EUROPEAN COMMISSION
DIRECTORATE-GENERAL FOR ENERGY AND TRANSPORT

Directorate H – Nuclear Energy
Radiation protection

TECHNICAL REPORT

VERIFICATIONS UNDER THE TERMS OF ARTICLE 35 OF THE EURATOM TREATY

DANISH NATIONAL MONITORING NETWORK FOR ENVIRONMENTAL RADIOACTIVITY

DENMARK

7 to 11 April 2008

Reference: DK-08/02

VERIFICATIONS UNDER THE TERMS OF ARTICLE 35 OF THE EURATOM TREATY

FACILITIES	Facilities for monitoring environmental radioactivity in Denmark
DATE	7 to 11 April 2008
REFERENCE	DK-08/02
INSPECTORS	V. Tanner (team leader)
	P. Vallet
	J-L. Frichet
	A. Ryan (trainee)
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DATE OF REPORT	18 February 2009

SIGNATURES

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TECHNICAL REPORT

ABBREVIATIONS

24/7	24 hours, 7 days per week
BEGe Detector	Broad Energy Germanium Detector
BSS	Basic Safety Standards
DD	Danish Decommissioning
DEMA	Danish Emergency Management Agency
DG TREN	Directorate-General for Energy and Transport
DTU	Danmarks Tekniske Universitet
EC	European Commission
EURDEP	EUropean Radiological Data Exchange Platform
FWHM	Full Width at Half Maximum
GM	Geiger-Müller (radiation detector)
GPS	Global Positioning System
HELCOM	Helsinki Commission
HELCOM COMBINE	Helsinki Commission – COoperative Monitoring in the Baltic marINe Environment
HELCOM MORS	Helsinki Commission – Monitoring Of Radioactive Substances
HEPA	High Efficiency Particulate
HPGe	High Purity Germanium (gamma radiation detector)
IAEA	International Atomic Energy Agency
ISO	International Standardization Organization
ISOCS	In Situ Object Counting System
MCA	Multichannel Analyser
NaI	Sodium Iodide (gamma radiation detector)
OLC	Operational Limits and Conditions
PAMS	Parameter Monitor Software
PET	Positron Emission Tomography
PMS	Permanent Monitoring Station
QA	Quality Assurance
SIS	Statens Institut for Strålebeskyttelse (Danish National Institute of Radiation Protection)
LiF TLD	Lithium-Fluoride Thermo luminescence Dosimeter
UPS	Uninterruptible Power Supply
UTC	Universal Time Coordinated

1. INTRODUCTION

Article 35 of the Euratom Treaty requires that each Member State shall establish facilities necessary to carry out continuous monitoring of the levels of radioactivity in air, water and soil and to ensure compliance with the Basic Safety Standards (BSS)[1].

Article 35 also gives the European Commission (EC) the right of access to such facilities in order that it may verify their operation and efficiency.

For the EC, the Directorate-General for Energy and Transport (DG TREN) and more in particular its Radiation Protection Unit (TREN H4) is responsible for undertaking these verifications.

For the purpose of such a review, a verification team from DG TREN visited sites located in Denmark, which are part of the national monitoring system for environmental radioactivity. The visit included meetings with representatives of the National Institute of Radiation Protection (SIS), Danish Decommissioning (DD), Risø National Laboratory for Sustainable Energy, Technical University of Denmark (Risø DTU), Copenhagen University Hospital (Rigshospitalet) and the Danish Emergency Management Agency (DEMA).

The present report contains the results of the verification team's review of relevant aspects of the environmental radiation surveillance in Denmark. The purpose of the review was to provide independent verification of the adequacy of monitoring facilities for air, soil, water and foodstuffs.

With due consideration to the scope of the verification mission and taking into account the relatively short time available for the execution of the programme, it was agreed that emphasis would be put on:

- The structure of the national environmental monitoring and sampling programme;
- DD and DTU analytical laboratories at the Risø site;
- Discharge monitoring at Rigshospitalet;
- Automatic monitoring systems and sampling at selected locations.

The present report is also based on information collected from documents referred to in Appendix 1 and from discussions with various persons met during the visit, listed in section 2.4.

The verification team acknowledges the co-operation it received from all participating individuals.

2. PREPARATION AND CONDUCT OF THE VERIFICATION

2.1. PREAMBLE

The Commission services decision to request the conduct of an Article 35 verification was notified to the Danish Government on 20 November 2007 (letter referenced TREN.H4/CG/cd D(2007) 326109 addressed to the Permanent Representation of Denmark to the European Union). The Danish Government subsequently designated the National Institute of Radiation Protection (SIS) to lead the technical preparations for the verification.

[1] Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the health protection of the general public and workers against the dangers of ionizing radiation

2.2. PREPARATORY DOCUMENTS

In order to facilitate the work of the verification team, information was supplied in advance by SIS in form of detailed answers to a questionnaire from the Commission services. Additional documentation was provided during and after the visit. All documentation received and other sources consulted are listed in Appendix 1. The information thus provided has been extensively used for the descriptive sections of this report.

2.3. PROGRAMME OF THE VISIT

EC and SIS discussed and agreed upon a programme of verification activities, based on a Communication by the EC[2], setting out the framework and modalities within which Article 35 verifications may be conducted.

A summary overview of the programme of verification activities is provided in Appendix 2. The verifications were carried out in accordance with the programme.

2.4. REPRESENTATIVES OF THE COMPETENT AUTHORITIES AND THE ASSOCIATED LABORATORIES

During the visit the EC verification team met the following representatives of the national authorities and other parties involved:

Representatives of the SIS

Name	Title
Mette Øhlenschlæger	Director
Kaare Ulbak	Chief advisor
Carsten Israelson	Head of section
Klaus Ennow	Specialist advisor
Hanne Waltenburg	Deputy director

Representatives of the DEMA

Name	Title
Michael Boesgaard Brøndel	Head of division
Steen Hoe	Senior advisor
Poul Erik Nystrup	Nuclear inspector
Jon Kristian Behring	Measurement specialist
Helle Karina Aage	Measurement specialist

Representatives of Risø DTU

Name	Title
Sven P. Nielsen	Head of the Radioecology Programme
Kasper Andersson	Senior scientist

[2] Verification of environmental radioactivity monitoring facilities under the terms of Article 35 of the Euratom Treaty, Practical arrangements for the conduct of verification visits in Member States, (OJ 2006/C 155/02).

Representatives of the DD laboratory at Risø

Name	Title
Per Hedemann Jensen	Head of Department
Kirsten Hjerrild Nielsen	Head of Department
Anne Sørensen	Head of Department
Bente Lauridsen	Senior health physicist

Representatives of Rigshospitalet

Name	Title
Liselotte Højgaard	Head of Department
Holger Jensen	Cyclotron Chief

3. BACKGROUND INFORMATION

3.1. INTRODUCTION

Denmark does not have a nuclear energy programme. There are several operational nuclear reactors in the vicinity of Denmark, in Germany and Sweden; therefore monitoring of radioactivity in the environment is well justified. Some parts of the Danish territory received a small radioactive deposition from the Chernobyl accident. In addition the long-term environmental contamination caused by the Thule nuclear weapon accident in Greenland in 1968 presents a very special challenge for environmental radiation monitoring in the Danish territory[3].

3.2. RESPONSIBLE ORGANISATIONS

3.2.1. National Institute of Radiation Protection

The National Institute of Radiation Protection (SIS) is a division in the National Board of Health. Its tasks have been laid down in the Danish legislation on X-rays, radioactive materials and nuclear installations. SIS is the ionizing radiation regulatory authority and one of the joint nuclear regulatory authorities according to the law on nuclear installations. Its tasks include protecting the Danish population, animals and the environment against unnecessary radiation, formulating regulations, licensing and inspection, providing information and advice, standardisation and carrying out supervision of radiation controlled areas. SIS is operating under the responsibility of the Ministry of Health and Prevention.

SIS always has a duty officer on call that can intervene in the event of a radiological emergency.

3.2.2. Danish Emergency Management Agency

The Danish Emergency Management Agency (DEMA) is as SIS one of the two joint nuclear regulatory authorities according to the law on nuclear installations. DEMA is responsible for the Danish nuclear emergency preparedness and response and for the international cooperation on nuclear safety and preparedness. It is also in charge of the permanent radiation monitoring stations. DEMA is operating under the responsibility of the Ministry of Defence.

DEMA always has a duty officer on call that can intervene in the event of a nuclear emergency.

[3] Greenland is not an EU territory, so the monitoring done in Greenland was not subject to verification.

3.2.3. Risø National Laboratory for Sustainable Energy, Technical University of Denmark

The Radiation Research Division of the Risø National Laboratory for Sustainable Energy (Risø DTU) works in the fields of radiation safety, radiation physics, dosimetry, radioecology, tracer studies, radiochemistry, isotopes, nuclear instruments and industrial and medical applications of nuclear methods. The Division carries out the national environmental radioactivity monitoring programme in Denmark.

Risø DTU carries out sampling and analysis of radionuclides in environmental samples collected on the Risø site and in Denmark as well as foodstuffs samples collected in Denmark.

3.2.4. Danish Decommissioning

Danish Decommissioning (DD) is an institution under the Ministry of Science, Technology and Innovation. It is responsible for the operation and decommissioning of the nuclear facilities at the Risø site.

