to natural radiation and so are part of the implementation of Title VII of the Directive.

Some key features are:

- 'Work activities' can be considered to be covered within the definition of '*radiation practices*' in Section 11 of Chapter 3: Definitions of the Radiation Act (592/1991) as amended which states that:

    - the term radiation practices shall denote:

        (a) the use of radiation

        (b) operations or circumstances in which human exposure to natural radiation causes or might cause a health hazard.

- Under Section 8(4) of the same Act it denotes 'natural radiation' as ionising radiation originating in outer space or radioactive materials occurring in nature and not used as radiation sources.

- Under Chapter 12 Section 45 anyone using natural materials, ores or materials produced from them in an industrial or comparable operation is required to investigate the radiation exposure caused by these activities in a manner acceptable to STUK if it is found or there is reason to suspect that the operation constitutes a *radiation practice* (see definition above). The same obligation applies if exposure from natural radiation in the workplace is suspected to cause or is liable to cause detrimental health effects such as radon for example in workplaces.

  STUK is empowered to order such an investigation if those so required fail to do undertake such an investigation.

- The Radiation Decree (592/1991) as amended Chapter 7 Section 27 states that investigations are required if exposure may exceed 1 mSv y^{-1} or the annual average concentration of radon exceeds 400 Bq m^{-3} on a permanent basis in the breathable air.

- Protection of aircrew is covered in Chapter 7 Section 28a of the Radiation Decree.

- Under Section 29 of the aforementioned Decree there is a special duty of notification requiring that the Radiation and Nuclear Safety Authority (STUK) is informed prior to commencing:

    1. Mining as referred to in the Mining Act (503/1965)

    2. Excavation work lasting longer than 2 months and mainly performed underground or in a confined space, and

    3. Extensive utilisation of natural resources, the uranium and thorium content of which exceed 0.1 kg per tonne, with the exception of practices supervised under the Nuclear Energy Act (990/1987).

- Further reference levels and maximum values to be applied for the purpose of limiting radioactive exposures in practices involving the presence of natural radiation sources are set out in Guide ST 12.1 Radiation Safety in Practices Causing Exposure to Natural Radiation.

- Under the Radiation Act Chapter 13: Radiation Waste Section 50 the responsible party has a duty of care when utilising natural resources containing radioactive materials, to ensure that radioactive waste poses no hazard to health or to the environment, both during the operations and on their conclusion.

Dose Constraints and Limits

- Dose constraint is defined in Section 7 of the Radiation Decree: '*STUK shall as necessary set dose constraints which are lower than the maximum values prescribed in Sections 3-6, when these are warranted in order to implement the principle of optimisation prescribed in Section 2 of the Radiation Act and in order to allow for exposure resulting from various radiation sources.'*

    - It has been stated in Guide ST 12.1 that *'In operations causing exposure to natural radiation, the population dose constraint for a specific radiation source may be 0.1 to 0.5 mSv per year'*. So a source specific dose constraint within this range could be issued to both effluent discharge and/or disposal of solid waste, depending on the case. However there has not been a need to establish discharge limits up to now and the regulations have been in place since 1992.

    - For the nuclear industry there is a limit (effectively a dose constraint) of 0.1 mSv for 'the expected committed effective dose to a member of the public resulting from one years operation' (Council of State Decision 398/1991). This value is used for deriving the limits of discharge from a nuclear site during normal operation.

- The reference levels and the maximum values to be applied for the purpose of limiting radiation exposures in practices involving the presence of natural radiation sources given in ST Guide 12.1 are:

  Occupational exposures:

  Reference levels

    - Radon in the workplace

Regular work	400 Bq m^{-3}
Max 600 h y^{-1}	1000 Bq m^{-3}
Max 300 h y^{-1}	2000 Bq m^{-3}
Max 100 h y^{-1}	6000 Bq m^{-3}

    - Other sources of natural radiation (external gamma, inhalation of dust): 1 mSv y^{-1} (radon exposure not included)

Dose limits and maximum values

- Radon in the workplace Regular work 3000 Bq m^{-3}
- Overall exposure to natural radiation sources (all exposure pathways considered i.e. radon, external gamma and inhalation of dust): 20 mSv y^{-1} (mean of 5 years, max 50 mSv in any year)

Public exposures

Exemption level:

- An investigation referred to in Section 45 of the Radiation Act is not required if the exposure is on the basis of the information provided in the notification under Section 29 of the Radiation Decree is in all probability less than 0.1 mSv y^{-1}. If such an investigation is carried out and the doses found to be less than 0.1 mSv y^{-1} the practice is exempt from limitation measures laid down in section 46 of the Radiation Act.

Sweden (Sverige)

Overview of Regulations

The Radiation Protection Act (1988:220) and the Radiation Protection Ordinance (1988:293) as amended 1st September 2001 implement the legal provisions of Title VII of the Council Directive and is regulated by the Swedish Radiation Protection Institute (SSI).

- Under the Act (1988:220) (Section 5 (1))'activities involving radiation' are defined in the Act as

    1. the manufacture, import, export, transport, sale, transfer, lease, acquisition, possession or use of, or comparable dealings with, radioactive substances.

This could perhaps be interpreted to include 'work activities' as defined by Title VII of the Directive.

- Under the Ordinance Section 2(1) radioactive material with a total activity or specific activity that does not exceed those set out in the appendix (which is the same as Table A of Annex I of the Directive) have been exempted from some of the provisions of the Act, the exemptions relate to medical examinations and licensing. It appears from the regulations that 'practices' and 'work activities' as defined in the Directive are not considered separately in Swedish legislation.

- Under Section 6 of the Act any person who conducts activities involving radiation shall, according to the nature of the activities and the conditions in which they are conducted,

    1. take the measures and precautions required to prevent or counteract injury to people and animals and damage to the environment,

2. supervise and maintain the radiation protection at the site, on premises and in other areas where radiation occurs,

3. maintain properly the technical devices and the measuring and radiation protection equipment used in the activities.

- Swedish legislation appears to be drawn up in a less prescriptive manner allowing those applying the legislation to take account of the nature of the specific activity with the provision under Section 12 for further regulations by the Government or a government appointed authority to be issued for the control of radiation in relation to the General Obligations (Sections 6 –11) if necessary.

- However it is the intention of the SSI to present a policy on how to treat natural radiation according to Title VII of the Directive in one or two years time when regulations for future NORM industries will be considered.

- Nevertheless SSI has an ongoing project for identifying industries with potential problems with enhanced natural radiation in accordance with Title VII of the Directive and the types and numbers of such industries are already fairly well known to SSI. The geological conditions, with an abundance of granite and pegmatites rich in uranium and thorium together with large areas of uranium-rich alum shale, exposure to natural radiation is not unusual in certain types of industries and other work activities in Sweden. Workplaces with elevated radon levels are common. (Mjönes and Åkerblom, 2002)

- SSI FS 1983:7 relates to the handling of solid and liquid wastes not associated with nuclear power. It is applicable to laboratories and similar workplaces that have special permission to handle radioactive substances and could be applied to NORM wastes however apart from this there are no national regulations specifically addressing NORM issues. The regulations set out the conditions for disposal of waste and provided the conditions are met they may be disposed of without the specific permission of SSI.

- The regulation SSI FS 1983:7 uses a release limit in terms of Bq per month and a concentration limit in Bq ml^{-1} and a similar approach is anticipated for applications related to NORM in cases when these regulations are not applicable. SSI FS 1983:7 is to be reviewed in 2003 and the Swedish system of regulations of NORM and other sources of radioactive waste outside of the nuclear industry will also be improved and further developed starting in 2003. This may give rise to new requirements for some industries to apply for authorisation for their operations that is not needed in the present system. A report 'RAKET' (in Swedish) has been produced to list all kinds of radioactive waste in Sweden coming from these activities which do not currently require authorisation and this will be an input into the review.

Dose Constraints and Limits

At present there is an ongoing investigation by a committee appointed by the Swedish government into proposals for a national system for handling radioactive waste outside the nuclear industry. Control of natural radiation following the publication of Title VII of the

Directive is being reviewed over the next two years. Under the current regulatory framework the dose constraint to members of a critical group is 10 μSv y^{-1}, however it must be emphasised that this is not NORM specific.

- The dose constraint definition used is that from the Directive *'a restriction on the prospective doses to individuals which may result from a defined source, for use at the planning stage in radiation protection whenever optimisation is involved.'*

United Kingdom

Overview of Regulations

The UK considers that their regulation have already taken NORM materials properly into account and that NORM industries are already covered by their regulations and are sufficiently regulated. But due to the complexity of the situation the Health and Safety Executive (HSE) has commissioned research which aims to obtain realistic data to enable employers to carry out practical assessments of radiation doses to employees from work with NORM. Reports by the NRPB have been completed for the Steel industry and Coal-Fired Power Stations.

Under the UK legislation control of wastes/protection of the environment and protection of workers and the public are controlled by two different pieces of legislation and enforced by two different regulators. Thus the provisions relating to 'work activities' and workers under Title VII is enacted by the Ionising Radiation Regulations 1999. The control of the waste will be regulated by the Environment Agency in England and Wales, the Scottish Environmental Protection Agency (SEPA) (in Scotland) and Industrial Pollution and Radiochemical Inspectorate (IPRI) in Northern Ireland, under the Radioactive Substances Act, these are also the regulators responsible for the control of non-radioactive environmental pollution in their respective regions.

- Employers are required under the Management of Health and Safety at Work Regulations 1999 Regulation 3(1) to undertake risk assessments of any potentially significant hazards within the workplace. If this assessment indicates that the reference level is exceeded the employer is required to ensure exposure is ALARP and comply with IRR99 requirements. (Cairns et al, 2001)

- The Ionising Radiation Regulations 1999 (IRR99) and associated Approved Codes of Practice (ACOP) which implement BSS Directive 96/29 Euratom in Great Britain set two reference criteria which cover natural radiation in the workplace (other than that arising out of a practice):

  - levels of radon gas exceeding 400 Bq/m^3 (averaged over any 24 hour period); (Reg 3(1)(b)) and

  - where work with naturally occurring radioactive materials (NORM) is likely to lead to employees or other people receiving an effective dose in excess of 1mSv in a year (ACOP para 11).

- Radioactive substances in the UK are regulated under the Radioactive Substances Act 1993 by means of registrations and authorisations. For certain practices and types of radioactive materials, there are orders which allow exemption from registration/authorisation, conditionally or unconditionally.

- There are 18 such Exemption Orders in force, seven of which could apply to natural radioactive material. These Exemption Orders work by withdrawing the requirement for registration and authorisation so that the full rigours of site-specific regulation are not imposed, but there is still a degree of regulatory control. The scope of the RSA93 is deliberately broad; it applies to radioactive waste from both nuclear and non-nuclear industries and to all types of radioactive waste: solid, liquid, gas, discharges to the environment and disposal by placement in a repository or by incineration. (McHugh, 1997)

Dose Constraints and Limits

- In UK legislation dose limits to workers and the public (in any one calendar year) are set out in Schedule 4 of IRR 99 under Regulation 11(1):
    - Employees of 18 years or over (para 1 - 2):
        - effective dose limit of 20 mSv
        - equivalent dose to the lens of the eye 150 mSv
        - equivalent dose to the skin 500 mSv averaged over an area of 1 cm^2
        - equivalent dose to hands, forearms, feet and ankles 500 mSv.
    - Trainees under 18 years (para 3 - 4):
        - effective dose limit of 6 mSv
        - equivalent dose to the lens of the eye 50 mSv
        - equivalent dose to the skin 150 mSv averaged over an area of 1 cm^2
        - equivalent dose to hands, forearms, feet and ankles 150 mSv.
    - Women of reproductive capacity (without prejudice to the effective dose limits above) (para 5):
        - equivalent dose to the abdomen 13 mSv in any consecutive three month period.

