EUROPEAN COMMISSION
DIRECTORATE-GENERAL FOR ENERGY
DIRECTORATE D - Nuclear Energy, Safety and ITER

Radiation protection and nuclear safety

TECHNICAL REPORT

VERIFICATIONS UNDER THE TERMS OF ARTICLE 35 OF THE EURATOM TREATY

Routine and Emergency Radioactivity Monitoring Arrangements in Denmark

21-23 April 2015

Reference: DK 15-02

VERIFICATIONS UNDER THE TERMS OF ARTICLE 35

OF THE EURATOM TREATY

FACILITIES:	Danish Health and Medicines Authority, National Institute of Radiation Protection (DHMA/NIRP) Danish Emergency Management Agency, Nuclear Division (DEMA) Radioecology Division, Centre for Nuclear Technologies, Technical University of Denmark (DTU Nutech) Danish Decommissioning (DD)
LOCATIONS:	Herlev, Lynæs, Risø, Birkerød
DATES:	21-23 April 2015
REFERENCE:	DK 15-02
TEAM MEMBERS:	Mr A. Ryan DG ENER (team leader) Mrs M. Marin Ferrer DG JRC
REPORT DATE :	10 December 2015

SIGNATURES:

A. Ryan

P.O. Veijo Tanner

M. Marin Ferrer

TABLE OF CONTENTS

1 INTRODUCTION

Article 35 of the Euratom Treaty requires that each Member State shall establish the 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[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. The radiation protection and nuclear safety unit (ENER D.3) of the EC's Directorate-General for Energy (DG ENER) is responsible for undertaking these verifications.

The main purpose of verifications performed under Article 35 of the Euratom Treaty is to provide an independent assessment of the adequacy of monitoring facilities for:

- Liquid and airborne discharges of radioactivity into the environment by a site (and control thereof).
- Levels of environmental radioactivity at the site perimeter and in the marine, terrestrial and aquatic environment around the site, for all relevant pathways.
- Levels of environmental radioactivity on the territory of the Member State.

Taking into account previous bilateral protocols, a Commission Communication[2] was published in the EU Official Journal on 4 July 2006 describing practical arrangements for the conduct of Article 35 verification visits in Member States.

2 PREPARATION AND CONDUCT OF THE VERIFICATION

2.1 PREAMBLE

The EC's decision to conduct an Article 35 verification was notified to Denmark by a letter addressed to the Danish Permanent Representation to the European Union. The Danish Government subsequently designated the National Institute of Radiation Protection (NIRP) to lead the preparations for this visit.

2.2 DOCUMENTS

In order to facilitate the work of the verification team, a package of information was supplied in advance by the national authorities. Additional documentation was provided during and after the visit. All documentation received is listed in Appendix 1 to this report. The information thus provided has been extensively used for drawing up the descriptive sections of the report.

2.3 PROGRAMME OF THE VISIT

The EC and the NIRP discussed and agreed upon a programme of verification activities, with due respect to the Commission Communication of 4 July 2006 setting out practical arrangements for the

[1] Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation (OJ L-159 of 29/06/1996) which will be superseded by Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom (OJ L 13 of 17.1.2014, p. 1)

[2] Commission Communication 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 C 155, 4.7.2006, p. 2–5)

conduct of Article 35 verification visits. The verifications were carried out in accordance with the programme in Appendix 2.

During the opening meeting the Head of NIRP presented the Danish participants, the programme of the visit, the principal bodies and legal provisions and the laboratory activities at the NIRP. The EC team leader gave a presentation outlining the provisions of Article 35, the objectives of the verification and the subsequent reporting.

At the Risø site presentations were given by both DTU Nutech and Danish Decommissioning. The Danish Emergency Management Agency (DEMA) introduced DEMA in general, but more specifically its nuclear division during the visit to their Birkerød headquarters.

The verification team notes the quality and comprehensiveness of all presentations made and documentation provided.

The following representatives of the national authorities and other parties involved were met:

Danish Health and Medicines Authority, National Institute of Radiation Protection (DHMA/NIRP)

Mette Øhlenschlæger	Head of NIRP
Kresten Breddam	Senior Adviser
Henrik Roed	Senior Adviser
David Garf Ulfbeck	Special Adviser
Rikke Harlou	Specialist
Hanne N. Waltenburg	Senior Adviser
Peter Kaidin Frederiksen	Specialist

The Danish Emergency Management Agency, Nuclear Division (DEMA)

Jeppe Søndergaard Pedersen	Head of division
Carsten Israelson	Chief Adviser
Peter Mylius Møller	Special Adviser
Jon Kristian Behring	M.Sc.Eng.

Radioecology Division, Centre for Nuclear Technologies, Technical University of Denmark (DTU Nutech)

Sven Poul Nielsen	Head of Division
Kasper Andersson	Senior Scientist

Danish Decommissioning (DD)

Per Hedemann Jensen	Head of Department
Kirsten Hjerrild Nielsen	Head of Department
Anne Sørensen	Head of Department
Jens Søgaard-Hansen	Senior Health Physicist
Anna W. Larsen	Engineer
Asger Chr. Krüger	Engineer
Kenn Skjørringe	Technician

3 MONITORING PROGRAMMES AND RESPONSIBLE ORGANISATIONS

3.1 INTRODUCTION

The bodies having competence in the field of environmental radioactivity monitoring in Denmark are outlined in the diagram below:

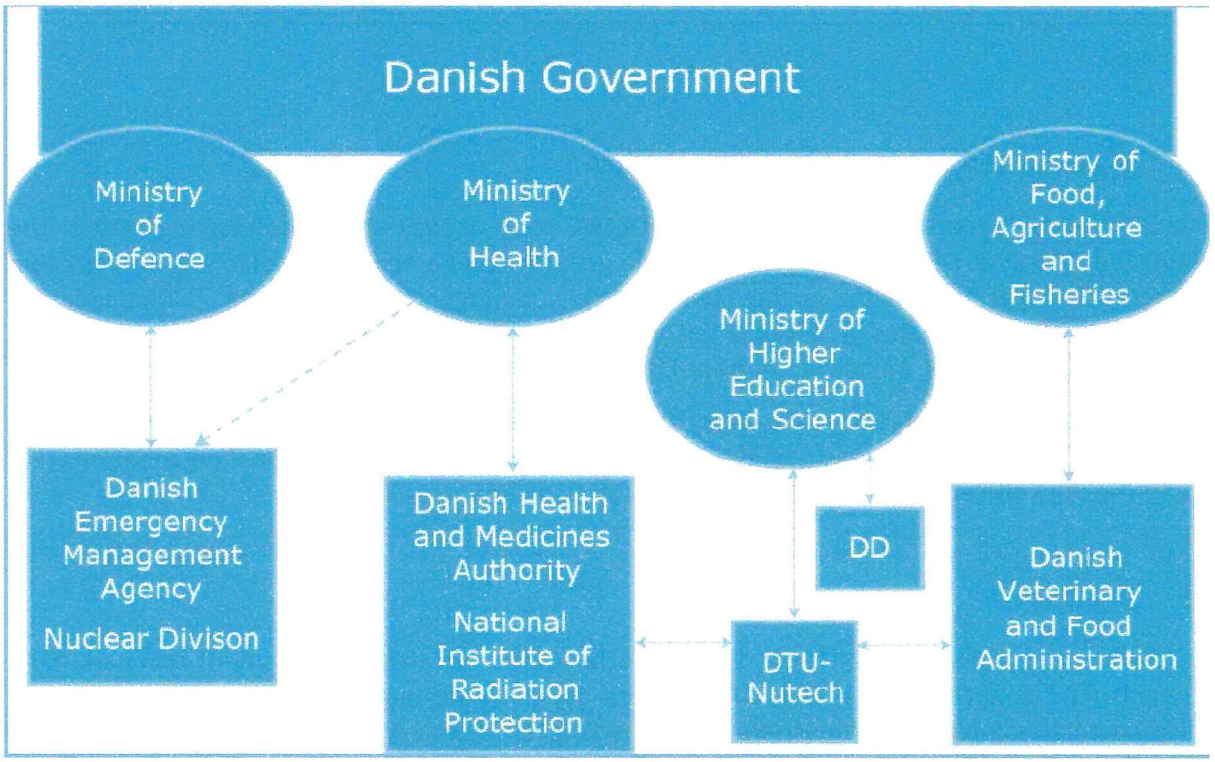

Figure 1. Bodies having competence in the field of environmental radioactivity monitoring in Denmark

3.2 THE DANISH HEALTH AND MEDICINES AUTHORITY

The Danish Health and Medicines Authority (DHMA) under the Ministry of Health is the competent authority concerning radiation protection and safety. DHMA is in addition one of the joint nuclear regulatory authorities according to the law on nuclear installations. The regulatory work is carried out by the National Institute of Radiation Protection (NIRP), a division in DHMA.