4. LEGAL PROVISIONS FOR ENVIRONMENTAL RADIOACTIVITY MONITORING

4.1. LEGALLY BINDING DOCUMENTS

Denmark has basic legislation in the area of radiation and nuclear safety, but a major part of the environmental monitoring framework is covered by agreements between government bodies rather than legislative texts. The main legal acts regulating the environmental radiation monitoring are:

- Law no. 170 of 16 May 1962 on nuclear installations, which gives the general framework for regulating the nuclear installations in Denmark (DD and Risø DTU).
- Law no. 94 of 31 March 1953 on the use of radioactive substances, which gives the general framework for regulating users of radioactive materials in Denmark.
- National Board of Health order no. 954 of 23 October 2000 on the use of unsealed radioactive sources in hospitals, laboratories etc., which gives the more detailed requirements for the use of unsealed radioactive sources.

4.2. NON-BINDING DOCUMENTS

In addition to the binding legal requirements, there are important guidance documents, which are relevant to the environmental radiation monitoring. The most important ones are:

- Commission Recommendation 2000/473/EURATOM of 8 June 2000 on the application of Article 36 of the Euratom Treaty concerning the monitoring of the levels of radioactivity in the environment for the purpose of assessing the exposure of the population as a whole.
- HELCOM Recommendation 19/3 (1998), Manual for the marine monitoring in the COMBINE programme of HELCOM.
- HELCOM Recommendation 26/3 (2005), Monitoring of radioactive substances.
- IAEA Safety Guide No. RS-G-1.7, Application of the Concepts of Exclusion, Exemption and Clearance.

- European Commission publication Radiation Protection 113, Recommended radiological protection criteria for the clearance of buildings and building rubble from the dismantling of nuclear installations (2000).

5. MONITORING PROGRAMMES

5.1. MONITORING IN THE VICINNITY OF THE NUCLEAR INSTALLATIONS AT THE RISØ SITE

5.1.1. General

Law no. 170 of 16 May 1962 on nuclear installations provides the general framework for regulating nuclear installations in Denmark (DD and Risø DTU). In pursuance of the Law and delegation by the Ministry of Health and Prevention, SIS and DEMA have, as nuclear regulatory authorities, issued Operational Limits and Conditions (OLC) for the DD and for the Risø DTU. Environmental radioactivity monitoring in the vicinity of the Risø area is required in the OLC. Discharge monitoring of airborne and liquid releases from DD as well as clearance monitoring of solid materials is also required in the OLC.

The Operational Limits and Conditions are updated as necessary. The last revision dates from the 27th November 2007.

5.1.2. Sampling programme overview

A specific monitoring program in the vicinity of the nuclear installations at the Risø site is carried out by the Risø DTU on behalf of and as a contractor to DD.

This environmental surveillance program is described in the chapter 5.4.5 of the OLC. Table 1 presents the sampling program.

Table 1. Risø site environmental monitoring program

Number of samples	Object	Place	Frequency	Measurement
1	Air sample	Risø-area	Weekly	γ-spectrometry
1	Rain sample	Risø-area	Monthly	γ-spectrometry
1	Rain sample	Risø-area	Monthly	Tritium
1	Sediment sample	Roskilde Fjord between Risø-area and Bolund	Yearly	γ-spectrometry
1	Water sample	Roskilde Fjord at the quay in Risø-area	Quarterly	Tritium
1	Water sample	Roskilde Fjord at the quay in Risø-area	Yearly	Cs-137
1	Grass sample	Risø-area	Weekly	γ-spectrometry
1	Marine biota sample	Roskilde Fjord between Risø-area and Bolund	Yearly	γ-spectrometry
1	Sewage water sample	Waste Management Plan	Weekly	Total β-activity
25	External radiation	Risø-area	½ yearly	Scintillation counter and TLD

With regard to grass samples the OLC also stipulates that, additionally to the table 1, samples from the vicinity of Risø must be collected to a distance of 16 km each year. These samples must be stored and will be analysed in case of release from the Risø site.

5.1.3. Site monitoring systems

For site radiation monitoring Risø DTU uses two types of monitoring devices. The first is a LiF TLD (manufacturer ALNOR). The TLD measurement period is from May to April. The second device is a 2x4 inch NaI detector.

Calibration of TLD's is carried out by irradiation at a calibration irradiator which is traceable to the SIS reference. The NaI detector is calibrated periodically vs. a Reuter Stokes ionisation chamber.

For air radioactivity measurements there is a high volume air sampler manufactured by the Risø DTU. Air is drawn through a polypropylene filter at a rate of about 2000 m^3/h. The filter is normally changed every week. The flow is monitored by a flow meter connected to the outlet pipe. The flow meter reading is compared to that of a reference flow meter approximately every 3 years.

For precipitation sampling the Risø site operates two rain collectors with different collection areas. There is a 1 m^2 collector for monthly samples analysed for tritium and a 10 m^2 collector equipped with an ion-exchange column. The larger collector provides monthly samples for tritium analysis and ion exchange resin, which is analysed by gamma spectrometry in order to determine Be-7, Cs-137 and Pb-210 activity. Additionally, the resin samples are stored and bulked for four consecutive months and then analysed for Sr-90.

Risø DTU takes part frequently in intercomparison exercises. The last one in the environmental field was with the National Physics Laboratory (UK) in 2007.

Figures 1 and 2 indicate the monitoring locations (TLDs, NaI measurement points, precipitation collectors, PMS and air sampler) in and around the Risø site.

5.1.4. Reporting

The OLC chapters 14.1.1 and 14.1.2 specify the way to report the results. DD must forward a copy of the Annual Report to the nuclear regulatory authorities by the 1st of May on the following year. A report of the results of the measurements, which have been performed in connection with the environmental surveillance program, must be prepared semi-annually. DD also publishes on their webpage the results of the specific monitoring programme at the Risø site.

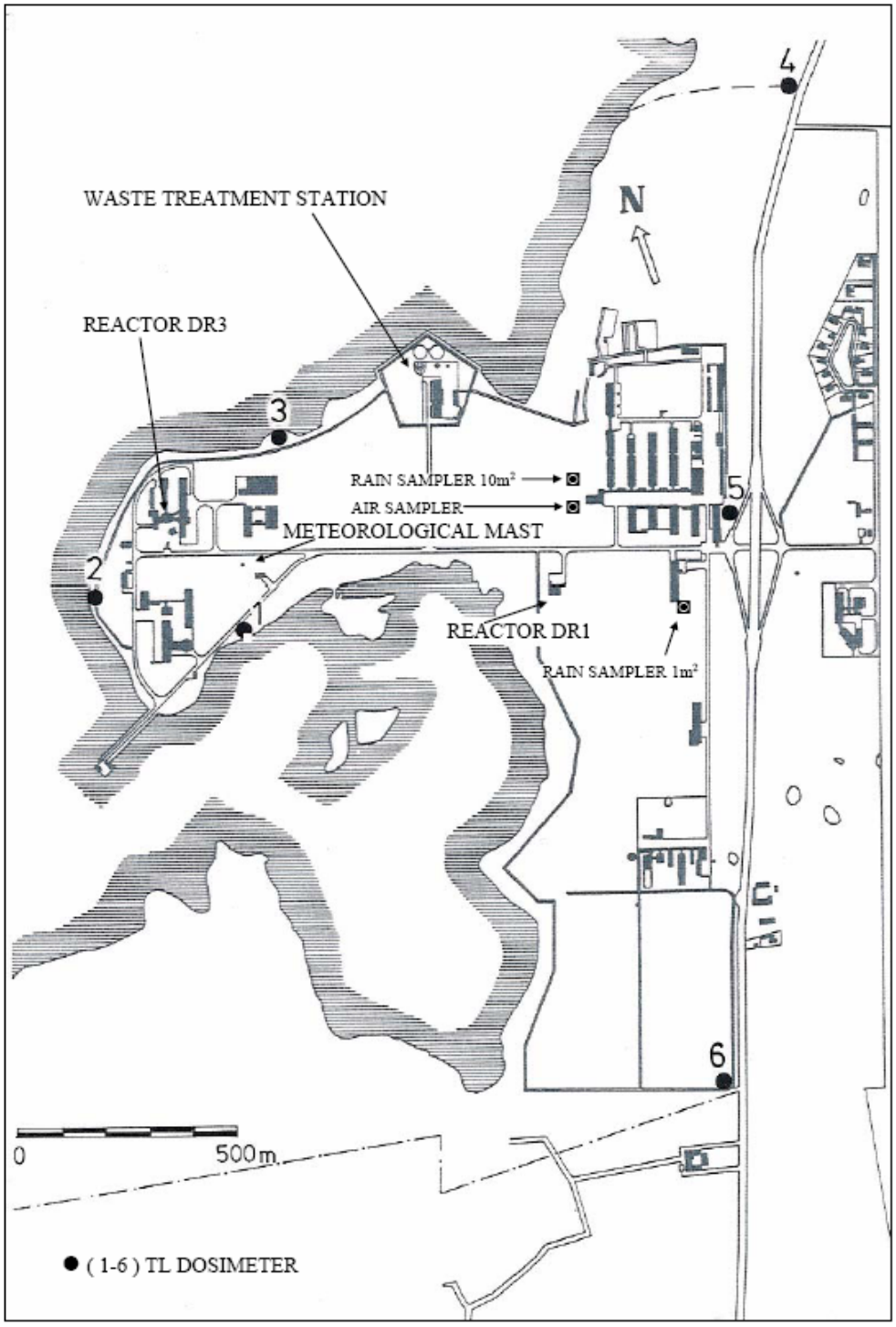

Figure 1. Monitoring equipment locations around the nuclear installations at the Risø site