- Other persons (para 6) (e.g. members of the public):
    - effective dose limit 1 mSv
    - equivalent dose to the lens of the eye 15 mSv
    - equivalent dose to the skin 50 mSv averaged over an area of 1 cm^2
    - equivalent dose to hands, forearms, feet and ankles 50 mSv.

- Every radiation employer (defined in as an employer who carries out work with ionising radiation (Regulation 2(1)) is required under Regulation 8(1) to restrict exposure to his employees and other people so far as is reasonably practicable. Under 8(3) where appropriate dose constraints should be used in restricting exposure.

- Dose constraint is defined (Regulation 2(1)) as '*a restriction on the prospective doses to individuals which may result from a defined source'.*

- Guidance issued to accompany the IRR99 states in paragraph 134 of the Approved code of Practice (note this paragraph is guidance and does not form part of the approved code of practice) that where the radiation employer anticipates that the new work activity or facility is likely to expose members of the public to direct radiation or contamination, it may be appropriate to use a dose constraint. The NRPB has recommended that the constraint on optimisation for a single new source should not exceed 0.3 mSv y^{-1}.

- Provisions related to UK policy on discharge of air-borne and liquid waste was included in the 'White Paper' Review of Radioactive Waste Management Policy Final Conclusions published in 1995 sometimes referred to as Command 2919 [HMSO, 1995].
    - In paragraph 68 it is stated that *'*...a maximum constraint of 0.3 mSv y^{-1} value should replace the target of 0.5 mSv y^{-1} when determining applications for discharge authorisations from a single new source, defined as a *facility, or group of facilities which can be optimised in terms of radioactive waste disposals*'.
    - In paragraph 70 an additional 'site constraint' was introduced equivalent to a previous site target of 0.5 mSv y^{-1}. This applies to the aggregate exposure from a number of sources with contiguous boundaries at a single location, irrespective of whether different sources on the site are owned or operated by the same or by different organisations.
    - In paragraph 73 the Government proposed a threshold for optimisation of 0.02 mSv y^{-1} and stated that if exposures are calculated to below this threshold regulators should not seek to secure further reductions in the exposure of the public, provided they are satisfied that the operator is using the best practicable means to limit discharges.

- In the more recent Government statement of policy, the UK strategy for radioactive discharges 2001-2020, it states "The progressive reduction of discharge limits, and of

actual discharges, having regard to the application of Best Practical Means (BPM) is a central tenet of the way in which radioactive discharges should be controlled and has been a feature of UK policy since 1993" (DEFRA, July 2002).

- At present no separate dose constraints for NORM discharges have been established, the constraints applied to other non-nuclear establishments such as small hospitals are used i.e. for a single new source 0.3 mSv y^{-1} and the whole site 0.5 mSv y^{-1}.

- To ensure compliance those discharging radioactive substances are required by their authorisations to maintain records and carry out monitoring. The Regulator will inspect these records and may take duplicate samples for independent analysis to confirm the results.

- Dose constraints are not applied to solid radioactive wastes.

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Appendix D - Guidance on assessing doses from atmospheric discharges

Guidance on the exposure pathways to consider, the methodologies to use to assess doses, and how to identify the relevant reference groups, for NORM discharges to atmosphere is given below.

Exposure pathways

In Jones et al (2002) the results of illustrative calculations for typical atmospheric releases from nuclear installations and for unit releases of a number of radionuclides were used to separate the exposure pathways into three types: those that should always be considered; those that should be considered depending on local conditions; those that should not normally be considered. They concluded that the following pathways should nearly always be considered:

- ingestion of radionuclides in terrestrial foods (e.g. milk, meat, vegetables and fruit),
- inhalation of radionuclides in the atmosphere and,
- external irradiation from radionuclides in the atmosphere and deposited on the ground.

Illustrative calculations of the doses from unit atmospheric releases of naturally occurring radionuclides have been undertaken as part of this study. These are described in Appendix F. The results indicate that the most important exposure pathways are:

- inhalation of radionuclides in the atmosphere and re-suspended following deposition,
- ingestion of radionuclides in terrestrial foods (e.g. milk, meat, vegetables and fruit), and
- external irradiation from radionuclides deposited on the ground.

Assessments carried out of the consequences of atmospheric releases from coal-fired power stations (Smith et al, 2001) and the steel industry (Crockett et al, 2002) in general agree with the above. The most important exposure pathways were ingestion of radionuclides in terrestrial foods and inhalation of radionuclides, including both particulates and radon, in the plume. For some radionuclides external irradiation from deposited radionuclides and inhalation of re-suspended radionuclides were also important. Doses from external irradiation from the plume were many orders of magnitude lower.

On the basis of the calculations undertaken and the supporting evidence it can reasonably be concluded that the following pathways should (nearly) always be considered:

- Ingestion of radionuclides in terrestrial foods (e.g. milk, meat, vegetables and fruit).
- Inhalation of radionuclides (including particulates and radon) in the atmosphere from the plume.

- External irradiation from radionuclides deposited on the ground.

- Inhalation of radionuclides re-suspended following deposition.

For any assessment it is important to consider the agricultural practices around the installation being considered. The foods considered are generally considered in groups; for example, green vegetables include all types of leafy and leguminous vegetables. If local information indicates that there are no cows in the vicinity of the site but that sheep or goats are present then these pathways should be considered. Local conditions may also affect which foods should be considered and the relative importance of these foods but in general it is important to consider the ingestion of terrestrial foods when assessing radiation doses from releases to atmosphere.

As already stated it is important to take account of local conditions when deciding on the exposure pathways to include in a dose assessment. The ingestion of radionuclides in 'free foods' is an example of a potential exposure pathway. Free foods include berries, mushrooms, rabbits, pheasants, reindeer etc. When considering the ingestion of free foods, it is essential to have information on local habit data. Regional or national habit data cannot take account of the free foods available in an area and large variability is observed between regions. In addition, soil to plant transfer factors for many wild plants e.g. lichen are difficult to obtain and can vary widely. For example many different species of mushroom grow in different areas, and since radionuclide uptake is species specific it would be very difficult to assess accurately doses due to ingestion of wild mushrooms in a general way. It is, therefore, not possible to give generic guidance on how to calculate realistic radiation doses from this pathway due to the site-specific nature of the assessment. Given the low doses predicted from atmospheric releases from NORM industries it is however unlikely that consideration of such pathways would be required.

It is not normally necessary to consider products from pigs and poultry that are housed inside and supplied with feed from a number of sources most of which will be some distance from the site of interest. However, they may be important in specific locations if other foods are not grown close to the location of interest.

Grain could be produced around NORM industry sites and could be important in terms of dose. However any grain produced for human consumption is normally mixed with other supplies obtained over a wide area before processing and distribution. Therefore, it is unlikely that an individual or group of individuals would consume grain produced by themselves. Therefore doses from consumption of grain should not normally be calculated. However if site-specific information indicates that the grain is produced and consumed locally then this pathway should be included.

Doses from drinking water and consumption of fish, where the discharge is to atmosphere with subsequent deposition onto land and water surfaces have been found to be negligible, see Appendix F. It is therefore not necessary to consider these exposure pathways.

The deliberate ingestion of soil by children or adults does not need to be considered in assessments because this pathway is a recognised medical condition, known as *pica*, which

tends to occur for a relatively short time. Inadvertent ingestion of soil and dust was considered in the illustrative unit release calculations reported in Appendix F. This pathway was not found to be important in comparison with doses from the pathways identified above as significant. A study to determine discharge screening levels for small producers of radioactive waste (referred to as Generalised Derived Constraints) for ^{238}U, ^{235}U, ^{234}U, ^{226}Ra, ^{210}Pb and ^{210}Po also indicated that doses from inadvertent ingestion of soil were significantly lower than those from the other pathways identified above (NRPB, 2002). However, where a facility is located in an area where agricultural production is not significant then it may be important to consider this pathway.

Assessment Methodology

If models are used to predict activity concentrations in the air and on the ground account should be taken of the range of meteorological conditions that occur in the course of a year. The effects of wet and dry deposition should be considered as well as radioactive decay. The meteorological conditions should be appropriate for the site in question and should preferably be averaged from several years of data. Such data may be available for the site itself or from nearby meteorological stations. The atmospheric dispersion model used also needs to consider the height of the release taking into account the effects of nearby buildings and any plume rise due to the thermal buoyancy and/or momentum of the released material. Gaussian plume dispersion, based on the use of stability category meteorological data (Pasquill, 1976) can be used. A new generation of models has been developed, e.g. ADMS (Carruthers et al. 1994) and AERMOD (Cimorelli et al. 1998). However when considering continuous releases there is little difference between the new models and the Gaussian plume model e.g. as implemented in PC-CREAM (Mayall et al. 1997).

There are a variety of climate types in Europe, but most of the continent is dominated by mild weather. This is caused by winds that blow across the continent from the Atlantic Ocean. The winds are warmed by the Gulf Stream, which carries warm water from the Gulf of Mexico to the western coast of Europe. The winds affect most of the continent because no mountain barrier is large enough to block them and because much of Europe is located within 480 kilometres of the Atlantic Ocean. The meteorological conditions in European countries can be classified into three types according to the geographic layout and weather conditions as shown in Figure D1:

- temperate oceanic climate in the British isles and western coast of Europe,
- temperate continental climate in the western European continent, and
- subtropical climate in southern Spain and Italy.

It is common practice to use a generic model, such as FARMLAND (Brown et Simmonds, 1995), for the transfer of radionuclides through terrestrial food chains. In such models similar foods are grouped together for modelling purposes, for example green vegetables and root vegetables are considered rather than specific crops such as cabbage or carrots. In most cases it will be acceptable to use generic parameter values for the food chain model.

For modelling the re-suspension of radionuclides deposited on the ground two approaches are possible (Simmonds et al, 1995). The first uses a re-suspension factor to relate the ground deposition to the activity concentration in air while the second uses a dust loading approach.

A model may also be required to calculate external radiation exposures from deposited material. This should allow for the downward migration of radionuclides in the soil as well as the build up of activity due to continuous deposition.

Reference groups

Factors relevant to the identification of reference groups for the key routes of exposure for atmospheric releases are discussed below. The radiation exposures will depend on the concentrations of radionuclides in air and on the ground around the site resulting from the discharges. This depends in turn on the location of the discharge points, the height of the release and the atmospheric conditions.

Inhalation
For inhalation of radionuclides in the plume, individuals working or living at locations with the highest air concentration will generally receive the highest doses from this pathway. Account has to be taken of occupancies as well as the activity concentrations in air in determining the location with the highest doses from inhalation. Inhalation rates for various age groups from the ICRP Task Group report on the model of the respiratory tract (ICRP, 1994) are provided in Table H1.