DHMA/NIRP are responsible for the protection of the people and the environment against unnecessary radiation. DHMA/NIRP provides regulations, requires licensing or registrations, carry out inspections and provides all information/supervision to other institutions and the public covering radiation protection and safety.

NIRP always has a duty officer on call 24/7 that can intervene in the event of a radiological emergency.

The environmental radioactivity monitoring in Denmark is carried out by DTU Nutech.

3.3 The Danish Veterinary and Food Administration

The Danish Veterinary and Food Administration (DVFA) at the Ministry of Food, Agriculture and Fisheries is the competent authority concerning food safety. The radiological surveillance of foodstuffs in Denmark is carried out by DTU Nutech.

DVFA is responsible for selecting samples of food and feed, imported from areas with risk of radioactivity, for analysis at DTU Nutech. At the moment DTU Nutech analyses samples of foodstuff and feed imported from Japan. In case of contaminated food or feed DVFA is responsible for the follow-up.

3.4 The Danish Emergency Management Agency

The Danish Emergency Management Agency (DEMA) is an agency under the responsibility of the Ministry of Defence. DEMA is responsible for the general nuclear emergency plan and coordination of the sector specific planning in the field of nuclear emergency preparedness in Denmark and Greenland. DEMA operates a network of permanent gamma radiation monitoring stations in Denmark and Greenland, mobile air- and car-borne measurement systems and air-filter stations.

DEMA has a nuclear emergency duty officer that can be reached 24/7. The duty officer can react to alarms from the automatic measurement systems and to alerts from international organisations (EC, IAEA). The duty officer will, if necessary, activate the nuclear emergency plan.

3.5 DTU Nutech

The Radioecology Division, Centre for Nuclear Technologies, Technical University of Denmark (DTU Nutech): DTU Nutech (former Risø DTU) carries out sampling and analysis of radionuclides in environmental samples and foodstuffs for the whole of Denmark, and additionally the specific monitoring programme for the Risø site.

3.6 Danish Decommissioning

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

4 LEGAL FRAMEWORK FOR ENVIRONMENTAL RADIOACTIVITY MONITORING

4.1 LEGISLATIVE ACTS REGULATING ENVIRONMENTAL RADIOACTIVITY MONITORING

- Act, no. 170 of 16 May 1962 on nuclear installations gives the general framework that regulates the nuclear installations in Denmark (DD and DTU Risø Campus). https://www.retsinformation.dk/Forms/R0710.aspx?id=49314
- The environmental radioactive monitoring in Denmark relevant for this Article 35 verification is carried out according to the agreement signed in December 2014 between the Danish Health and Medicines Authority and DTU Nutech including technical appendices.
- In pursuance of the Act, no. 170 of 16 May 1962 DHMA/NIRP and DEMA have as nuclear regulatory authorities issued "Operational Limits and Conditions" for DD http://sundhedsstyrelsen.dk/da/sundhed/straalebeskyttelse/nukleare-anlaeg-atomanlaeg/~/media/CA52C79CF0364691835C3402D0C087AE.ashx and DTU Risø Campus http://sundhedsstyrelsen.dk/da/sundhed/straalebeskyttelse/nukleare-anlaeg-atomanlaeg/~/media/012F6B53E67D478397DDB47E4ACD7CA3.ashx
- Environmental radioactivity monitoring in the vicinity of the Risø area as well as discharge monitoring of airborne and liquid releases from DD is required in the "Operational Limits and Conditions" for DD. Clearance levels for solid materials are specified as well. The Operational Limits and Conditions are updated as necessary, most recently on 24. June 2014.
- Act, no. 94 of 31 March 1953 on use etc. of radioactive substances gives the general framework that regulates the use of radioactive materials in Denmark https://www.retsinformation.dk/Forms/R0710.aspx?id=49298
- National Board of Health order no. 954 of 23 October 2000 on the use of unsealed radioactive sources in hospitals, laboratories etc. gives the more detailed requirements on the use of unsealed radioactive sources. The order specifies the requirements and limits for disposal of unsealed radioactive sources (solid, liquid and gaseous), including disposal to the public sewage system. If DHMA/NIRP finds it necessary to require specific discharge monitoring of airborne releases from a facility/laboratory, this will be part of additionally specific requirements in the license for that facility/laboratory/hospital https://www.retsinformation.dk/Forms/R0710.aspx?id=21441

4.2 LEGISLATIVE ACTS REGULATING THE RADIOLOGICAL SURVEILLANCE OF FOODSTUFFS

In accordance with the Danish Food Act, no. 467/2014 the radiological surveillance of foodstuffs in Denmark is carried out according to the agreement signed in December 2014 between the Danish Veterinary and Food Administration and DTU Nutech including technical appendices https://www.retsinformation.dk/Forms/R0710.aspx?id=162871

4.3 INTERNATIONAL LEGISLATION AND GUIDANCE DOCUMENTS

- Council Directive 1996/29/EURATOM of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation.
- Council Directive 2013/59/EURATOM of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation.
- 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.

- IAEA's Safety Guide No. RS-G-1.7, Application of the Concepts of Exclusion, Exemption and Clearance.
- European Commission Radiation Protection 113, Recommended radiological protection criteria for the clearance of buildings and building rubble from the dismantling of nuclear installations, 2000.
- HELCOM Recommendation 7/7 (2014), Manual for the marine monitoring in the COMBINE programme of HELCOM.
- HELCOM Recommendation 26/3 (2005), Monitoring of radioactive substances. Revised 22 September 2014.

5 THE NATIONAL ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMME

5.1 INTRODUCTION

The Danish environmental radioactivity monitoring programme is composed of:

- A general monitoring programme for external gamma dose rate and radioactivity in air, water, soil and foodstuffs carried out by DTU Nutech.
- A specific monitoring programme in the vicinity of the nuclear installations at Risø site carried out by DTU Nutech on behalf of and as a contractor to DD.
- An automatic nationwide monitoring network for external gamma dose rate as part of the Danish nuclear emergency preparedness under the responsibility of DEMA.

In the event of a nuclear emergency, foodstuffs, feeding stuff and environmental samples can be analysed by DTU Nutech, NIRP and DD.

5.2 EXTERNAL GAMMA DOSE RATE MONITORING

The network, managed by DEMA, consists of 14 locations with gamma monitoring stations in Denmark (11) and Greenland (3) supplied by Envinet and put into operation in 2012. Each station is equipped with:

- An Envinet S-type spectral station (AGS710F) with a 2x2´´ NaI crystal. The stations in Greenland are equipped with a heating element.
- An Envinet D-type dose rate station with a GM-tube (AGS421F)

Network monitoring software (NMC-RAD) is used for central control and administration of the stations and for handling, storage, analysis, presentation and publication of the collected readings. The software is installed in the data centre at DEMA headquarters in Birkerød and can be accessed by intra- and internet. The stations have an automatic alert system that goes directly to the nuclear emergency duty officer. Results from the monitoring stations are reported in real time to the European Radiological Data Exchange Platform (EURDEP).