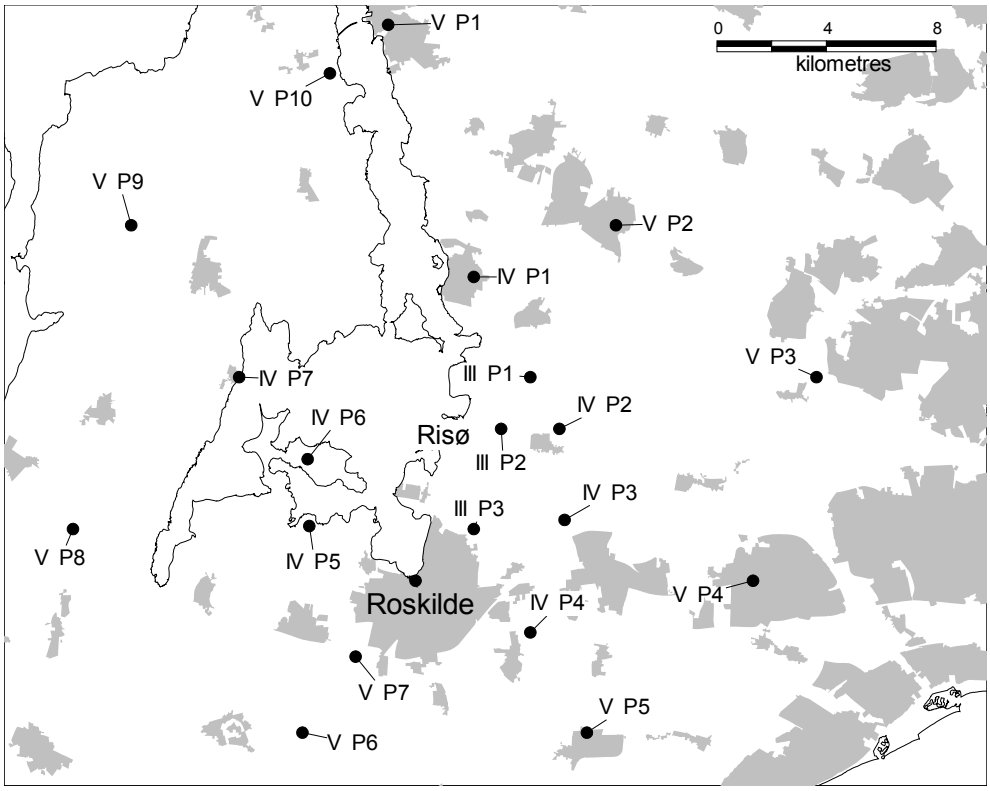

Figure 2. External background monitoring locations in the vicinity of the Risø site carried out with TLD's and NaI detectors

5.2. MONITORING OF RADIOACTIVE DISCHARGES

5.2.1. General

Law no. 170 of 16 May 1962 on nuclear installations provides the general framework for regulating nuclear installations in Denmark. In pursuance of the Law and delegation by the Ministry of Health and Prevention SIS and DEMA, as nuclear regulatory authorities, issue operational limits and conditions for nuclear sites.

5.2.2. Radioactive discharges from hospitals

Discharge monitoring from hospitals of liquid (patient treatment) and airborne (cyclotrons and radiochemical laboratories) releases is required in the license issued by SIS to such facilities.

5.2.3. Radioactive discharges from the nuclear facilities at the Risø site

Discharge monitoring of airborne and liquid releases from the nuclear facilities at Risø as well as clearance monitoring of solid materials is required in the Operational Limits and Conditions for the Danish Decommissioning.

The OLC specifies annual limits for discharge of radioactive substances to the atmosphere and to the Roskilde Fjord as well as lower levels for reporting to the authorities within 14 days. For clearance the OLC specifies requirements for accredited measurements and documentation and defines the clearance levels to be used. Main reference documents are RS-G-1.7 (IAEA) for solid materials and objects and RP113 (EC) for buildings. Land is treated on a case by case basis.

5.3. NATIONAL ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMME

5.3.1. General

Danish national environmental radioactivity monitoring programme is composed of a monitoring programme for external gamma dose and a monitoring programme for radioactivity in air, water, soil and foodstuffs. In addition there is an automatic nationwide monitoring network for external gamma dose rate.

No specific legislative act establishes the responsibilities for the national environmental radioactivity monitoring. The monitoring is based on long term traditions and agreements on the work shared between Risø DTU, SIS and DEMA.

In the event of a nuclear emergency monitoring of foodstuffs, animal feeding stuffs and environmental samples can be carried out by the Risø DTU, SIS and DD. In addition to this SIS has agreements for supplementary gamma spectrometry measurements with university laboratories and hospitals.

5.3.2. Automatic monitoring of external gamma dose rate

Monitoring of external gamma dose rate is carried out using an automatic measurement network, presented in figure 3. The network consists of 11 permanent monitoring stations (PMS). The stations measure continuously gamma dose rate (ionisation chamber), gamma spectra (NaI), precipitation intensity and temperature. The PMS stations are connected to two national data centres (DEMA Birkerød and Risø DTU), which collect the data from each station on an hourly basis. The DEMA server at Birkerød also provides the data to the EURDEP system.

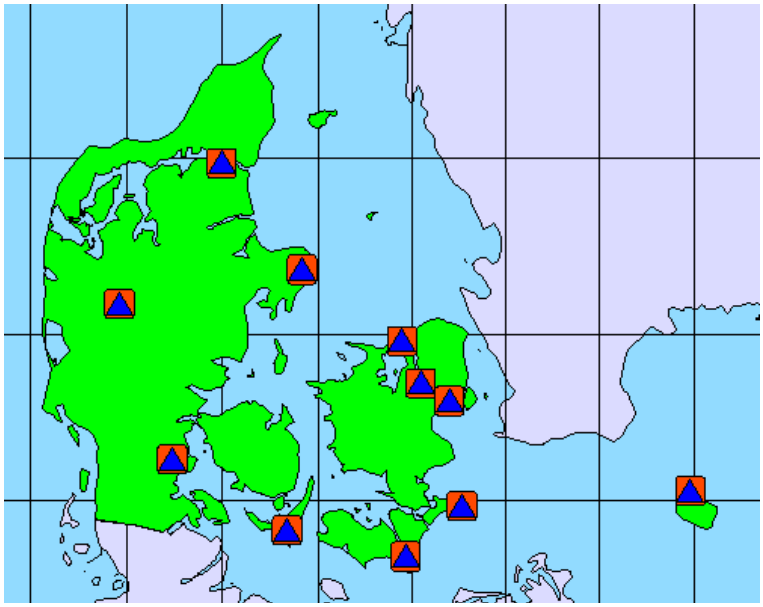

Figure 3. Permanent automatic monitoring stations (PMS) in Denmark

5.3.3. Monitoring of external gamma dose

In addition to the automatic gamma dose rate monitoring the ambient gamma dose is monitored using TLD and NaI detectors at locations presented in figures 4 and 5.

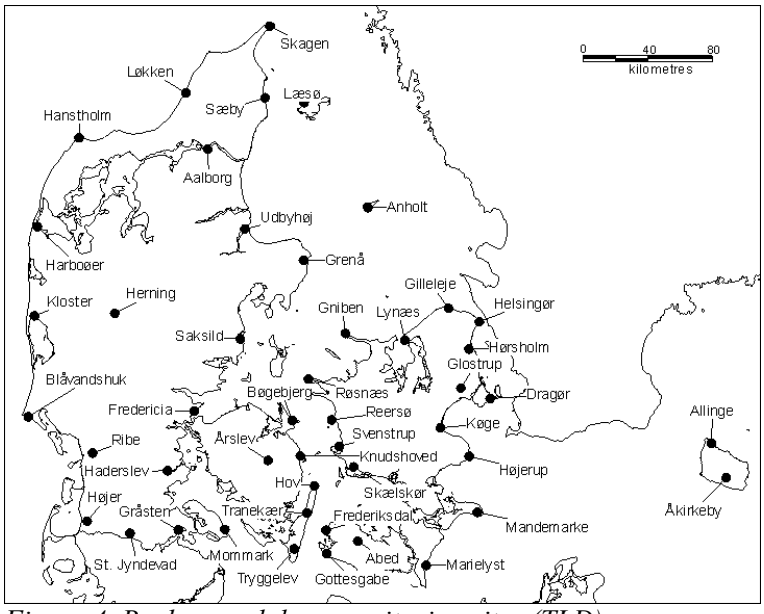

Figure 4. Background dose monitoring sites (TLD)