External irradiation
People can be exposed to external irradiation in two ways; from material deposited on the ground or in the atmosphere. For external irradiation from deposited material groups located where there is the highest ground deposition are likely to receive the highest exposures. However due to the movement of radionuclides in the atmosphere the area of highest ground deposition is not necessarily the area with the highest activity concentration in air. Therefore individuals who receive the highest exposure due to irradiation from deposited material may not coincide with the individuals with the highest doses due to irradiation from the atmosphere.

For time spent indoors account should be taken of the degree of shielding offered by the building to reduce the external irradiation exposure and the occupancy of the building. Table H3 gives percentages of time spent indoors for 1 y olds, 10 y olds and adults based on (Roy and Courtay, 1991). The dose indoors is reduced by a factor of 0.2 for irradiation from the cloud and 0.1 from deposited activity due to shielding (Brown and Jones, 1993). Doses to people outdoors from the external gamma exposure from the cloud in an urban area are also likely to be smaller than those outdoors in a rural area due to shielding by surrounding buildings. (Brown and Jones, 1993) indicates that dose rates from the external gamma exposure from the cloud outdoors in urban areas can be obtained by multiplying dose rates outdoors in rural areas by 0.7. For doses outdoors from exposure to deposited activity no reduction in dose for either rural or urban areas was recommended.

If the building is a workplace then assuming occupancy during working hours only is sufficient. The combination of occupancy and shielding may mean that the nearest building to the source is not the location of the most exposed group.

Consumption of terrestrial foods

Atmospheric discharges lead to a transfer of radionuclides to terrestrial foods. People who subsequently ingest these foods must be considered. The areas of land used for agricultural production where the deposition from atmosphere is highest need to be identified. It is possible for people to grow vegetables in their gardens and this should be considered if appropriate. Local factors should be taken into account in determining the foods to consider.

Agricultural production occurs over large areas and so it is unrealistic to assume that all food consumed could be produced close to the source of the discharge. It might be cautiously assumed that a few foods could be produced over an area, which has a centre at a distance of few hundred metres from a discharge site's boundary. However, where it assumed that a number of different types of foods (e.g. milk, meat and vegetables) are produced close to the source of discharge, then it is more realistic to take account of the need for larger grazing areas, movement of livestock around a farm and rotation of crops. Thus, a distance of 500 m from the site fence would be a more realistic minimum distance for the production of food.

Intake rates of different terrestrial foods are required to estimate doses. Information is available for the EU of the amount of food consumed by the population as a whole and Table H5 gives the average per capita consumption for the EU. For estimating doses to reference groups, higher intakes are used for the key foods as the aim is to calculate doses to the group that is most exposed. There are two difficulties with this. The first is in knowing what higher intake rates to use and the second is knowing how many foods are eaten at these higher rates. Ideally survey information would be available showing the distributions in intakes for different foods and for combinations of foods. In the absence of this, use has to be made of the information that is available.

It is unlikely that people will eat all of their foods with a high intake and therefore high intake rates have been derived for each EU country for the four food types most likely to give rise to the highest doses. Table H5 gives the high consumption rates for milk, root vegetables, fruit and green vegetables. There is evidence from UK national and regional habit surveys that people rarely consume more than two foods at high rates (Ministry of Agriculture Fisheries and Food, 1996). In realistic assessments local knowledge should be used to determine which foods are consumed at high rates and which foods are consumed at average rates. The foods chosen for consumption at the highest rates should be those that give rise to the highest dose. The amount of food derived from local sources will also need to be determined as local agricultural practices and lifestyles will vary according to the site considered. The most cautious assumption will be to assume that all the terrestrial foods are locally produced. However this will probably be unrealistic and will lead to an overestimation in doses.

There is little information available on food consumption rates for infants and children. The information available is discussed in Jones et al (2002) and can be used to determine generic intake rates in the absence of local information. Table H7 gives scaling factors which could be applied to the average and high consumption rates (Table H4 and Table H5) to give consumption rates of 1 y and 10 y olds for EU countries. However these factors are based on

UK data (Byrom et al, 1995) and patterns of consumption vary between EU countries and between age groups. Therefore it is preferable to use data gathered in the region being considered.

Figure D1: The Climate in Europe

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Appendix E - Guidance on assessing doses from aquatic discharges

Guidance on the exposure pathways to consider, the methodologies to use to assess doses, and how to identify the relevant reference groups, for NORM aquatic discharges is given below.

Exposure pathways

From information on NORM industries obtained as part of Task 1 and from other sources it is clear that aquatic discharges can occur to rivers, estuaries, and the marine environment. Discharges to each are considered in turn below. Results from assessments of the consequences of such releases and similar information on the consequences of releases from nuclear installations are used to separate the exposure pathways into several types:

- those pathways that should always be considered;
- those that should be considered depending on local conditions; and
- those that should not normally be considered.

For marine and river releases, the local-specific pathways have been split into: those that will give rise to significant doses compared with those that could give rise to less significant doses. Less significant doses are those likely to be around one order of magnitude less than the most dominant 'conventional' pathway. A 'conventional' pathway is one that is typically found at the majority of sites e.g. consumption of fish, time spent on inter-tidal areas. Unconventional pathways are those that may occur around a few sites, e.g. consumption of cow's milk from animals grazing on salt marshes, but are not characteristic of most sites.

Discharges to the aquatic environment can result in markedly different doses for the same release rates depending on the receiving water body. For example, the doses received from discharges to a river would be dependent on the volumetric flow of the river. Similarly, discharges to the marine environment would result in doses that are affected by the currents in the area. Additionally, radionuclides exhibit differing sediment partitioning and biota uptake in marine and freshwater environments. In general, assessments due to aquatic discharges must include an element of site-specificity in the modelling of their impact.

Marine Discharges

Discharges to the sea from off-shore installations
A study carried out on the radiological impact or releases from off-shore oil and gas platforms (Warner Jones et al, 2002) considered the following exposure pathways: consumption of fish, crustaceans, molluscs and, where applicable, seaweed; inhalation of sea spray; and external irradiation from contaminated fishing gear.

The majority of the predicted individual doses (>99%) was from the consumption of fish, crustaceans and molluscs. These doses were determined using consumption rates typical of

high UK consumers however it is considered that the importance of the consumption of seafood is likely to dominate doses from marine releases from all EU nations. Doses from sea spray were six orders of magnitude lower and can therefore be generally discounted from consideration in such assessments. Doses from external irradiation from fishing gear were approximately three orders of magnitude below the dose from seafood consumption and therefore not of general significance.

Pathways that should always be considered for marine releases from offshore installations:

- Ingestion of seafood (fish, crustaceans, mollusc)

If the discharge is close to shore then additional pathways such as external exposure from beach sediment may also need to be considered.

Discharge to estuaries and the sea from off-shore facilities
A study carried out to assess the radiological impact of discharges to the marine environment by pipeline from an onshore facility for cleaning components from off shore oil and gas platforms (Warner Jones et al, 2002) considered the following exposure pathways: consumption of fish, crustaceans, molluscs; inhalation of sea spray; inhalation of beach sediments, external irradiation from contaminated fishing gear; and external irradiation from beach sediments.

Again the dominant pathway was consumption of seafood. Doses from inhalation of sea spray and beach sediment were over seven orders of magnitude lower and could therefore be discounted from consideration. Doses from external irradiation from beach sediment and from fishing gear were again approximately three orders of magnitude lower. These conclusions are appropriate for the radionuclides considered in the study i.e. ^{226}Ra+ and ^{228}Ra+ and daughters.

In Jones et al (2002) the results of illustrative calculations for typical releases to estuaries and the marine environment from nuclear installations and for unit releases of a number of radionuclides were used to identify the exposure pathways that should nearly always be considered. These were: ingestion of radionuclides in the main marine foods (e.g. fish, crustaceans, and molluscs) and external irradiation from gamma-emitting radionuclides on beaches.

Doses from external irradiation dominated those from ingestion for those radionuclides which, as expected, are strong gamma emitters. It was also found for a small number of radionuclides that inadvertent ingestion of sediment or inhalation of re-suspended sediment dominated doses.

NCRP have also given guidance on screening models for assessing the consequences of releases of radionuclides to the environment (NCRP, 1996). The screening model for release to the marine environment includes the following exposure pathways:

- Ingestion of fish

- External irradiation from beach deposits

- External irradiation while swimming and boating

Doses from unit discharges of a large number of radionuclides, including all those considered in this study to a generic marine environment are also presented in the report. The doses from swimming and boating were trivial for all the radionuclides concerned. The importance of other pathways for the radionuclides considered is presented in the table below:

Radionuclide	**Exposure pathways**
^{238}U	External irradiation from beach
^{235}U	External irradiation from beach
^{234}U	Fish consumption, external irradiation from beach
^{232}Th	Fish consumption, external irradiation from beach
^{230}Th	Fish consumption
^{228}Th	Fish consumption, external irradiation from beach
^{231}Pa	Fish consumption, external irradiation from beach
^{227}Ac	External irradiation from beach, fish consumption
^{226}Ra	External irradiation from beach, fish consumption
^{210}Pb	Fish consumption
^{210}Po	Fish consumption

On the basis of the above information pathways that should always be considered for releases to estuaries and the marine environment from onshore installations:

- Ingestion of seafood (fish, crustaceans, molluscs)

- External irradiation from beach/estuary sediments

Important pathways to consider if local conditions indicate appropriate
These pathways give rise to relatively important doses for the majority of sites, irrespective of the local dispersion conditions in the locality of the site. The pathways also represent those likely to give doses of the order of the most dominant 'conventional' pathway.

If there are indications that local people consume marine/estuary plants then the doses received from this pathway can form a significant proportion of the total dose received by an individual. Habit surveys should be used, where possible, to identify whether individuals ingest such plants in the locality of a site.

Other pathways which can result in relatively important doses if local conditions suggest they occur are the consumption of marine biota other than plants e.g. Aphrodite aculeate (sea mice) and the ingestion of animal products produced from animal grazing on salt marshes.

Pathways that could be considered if local conditions indicate appropriate
The ingestion of crops grown on soil conditioned using seaweed (e.g., grain, root vegetables) could be significant if this practice occurs in the locality of the site. Seaweed can be used as a conditioner to improve soil fertility. This allows radionuclides incorporated in the seaweed to be available for uptake by crops grown on such soil.

Exposure while swimming could be relevant if there are individuals who spend long periods of time swimming e.g. a hour a day.

An additional pathway for consideration is desalinated water used for drinking water. The importance of this pathway will be very much dependent on the location of the abstraction of the seawater compared to the discharge point and whether the desalinated water is used for drinking water.

Pathways not normally considered
As mentioned above, the inhalation of sea spray was found to be unimportant for marine releases from oil and gas facilities. This conclusion was also reached for the nuclear plant discharge scenarios considered in Jones et al (2002). It was also found in Jones et al (2002) that inadvertent ingestion of seawater while swimming was an unimportant pathway. Doses from crops or animals farmed on land exposed to sea spray or reclaimed from the sea were also found to be negligible. Inadvertent ingestion of beach/estuary sediment was found to lead to insignificant doses. However for infants although the doses from this pathway were insignificant, i.e. order of few $\mu Sv\ y^{-1}$, as infants receive less exposure from the conventional pathways (e.g. consumption of seafood, exposure from sediments) then the relative contribution from this pathway is higher.