The green rectangles on the map below indicate the network of permanent monitoring stations (PMS) in Denmark, and the location of the nuclear power plants closest to the Danish borders:

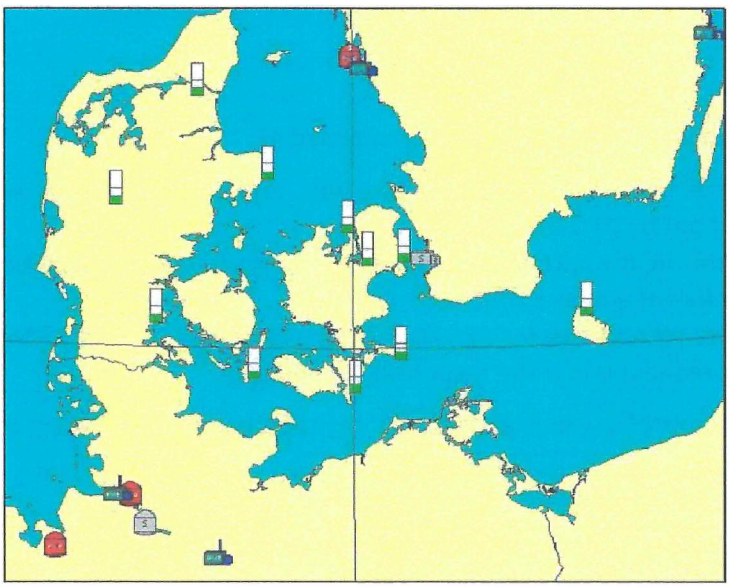

Figure 2. Permanent monitoring stations in Denmark and nuclear power plants closest to the Danish borders

In addition DTU Nutech has a network consisting of the following external radiation monitoring devices:

- TLD: LiF, measurement frequency annually from May to April. TLD equipment manufacturer: ALNOR/RADOS
- NaI detector: 3x3 inch, SAM 935 Surveillance and Measurement System, Berkeley Nucleonics Corporation, USA, with visual read-out

Calibration of the TLDs is carried out by irradiation at the NIRP calibration irradiator. Calibration has been verified by measurement with an ionisation chamber from the National Physical Laboratory, UK (NPL). The NaI detector is calibrated periodically vs. a Reuter Stokes ionisation chamber.

The 3 maps below show firstly the external background monitoring in and around the Risø site carried out with TLDs and NaI detectors, secondly external background monitoring in Denmark carried out with TLDs, and lastly the external background monitoring carried out with a NaI detector.

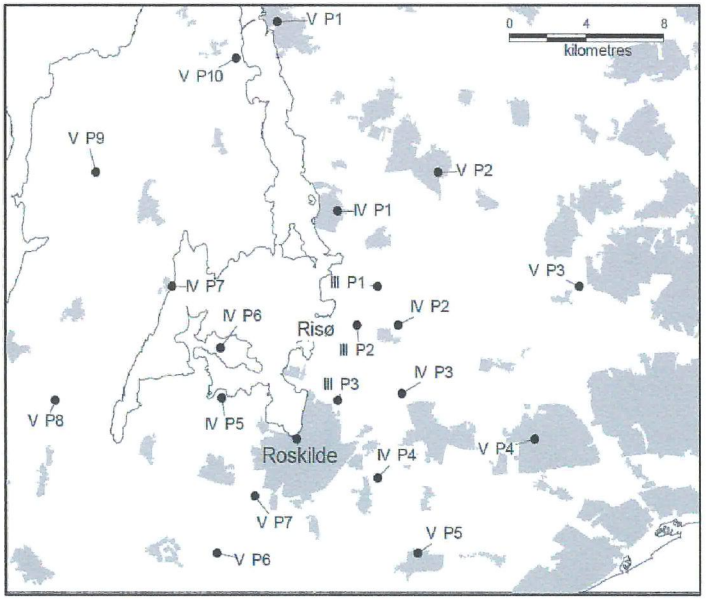

Figure 3. External background monitoring in and around the Risø site carried out with TLDs and NaI detectors

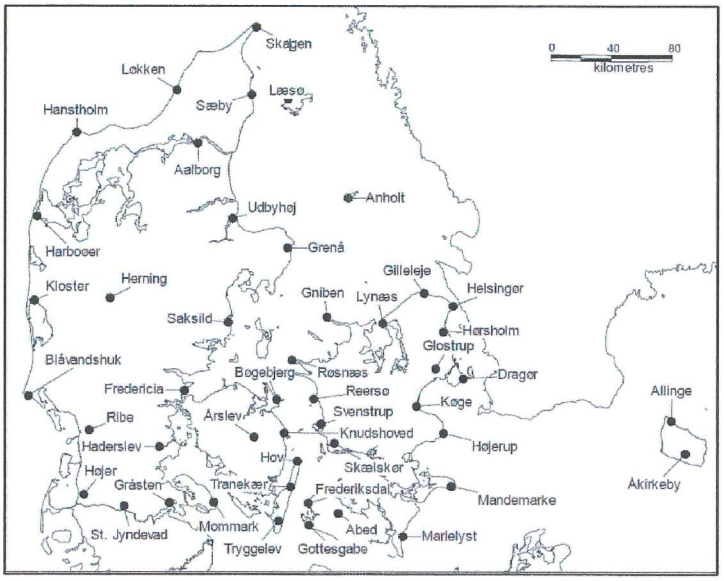

Figure 4. External background monitoring in Denmark carried out with TLDs

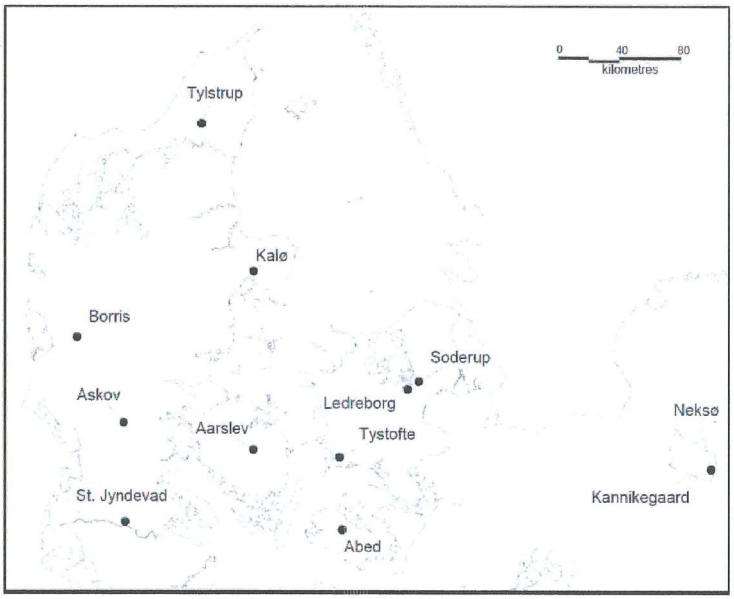

Figure 5. External background monitoring in Denmark carried out with a NaI detector

5.3 AIR RELATED PROGRAMME

DTU Nutech operates the air sampler at the Risø site, whilst DEMA manages the air samplers at Allinge and Haderslev, which are placed close to the PMS.

The sampler at the Risø site is manufactured by 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 rate is monitored by a gas meter connected to a shunt. The gas meter reading is compared to that of a reference gas meter intermittently.

The map below indicates the locations of the 3 air samplers installed in Denmark.

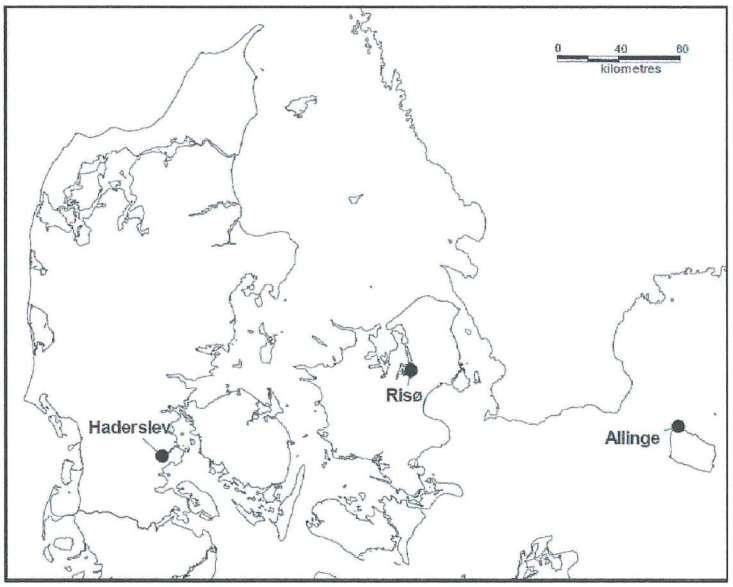

Figure 6. High-volume air samplers installed in Denmark

DEMA's two air samplers are medium to high volume samplers (400 m^3/h), type JL-400 Watchman, made by SENYA, Finland. They are designed for continuous sampling and have particle filters. The samplers can also be equipped with activated carbon cartridges to monitor gaseous iodine, but this functionality is not in use for the stations at the moment. The specifications are summarised below:

Gas ring vacuum pump	Nash Elmo
Voltage	400v, 50Hz
Power	40kW
Air quantity filter carbon	 >400 m^3/h 0-14 m^3/h
Activated carbon cartridge	0.5 l
Pressure difference meter	HK Instruments
Panel meter	Nokeval

The samplers have microprocessor based panel meters for pressure difference, air velocity, air volume and time. These parameters can be read from the panel meters, separately both for filter and carbon cartridge. The filters are exchanged once a week and sent to DTU Nutech for analysis together with the main parameters (sample volume, time, date, etc.).