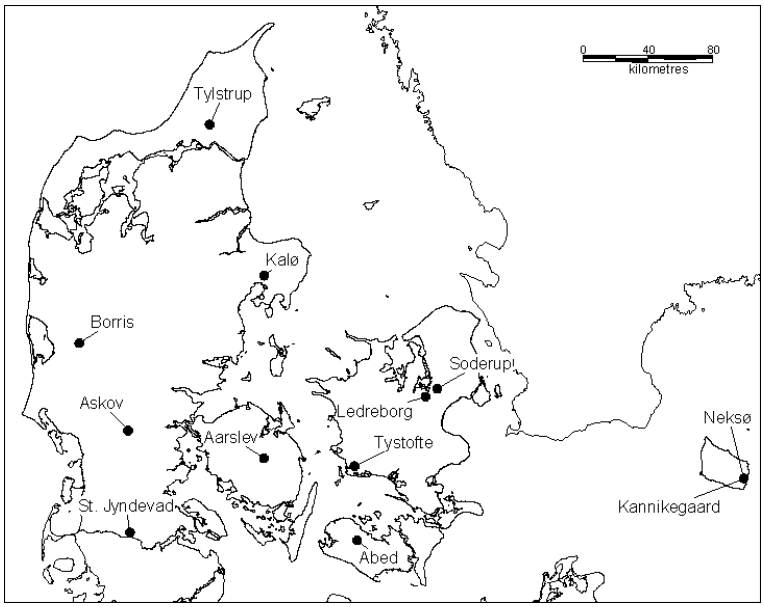

Figure 5. Background dose monitoring sites (NaI detector)

5.3.4. Monitoring of air

Monitoring of radioactivity in air is carried out using three high-volume air samplers. Locations of the samplers are presented in figure 6. Risø DTU is in charge of the sampler located at the Risø site and DEMA of the samplers at Haderslev and Allinge. DEMA samplers have NaI detectors mounted over the filter, allowing on-line monitoring of the filter activity as part of the national automatic monitoring system. Risø DTU carries out the laboratory analysis of filters from for all three samplers.

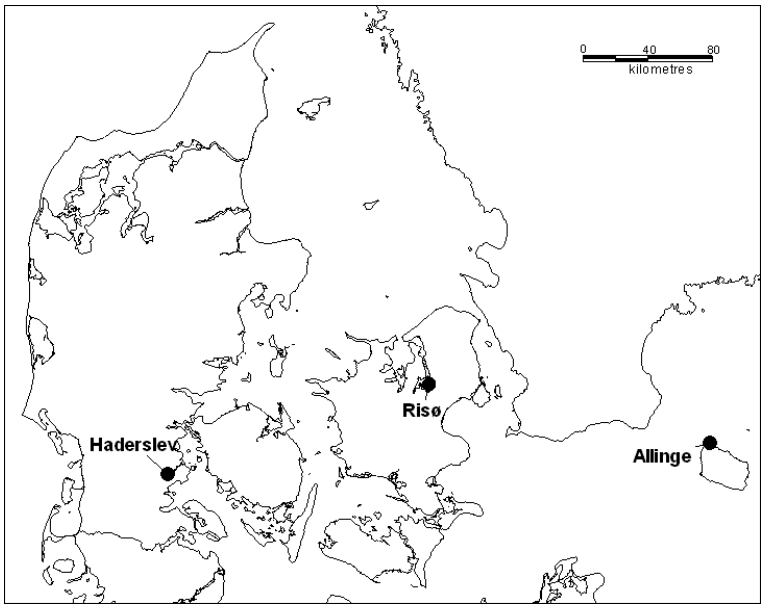

Figure 6. High-volume air sampler locations

5.3.5. Monitoring of fresh water

Surface water

Fresh water samples are collected from locations presented in figure 7. Samples are filtered on site and the filters sent to Risø DTU for Cs-137 analysis. In addition every three years 200 litre samples are collected for Sr-90 analysis.

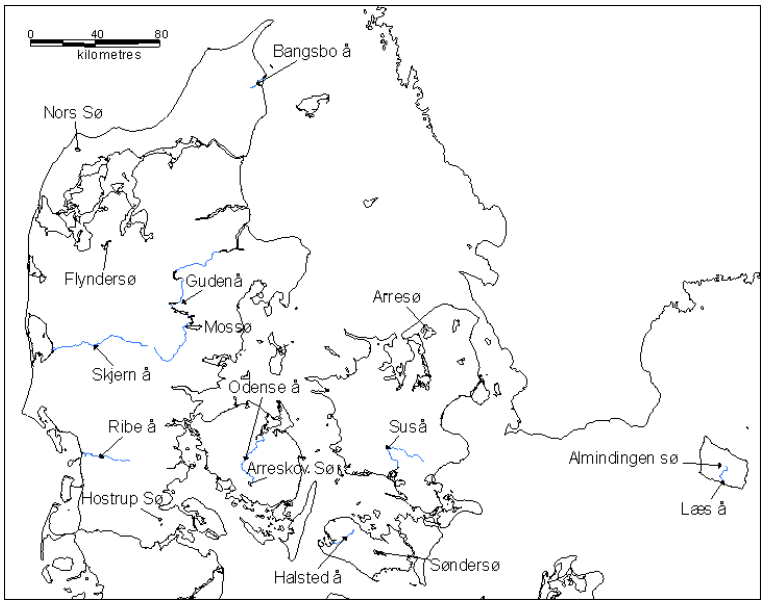

Figure 7. Fresh water sampling locations

Ground water and drinking water

Ground water is sampled every three years from locations presented in figure 8. At Feldbak site the sampling is carried out annually. Samples are analysed for Tritium and Sr-90, Feldbak samples also for Cs-137.

Most of the drinking water in Denmark is ground water, so there is no separate national program for monitoring drinking water. A large drinking water survey was carried out by Risø DTU in 2001-2003. Results indicated that the probability of finding high levels of radioactivity in the Danish drinking water sources is very low, so there is no need to implement a regular monitoring programme.

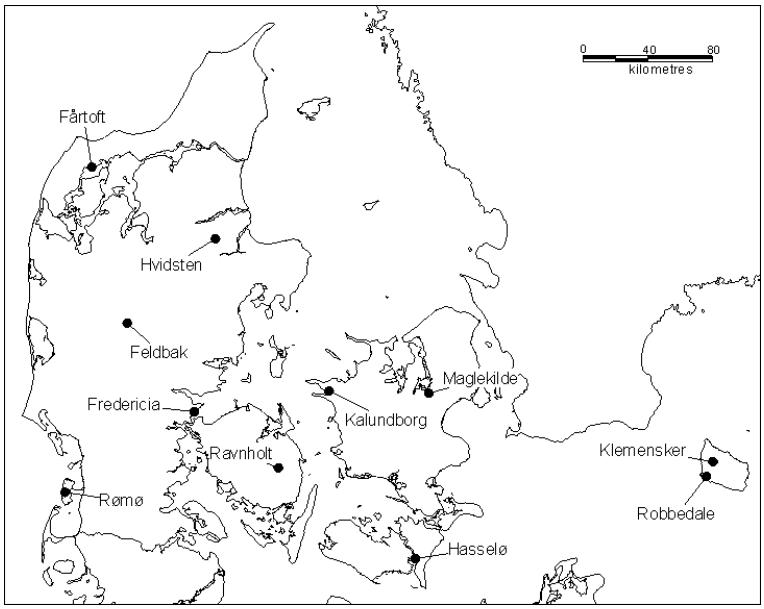

Figure 8. Ground water sampling locations

Precipitation

Rain water collector locations are presented in Figure 9. These collectors are usually situated at the State experimental farms. Each site has three unheated collectors with total collection area of 0.42 m^2. In addition the Risø site has one 1 m^2 collector and a large 10 m^2 heated precipitation collector. Analysis of bulked precipitation samples from the State farms is carried out by Risø DTU for Sr-90 and Cs-137 annually. The samples collected by the large collector in Risø are analysed for Tritium on monthly basis.

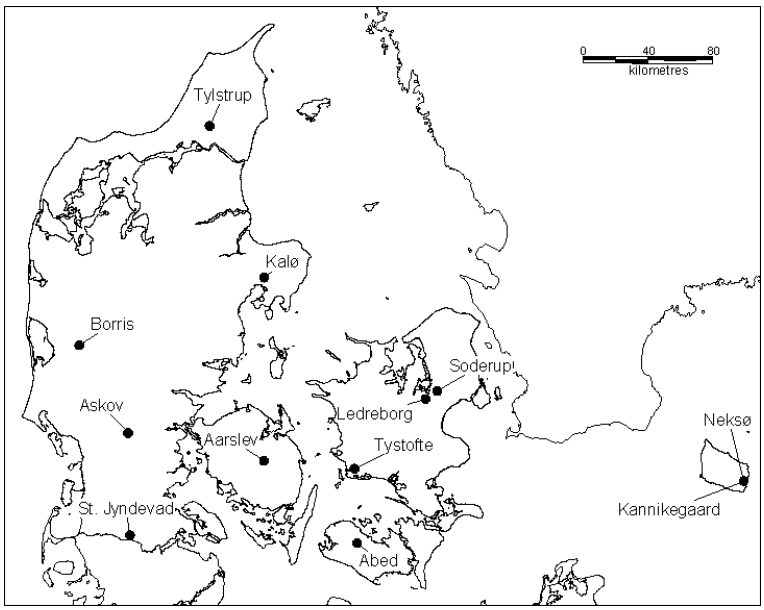

Figure 9. Precipitation sampler locations

5.3.6. Monitoring of soil and biota

Soil radioactivity is monitored by collecting soil core samples every five years from the State experimental farms, presented in figure 10. The samples are dried, ashed and sieved before Sr-90 and Cs-137 analysis.