Negligible doses were found to be received from beta-emitters in beach/estuary sediment and the inadvertent ingestion of seawater. The doses from beta and gamma-emitters entrained in fishing gear gave extremely small doses. The skin dose received while bait-digging was found to be negligible. The exposure of individuals who spend time on boats does not lead to significant doses. The inhalation of re-suspended sediments or conditioned soil were both found to be insignificant contributors to dose.

Riverine discharges

A number of studies have been carried out of the radiological consequences of discharges of naturally occurring radionuclides to rivers. Many are relevant to this discussion of the most important exposure pathways to consider and the conclusions of these studies are presented below.

A study has been carried out to determine screening levels for river discharges from small users containing the following radionuclides: ^{238}U, ^{234}U, ^{226}Ra, ^{210}Pb and ^{210}Po (NRPB, 2002). This used conservative assumptions to determine screening levels. The following five exposure pathways were considered:

- External exposure to riverbed sediments
- Internal exposure from inhalation of riverbed sediments
- Ingestion of freshwater fish
- Ingestion of water
- Ingestion of foods (green vegetable and root vegetables) produced on land irrigated with river water

The most important pathways were ingestion of water, freshwater fish and foods grown on irrigated land. The dose from inhalation of riverbank sediments was trivial and that from external exposure was always less than 0.5%.

A related study to determine generalised derived limits (GDLs) for freshwater and freshwater sediments for the same radionuclides (NRPB, 2000) considered the following exposure pathways

Environmental medium	Exposure pathways
Freshwater	***Aquatic exposure pathways*** Ingestion of river water Ingestion of freshwater fish External exposure from shoreline sediment Inhalation of re-suspended shoreline sediment ***Exposure pathways from soil irrigation*** External exposure from irrigated soil Inadvertent ingestion of irrigated soil Inhalation of re-suspended soil Ingestion of plant products from irrigated soil
Freshwater sediments	External exposure from sediment Inadvertent ingestion of sediment Inhalation of re-suspended sediment

For the freshwater GDL ingestion of drinking water, freshwater fish and terrestrial foods are the most important contributors. Inhalation, inadvertent ingestion and external irradiation from irrigated soil contributed less than 3% to the GDL.

For freshwater sediments inadvertent ingestion accounts for nearly 100% of the GDL for ^{210}Po and 96% of the GDL for ^{210}Pb. The external pathway accounts for between 90% and 99% of the GDLs for ^{238}U, ^{235}U and ^{226}Ra. The GDL for ^{234}U is dominated by the inadvertent ingestion pathway.

An IAEA report on generic models for use in assessing the impact of discharges of radioactive substances to the environment (IAEA, 2001) includes results for generic

conservative calculations of doses received following unit discharges to rivers of a number of radionuclides including ^{238}U, ^{235}U, ^{234}U, ^{232}Th, ^{230}Th, ^{231}Pa, ^{228}Th, ^{226}Ra, ^{210}Pb and ^{210}Po. These considered only three exposure pathways:

- Ingestion of drinking water
- Ingestion of fish
- External irradiation from shore sediment

The percentage contribution is shown in the following table:

Nuclide	Contribution %		
	Drinking water	Fish	External
^{238}U	61	35	4
^{235}U	63	36	0
^{234}U	61	35	4
^{232}Th	10	50	40
^{230}Th	11	54	35
^{231}Pa	66	33	1
^{228}Th	15	75	10
^{226}Ra	25	73	2
^{210}Pb	5	95	0
^{210}Po	26	74	0

NCRP have also given guidance on screening models for assessing the consequences of releases of radionuclides to the environment (NCRP, 1996). The screening model for release to rivers includes the following exposure pathways:

- Ingestion of water
- Ingestion of freshwater fish
- Ingestion of foods produced on irrigated soils: vegetables, milk and meat
- Inadvertent ingestion of soil
- External irradiation from shoreline deposits and irrigated soil
- Irradiation while swimming and boating

Doses from unit discharges of a large number of radionuclides, including all those considered in this study, to a generic river are also presented in the report. The doses from swimming and boating were trivial for all the radionuclides concerned. The importance of the pathways for the radionuclides are presented in the following table.

Radionuclide	Exposure pathways
^{238}U	External (55%), vegetables, water and soil - 93%
^{235}U	External (80%), vegetables, water and soil - 97%
^{234}U	Vegetables, water, soil (85%), fish, milk and meat - 100%
^{232}Th	External (76%), fish, vegetables, soil and water - 100%
^{230}Th	Fish (40%), vegetables, water, soil and external - 100%
^{228}Th	External, fish, vegetables, water and milk - 97%
^{231}Pa	Vegetables, soil, water, external, and fish - 97%
^{227}Ac	External irradiation, water, vegetables, soil and fish - 100%
^{226}Ra	External (72%), soil, water, fish and vegetables - 97%
^{210}Pb	Water, fish, vegetables and soil - 98%
^{210}Po	Fish, water, vegetables (87%), milk and meat - 100%

NB Percentages in () are subtotals for the preceding exposure pathways. Percentages at the end are the total for all the exposure pathways included.

It should be noted that the results for the NCRP study are generally in broad agreement with the other studies. The only pathway for which this is not the case is the inadvertent ingestion of soil. The NCRP study assumes a consumption rate of 0.25 g d^{-1} (equivalent to 9.13 10^{-2} kg y^{-1}). The inadvertent soil consumption rates used in the NRPB GDL study were a factor of two lower for infants (the highest consuming group).

It is clear that the important exposure pathways for releases to rivers depend in detail on site-specific factors such as whether it is used for drinking water, irrigation etc. and the quantities used. However, on the basis of the above information it is clear that in the majority of cases the following exposure pathways should be considered:

- Ingestion of drinking water
- Ingestion of freshwater fish
- External irradiation from radionuclides in river bank sediments

If the river is used for irrigation then the following exposure pathways should be included.

- Consumption of foods grown on irrigated land

Important pathways to consider if local conditions indicate appropriate
External exposure on houseboats can be a relatively important pathway due to the amount of time spent on the water with relatively little shielding. Data on occupancy times should be taken from habits surveys, if available.

Pathways that could be considered if local conditions indicate appropriate
These pathways could give rise to relatively important doses for some sites, dependent on the local dispersion conditions in the vicinity of the site. These pathways also represent those likely to give doses less than the most dominant 'conventional' pathway. Some of these pathways are unlikely to be additive to the 'conventional' pathways e.g. it is unlikely that someone would spend 300 h y^{-1} swimming in addition to spending 500 h y^{-1} on the river bank.

The illustrative calculations in Jones et al, (2002) demonstrate that for releases from nuclear installations it can be important to consider the ingestion of freshwater molluscs and crustaceans. Ingestion of animal meat or milk from animals drinking river water should be considered as a pathway if likely to occur. These pathways may give rise to relatively important doses from some sites dependent on the local dispersion conditions in the locality of the site. The ingestion of crops grown on previously flooded land can form a significant proportion of the total dose, especially to infants. The inadvertent ingestion of riverbank sediment becomes important for younger age groups, depending on the mix of radionuclides released to the river. External exposure during swimming or while using boats for recreational purposes can be important dependent on the occupancy and radionuclides released.

Lake discharges

For discharges to lakes the situation will be similar to that for discharges to rivers. The same exposure pathways should be considered with local factors taken into account. Limited calculations for discharges to a lake in the UK indicate that doses are likely to be higher for discharges to a lake than for the equivalent discharges to a river because of the limited movement of water out of the lake.

Assessment Methodology

Radionuclides discharged to water bodies are dispersed due to general water movements and sedimentation processes. Liquid wastes may be discharged to freshwater, marine or estuarine environments. Much depends on the local characteristics of the receiving environment and it is not possible to have a totally generic model for liquid releases. Discussion on the various models available for simulating transfer in the aquatic environment occurred previously in a European Commission Concerted Action (Simmonds et al., 2000). Models available vary in purpose and complexity and should be selected appropriately. Examples of compartmental models available for marine discharges are PC CREAM (Mayall et al., 1997) and Poseidon (Lepicard et al., 1998). Both of these models represent the European marine waters as a series of inter-linked water and sediment compartments. Another approach is that used for CSERAM (Aldridge, 1998). This is a more complex model used for a specific region of the marine environment, i.e. Irish Sea. For continuous routine releases all of these models are likely to give similar results.

If water is discharged into a river, then the influential parameters are the discharge rate and the river flow rates, the river size, the sedimentation rate and the nature of the sediment. Generally speaking, the maximum concentration within the water body is near the discharge point. At some kilometres distance downstream, around 10 km, homogeneity in the radionuclide concentrations in the water body exists (SSK, 1992). However, additional

dispersion occurs due to sedimentation and the presence of tributary waters leading to a reduction in radionuclide concentration.

(i) The amount of dispersion may be different for the different pathways e.g. water for irrigation purposes is abstracted solely during summer dry periods. The amount of dispersion for this pathway should therefore to be based on the summertime flow rate (SSK, 1992). The fish habitat may comprise of tributaries of small rivers and streams both up- and downstream of the discharge point. The amount of dispersion will be an average weighted over the different compartments of the river that are used to calculate the radionuclide concentration in the fish.

(ii) If a lake is the receiving medium, then the maximum dispersion depends on the flow rate of the water passing through the lake. In countries with seasonal drought the concentration of radionuclides in the lake may vary throughout the year, especially if the draining from the lake ceases completely for a period of time.

In assessing doses to the reference group, the highest activity concentrations and hence doses will generally arise close to the discharge point. However, there is the possibility of exposures arising from further a field, for example where drinking water is abstracted or where there is a major fishery. Freshwater may be used for irrigation of agricultural land and then the transfer of radionuclides to the terrestrial food chains needs to be considered. The models discussed above for releases to atmosphere can be used also where the source of radionuclides is via irrigation water.

Discharges to sewage works

Work by Titley et al. 2000 has indicated that if radioactive waste from a non-nuclear site is discharged directly to a sewage works then there is the potential for sewage workers to receive significant doses. Therefore if assessing doses from a site which directly discharges to a sewage plant it is important that the doses to sewage workers are assessed. Account also has to be taken of the radiation doses that could arise from the disposal of the sewage sludge. Possibilities include incineration of the sludge or using the sludge as land treatment (see (Titley et al., 2000), (NRPB, 1998) and (NRPB, 2000)). Because of the low activity, large volume nature of much of the discharges from NORM industries it is unlikely that discharges from NORM industries would be made to sewers (Task 1 identified only one facility for which this was a disposal route).

Reference groups

Factors relevant to the identification of reference groups for the key routes of exposure for aquatic releases are discussed below.

Marine discharges

For discharges to the marine environment, the most exposed groups are likely to include those persons who consume higher than average amounts of locally caught seafood (fish, crustaceans and molluscs) and those people who spend a relatively large amount of time on areas of sediment or sand and so are exposed to external irradiation (this could also include

handling sediment or sand). It should be noted that the reference group for marine discharges does not necessarily live close to the source of the discharge. The activity concentration of seafood is very dependent on the site where the fish, crustaceans etc. inhabit. Table H8 gives the marine food consumption rates for the EU member states. Table H3 gives generic occupancy rates over intertidal sediments for reference groups.