DTU Nutech analyses filters from all three high-volume air samplers by gamma spectrometry shortly after filter change to check for the presence of short-lived man-made radionuclides. The air filters are subsequently stored for a minimum of one week to allow for decay of short-lived naturally occurring radionuclides before further analysis. DTU Nutech analyses the air filters from the Risø site for ^{137}Cs, ^{7}Be and ^{210}Pb on a weekly basis; ^{90}Sr is determined on a semi-annual basis on bulked samples.

DTU Nutech also analyses the air filters from Allinge and Haderslev by gamma spectrometry on monthly bulked samples.

5.4 DEPOSITION COLLECTORS

Radioactive deposition is monitored by analysis of the radioactivity in precipitation. The 11 locations including the Risø site with rain collectors are shown on the map below:

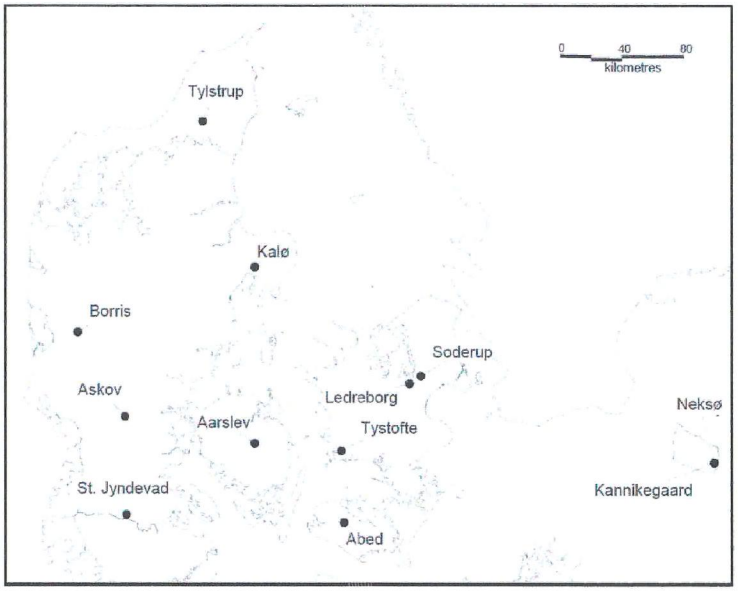

Figure 7. Location of rain collectors

Each site has three unheated rain collectors with a total area of $0.42m^2$. Each collector has a funnel situated above a 25 litre plastic container. The Risø site, furthermore, operates a large rain collector of $10m^2$. The collector is heated and water is passed through an ion exchange column to a large tank.

Plastic containers with precipitation are sent to DTU Nutech on a monthly basis, where samples are bulked for each location to provide annual samples which are analysed for ^{90}Sr and ^{137}Cs.

The $10m^2$ collector provides monthly samples of rain water analysed for tritium and ion exchange resin, which is analysed by gamma spectrometry (^{7}Be, ^{137}Cs and ^{210}Pb). The resin is also bulked for 4 consecutive months and analysed for ^{90}Sr.

5.5 WATER SAMPLING PROGRAMME

The water sampling programme consists of seawater, fresh water from streams and lakes, and ground water. The maps below indicate the locations for sampling of surface waters (firstly seawater, secondly fresh water from streams and lakes) and lastly groundwater.

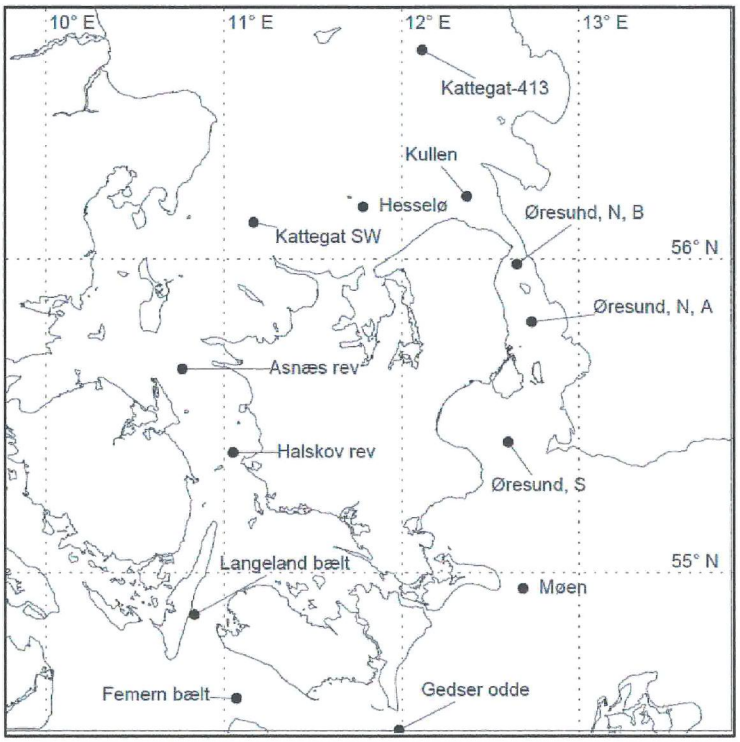

Figure 8. Seawater sampling locations

Figure 9. Fresh water sampling locations

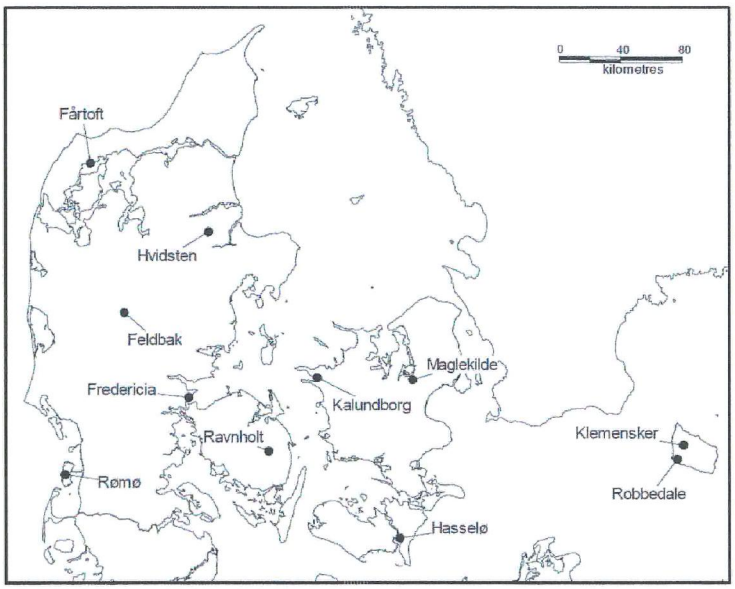

Figure 10. Groundwater sampling locations

Samples of seawater (50-100 litres) from 12 locations (surface and bottom) are collected twice a year by the Danish Navy and transported to DTU Nutech for analysis. In addition samples of water from Roskilde Fjord (not shown on the map) are collected monthly and surface seawater annually from Svenskehavn on Bornholm (also not shown on the map). All seawater samples are analysed for ^{90}Sr, ^{137}Cs, ^{99}Tc, Pu, and ^{237}Np. Samples from Roskilde Fjord are additionally analysed for ^{3}H; and annually for ^{137}Cs.

Fresh water samples from 8 streams and 8 lakes are collected annually. Samples of 100-600 litres for ^{137}Cs analysis are passed through impregnated filters in the field before the filters are taken to the lab. In addition, 200 litres samples are collected for ^{90}Sr analyses every 3 years.