Biota is monitored by collecting grass samples weekly at the Risø site. Samples are bulked together for monthly and quarterly samples and analysed for Cs-137 and Sr-90.

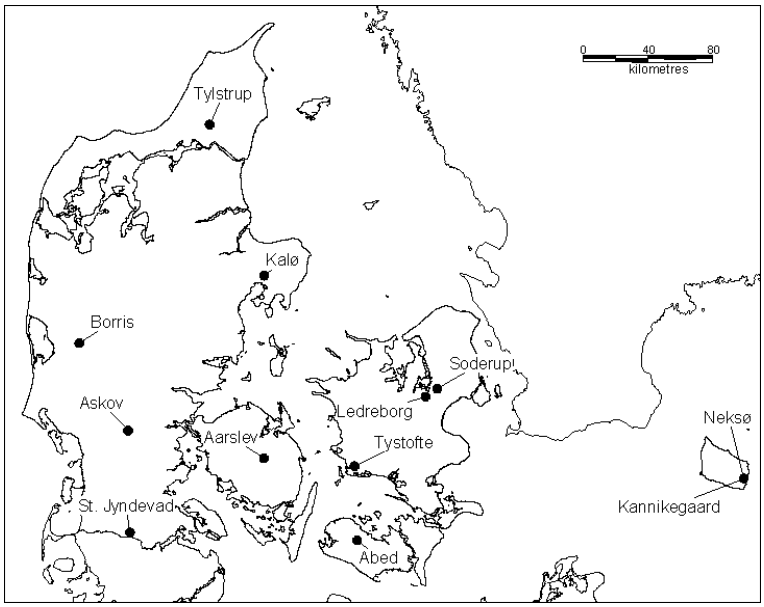

Figure 10. Soil sampling locations

5.3.7. Monitoring of radon

Radon activity monitoring in dwellings has been carried out in a large survey in 1996. The results indicated that there are large territorial differences in radon activity; in some areas some 10% of the houses have a radon concentration above 200 Bq/m^3 (recommended action level).

5.3.8. Monitoring of foodstuffs

Milk

Milk samples are collected every second month from zones presented in figure 11. Samples are analysed for Cs-137 and Sr-90.

Mixed diet

Food samples are collected from the market in 8 cities and Copenhagen annually. The samples are mixed together to composite samples representing the average diet and analysed for Cs-137 and Sr-90.

Other foodstuffs

Samples representing local and imported foodstuffs are collected on a regular basis and measured for Cs-137 and Sr-90.

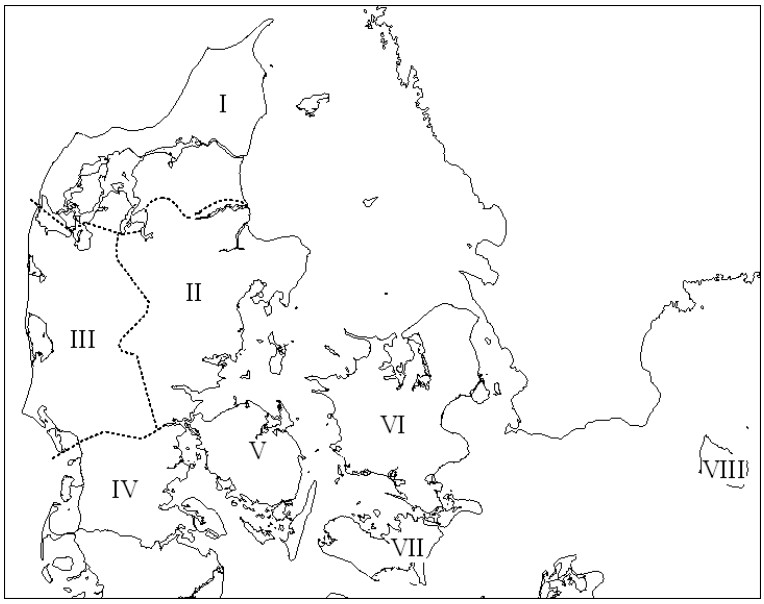

Figure 11. Milk sampling zones

5.3.9. Monitoring of marine radioactivity

Marine radioactivity monitoring is carried out in accordance with the HELCOM marine programme guidelines. Results are reported annually to the HELCOM database and compared with the results from other Baltic Sea countries.

Seawater

Seawater samples of 50-100 litres are collected twice a year by the Danish navy at locations presented in figure 12. Samples are sent to Risø DTU for analysis of Sr-90, Cs-137, Tc-99, Pu and Np-237.

Sediments

Marine sediment sampling is carried out by the National Environmental Research Institute, Århus University, in accordance with the HELCOM Baltic Sea monitoring programme. Samples are collected annually from the Arkona Sea in the Baltic Proper, the Kattegat, the Great Belt and the Sound and analysed for content of Cs-137 by Risø DTU.

Biota

Seaweed samples are collected quarterly from three locations (Jutland, Zealand and Bornholm) and analysed for Cs-137 and Tc-99.

Marine fish samples are collected annually from harbours in West Jutland, Zealand and Bornholm and analysed for Cs-137 and Po-210. Lobster is collected annually from Kattegat and analysed for Tc-99.

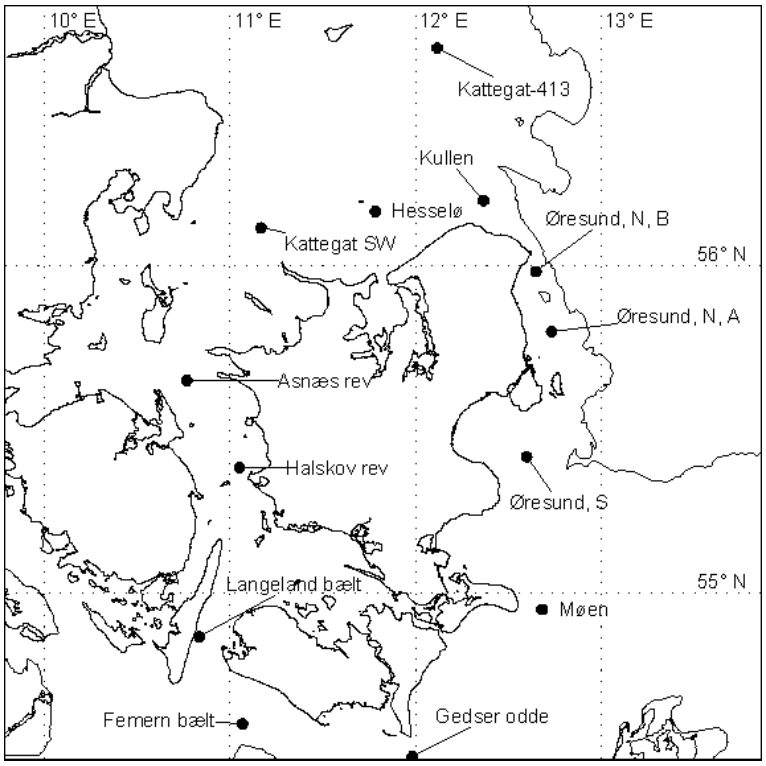

Figure 12. Seawater sampling locations

5.3.10. Mobile measurement systems

DEMA maintains capability to carry out mobile radiation monitoring using ground vehicles and helicopters. These arrangements are not part of the routine monitoring programme, but they would be activated in the event of an emergency.

6. VERIFICATION ACTIVITIES

6.1. INTRODUCTION

In order to verify different aspects of the Danish monitoring systems the verification team visited, in accordance with the agreed verification programme, the following locations:

- SIS headquarters in Herlev
- Danish Decommissioning laboratory at Risø
- Laboratories at Risø DTU
- Danish Emergency Management Agency headquarters in Birkerød
- Rigshospitalet in Copenhagen
- Sampling and monitoring sites in western Denmark (Haderslev, Askov and Fredericia)
- Sampling and monitoring sites in eastern Denmark (Møn, Lolland and Falster)

Although a significant part of the environmental radiation monitoring activity in Denmark is devoted to the territory of Greenland (Thule accident monitoring etc.), the verification covered only the activities related to the mainland Denmark, Greenland not being a part of the EU territory.

6.2. SIS HEADQUARTERS

6.2.1. General

Verification team was informed, that since the implementation of the national monitoring programme is done by Risø DTU, the SIS laboratory facilities are not directly involved in the routine monitoring programme. However, they are available for use in emergency situations to support DEMA and Risø. The SIS measurement facilities are not accredited. SIS maintains a 24h radiation expert stand-by duty for emergency situations.

6.2.2. Dosimetry laboratory

In its headquarters the SIS has a dosimetry laboratory, which provides a calibration facility for radiation dose meters (X-ray and Co-60) used in the Danish laboratories and hospitals. Accreditation of the laboratory according the ISO 17025 is on the work programme for 2009.

Verification does not give rise to recommendations. The verification team supports the intention to proceed towards a formal laboratory accreditation.