Freshwater discharges

For discharges to freshwater the exposure pathways of concern may include consumption of freshwater fish and exposure due to irradiation whilst on riverbanks. Table H6 gives the consumption rate data of freshwater fish for EU Countries for average and high intake rates and Table H3 gives the occupancies on river banks.

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Appendix F - Illustrative calculations to determine the important exposure pathways for atmospheric releases

Methodology

Discharges to the atmosphere can lead to exposure to the public by a variety of pathways. A series of illustrative calculations to investigate the relative importance of different exposure pathways following unit discharges of naturally occurring radionuclides to the atmosphere were undertaken, and the results are presented here.

A general methodology was established to assess radiation doses for unit discharges to atmosphere. Unit discharges of all the decay chain segments listed in Table 35 of the main text were considered. A list of exposure pathways considered in this study is given in Table F1. In most situations, the radionuclide activity concentrations in environmental media from discharges of naturally occurring radionuclides cannot be measured against the natural background levels and thus cannot be used for calculations of public exposure. It is for this reason that mathematical models are used to simulate the transfer of the radionuclides in the environment. The doses presented here were principally determined using the radiological impact assessment software PC CREAM (Mayall et al., 1997) which was developed for the European Commission and is a personal computer (PC) implementation of CREAM (Consequences of Releases to the Environment: Assessment Methodology) (Simmonds et al., 1995a).

Atmospheric dispersion of the radionuclides was estimated using a Gaussian Plume model (Simmonds et al., 1995a). All discharges were assumed to have been emitted from a 50 m stack in uniform windrose meteorological conditions, using meteorological conditions appropriate for northern Europe. Both wet and dry deposition to the ground were considered. Dry deposition was estimated using a source depletion model and a deposition velocity of 10^{-3} m s^{-1}, a value appropriate for 1 μm particles (Mayall et al., 1997). Wet deposition was estimated using a washout coefficient of 10^{-4} s^{-1}.

External gamma exposure from the radionuclides in the plume was estimated using a finite cloud model (Simmonds et al., 1995a), The transfer of deposited activity into local foods was calculated using the FARMLAND model, which is part of the suite of PC CREAM models and is described in (Brown and Simmonds, 1995). The activity concentrations in air due to wind driven resuspension and the external dose due to deposited activity were estimated using models described in (Simmonds et al., 1995a).

A number of exposure pathways listed in Table F1 are not included in PC CREAM. These pathways were the inadvertent ingestion of house dust, the inadvertent ingestion of soil, the consumption of pork, chicken, eggs, goat's milk, and sheep's milk, and the consumption of drinking water and freshwater fish following deposition on reservoirs. Doses were calculated for these pathways using deposition rates and activity concentrations predicted by PC CREAM. It was assumed that the diet of pigs and chickens consisted solely of cereals (MAFF, 1990) grown 500 m from the discharge point. The concentration of radionuclides in cereals was obtained from PC-CREAM. Models for the transfer of radionuclides from atmosphere into drinking water supplies were adapted from (Dionian and Linsley, 1983), and

the activity concentrations in the reservoir predicted by these models were used to calculate the activity concentration in fish from those water bodies.

Table F1 Exposure pathways considered for the atmospheric release

PATHWAY	DESCRIPTION	MODEL
Inhalation	Inhalation of radionuclides in the plume	PC CREAM (PLUME)
	Inhalation of resuspended activity	PC CREAM (RESUS)
	Inhalation of dust resuspended into the indoor environment	Method described herein
External Irradiation	External gamma from airborne radionuclides	PC CREAM (PLUME)
	External beta from airborne radionuclides.	PC CREAM (ASSES)
	External gamma from deposited radionuclides	PC CREAM (GRANIS)
	External beta from deposited radionuclides.	PC CREAM (ASSES)
Inadvertent Ingestion	Inadvertent ingestion of house dust	Method described herein
	Inadvertent ingestion of soil	Method described herein
Ingestion	Cow meat	PC CREAM (FARMLAND)
	Cow's milk	PC CREAM (FARMLAND)
	Cow's milk products	PC CREAM (ASSES)
	Cow liver	PC CREAM (FARMLAND)
	Sheep meat	PC CREAM (FARMLAND)
	Sheep liver	PC CREAM (FARMLAND)
	Green vegetables	PC CREAM (FARMLAND)
	Root vegetables	PC CREAM (FARMLAND)
	Grain	PC CREAM (FARMLAND)
	Fruit	PC CREAM (FARMLAND)
	Pork, chicken and eggs	Method described herein
	Goat milk and sheep milk	Method described herein
	Drinking water following atmospheric deposition on reservoirs	Method described herein
	Freshwater fish following atmospheric deposition on reservoirs	Method described herein

Dose coefficients were taken from the Directive and are listed in Table 36 in the main text.

For each release doses were calculated to the three age groups identified in the main text: 1 year old, 10 year old and adult.

For each age group, food consumption rates averaged over EU countries have been used as representative of the reference group. It was assumed that the source of all terrestrial foods was 500 m from the discharge point. To be consistent with assumptions made in the calculation of exemption and clearance levels for natural radionuclides (European Commission, 2001) it was also assumed that 50% of all foods consumed were produced locally. It was assumed that the two most important foods were consumed at higher than average rates and the other foods at average rates. For each nuclide, the two most important

foods for each age group were identified by comparing the ingestion doses at critical ingestion rates for all the food types. Therefore the two most important foods could be different for different age groups and nuclides.

For some regions of the EU sheep and goats may be the main milk producing herds rather than cows. Therefore dose calculations were also done on the basis of the ingestion rate for goat's milk or sheep's milk being assumed to be equal to that for cow's milk in order to quantify any differences in dose.

Inadvertent ingestion rates appropriate for soil are based on a study by van Wijnen et al (1990) on the soil ingestion habits of children aged between 6 months and 5 years. This work provides soil ingestion rates under normal and extreme conditions (children staying in a campsite). These data are used as the basis for the average and high daily ingestion rates for 1 y old children given in Table F2. The corresponding values for older ages are estimated assuming an exponential decrease in soil ingestion with each year of life up to the age of 18 (Sedman and Mahmood, 1994).

Table F2 Inadvertent ingestion rates of soil and house dust

	Soil Ingestion rate (kg y^{-1})		House dust ingestion (kg y^{-1})
Age Group	**Average**	**High**	**Average**
1 y old	0.0365	0.044	0.0365
10 y old	0.0110	0.018	0.00365
Adult	0.00365	0.0083	0.00365

An intake rate of 100 mg d^{-1} (i.e., 0.0365 kg y^{-1}) of house dust is generally considered appropriate for 1 y olds, and has been used in previous assessments (Simmonds et al, 1995b). 10 y old children and adults are assumed to have intakes of a factor of 10 lower.

It was assumed that all individuals live 500 m from the discharge point, except for determining doses from inhalation of the plume where it was assumed that the individual was at the point of maximum ground air concentration. The percentage of time spent outside is given in Table H2 (the adult was assumed to be an outdoor worker). It was assumed that the individual resided at the chosen location throughout the year (8760 hours).

A number of potential exposure pathways following from the release of radionuclides into the environment were not included in the assessments carried out for this report. These include ingestion of free foods and deliberate ingestion of soil (pica). Free foods include berries, mushrooms, crab apples, rabbits, pheasants etc. When considering the ingestion of free foods, it is essential to have information on local habit data. Regional or national habit data cannot take account of the free food available in an area and large variability is observed between regions (Green et al, 1999). In addition, soil to plant transfer factors for many wild plants are difficult to obtain. For example, many species of mushroom grow in some areas, and since radionuclide uptake is species specific (Barnett et al, 1996) it would be very difficult to assess accurately the dose due to ingestion of wild mushrooms. It is, therefore, not possible to consider the ingestion of free foods in a generic way. The deliberate ingestion of soil by children or adults was not considered in this assessment because this pathway is a

recognised medical condition, known as *pica*, which tends to occur for a relatively short time.

Methodologies for the calculation of doses from pathways included in PC CREAM are described in Simmonds et al (1995a). Default data were used except as described above. Methodologies and data for the calculation of doses from the other exposure pathways are described below.

Inhalation of dust re-suspended into the indoor environment
The effective doses to each age group for each radionuclide from inhalation of house dust were determined using,

$$D_{idust} = A_{dust}\, B_{inh}\, D_{inh} \qquad A1$$

Where
D_{idust} = effective dose from house dust 500m away from release point (Sv y^{-1} per Bq s^{-1})
A_{dust} = radionuclide concentration of airborne activity in the 50th year due to resuspended house dust (Bq m^{-3} per Bq s^{-1}).
B_{inh} = inhalation rate (m^3 y^{-1}) as listed in Table H1.
D_{inh} = dose coefficient for inhalation (Sv Bq^{-1}) (Table 36 in the main text).

The ratio of house dust to outdoor soil concentration was assumed to be 2 (Simmonds et al, 1995b). To calculate the concentration of the resuspended house dust, a dust loading approach was taken,

$$A_{dust} = 2\, A_{soil}\, S_E \qquad A2$$

Where
A_{soil} = radionuclide concentration of soil estimated using FARMLAND (Bq kg^{-1} per Bq s^{-1})
S_E = dust loading factor, 10^{-4} kg m^{-3} (Simmonds et al., 1995b)

Inadvertent ingestion of house dust
The dose to each age group, for each radionuclide, from ingesting house dust were calculated using

$$D_{ingdust} = 2A_{soil}\, I_{ingdust}\, D_{ing} \qquad A3$$

Where
$D_{ingdust}$ = effective dose from ingestion of house dust at 500 m away from the point of discharge (Sv y^{-1} per Bq s^{-1})
$I_{ingdust}$ = ingestion rate (kg y^{-1}) (Table F2).
D_{ing} = dose coefficient for ingestion (Sv Bq^{-1}) (Table 36 of the main text).

Inadvertent ingestion of soil
The dose from inadvertent ingestion of soil to each age group from contaminated soil 500 m away from the point of discharge were determined using,

$$D_{ingsoil} = A_{soil}\, I_{ingsoil}\, D_{ing} \qquad A3$$

Where
$D_{ingsoil}$ = effective dose from ingestion of soil at 500 m away from the point of discharge (Sv y^{-1} per Bq s^{-1})
$I_{ingsoil}$ = soil ingestion rate (kg y^{-1}) (Table F2).
D_{ing} = dose coefficient for ingestion (Sv Bq^{-1}).

Ingestion of pork, chicken and eggs
Foods that are not included in standard PC CREAM calculations include pork, chicken and eggs. The activity concentrations in the food products were determined using,

$$A_{food} = A_{feed}\, I_{feed}\, T_{feed} \qquad A5$$

Where
A_{food} = activity concentration in food products (Bq kg^{-1} per Bq s^{-1})
A_{feed} = activity concentration in feed (Bq kg^{-1} per Bq s^{-1}) estimated using FARMLAND.
I_{feed} = daily intake rate of feed (kg d^{-1}) (Table F3).
T_{feed} = equilibrium transfer factor of feed to animal (d kg^{-1}) (Table F4).