There is no monitoring programme of drinking water intended for human consumption. The Danish Nature Agency and the Danish Health and Medicines Authority/NIRP have documented in 2014, using past monitoring and representative surveys with very low levels of radioactivity in water for human consumption, levels below the respective parametric values for radon, tritium and indicative dose listed in Annex I of the Council Directive 2013/51/EURATOM of 22 October 2013, laying down requirements for the protection of the health of the general public with regard to radioactive substances in water intended for human consumption. Consequently, it has been concluded[3] that water in Denmark intended for human consumption shall not be subject to monitoring. The conclusion is in addition to the results from earlier monitoring and representative surveys based on the fact that all water for human consumption in Denmark is produced from ground water.

5.6 SOIL RELATED PROGRAMME

Soil samples are collected approx. every 5 years from 10 locations, shown on the map below. A coring device is used to collect 13 sub-cores which are separated in depth segments of 0-5 cm, 5-10 cm, 10-20 cm, 20-30 cm and 30-50 cm and combined by depth. Samples are dried, ashed and sieved. Samples are analysed for ^{90}Sr and ^{137}Cs (and natural gamma emitters), occasionally for Pu.

[3] Dokumentation for lavt indhold af radioaktive stoffer i dansk drikkevand, NIRP, 10 November 2014 (in Danish)

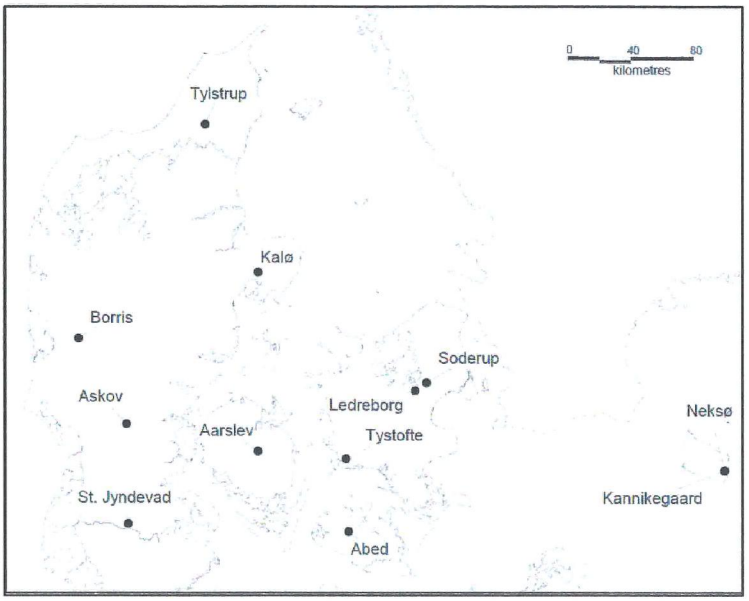

Figure 11. Soil sampling locations

5.7 TERRESTRIAL AND AQUATIC BIOTA AND FLORA

Grass samples are collected weekly at the Risø site are analysed by gamma spectrometry. Samples are bulked to monthly samples which are analysed for ^{137}Cs and bulked further to quarterly samples which are analysed for ^{90}Sr.

Seaweed samples are collected annually from Roskilde Fjord at the Risø site and analysed for ^{137}Cs, quarterly from three locations in Jutland and Zealand and annually at one location on Bornholm; and analysed for ^{137}Cs and ^{99}Tc. The map below indicates the locations of seaweed sampling.

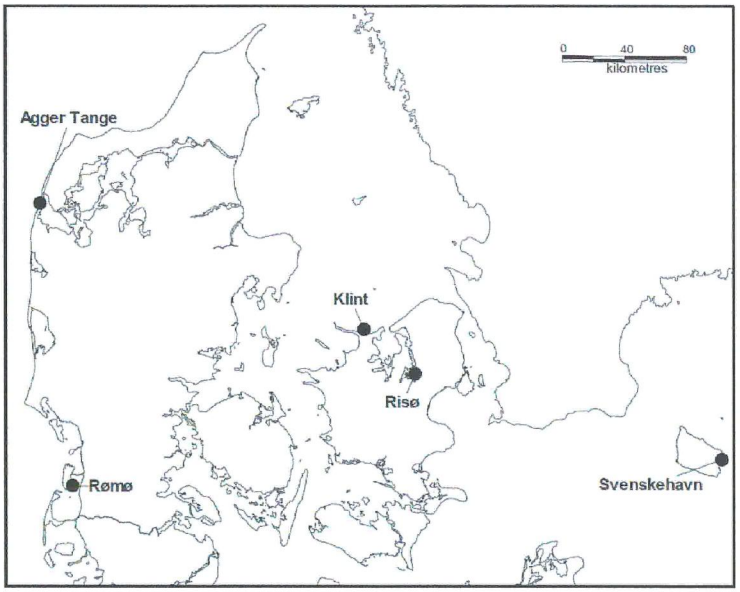

Figure 12. Seaweed sampling locations

Marine fish samples (cod, herring and plaice) are collected annually from harbours in West Jutland, Zealand and Bornholm and analysed for ^{137}Cs and ^{210}Po. Lobster is collected annually from Kattegat and analysed for ^{99}Tc.

5.8 FOOD SAMPLING PROGRAMME

The programme encompasses milk, mixed diet and foodstuffs.

5.8.1 Milk

Milk samples are collected every second month from 8 zones in Denmark, shown on the map below, and analysed for ^{137}Cs and ^{90}Sr.

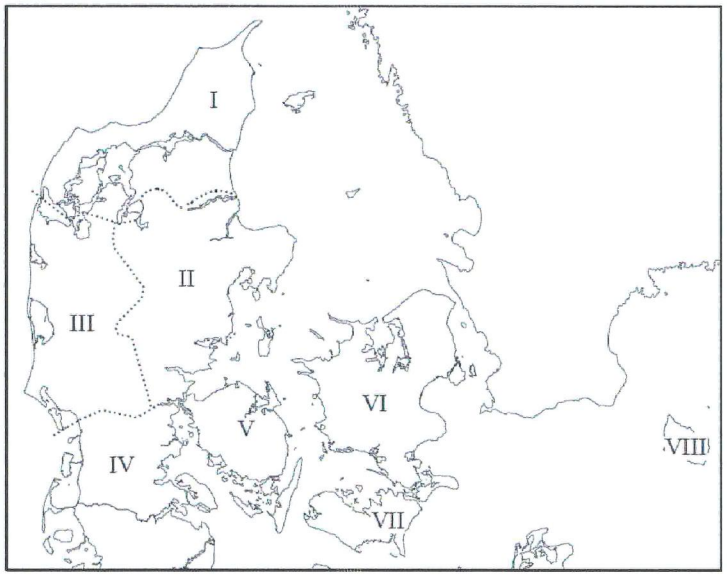

Figure 13. Milk sampling zones

5.8.2 Mixed diet

Food ingredients are collected from shops in Copenhagen and 8 other cities annually and mixed to form composite samples of an average daily intake corresponding to 4 daily meals. Samples are bulked by region to cover Jutland, the islands and Copenhagen and analysed for ^{137}Cs and ^{90}Sr.

5.8.3 Foodstuffs

Cereals (oats, wheat, barley and rye) are collected at 10 locations annually; and bulked by species. Vegetables, fruit, potatoes, beef, and pork are collected at the market in Roskilde annually. Imported food (bananas, oranges, rice, oatmeal, coffee, tea, and nuts) are sampled every 3 years in Copenhagen. Samples are analysed for ^{137}Cs and ^{90}Sr.

5.9 EMERGENCY MOBILE MEASUREMENT SYSTEMS

DEMA has two identical car-borne (CGS) and two identical airborne (AGS) measurements systems which can be operated by emergency reserve officers or volunteers (fire fighters) trained at DEMA. The operators receive training which enables them to perform measurements according to instructions, deliver data to a reach back capacity and to assist in calibration tasks.

Training of CGS and AGS operators, mounting of equipment and exercises in the air and on the ground are performed two to three times a year.

Car-borne Gamma Spectrometry (CGS)

The two systems are permanently mounted on two VW Multivans each consisting of 1 Radiation solution RS-701 console, 1 Radiation Solutions RSX-1 4l NaI(Tl) crystal, 1 Radiation Solutions RS-725/21, 0.39L (3" x 3") NaI(Tl) crystal and a Panasonic ToughBook running RadAssist software with mapping and nuclide identification features. The two detectors can be operated in parallel or separately.