6.2.3. Radiochemistry laboratory

SIS has a radiochemistry laboratory for sample preparation and a laboratory for activity measurements, equipped with a general purpose HPGe detector (Canberra, 40 % relative efficiency) and NaI detectors. Typical applications are measurements of urine samples, swipe samples and Uranium/Thorium measurements. Number of samples is quite low, so there is no actual laboratory sample database; samples are logged in a simple logbook.

Counting room is equipped with HEPA-filters and background shielding. Detector calibration is done using commercial mixed nuclide standards. There is also a Monte Carlo –based programme (Canberra ISOCS) available in order to adapt different measurement geometries.

Verification does not give rise to recommendations.

6.3. RISØ SITE

6.3.1. Danish Decommissioning Clearance Laboratory

The verification team visited the Danish Decommissioning Clearance Laboratory. The Laboratory (building 257) conducts all measurements to verify that materials can be cleared as non-radioactive materials in accordance with the requirements in the OLC for DD. There are no actual radioactive discharges to the environment from this facility.

The laboratory is divided in 3 sections: an entrance section where the materials to be controlled are received, a hall for measurements and a control room.

The verification team inspected in detail the measurement hall where all the equipment is installed. The dimensions of this hall are approximately 9x24 m. It can be divided (in order to separate the germanium detectors) in different sections using movable shielding walls. The floor is covered by epoxy for easy decontamination. In order to minimize the effect of radon gas from the ground, a membrane covers the foundation.

To avoid interference during the clearance measurements no other material is stored in the hall. Background measurements are done frequently and the different surfaces are controlled so that the laboratory can keep its "low-level laboratory" classification.

Three gamma detectors are used for gamma measurements:

- gamma 1 is a Canberra HPGe coaxial detector (type GC 4520);
- gamma 2 is a thin-window Canberra coaxial germanium detector (type GX 15023);
- gamma 3 is a thin-window Canberra coaxial germanium detector (type GX 10021).

GX 15023 and GX 10021 are germanium detectors with a relative efficiency of 150% and 100%, respectively. The peak FWHM is less than 2.2 keV at 1330 keV; applicable gamma energy range is from 10 keV to 7 MeV. The detectors can be shielded with 2.5 cm and 5 cm circular lead shields, which can be arranged to give different apertures. In case of a non-homogeneous activity distribution, the material to be analysed is placed on the rotation table in front of a detector in order to have an average of the activity. The table can rotate and is built to support objects with a weight up to one tonne. The verification team witnessed the utilisation of this rotation table with detector GX 10021.

For gamma spectroscopy, the laboratory uses Canberra InSpector 2000 with Genie 2000 sofware.

The laboratory has developed detailed instruction manuals for each instrument and a quality manual is in place. DD is accredited in accordance with DS/EN ISO 9001:2000 and ISO/IEC 17025 by DANAK (DANAK is the Danish national body for accreditation appointed by the Danish Safety Technology Authority).

Verification does not give rise to recommendations.

6.3.2. Site discharge monitoring

The verification team visited the Waste Management Plant and the closed DR3 reactor at the Risø site. Radionuclide releases from these facilities consist of ^{3}H (tritiated heavy water) and ß-activity to the atmosphere and to the Roskilde Fjord.

There are no liquid releases from DR3. Water vapour in the ventilation air is trapped in a HETO cooling trap. The concentration of tritium in the frozen sample is measured after melting in a liquid scintillation counter (TriCarb 1900 TR) operated by the Radiation Research Division of Risø DTU. In addition the air from the ventilation system of DR3 is continuously sampled using a glass fibre filter which is measured weekly by gamma spectrometry at the Department of Radiation and Nuclear Safety in the Danish Decommissioning.

Radionuclide discharges from the Waste Management Plant include both atmospheric and aquatic releases. The ventilation air from the asphalt and distillation facilities is discharged to the atmosphere through the ventilation stack. Monitoring is by means of a detector continuously measuring the collected activity on the filter paper. Weekly analysis of the filter using a proportional counter is carried out. Calibrations are done during an annual service check and include a dual calibration with certified Am-241 alpha and Cl-36 beta sources and an airflow calibration with a calibrated airflow meter in series with a flow regulator valve.

There are several underground active liquid tanks in the Risø site buildings to collect liquid waste. The contents of these tanks are transferred to the distillation facility according to the volume which has accumulated. Gross-beta measurements of samples are carried out at various stages and consist of

- Samples from the distillation process (to the water treatment plant)
- Samples from collection tanks (to the water treatment plant)
- Daily samples from water treatment plant (to the fiord)

Calibration of the beta measurement equipment consists of weekly measurements of KCl sources and weekly measurements of Tc-sources as control. As part of the Quality Management system an internal audit is carried out six monthly or annually.

Verification does not give rise to recommendations.

6.3.3. Automatic monitoring network back-up data centre

Verification team visited the back-up data centre for the national on-line PMS network located at the Risø site. The centre automatically calls each PMS-station every hour in order to collect the data. On high readings there is an automatic alerting system. A UPS back-up is available for electrical power.

Verification does not give rise to recommendations.

6.3.4. Risø DTU

General

The verification team visited the laboratories of the Radiation Research Division at Risø DTU, which is in charge of implementation of the national environmental monitoring program and the local program around the Risø site. The laboratories are well equipped and have a staff of 13, five of whom have university level degrees. Laboratory staff takes care of most of the sample collection; in practice the collection is a full time work of one staff member. Rainwater samples and air-PMS filters are collected and sent to the laboratory by the local staff of the state experimental farms or DEMA.

The Risø DTU laboratory which carries out the environmental monitoring is not accredited and it has no formal quality management system, but the verification team was informed that accreditation is being considered due to customer requirements. Nevertheless the laboratory is very well equipped and staffed and it has participated in numerous intercomparison exercises.

Verification does not give rise to recommendations. The verification team suggests that the laboratory proceeds towards a formal accreditation.

Sample receipt and preparation

Each sample is logged when it arrives at the laboratory. Sample preparation typically includes drying or ashing. The laboratory has a large number of drying cabinets and furnaces. Freezers and a freeze-dryer are also available.

Scales used for sample weighting are calibrated on two year intervals by an external calibration service.

Verification does not give rise to recommendations.

Chemistry rooms

The laboratory has several chemistry laboratory rooms for sample chemical treatments. These rooms are well equipped to handle also large sample volumes and complicated chemical procedures. Staff is mostly cross-trained for different tasks, although there exists also activities, on which only one staff member has been trained.

Verification does not give rise to recommendations.

Gamma counting room

The gamma counting room is equipped with ten HPGe detectors (two well-type, eight coaxial). Typically the counting times are very long (3-4 days), which limits the laboratory throughput. Gamma spectra and the corresponding analysis reports are stored on the laboratory database.

Calibration of the HPGe-detectors is based on commercial standards; an interpolation program is available for geometries between calibrations obtained from reference measurements. Peak energy, efficiency and width (FWHM) are controlled monthly.

Verification does not give rise to recommendations.

Alpha-beta counting room

The alpha-beta counting room is equipped with 32 alpha counters and two 4×5 sample matrix beta counters. High number of counters is needed since counting times are very long (typically one week). In addition there is a low-level scintillation counter (Quantulus).

Both counting rooms are temperature controlled.

Verification does not give rise to recommendations.

Water samples

The laboratory has a separate handling and storage area for water samples, so it is particularly well equipped for handling large volume water samples.

Verification does not give rise to recommendations.

Sample archive

Sample archive for ashed samples and air filters is kept in a movable shelf storage system in good order with excellent labelling. There is no formal achieving policy defined by a quality system.

Verification does not give rise to recommendations. The verification team suggests defining a formal sample archiving policy as a part of the laboratory quality system.

TLD reader

The laboratory has an Alnor DOSACUS TLD-reader for reading the TLDs used in the monitoring program. Calibration of this device is done on a monthly basis using a reference TLD irradiated in the SIS reference calibration facility.

Verification does not give rise to recommendations.

Reporting

Results of the analyses are compiled into a report, which is made available to the public through the internet. In addition relevant results are sent to the EU REM database and the on-line dose rate data is made available at the EURDEP website. There is no formal reporting mechanism of the results.

Verification does not give rise to recommendations. The verification team suggest defining a formal reporting policy for environmental monitoring results.

6.3.5. Site environmental monitoring systems

The verification team verified that the Risø site monitoring equipment consists of the following: an air sampler, two rain collectors and TLDs.

Air sampler

The air sampler is manufactured by the Risø DTU. Air is drawn through a polypropylene filter at rate of approximately 2000 m^3/h. The filter is changed weekly. The air flow is controlled by a gas flow meter.

The filters are analysed by gamma spectrometry shortly after filter change to check if short-lived man-made radio nuclides are present. Air filters are then stored for a minimum of one week to allow for decay of short-lived naturally occurring radio nuclides before further analysis.

Verification does not give rise to recommendations.

Precipitation collectors

The verification team verified two rain water collectors: one of approximately 1 m^2 collection area and a larger heated collector of approximately 10 m^2 collection area. In the large collector water passes through an ion exchange column and goes into a large tank.

The water from the 1 m^2 and 10 m^2 collectors is used for monthly analyses for tritium. Analyses of ion exchange resin by gamma spectrometry are carried out for Be-7, Cs-137 and Pb-210. Additionally, the bulked resin is after 4 consecutive months analysed for Sr-90.