Table F3 Diet and consumption rates for pigs and chickens

	Diet	Daily intake (kg d^{-1})
Pig	Cereals (100%)	1.0
Laying Chicken	Cereals (100%)	0.1
Table Chicken	Cereals (100%)	0.05

Table F4 Equilibrium transfer factors for pigs and chickens

	Pork	Chicken	Eggs	Goat/sheep milk
U	0.04	1.0	1.0	6E-4
Ra	0.0025	0.48	0.25	4E-4
Pa	0.005	0.004	0.004	5E-6
Pb	0.01	1.2	1.2	3E-4
Po	0.4	8.3	8.3	1E-4
Th	0.005	0.18	0.18	5E-6
Ac	0.0005	0.0066	0.016	2E-6

To calculate the dose due to the ingestion of these food products the following was used,

$$D_{food} = F_f\, A_{food}\, I_{ing}\, D_{ing} \qquad A6$$

Where
D_{food} = effective dose from ingestion of the food product produced at 500 m (Sv y^{-1} per Bq s^{-1})
I_{ing} = ingestion rate of the food (kg y^{-1}) (Table F5).
F_f = fraction of food grown locally, $F_f = 0.5$

Table F5 Consumption rates of foodstuffs (average) (kg y^{-1})

Food	Infant - 1 yr	Child - 10 yr	Adult
Pork	6	25	40
Poultry	6	15	30
Eggs	15	20	25
Sheep/goat milk	137	126	105

Ingestion of goat milk and sheep milk
Other foods not included in PC CREAM are goat and sheep milk. Radionuclide concentrations in these were determined using the following,

$$A_{milk} = A_{grass} I_{grass} F_m \quad \text{A7}$$

Where
A_{milk} = activity concentration in milk (Bq l^{-1} per Bq s^{-1})
A_{grass} = activity concentration in grass (Bq kg^{-1} per Bq s^{-1}) calculated using FARMLAND
I_{grass} = goat or sheep grass ingestion rate (kg d^{-1}) (Goats and sheep diet is assumed to consist solely of grass). I_{grass} value of 2.5 kg d^{-1} for sheep and goats is used (Prosser et al., 1999).
F_m = milk transfer coefficient (d l^{-1}). F_m represents the amount of the total daily intake of a radionuclide that is transferred to a litre of milk at equilibrium.

To calculate the dose due to the ingestion of these food products the following was used,

$$D_{imilk} = A_{milk} I_{imilk} D_{ing} \quad \text{A8}$$

Where
D_{imilk} = effective dose from ingestion of milk (Sv y^{-1} per Bq s^{-1})
I_{imilk} = ingestion rate of goat/sheep milk (kg y^{-1}). (No values of I_{imilk} have been found for sheep or goats. In the absence of actual values, average ingestion rates of milk equal to cow milk were used).

Consumption of water and freshwater fish following atmospheric deposition on a reservoir
The characteristics of a typical reservoir used in this study are listed in Table F6.

Table F6 The characteristics of a typical reservoir in the UK (from Dionian and Linsley, 1983)

Reservoir parameters	Characteristics of a General Reservoir
Catchment Area (km^2)	40
Surface area of reservoir (km^2)	3
Average annual volume (m^3)	3×10^7
Residence time (d)	200

Dionian and Linsley (1983) developed transfer models from atmosphere to reservoirs for radionuclides ^{137}Cs and ^{90}Sr, based on data collected from three upland reservoirs

from 1950s to 1980s. The ^{137}Cs model was adapted in this study for naturally occurring radionuclides. Progeny ingrowth was added for daughters that have significant ingrowth in 50 years. The difference between the ^{137}Cs model and the ^{90}Sr model is the additional reservoir sediment compartment for ^{137}Cs, which represents the sorption on sediments of ^{137}Cs. We considered that sedimentation of many naturally occurring radionuclides was an important process that could not be excluded.

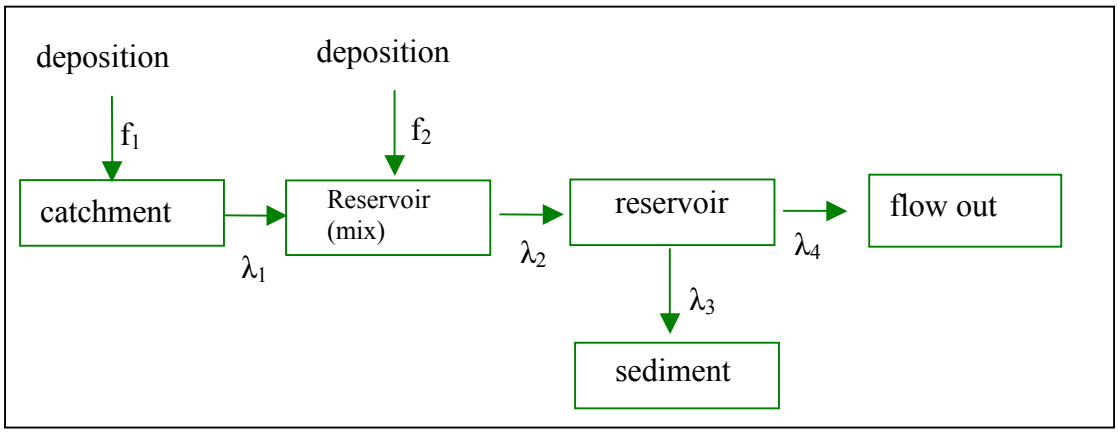
As shown in Figure F1, radionuclides released from stacks deposit on both the catchment area of a reservoir and the water surface. For continuous unit atmospheric release, the deposition rates, f1 and f2 are expressed as,

$f1 = R_{cat\_dep}\ SA_{cat}\ TT$ A9
$f2 = R_{res\_dep}\ SA_{res}\ TT$ A10

Where
f1, f2 = deposition rate due to unit release (Bq y^{-1} per Bq s^{-1})
R_{cat_dep} = deposition rate on catchment surface area (Bq m^{-2} s^{-1} per Bq s^{-1})

R_{res_dep} = deposition rate on reservoir surface area (Bq m^{-2} s^{-1} per Bq s^{-1})
SA_{cat} = catchment area (m^2) (Table F6)
SA_{res} = surface area of a reservoir (m^2) (Table F6)
TT = conversion factor of second to year, TT = 3.15E7

Figure F1 General model for the transfer of radioactive nuclides into a reservoir (λ_1=0.001 y^{-1}, λ_2=1 y^{-1}, λ_3=1.8 y^{-1}, λ_4=1.8 y^{-1})



It was assumed that the release point is at the centre of the catchment and the catchment is a circular area with a radius of 3.6 km. A uniform wind rose with 60% of Pasquill stability category D was assumed.

The reservoir is assumed to be 300 m from the discharge point. The reservoir is of a circular shape with radius of 1 km.

The radionuclide transfer rates assumed for the model were obtained from Dionian and Linsley (1983).

Table F7 Sedimentation –water distribution coefficients for freshwater environments and equilibrium concentration factors for freshwater fish (Aquatic modelling project committee report, Green Manual version 2).

Nuclide	Fish concentration factor ($Bq\ kg^{-1}/Bq\ m^{-3}$)
Pb	0.3
Po	0.05
Ra	0.05
Ac	0.03
Th	0.03
Pa	0.01
U	0.01

The activity concentration in the reservoir and drinking water are given by,

$$AC_{res} = A_{water} / V_{res} \quad \text{A11}$$
$$AC_{water} = AC_{res} (1 - Fr) \quad \text{A12}$$

Where
AC_{res} = activity concentration in the reservoir (Bq m^{-3} per Bq s^{-1})
AC_{water} = activity concentration in drinking water (Bq m^{-3} per Bq s^{-1})
A_{water} = activity in the reservoir (Bq per Bq s^{-1})
Fr = nuclide removal efficiency by treatment plant as a result of coagulation, settling etc. In the absence of relevant data, it is conservatively assumed to be zero
V_{res} = water volume in the reservoir (m^3)

The activity concentration in fish flesh was estimated using concentration factor

$$AC_{fish} = AC_{res} F_{fish} \quad \text{A13}$$

Where
F_{fish} = concentration factor of freshwater fish (Bq kg^{-1} per Bq m^{-3}) (Table F7)

Effective doses were calculated for three age groups from drinking water using,

$$D_{water} = AC_{water} I_{water} D_{ing} \quad \text{A14}$$

Where
D_{water} = effective dose in the 50^{th} year (Sv y^{-1} per Bq s^{-1})
D_{ing} = ingestion dose coefficient for the nuclide (Sv Bq^{-1})
I_{water} = ingestion rate of water (m^3 y^{-1})

The dose to each age group from ingestion of fish caught in the reservoir is

$$D_{fish} = AC_{res} I_{fish} D_{ing}$$

Where
I_{fish} = ingestion rate of freshwater fish (kg y^{-1})

Results

Radiation doses were estimated for unit releases (1 Bq s^{-1}) of all the naturally occurring radionuclide decay chain segments indicated in Table 35 in the main text. The purpose of these calculations was to illustrate the importance of different pathways for various radionuclides.

The resulting doses to each age group by radionuclide in μSv y^{-1} are given in Table F8.

Table F8 Estimated doses for a unit atmospheric release

	Dose, μSv y^{-1} per Bq s^{-1}		
Nuclide	**1 y old**	**10 y old**	**Adult**
U+238	3.6E-9	4.0E-9	4.2E-9
U-234	4.0E-9	4.7E-9	4.9E-9
Th-230	1.1E-8	1.5E-8	1.9E-8
Ra+226	1.6E-8	1.8E-8	1.4E-8
Pb+210	1.7E-8	1.2E-8	7.2E-9
Po-210	3.0E-8	1.9E-8	1.5E-8
Th-232	2.0E-8	3.0E-8	4.4E-8
Ra+228	1.2E-8	1.1E-8	6.2E-9
Th+228	4.3E-8	5.4E-8	5.7E-9
U+235	3.8E-9	4.4E-9	4.7E-8
Pa+231	9.2E-8	1.6E-7	2.0E-7
Ac+227	5.1E-7	6.7E-7	7.5E-7

The breakdown by pathway of individual doses to an adult due to unit releases is shown in Figure F2.