For mobile measurements outside the Multivan, the console and the smaller detector (RS-725) can be removed and installed in any vehicle or airplane where a 12V power supply is available. This operation mode is especially useful for international missions.

Airborne Gamma Spectrometry (AGS)

The two systems consist of 1 Radiation solution RS-701 console, 2 Radiation Solution RSX-1 4l NaI(Tl) crystals, an UPS for uninterrupted power supply and a Panasonic ToughBook with RadAssist software. The systems are installed in a DART helipod which can be mounted on an AS-550 Fennec helicopter operated by the Danish Air Force.

An agreement with the Danish Air Force assures that the airborne systems can be mounted and put into operations within 48 hours after notification.

6 LABORATORY PARTICIPATING IN THE NATIONAL ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMME

6.1 DTU NUTECH

The Radioecology Division, Centre for Nuclear Technologies, DTU Nutech, which is part of the Technical University of Denmark carries out sampling and analysis of radionuclides in environmental samples and foodstuffs as part of the national environmental monitoring program and the local program around the Risø site (located in Roskilde).

6.1.1 Sample reception and preparation

Sample ID numbers are entered in log books. Methods used to prepare samples before measurement include drying, freeze drying, ashing, sorting, and sieving. Selected samples are archived.

6.1.2 Measurement devices

The laboratory has 8 Ge detectors for gamma spectrometry. Calibration of detectors using mixed-nuclide standards is carried out occasionally. Monthly checks of detector efficiency and energy resolution are performed as well as background measurements, which are done a few times per year. Gamma spectra are analysed with software developed at DTU.

32 Si detectors for alpha spectrometry are available in the laboratory. Calibration of Si detectors is done using sources produced from standard solutions. Results of alpha analyses are calculated in spreadsheets.

In addition the laboratory has low-level Geiger-Müller counters used for assessing ^{90}Sr and ^{99}Tc and a liquid scintillation counter used for tritium analysis.

6.1.3 Analytical results, data handling and reporting tools

Analytical results are printed on paper, recorded in log books and stored in a data base on the intranet. Results below detection limits are recorded as such. Spreadsheets are used for calculating results from raw data.

6.1.4 Statutory accounting and reporting

DTU Nutech reports environmental results to the European Commission and HELCOM. Results for the environmental monitoring at the Risø site are forwarded to DD, which reports these results to the NIRP and DEMA.

6.1.5 Quality assurance, laboratory accreditation and intercomparison exercises

All analytical results are checked by experienced staff and discussed with senior scientists if questions arise. DTU Nutech is accredited for measuring radioactivity levels by the Danish accreditation body DANAK according to the international standard ISO 17025. The accreditation covers testing for certain non-gamma emitting radionuclides, and not radionuclides occurring in the environment and food in general. DTU Nutech participates in international intercomparisons as listed in appendix 3.

7 DANISH DECOMMISSIONING

7.1 INTRODUCTION

The 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, NIRP and DEMA have, as nuclear regulatory authorities, issued Operational Limits and Conditions (OLC) for DD. 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.

7.2 DISCHARGE LIMITS

Discharge of radioactive substances to the environment from the operation and decommissioning of the nuclear installations shall be optimised, i.e. be as low as reasonably achievable. Limits for the discharge of radioactive substances from operation and decommissioning of the nuclear installations are based on a reference dose (dose constraint) for members of the public outside DD of 0.05 mSv/y for the specific installation and 0.1 mSv/y for DD considered as one installation.

The following annual limits apply for discharges to the atmosphere from a single nuclear installation:

Radionuclide	Annual limit GBq/y
^{3}H	1 000 000
^{14}C	1 000
^{60}Co	1 000
^{90}Sr	200
^{137}Cs	700
$^{152\text{-}154}Eu$	700
Actinides	1

The following annual limits apply for discharges to Roskilde Fjord from a single nuclear installation:

Radionuclide	Annual limit GBq/y
^{3}H	1 000 000
^{137}Cs	400

7.3 DISCHARGES AND MONITORING

During operation of the closed reactor DR 3 and the Waste Treatment Plant, radionuclides are released to the atmosphere through the ventilation systems and to Roskilde Fjord after cleaning of contaminated liquids. The radionuclide releases to the environment include:

- release of ^{3}H (tritiated heavy water) and β-activity to the atmosphere from reactor DR 3
- release of *β*-activity to the atmosphere and to Roskilde Fjord from the Waste Management Plant

The activity releases to the environment from these facilities are determined from calculations using the results of sample measurements.

Reactor DR 3

Tritium is released to the atmosphere through the ventilation stack which is equipped with HEPA filters. The source for this continuous release is tritiated heavy water trapped in the graphite within the steel tank. If there is a failure in the HEPA-filters, radioactive particles might be released through the ventilation stack.

Water vapour in the ventilation air is trapped in a cooling trap through which air is continuously sampled from the ventilation system. The concentration of tritium in the frozen sample is measured, after melting, in a liquid scintillator.

Air from the ventilation system is continuously sampled through a glass filter paper. Every week the activity content on the filter paper is determined by γ-spectrometry. Usually, no activity is found on the filter paper.

Waste Management Plant

Releases of radionuclides to the environment from the Waste Management Plant include atmospheric and aquatic releases.

Releases of radionuclides to the atmosphere originate from:

- ventilation of the asphalt facility
- ventilation of the distillation facility

The ventilation air is discharged to the atmosphere through the ventilation stack.

Radionuclide releases to the aquatic environment originate from:

- the distillation facility
- collecting tanks for active laboratories (active tanks)
- collecting tanks for cooling water (cooling water tanks)
- rain water tanks for tailing ponds

All aquatic releases to the sewer system or to Roskilde Fjord via the biological sewage treatment facility are controlled for radionuclide content by measurements of gross β-activity in samples.

Active tanks are placed below ground in several buildings at the Risø site. The content of the active tanks is transferred to the distillation facility. The distillate from the facility can be discharged to the biological sewage treatment facility if the concentration of gross β-activity is less than 1.5 Bq/ml.

The content of the cooling water tanks can be discharged to the normal sewer system if the concentration of gross β-activity is less than 0.15 Bq/ml. If the concentration is greater than 0.15 Bq/ml the content is transferred to the distillation facility.

The content of the drain water tanks for the tailing ponds can be transferred to the inactive sewage treatment facility if the concentration is less than 0.4 Bq/ml measured as gross β activity. If the concentration is greater than 0.4 Bq/ml the content is transferred to the distillation facility.

The cleaned water from the biological sewage treatment facility is collected in a basin before discharge to Roskilde Fjord. Water samples are collected every working day and measured for gross

β-activity. If the concentration exceeds 0.15 Bq/ml the water discharge will be stopped and investigations carried out.

The ventilation air in the stack is monitored by a continuous air monitor in which air from the ventilation system is continuously sampled through a glass filter paper. A monitor detects the collected activity on the filter paper. Once a week the collected activity on the filter paper is determined by counting in a proportional counter. Usually, no activity is found on the filter paper.

Hot Cells

The ventilation air in the stack is monitored by a continuous air monitor in which air from the ventilation system is continuously sampled through a glass filter paper. A monitor detects the collected activity on the filter paper. Once every week the collected activity on the filter paper is determined through counting in a proportional counter. If the activity content is above the natural background the nuclide-specific activity is determined by γ-spectrometry.

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. Mass-specific clearance measurements in the clearance laboratory and surface-specific clearance measurements started in May 2007, after the accreditation by DANAK. The total amount of materials that has been cleared up until the end of 2014 is 537 tonnes by mass-specific measurements and 358 tonnes by surface-specific measurements. The clearance laboratory has since 2007 participated in Environmental Radioactivity Proficiency Test Exercises performed by the UK National Physical laboratory (NPL).