Verification does not give rise to recommendations.

TLDs

For ambient gamma dose monitoring purposes, Risø DTU uses TLDs manufactured by ALNOR. They are calibrated by irradiation at a calibration irradiator. Traceability of delivered doses is ensured through calibration of the irradiator dose rate against the SIS reference.

The verification team verified the TLD located on the site fence near the entrance; this TLD was protected in a plastic bag.

Verification does not give rise to recommendations.

6.4. DEMA IN BIRKERØD

6.4.1. Automatic monitoring network data centre

Verification team visited the data centre of the PMS network at DEMA, Birkerød. The central PC collects the data from the network PMS-stations on hourly basis and initiates an alert in the event of an elevated value.

Verification does not give rise to recommendations.

6.4.2. Mobile monitoring systems

DEMA has two 4x4 vehicles equipped with a gamma-ray spectrometry and NaI detector systems. One of the vehicles carries also a neutron detector, which is placed in an aluminium box on the roof of the car in order to avoid contamination.

DEMA has two airborne gamma spectrometry systems, each consisting of a Exploranium NaI(TI) detector, GPS, radar altimeter and a PC equipped with special software. The systems are kept on stand-by, ready to be used on a helicopter of the Danish Air Force.

Verification does not give rise to recommendations.

6.4.3. Modelling tools for atmospheric dispersion

The ARGOS system was demonstrated to the verification team. Originally the system was developed to model a possible release from the Barseback reactors located close to Copenhagen. The system has over the years developed into a very sophisticated modelling tool, which is able to perform atmospheric dispersion and dose prediction calculations also in an urban environment. Latest development of the system has been towards expanding its use also for chemical and biological dispersion situations.

Verification does not give rise to recommendations. Verification team acknowledges DEMAs sophisticated approach to atmospheric dispersion modelling.

6.5. RIGSHOSPITALET IN COPENHAGEN

6.5.1. General

The verification team visited Rigshospitalet in Copenhagen, founded in 1757 as the King Frederiks Hospital, which is for patients with highly specialised diagnostic needs. As an aid to understanding the processes which may give rise to gaseous discharges the verification team was given a very comprehensive presentation of the development of nuclear medicine in general and PET in particular.

Denmark with 15 scanners and 5 cyclotrons (2007) for 5 million people can be considered a leader in this specialised field. Rigshospitalet operates two cyclotrons, a Scanditronix 32 Mev (1992) and a Siemens/CTI RDS Eclipse 11 MeV (2005).

Approximately 25000 patients per year attend the department of Clinical Physiology and Nuclear Medicine & PET and Cyclotrone unit, for specialist diagnosis, treatment and radiotherapy planning.

The extremely short half-life of certain radio-isotopes means that their production must take place as close to the patient as possible. Typical radioisotopes and their half lives are presented in Table 2.

Table 2. Typical radioisotopes produced at the Rigshospitalet

Radioisotope	Half-life (min)
^{18}F	109.8
^{11}C	20.4
^{13}N	9.97
^{15}O	2.05
^{81}Rb	4.58

Typical weekly isotope production and the activity generated is as follows:

- 8-10 productions of ^{18}F (100-150 GBq)
- 3 productions of ^{81}Rb (20-30 GBq)
- 5-7 productions of ^{11}C (50-60 GBq)
- 1 production of ^{15}O (2 GBq)
- 3-4 productions of ^{13}N (3-4 GBq).

Handling of the radioisotopes takes place in three chemistry laboratories – two for routine production and one for research and development.

6.5.2. Gaseous discharge monitoring

The major contribution to airborne releases originates from ^{11}C labelling. The PET and cyclotron unit is equipped with a continuous stack monitor from Canberra to follow the possible releases of radioactivity when removing air from the isotope production centres.

The monitoring hardware consists of two NaI detectors mounted in lead housings, placed on a support table, looking at two pipes through which the air is passing, and flow monitoring detectors for each pipe. One dedicated pipe is used for the ventilation for the research and development laboratory ("small" pipe) and the other pipe is ventilating the two cyclotrons and the two routine production laboratories ("large" pipe). The detectors are connected to a PC which controls the system. This PC can be accessed either locally or from a workstation on the hospital's internal computer network. Currently only one user can be connected at any time but it is proposed to provide multi user access in the future. Figure 13 provides a schematic representation of the system.

Two 3x3" ruggedized NaI detectors look at the centre of each pipe. A Canberra Unispec MCA supplying the HV for the detector and amplifying the signals of the detector is plugged into the photo-multiplier of the detector. The detector communicates with the PC via a USB connection. To reduce the influence of the environmental background at the back and hence improve the detection limit each detector is placed in a lead collimator mounted on a support plate in such a way, that the distance between the detector and pipe is only 5 mm. In order to have a ^{40}K peak present in the spectrum (used for energy stabilization) some free space has been left around the photo-multiplier for placing some K-salt.

The following operations are performed by the PC:

- Check the count rate for user defined energy windows in the gamma spectrum of both MCAs collecting data on the radio-activity concentrations of the air in both pipes.
- Monitor the flow rate of the air in the pipes and the temperature inside the cabinet.
- Determine the released activity for user defined isotopes using a measurement cycle of one hour.
- Generate a remote alarm for a too high or too low reading for any of the monitored parameters. It is planned to connect a warning light in the chemical labs as a more visual warning.
- Perform an automatic backup of the data on the hard disk. The prospect of adding a 2nd PC for use in case of failure is under consideration.

The stack monitor software is based on the PAMS package of Canberra. It collects and checks data for the predefined parameters every 5 seconds (short cycle). It also acquires and saves MCA spectra, counted for one hour, for activity analysis (long cycle). The software consists of the DataTRF program which is launched by the Genie-2000 analysis sequence, which is started by PAMS to analyse the recorded long cycle spectra. The program transfers the activities of the isotopes to a dedicated MS Access database. The efficiencies used to calculate the activities are derived on a theoretical basis using the ISOCS software and has been verified using controlled releases of known amounts of activity. Finally a software package - Crystal Reports – is used to read activity data from the MS Access database and generate automatic summary reports of the released activity.

Verification does not give rise to recommendations.

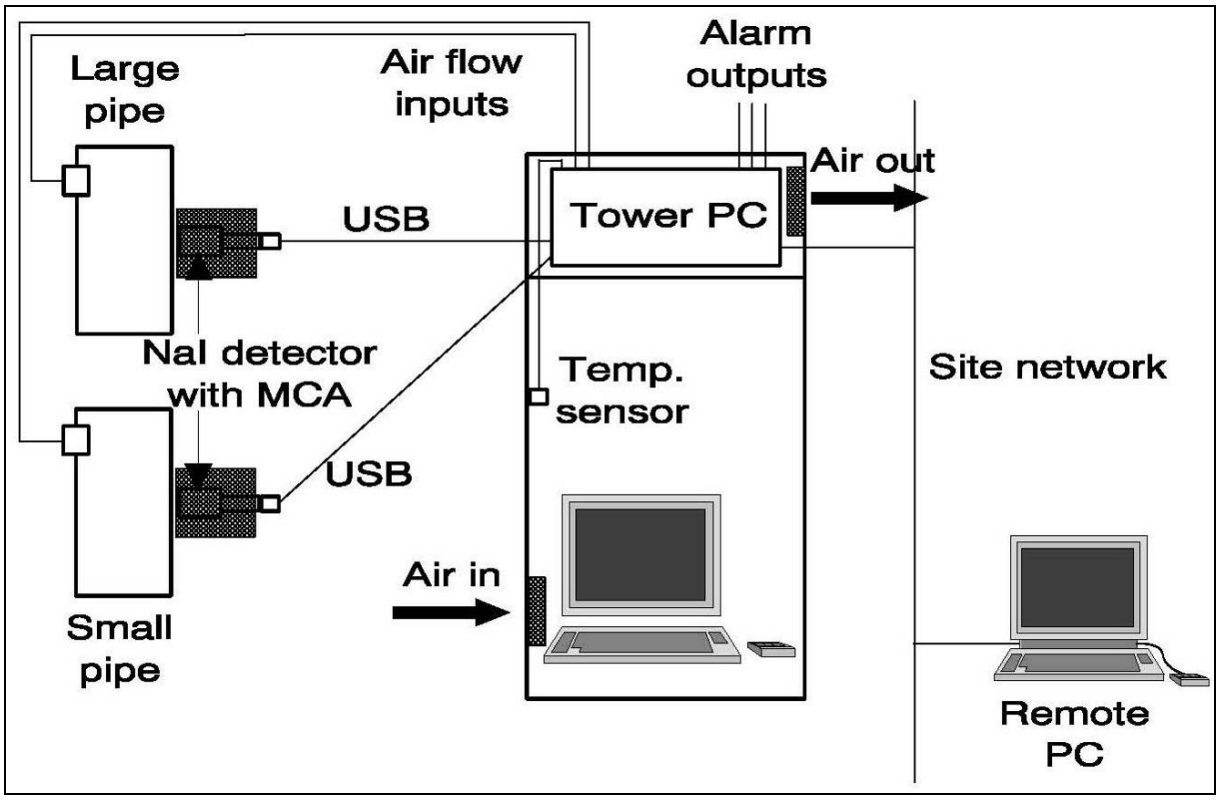

Figure 13. Gaseous discharge monitoring system at Rigshospitalet

6.5.3. Liquid discharge monitoring

The verification team focused at the verification of the gaseous discharges from the hospital. As regards the liquid discharges, the verification team was informed that the drain from the toilets used by patients treated with I-131 is directed to delay tanks. The activity is diluted with ordinary waste water until the concentration is below a determined value given in the Danish legislation. For I-131 this value is 0.1 MBq per litre. After delay and dilution the waste water is released to the public sewer without further monitoring. SIS has carried out measurement campaigns to demonstrate that the potential dose to the sewer workers does not exceed the regulatory limits.