Figure F2 Breakdown of individual dose to an adult due to atmospheric release of a nuclide shown by pathway

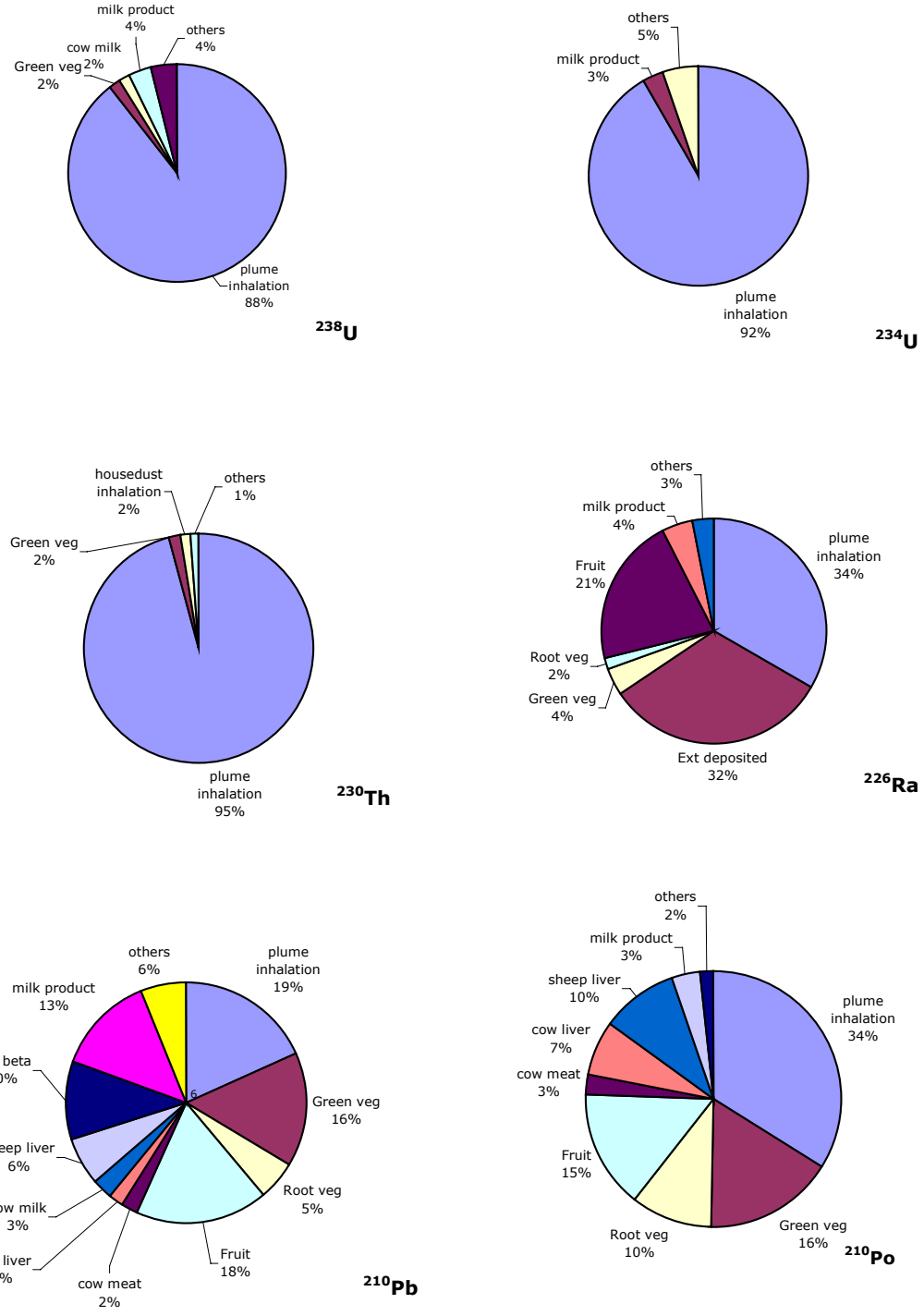
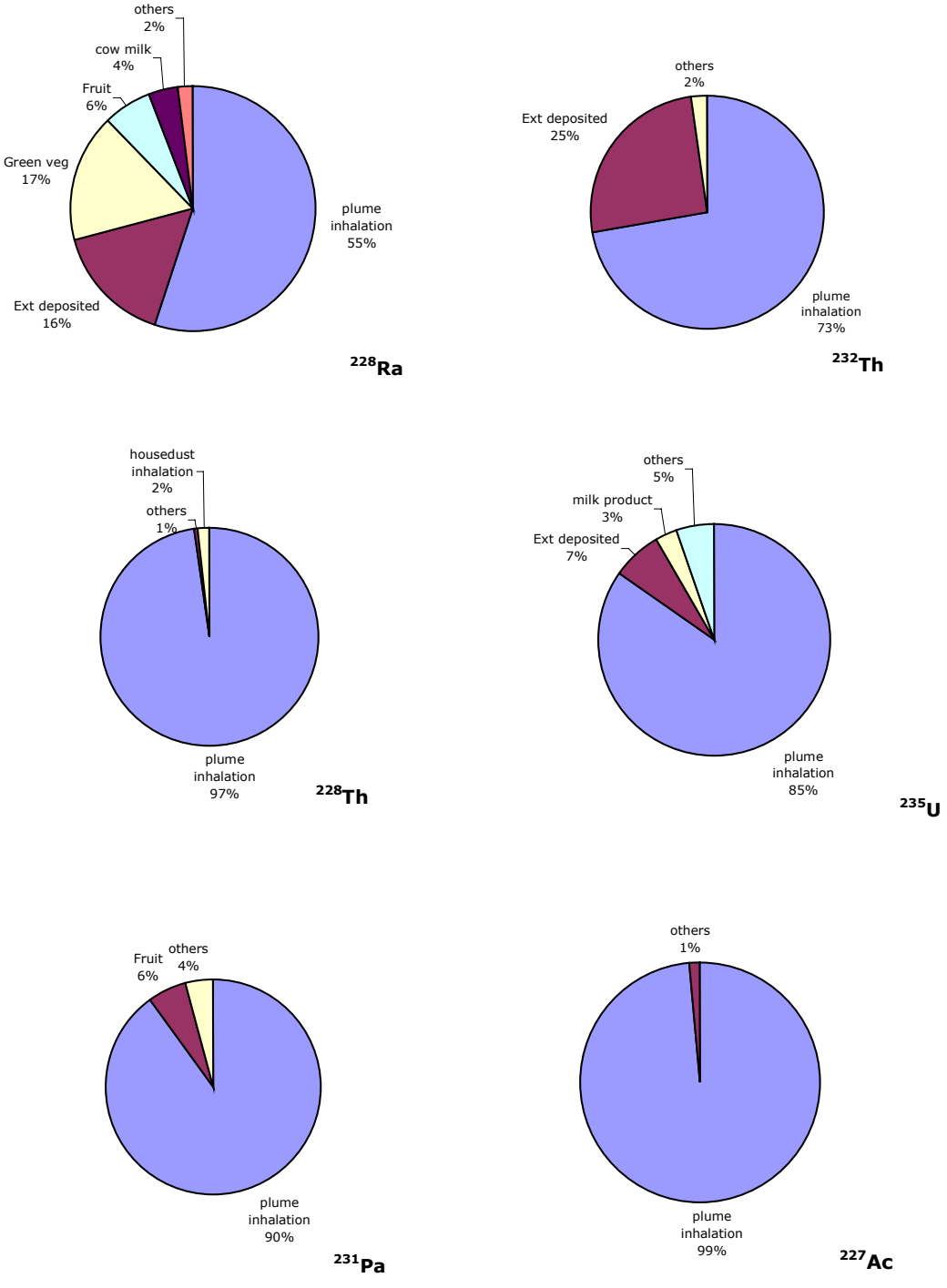


Figure F2 (cont'd)



NB: Pathways with a contribution greater than 1% of total dose are labelled individually; pathways less than 1% are summed together and labelled "others".

Doses via the ingestion of drinking water and the ingestion of freshwater fish following atmospheric deposition on reservoirs were not included in the above analysis. These were also estimated for unit releases of radionuclides. The resulting doses to each age group by radionuclide are given below.

Table F9 Estimated doses via ingestion of drinking water calculated for a unit atmospheric release

	Dose, μSv y^{-1} per Bq s^{-1}		
	1 y	10 y	Adult
U+238	1.6E-11	1.1E-11	1.3E-11
U-234	1.5E-11	1.1E-11	1.3E-11
Th-230	4.6E-11	3.6E-11	5.5E-11
Ra+226	2.9E-10	2.1E-10	1.4E-10
Pb+210	4.5E-10	5.5E-10	3.9E-10
Po-210	1.9E-10	7.6E-11	6.0E-11
Th-232	2.7E-10	2.4E-10	1.2E-10
Ra+228	5.1E-10	4.5E-10	1.4E-10
Th+228	6.9E-11	3.7E-11	2.1E-11
U+235	1.5E-11	1.1E-11	1.2E-11
Pa+231	2.2E-10	1.8E-10	2.3E-10
Ac+227	4.4E-10	2.8E-10	2.9E-10

Table F10 Estimated doses via ingestion of freshwater fish calculated for a unit atmospheric release

	Dose, μSv y^{-1} per Bq s^{-1}		
	1 y	10 y	Adult
U+238	6.3E-13	1.6E-12	4.2E-12
U-234	5.6E-13	1.6E-12	4.2E-12
Th-230	5.3E-12	1.6E-11	5.5E-11
Ra+226	1.1E-10	2.9E-10	4.4E-10
Pb+210	4.5E-10	1.3E-09	2.0E-09
Po-210	3.7E-11	5.4E-11	1.0E-10
Th-232	4.6E-11	1.5E-10	1.6E-10
Ra+228	9.5E-11	3.2E-10	2.3E-10
Th+228	8.0E-12	1.6E-11	2.1E-11
U+235	5.7E-13	1.6E-12	4.1E-12
Pa+231	1.4E-11	3.9E-11	1.1E-10
Ac+227	5.1E-11	1.2E-10	2.9E-10

Doses estimated from ingestion of drinking water and freshwater fish are lower than those presented in Table F8 i.e. for the main exposure pathways for atmospheric. Therefore consumption of drinking water and fish should not normally be considered in a dose assessment for atmospheric releases.

The dominant pathways for each radionuclide for each of the three age groups are presented in Tables F11, F12 and F13.

Table F11 Principal exposure pathways following atmospheric releases for a 1 y old child

Nuclide	Dominant Pathway
U+238	Plume inhalation, milk and milk products
U-234	Plume inhalation, milk and milk products
Th-230	Plume inhalation
Ra+226	Fruit, milk and milk products, plume inhalation
Pb+210	Milk and milk products, fruit, plume inhalation
Po-210	Root vegetable, fruit, egg
Th-232	Plume inhalation, external deposition
Ra+228	Milk and milk products, plume inhalation, fruit
Th+228	Plume inhalation
U+235	Plume inhalation, milk and milk products
Pa-231	Plume inhalation, fruit
Ac+227	Plume inhalation

Table F12 Principal exposure pathways following atmospheric releases for a 10 y old child

Nuclide	Dominant Pathway
U+238	Plume inhalation
U-234	Plume inhalation
Th-230	Plume inhalation
Ra+226	Fruit, plume inhalation
Pb+210	Milk and milk products, fruit, plume inhalation
Po-210	Plume inhalation, root vegetable, fruit
Th-232	Plume inhalation, external deposition
Ra+228	Milk and milk products, plume inhalation, fruit
Th+228	Plume inhalation
U+235	Plume inhalation
Pa-231	Plume inhalation, fruit
Ac+227	Plume inhalation

Table F13 Principal exposure pathways following atmospheric releases for an adult

Nuclide	Dominant Pathway
U+238	Plume inhalation
U-234	Plume inhalation
Th-230	Plume inhalation
Ra+226	Plume inhalation, external deposition, fruit
Pb+210	Plume inhalation, fruit, milk and milk products, green vegetables.
Po-210	Plume inhalation, green vegetables, root vegetables, fruit,
Th-232	Plume inhalation, external deposition
Ra+228	Plume inhalation, green vegetables, external
Th+228	Plume inhalation
U+235	Plume inhalation
Pa-231	Plume inhalation
Ac+227	Plume inhalation

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Appendix G - The significance of foetal doses for NORM discharges

Foetal doses are not normally included in assessments of radiation doses for members of the public. However, the recent publication of foetal dose coefficients (ICRP, 2001) permits the assessment of foetal doses for some of the naturally occurring radionuclides considered here (^{238}U, ^{235}U, ^{234}U, ^{234Th}, ^{232}Th, ^{230}Th, ^{228}Th, ^{228}Ra, ^{226}Ra, ^{224}Ra, ^{210}Pb, ^{210}Po).