7.4 ENVIRONMENTAL SURVEILLANCE PROGRAMME

In addition to discharge monitoring the OLC requires also an environmental surveillance programme. Samples are analysed by DTU Nutech on behalf of and as a contractor to DD according to the table below:

Number	Object	Place	Frequency	Measurement
1	Air filter 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 the Risø-area	Quarterly	Tritium
1	Water sample	Roskilde Fjord at the quay in the Risø-area	Yearly	^{137}Cs
1	Grass sample	Risø-area	Weekly	γ-spectrometry
1	Sea plant 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	Half yearly	Scintillation counter and TLD

8 VERIFICATIONS

8.1 NATIONAL INSTITUTE OF RADIATION PROTECTION

The NIRP has a workforce of 30, comprising a Director, 23 experts, 3 technicians and 3 administrative staff. A radiation expert is on 24h stand-by duty for emergency situations (principally radiological). They are able to scale from routine to emergency and have additional facilities and people that can help in case of emergency using mobile equipment. At their headquarters in Herlev there are 2 laboratories, though neither performs measurements pertinent to Article 35, under normal situations. These facilities could nevertheless provide backup to DTU Nutech in emergency situations.

Radiochemistry laboratory

Equipment in the laboratory consists of

- 1 Stationary high-resolution, low-background Ge-detector (gamma)
- 2 Mobile Falcon high-resolution Ge-detectors (gamma)
- 2 Mobile NaI-detectors
- 1 Stationary NaI-detector (I-125)
- 1 Tri Carb 2900TR liquid scintillation detector (beta, alpha, gamma)

All equipment was well labelled with calibration dates etc.

Normal applications are measurements of urine samples, surface contamination and leak test measurements, nuclide identification, on-site and off-site investigation of "unknown" samples. Detector calibration is done using commercial mixed nuclide standards (^{3}H, ^{125}I, ^{14}C, and ^{125}Eu). Canberra LabSocs is used for emulated calibrations, including ^{131}I, ^{137}Cs, ^{60}Co, ^{241}Am, and NORM. Through the choice of construction materials the background radiation has been reduced to one third of normal. In addition the floor has been raised to increase the distance from the concrete below.

All results are stored on a central computer with regular backups. In the event of an electrical power failure a UPS is available to bridge the gap in power supply before a diesel generator takes over the task.

To avoid possible contamination of equipment unknown samples are received in a different area of the building. Furthermore there are 3 radiation portal monitors in the common area which separate the 2 labs, ensuring that no (highly) contaminated samples and/or sources are inadvertently moved from the radiochemistry lab to the dosimetry lab.

Amongst the international comparison exercises in which the laboratory has participated are: EC Interlab, NKS (Nordic Nuclear Safety Research) 2011, 2013 and 2015.

Accreditation is pending, though ISO-17025 and ISO 11929 are implemented. In particular the procedures were available next to each piece of equipment.

The verification does not give rise to recommendations

Dosimetry laboratory

The dosimetry laboratory provides a calibration facility for radiation dose meters (X-ray and ^{60}Co) used in the Danish laboratories and hospitals. Accreditation of the laboratory according the ISO 17025 (DANAK) has been achieved since the last verification.

Currently a Gammabeam X200 Research Irradiator with a 435 TBq ^{60}Co source is used. However it is expected that by December 2015 a Gamma Irradiator and calibration bench - HVF-OG-8, will be installed loaded with

- ^{137}Cs-1.48TBq
- ^{137}Cs-50GBq
- ^{137}Cs-1.6GBq
- ^{241}Am-220GBq
- ^{60}Co-50GBq

The personal dosimetry service represents between 60 and 65000 readings per year.

The verification does not give rise to recommendations.

8.2 GAMMA DOSE RATE MONITORING NETWORK

Owing to time constraints and the large distances separating the 11 stations (excluding the 3 on Greenland) which make up the network, it was only possible to visit Lynæs, about 1hr from Copenhagen. Due to the amount of snowfall in Greenland it was decided to position each detector at a height of 2m, to ensure comparability between results. All stations have a common setup, comprised of 2 independent detectors (NaI and GM tube) with auto-recalibration based on natural K from the ground. The NaI detector is an Envinet Sara model whilst the GM tube has 3 probes, 2 for low dose rate and a 3rd one for high dose rate, with a rain sensor on the top of the detector. The former transmits data every 10 minutes to DEMA headquarters using a LAN connection, whilst the latter uses the GSM network, which for cost reduction purposes is limited to twice daily transmission. If necessary the interval can be reduced to 10 minutes. Calibrations are carried out every 2-3 years.

Siting was good on a flat area not far from the fjord, on the outskirts of the village. As the site is shared by 3 different entities, there were 3 locks on the gate. Although there were some young trees in the vicinity, these do not interfere with the instruments. The electronics are housed in a small locked hut within the fenced area, which also houses a UPS which can maintain power for 5-7 days. An alarm is automatically sent to DEMA and there is a person locally who can intervene to restore power. A TLD belonging to the DTU Nutech network was also sited within the compound.

The verification does not give rise to recommendations. The verification team was impressed by the design of each station, consisting of 2 independent detectors (indeed based on different technologies) using distinct communication systems.

8.3 AIR SAMPLERS

Owing to the fact that the 2 air samplers, which may be equipped with activated carbon cartridges, operated by DEMA are in Allinge and Haderslev, it was not possible to visit these sites in the time available. During the visit to DTU Nutech the sampler at the Risø-site was shown to the verification team.

Whilst it was not possible to visit the 2 air samplers operated by DEMA the verification team would encourage occasional analysis of the activated carbon cartridges from these stations to ensure that laboratory staff is adequately trained in this method.

The verification of the air sampler at Risø does not give rise to any remarks.

8.4 DTU NUTECH

The former Radiation Research Division at Risø DTU, which was in charge of implementation of the national environmental monitoring program and the local program around the Risø site, has been fully integrated into DTU Nutech since 2011. Total staff employed on site is 80, though only 14 (including 7 technicians, 2 PhD and 5 Scientists) belonging to the Radioecology Division are involved in both monitoring programs, at site level and at national level according to the Euratom Treaty. Though part of the Danish Technical University the site has no formal teaching role, its contribution being the education and training of PhD students.

Whilst DTU Nutech holds ISO 17025 accreditation covering testing for certain non-gamma emitting radionuclides, this is mainly to underpin analyses performed for Danish Decommissioning. Nevertheless the lessons learned in the process are put into practice in relation to the analysis of environmental samples. Many of the instruments were developed "in-house" and have proved their efficiency, particularly through regular participation in intercomparison exercises. Any move to obtain ISO 17025 accreditation would thus firstly involve homologation of this equipment.

Unfortunately at the time of the visit work was ongoing in upgrading the labs thanks to funds provided by the Danish Government to be dedicated to the laboratories' renovation. This upgrade of the laboratories started in February 2015 and its conclusion is foreseen to be in October 2015. In particular the sample receipt (except water) and initial preparation (drying, ashing etc.) will be transferred to the former boiler room which became available following connection to the district heating network. This will considerably reduce the discomfort in the laboratory area caused by smoke and fumes. In future liquid nitrogen will be supplied via a pipeline in the laboratories.

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. The room devoted to seawater preparation was completely empty at the time of the verification.

Scales used for sample weighting are calibrated every two years by an external calibration service.

Chemistry rooms
The laboratory has several rooms for the necessary chemical treatments of samples. These rooms are well equipped to handle 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. Fume cupboards will be upgraded as part of the renovation programme underway.

Gamma counting room
The new gamma counting room will comprise 12 HPGe detectors, though at the time of the visit only 7 were operational and were sufficient to ensure that the laboratory continued analyses. 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. Stability of the energy calibration, efficiency calibration and peak are controlled monthly.

Alpha-beta counting room
The alpha-beta counting room is equipped with 32 alpha counters and two 4×5 sample matrix beta counters. A high number of counters are needed since counting times are very long (typically one

week). In addition there is a low-level scintillation counter (Quantulus), though this is not routinely used for analysis of environmental samples.

Both counting rooms are temperature controlled.

Sample archive
Ashed samples and air filters are kept in a movable shelf storage system in good order with an excellent colour labelling system. Air samples date back to the 1960's, and particular care is taken to conserve samples from Greenland, relating to the 1968 Thule crash site.

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 NIRP reference calibration facility.

Currently it is being investigated whether the TLD programme will be continued, particularly in view of the other systems in place which give more immediate results and the fact that there are no nuclear activities on the site. DTU Nutech considers that the TLD programme which performs yearly measurements has a lower quality and poorer representativeness than the monitoring and analysis carried out both as part of the national and the Risø site specific programmes.

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 external gamma dose rate data is made available at the EURDEP website.