Verification does not give rise to recommendations.

6.6. SAMPLING AND MONITORING SITES IN WESTERN DENMARK

6.6.1. DEMA South Jutland at Haderslev

General

Verification team visited the DEMA South Jutland facility at Haderslev, which is one the DEMA emergency centres. This large facility has several operational and training functions in the area of civil protection and has been chosen as one of the main sites for the local and national environmental radiation surveillance.

Radiation instruments are located in a fenced area in the middle of a grass field and are provided with lightning protection. The most sensitive instruments are housed in a wooden shack, equipped with a heating system, back-up batteries and an intruder alarm. Data from the station is fetched by the Birkerød and Risø DTU centres on a daily basis.

Maintenance of the station is carried out by the DEMA Birkerød personnel, local staff does not carry out any maintenance operations (other that filter replacement) and has no access to the station PC. Operational testing of the dose rate equipment is carried out by comparing instrument readings with each other, no radiation sources are used to test the detector response.

PMS station

The PMS station at Haderslev is a standard PMS station with dose rate, temperature and rain measurements. Additionally the station is equipped with a low-level ionisation chamber (Reuter-Stokes, USA), located in the shack.

Air-PMS station

The Air-PMS station at Haderslev is identical to the high-volume air sampler in Bornholm. The station has a heated fibreglass filter, which is changed on a weekly basis. A NaI detector is located above the filter for on-line filter activity and gamma spectrum monitoring. Air flow is measured with a vortex flow meter. Meter calibration is based on original manufacturer specifications; a recalibration has been considered, but not implemented due to high cost. Verification team was informed that airflow depends heavily on the amount of material collected by the filter – an old filter can have 50% lower air flow volume than a new one. A typical value for an old filter air flow is about 450 m^3/h.

The local DEMA personnel carry out the filter change and send the old filter to Risø DTU for measurements. In an emergency situation the filter change frequency will be increased.

TLD

The verification team was informed that there is a TLD from the Risø DTU at the Haderslev station fence, but the team could not locate it on site, so its existence could not be verified.

Other instrumentation

Due to the short distance to the German border, the facility hosts also one radiation dose rate monitor of the German national network (BUND 6665-12-315-159). DEMA has access to this data and it is being used for comparison purposes.

> *Verification does not give rise to recommendations. The verification team suggests using a small radiation source to test the dose rate response during maintenance of the systems.*

6.6.2. State experimental farm in Askov

Verification team visited the rain water collection site at the State experimental farm in Askov. The site has three unheated funnel-type collectors close to an automatic weather station at an open field area. Each collector has a 25 litre sample canister. Sample is collected by the local staff and sent to Risø DTU for analysis. The sampling site is not fenced and there is no access control to it.

> *Verification does not give rise to recommendations. It is suggested to locate the sample collection equipment in a place restricted from public access to avoid unwanted tampering.*

6.6.3. Fredericia

Verification team visited the TLD from Risø DTU at Fredericia. The TLD (No. 25) is located at about 2 meter height in a tree next to a public parking area. There is no access control or surveillance of the area, so there is a risk of losing the TLD.

Verification does not give rise to recommendations. It is suggested to locate the TLDs in a place restricted from public access or well hidden in order to avoid unwanted tampering.

6.7. SAMPLING AND MONITORING SITES IN EASTERN DENMARK

6.7.1. Møn

Verification team visited the Møn PMS station situated in the little village of Kongsberg. Instruments are located in a hut near a farm. In the event of a power cut, a UPS (a battery for maximum ten days) is engaged. The station is of the same type as the other ten spread around the country, with the following measurement equipment:

- ionisation chamber (Environmental Radiation Monitor from Reuter-Stokes, USA.);
- NaI detector (the NaI crystal spectrum is calibrated once a year);
- rain intensity sensor (dripping bucket);
- thermal probes for the outside temperature, the temperature of the NaI detector (the most important), and the temperature in the enclosure of the ionisation chamber.

A PC computer with special software runs all sensors, an ISDN-modem, a watchdog-program, a burglar alarm and the back-up battery for the power supply. Data are fetched once per hour by Risø DTU and DEMA, or every ten minutes in case of alarm.

Verification team also verified a local TLD fixed at about two meter height near the hut.

Verification does not give rise to recommendations.

6.7.2. Falster

Verification team verified the PMS station in Falster, which is exactly the same type as the Møn station. It is located in the area of a local sewage treatment plant.

Verification does not give rise to recommendations.

6.7.3. Abed

Verification team verified the environmental sampling arrangements at the Abed automatic meteorological station. The site has altogether four rain samplers. Three collectors have 25 litre sample canisters. The fourth one, with a smaller opening, is equipped with a wind breaker. Samples are collected by the local staff and sent to DTU for analysis.

Verification does not give rise to recommendations.

7. CONCLUSIONS

All verification activities that had been planned were completed successfully. In this regard, the information supplied in advance of the visit, as well as the additional documentation received during and after the verification activities, was useful.

The information provided and the verification findings led to the following observations:

(1) The verification activities that were performed demonstrated that the facilities necessary to carry out continuous monitoring of levels of radioactivity in the air, water and soil with regard to the surveillance of the Danish territory are adequate. The Commission could verify the operation and efficiency of these facilities.

(2) However, a few improvement suggestions are formulated. These suggestions aim at improving some aspects of the environmental surveillance. These suggestions do not detract from the general conclusion that the Danish national monitoring system is in conformity with the provisions laid down under Article 35 of the Euratom Treaty.

(3) The recommendations presented in this report are summarized in the 'Main Findings' document that is addressed to the Danish competent authority through the Permanent Representative of Denmark to the European Union.

APPENDIX 1

REFERENCES AND DOCUMENTATION

1. Questionnaire on the implementation of Art. 35 of the EURATOM Treaty in the Kingdom of Denmark, 2005.

2. Verification activities under the terms of Art. 35 of the Euratom Treaty, Preliminary information questionnaire addressed to the national competent authority in view of preparing the Article 35 verification in Denmark, 7-11 April 2008.

3. Bekendtgørelse om anvendelse af åbne radioaktive kilder på sygehuse, laboratorier m.v., Bekendtgørelse nr. 954 af 23. oktober 2000, Denmark.

4. Detector System "Grenaa", Technical description, Ørsted, DTU, April 2002, Denmark.

5. Basis Test of Early warning Station Detector System "Grenaa", Technical description, Ørsted, DTU, April 2002, Denmark.

6. Project proposal Thule-2007 – Investigation of radioactive contamination on land, Risø National Laboratory, Technical University of Denmark, April 2007.

7. International Peer Review of the technical content of the project proposal "Thule – 2007 Investigations of radioactive contamination on land", International Atomic Energy Agency, Vienna 2008.

8. Final survey report for DR 1, Clearance of building and land, DD-19(EN), Danish Decommissioning, Roskilde, December 2005.

9. Radon in Danish dwellings, Mapping of State, county and municipality values; National Institute of Radiation Protection, 2001.

10. Radioactive isotopes in Danish Drinking Water, Danish Environmental Protection Agency, 2006.

APPENDIX 2

VERIFICATION PROGRAMME

Monday 7 April

14:00 Opening meeting at the National Institute of Radiation Protection (SIS)

- Introductions / presentations / program of the visit
- Verification of environmental monitoring activities at SIS

Tuesday 8 April

10:00 Verifications at the Risø site

- Site discharge monitoring
- Site environmental monitoring
- Risø DTU Radiation Research Department laboratory
- DD Clearance laboratory
- Automatic monitoring network data centre

Wednesday 9 April

10:00 Verification of monitoring arrangements at Rigshospitalet and at the Danish Emergency Management Agency

Team 1 / *Nuclear division of the Danish Emergency Management Agency (DEMA)*

- National monitoring network data centre
- Mobile monitoring systems
- Emergency monitoring arrangements

Team 2 / *Rigshospitalet in Copenhagen*

- Monitoring of radioactive discharges

Thursday 10 April

10:00 Verification of the Danish monitoring network

Team 1 / Verification of the monitoring systems in western Denmark

- Air radioactivity monitoring at Haderslev
- Automatic dose rate monitoring system at Haderslev
- Environmental sampling arrangements at Askov and Fredericia
- TLD monitoring at Haderslev and Fredericia
- Possible other monitoring sites in the area

Team 2 / Verification of the monitoring systems in eastern Denmark

- Automatic dose rate monitoring systems at Falster and Moen
- Environmental sampling arrangements at Tystofte and Abed
- Possible other monitoring sites in the area

Friday 11 April

9:30 Closing meeting at SIS

- Presentation of preliminary verification findings