Comparisons of foetal dose coefficients from ICRP Publication 88 (ICRP, 2001) with corresponding adult dose coefficients (Stather et al, 2002) show that doses received by a woman from intakes before or during pregnancy will in most cases be substantially greater than doses to her foetus. However, doses to the foetus can exceed doses to the mother for a number of radionuclides. With respect to the naturally occurring radionuclides listed above the only isotopes for which doses to the foetus can be higher than those to the mother are isotopes of radium (*the requirements of skeletal development during foetal growth, particularly in late pregnancy, can lead to significant uptake of radioisotopes of calcium and, to a lesser extent, other alkaline earth elements. Although strontium, barium and* ***radium*** *are chemically similar to calcium and are therefore taken up by the foetal skeleton, the placenta discriminates against them relative to calcium*). Table G1 gives the ratio of foetal doses to adult doses (from ICRP Publications 88 and 72 respectively) for ingestion of radium isotopes. This indicates that for chronic exposures, which are those that arise from the discharge of naturally occurring radionuclides to the environment, the foetal doses for ^{226}Ra and ^{224}Ra are greater than those to the adult for ingestion (note that foetal doses for inhalation of these radionuclides are less than the adult doses for all intake scenarios).

Table G1: Ratios of effective doses to the offspring to those for the reference adult for ingestion of radioisotopes of radium by female members of the public for acute intakes at various times before, at conception or after conception and for chronic intakes.

[data from (Phipps, 2002) derived from ICRP (2001) and ICRP (1996)]

Radionuclide	**Ratio for acute intakes at specified weeks or chronic intake**						
	0	5	10	15	25	35	Chronic
^{228}Ra	-	-	0.1	0.2	0.5	1.2	0.4
^{226}Ra	-	0.1	0.8	1.3	1.8	1.3	1.1
^{224}Ra	0.2	0.2	3.5	4.0	4.3	5.4	3.4

The data in Table G1 indicates that doses to the foetus from chronic intake for ^{226}Ra are 10% higher than those to the adult. In the majority of cases ^{226}Ra is present in equilibrium with all its daughters (including ^{210}Pb and ^{210}Po). Under these circumstances the total dose to the foetus from all the radionuclides in the decay chain will be less than that to an adult. Given the uncertainty in the determinations of foetal dose and other uncertainties in the dose assessment process it is considered reasonable even when ^{226}Ra is present unsupported by

longer-lived daughters to consider only the standard age groups when assessing doses from ^{226}Ra.

The ratio of foetal to adult dose for chronic intake of ^{224}Ra is 3.4. ^{224}Ra has a short half-life (3.66 days) and therefore does not contribute significantly to doses from discharges of naturally occurring radionuclides except as part of segments of the ^{232}Th decay chain. On the basis of foetal dose coefficients for Thorium and Radium given in ICRP Publication 88 it is clear that the foetal dose coefficient for intake of the ^{232}Th decay chain in equilibrium is approximately half that for the adult. The adult dose is also higher than the foetal dose for the ^{228}Ra decay chain in equilibrium. However, the foetal dose coefficient for intake of the ^{228}Th chain in equilibrium is approximately double that of the adult dose coefficient. Under most circumstances predicted doses from discharges of naturally occurring radionuclides will not be dominated by those from the ^{228}Th decay chain in equilibrium. Doses from discharges of naturally occurring radionuclides are also generally way below the relevant dose limits or constraints and as such consideration of foetal doses will generally be unnecessary.

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Appendix H - Habits for reference groups

This Appendix defines the generic habit information discussed in this report.

Inhalation rates

Inhalation rates derived from the ICRP Task Group report on the model of the respiratory tract (ICRP, 1994) are presented in Table H1.

Occupancy data

Indoor occupancy rates
There is the potential for reduction in dose, from external exposure and inhalation from radioactivity in the environment, during periods spent inside buildings. As a result, information on the amount of time spent indoors is required for many dose assessment purposes. There is little information available on occupancy rates within the EU. The information presented here is based on Northern European data and there may be differences in occupancies throughout Europe depending on the climate.

Two adult population groups are of interest for general assessment purposes: those who work predominantly outdoors and those who spend a significant fraction of their time indoors at home, work or school.

An analysis of the available data was reported in Jones et al (2002) and if no country or site specific data are available the data in Table H2 are recommended.

Occupancy rates over intertidal areas and river banks
As with the previous section, there is a paucity of data on occupancy rates on intertidal and beach areas and river banks for EU countries. The data presented here are based on information gathered for the UK and there will undoubtedly be variability in the occupancies over intertidal areas and river banks throughout the EU. The data from a review described in Jones at al (2002) are presented in Table H3. These data could be used if necessary but ideally regional or site-specific data should form the basis of a realistic assessment of doses.

Ingestion rate data

Terrestrial foods
The consumption of foods both terrestrial and aquatic are important exposure pathways. The basis of the data presented for terrestrial food and freshwater fish intake rates is the United Nations Food and Agricultural Organisation (FAO) food supply balance sheets (FAOSTAT, 2000). These were analysed in Jones at al (2002) to determine average consumption rates. Factors to convert from average to high consumption rates and from adult to child and infant consumption rates were derived in Jones at al (2002). The consumption rates and conversion factors are presented here in Tables H4-H7.

Marine foods
In Jones at al (2002) data from Simmonds at al (1995) were used to calculate the fish/crustaceans/molluscs consumption of a country from the sea area nearby, which were

taken from International Council for the Exploration of the Sea (ICES) annual reports. Scaling factors to convert to high consumption rates were also derived. The average and high consumption rates are presented in Table H8. Factors to convert to child and infant rates are given in Table H7.

Table H1 Inhalation rates

Age Group	Inhalation rate m^3y^{-1}
1 y old	$1.9\ 10^3$
10 y old	$5.6\ 10^3$
Adult	$8.1\ 10^3$

Data source: (ICRP, 1994)

Table H2 Indoor occupancy

Age group	% of day spent indoors
1 y old	95
10 y old	90
Housewife	95
Employed person	90
Outdoor worker	70

Table H3 Occupancy rates on intertidal areas and river banks (h y^{-1})

Age group	Occupancy rate (h y^{-1})	
	Intertidal area	River bank
1 y old	30	30
10 y old	300	500
Adult	2000	500

Data Source: Jones et al., 2002

Table H4 Average Per Capita consumption rates for EU countries for 1996 from Food and Agricultural Organisation database (kg y^{-1})

Food	Denmark	Germany	Greece	Spain	France	Ireland	Italy	Nether-lands	Austria	Portugal	Finland	Sweden	UK
Cereals	54	50	75	51	57	68	80	39	50	59	47	50	50
Root Vegetables	38	44	35	48	37	69	20	47	32	74	37	34	60
Fruit	42	57	66	49	43	43	62	67	49	55	34	44	40
Green Vegetables	16	15	32	22	22	14	25	16	18	27	12	12	15
Eggs	11	10	8	11	12	7	10	12	11	7	8	10	8
Milk	95	97	97	68	104	93	104	138	106	76	140	147	95
Milk Products	65	90	17	8	86	81	33	14	67	17	85	94	20
Beef	19	16	20	13	27	13	24	18	21	14	19	18	15
Mutton	0.4	0.5	6	3	2	4	0.7	0.6	0.5	2	0.2	0.3	3
Poultry	5	4	5	7	7	7	5	6	4	6	3	3	8
Pork	41	33	15	33	22	20	22	32	41	24	20	22	15
Offal	1	3	3	3	7	15	3	2	2	4	2	1.3	2

Data Source: ((FAOSTAT, 2000), 1996 Food Balance Sheets)

Table H5 High ingestion rates of terrestrial foods for EU Member States (kg y^{-1})

Food	Denmark	Germany	Greece	Spain	France	Ireland	Italy	Nether-lands	Austria	Portugal	Finland	Sweden	UK
Root Vegetables	81	95	76	104	79	150	44	102	69	161	81	74	130
Fruit	80	106	123	92	81	81	117	127	91	103	64	82	75
Green Vegetables	47	46	96	67	67	42	75	47	53	82	36	35	45
Milk	241	246	245	171	264	236	264	348	268	192	354	372	240

Data Source: ((FAOSTAT, 2000), 1996 Food Balance Sheets)

Table H6 Average and high ingestion rates (kg y^{-1}) of freshwater fish for EU Member States

Country	Average	High
Denmark	4.1	41
Germany	2.2	22
Greece	3.1	31
Spain	1.8	18
France	3.3	33
Ireland	3.3	33
Italy	1.8	18
Netherlands	2.5	25
Austria	2.9	29
Portugal	0.4	4
Finland	7.6	76
Sweden	3.9	39
UK	2.3	23

Data Source: ((FAOSTAT, 2000), 1996 Food Balance Sheets

Table H7 Factors to scale adult consumption rates to other age groups

Scaling factors (High rates)	1 y	10 y
Cow's meat	0.2	0.7
Cow's milk	1.3	1.0
Cow's milk products	0.8	0.8
Cow's liver	0.3	0.5
Sheep meat	0.1	0.4
Sheep liver	0.3	0.5
Green Veg	0.2	0.4
Root Veg	0.3	0.7
Grain	0.3	0.8
Fruit	0.5	0.7
Pork	0.1	0.6
Poultry	0.2	0.5
Eggs	0.6	0.8
Freshwater fish	0.1	0.3
Marine Fish	0.1	0.2
Marine Crustacea	0.0	0.3
Marine Molluscs	0.0	0.3
Scaling factors (Average rates)		
	1 y	**10 y**
Cow's meat	0.2	0.7
Cow's milk	1.3	1.2
Cow's milk products	0.8	0.8
Cow's liver	0.2	0.5
Sheep meat	0.2	0.5
Sheep liver	0.2	0.5
Green Veg	0.2	0.3
Root Veg	0.3	0.8
Grain	0.3	0.9
Fruit	0.5	1.0
Pork	0.1	0.5
Poultry	0.1	0.5
Eggs	0.6	0.8
Freshwater fish	0.3	0.7
Marine Fish	0.3	0.7
Marine Crustacea	0.0	0.6
Marine Molluscs	0.0	0.6

Data source: Jones et al (2002)

Table H8 Average and high ingestion rates (kg y^{-1}) of marine foods for EU Member States

Country	Fish		Crustaceans		Molluscs	
	Average	High	Average	High	Average	High
Belgium	7	68	1.4	28	7	23
Denmark	38	349	5	92	1.0	3
Germany	5	47	0.5	10	0.4	1.5
Greece	3	80	0.3	18	0.6	5
Spain	12	125	1.2	35	2	12
France	7	67	3	61	9	31
Ireland	21	191	0.8	15	0.7	3
Italy	3	42	0.7	32	2	21
Netherlands	11	99	3	57	5	18
Portugal	26	239	2	39	4	14
Finland	20	185	0.0	0.2	0.0	0.1
Sweden	16	150	1.1	23	1.2	4
United Kingdom	10	91	1.0	20	1.0	3

Data Source: Jones et al., 2002

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