HVAS
There is a large high volume air sampler, with a flow rate of 2000 m^3/h on the Risø site comprising 6 panels of 1.5 m^2 which was developed by the former Risø DTU research facility. Filters are cut from a roll of material. After a one week collection period a press is used to compress the filters into the relevant Marinelli geometry for analysis. A smaller sampler is located alongside and an analysis of the beryllium trapped by this serves to verify the flow rate of the larger sampler using the proportionality principle.

Precipitation collector

The verification team were shown the larger heated collector with an approximately 10 m^2 collection area where the collected water passes through an ion exchange column and into a large tank. Analysis of the ion exchange resin by gamma spectrometry is carried out for ^{7}Be, ^{137}Cs and ^{210}Pb. Moreover, the bulked resin is analysed for ^{90}Sr after 4 consecutive months. Monthly analyses for tritium are carried out on the water collected.

> *The verification does not give rise to recommendations. The verification team would support withdrawing the TLD measurements and the allocation of the resources to other areas of the monitoring programme. Performing routine measurements within a research environment is seen as positive approach as it allows new techniques and procedures to be introduced, which may serve to improve the quality of the analyses carried out.*

8.5 Danish Decommissioning

Although not initially foreseen in the verification planning, it was nevertheless decided to include a brief visit to the waste treatment plant, the former hot cells, the DR 3 reactor (tritium facility) and

the clearance laboratory. A detailed description can be found in chapter 7 of this report. Explanations were given concerning the activities carried out in the clearance laboratory and the monitoring systems in place in the other units.

The verification does not give rise to recommendations.

8.6 DANISH EMERGENCY MANAGEMENT AGENCY

The nuclear division of DEMA consists of 10 persons. Three people are on 24hr standby for general emergency, nuclear incidents and maintenance of the IT infrastructure. Nationwide there are 6 fire & rescue centres, though nuclear incidents would only be handled at the headquarters in Birkerød. A number of incident centres are located here, which are routinely used for meetings. This use of the incident centres allows verification that the equipment is functioning. Where more than 1 room is used a video conference system serves for communication between the rooms. A separately cabled and secure analog phone is fitted for communications in the event of failure of the digital network. Each room has a computer whilst participants would bring their own laptops, with which they are more familiar.

The nationwide alarm system (conventional and nuclear) is duplicated at Siemens, who have instructions to contact the emergency centre in the event of an alert.

Whilst DEMA's responsibility is principally related to nuclear incidents, whereas the NIRP is responsible for radiological incidents, both organisations have close cooperation and carry out joint inspections in the nuclear field within Denmark. Unlike DEMA the NIRP does not have personnel trained to go into hazardous areas (nuclear or radiological).

Currently DEMA has 15 people trained to carry out measurements in the event of a nuclear incident, with some having received additional training enabling them to locate sources or identify nuclides. It is planned to extend the number of such trained personnel, not with a view to creating specialists, but to ensure staff have wider capabilities beyond simple measurements.

The ARGOS decision support system has been programmed to simulate accidents at the 4 nuclear power plants located closest to Denmark and it receives regular updates of the weather forecast, which allows for a fast reaction time in the event of an emergency.

Two 4*4 VW Multivans are kept fully equipped with all necessary personal protective equipment, hand held detectors (RS-220 and NaI). One vehicle also carries a neutron detector, which is placed in an aluminium box on the roof of the car in order to avoid contamination. In addition two airborne gamma spectrometry systems, each consisting of an Exploranium NaI(TI) detector (4 l), GPS, radar altimeter and a PC equipped with special software are kept on stand-by, ready to be mounted on a helicopter of the Danish Air Force. In 2014 an exercise was carried out using a Canberra Colibri detector mounted on a drone, and it is planned to further develop this approach. Currently DEMA doesn't have any neutron detector, but if needed they can call upon NIRP, which has neutron measurement capabilities.

The verification does not give rise to recommendations. The verification team acknowledge DEMA's extensive emergency preparedness arrangements.

Overall the monitoring arrangements are of a high standard. The verification team express the hope that this level of quality can be maintained in the future, through equipment maintenance, and above all through preserving a sufficient level of trained staff, as exists at present.

9 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 lead 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 at the sites visited are adequate. The Commission could verify the operation and efficiency of these facilities.

(2) A few technical recommendations and suggestions are formulated. These aim at improving some aspects of the national monitoring system. They do not discredit the fact that the verified parts of the national monitoring system for environmental radioactivity are in conformity with the provisions laid down under Article 35 of the Euratom Treaty.

(3) The recommendations are summarised in the 'Main Conclusions' document that is addressed to the Danish competent authority through the Danish Permanent Representative to the European Union.

(4) The Commission Services ask the Danish competent authority to inform them of any achievements with regard to the situation at the time of the verification.

(5) The verification team acknowledges the excellent co-operation it received from all persons involved in the activities it performed.

APPENDIX 1

REFERENCES & DOCUMENTATION

1. Preparation questionnaire for the Euratom Article 35 verification visit to Denmark, April 2015
2. Task agreement between NIRP and DTU Nutech from 2015 (excerpt)
3. Operational limits and conditions for DD (translation of selected parts) NIRP March 2015
4. Release monitoring at the nuclear facilities of DD Danish Decommissioning March 2015
5. Semi-annual release reports for the period 2013-2015 from the waste management plant
6. Semi-annual release reports for the period 2013-2015 of tritiated heavy water from the DR3 reactor

APPENDIX 2

THE VERIFICATION PROGRAMME

ARTICLE 35 VERIFICATION
Denmark – Routine and Emergency Radioactivity Monitoring Arrangements
21-23 April 2015

Day / date	Time	Activities
Tuesday 21 April	9.00 – 12.00	NIRP (Herlev): – Opening meeting – Laboratories
	14.00 – 17.00	Lynæs, North Zealand, – Gamma monitoring station – Background dose monitoring (TLD)
Wednesday 22 April	9.00 – 17.30	Risø site: DTU-Nutech (former Risø DTU): – DTU-Nutech laboratories – On-site high volume air sampler Danish Decommissioning: – Discharge monitoring from the Waste Management Plant, Hot Cells and DR 3 – Clearance Laboratory
Thursday 23 April	9.00 – 13.00	DEMA Birkerød: – Automatic monitoring network data centre – Mobile monitoring systems
	14.30 – 16.00	Closing meeting

APPENDIX 3

DTU Nutech participation in international comparaison exercices since 2007

Year	Title	Organiser	Sample type	Radionuclides
2015	Radon in drinking water	Proftest SYKE	Water	^{222}Rn
2015	EC Interlab Comparison	IRMM	Air filter	^{137}Cs
2014	Env Rad PTE 2014	NPL	Water	Gamma emitters, ^{3}H, ^{14}C, ^{36}Cl
2014	IAEA-TEL-2014-04	IAEA	Water, seaweed, sediment	Gamma emitters, ^{90}Sr, Ra, U
2014	IAEA TEL 2014-1	IAEA	Gamma spectra	Gamma emitters
2014	NAEL Monaco	IAEA	Seawater	^{3}H, ^{90}Sr, ^{134}Cs, ^{137}Cs
2013	Env Rad PTE 2013	NPL	Water	Gamma emitters, ^{3}H, ^{14}C, ^{63}Ni, ^{90}Sr, ^{241}Pu
2013	IAEA-TEL-2013-04	IAEA	Water and flour	Gamma emitters, ^{90}Sr
2013	IAEA-410 and IAEA-412	IAEA	Sediment	Gamma emitters, ^{129}I, U, Th
2013	RAS/7/021 PTE 2013	IAEA	Seawater	^{90}Sr, ^{134}Cs, ^{137}Cs
2013	NKS Intercomparison	DTU/NKS	Soil	Gamma emitters
2012	IAEA-TEL-2010-04	IAEA	Water, hay, soil	Gamma emitters, ^{90}Sr, Pu, U
2012	EC Interlab Comparison	IRMM	Drinking water	Gross alpha and beta
2012	EC Interlab Comparison	IRMM	Soil	Gamma emitters, ^{90}Sr, U, Th, Pu
2012	Env Rad PTE 2012	NPL	Water	Gamma emitters, ^{3}H, ^{14}C, ^{36}Cl, ^{90}Sr, ^{99}Tc, ^{147}Pm, Ra, U, Th, Pu, Cm
2011	IAEA-446	IAEA	Macroalgae, Fucus	Gamma emitters
2011	EC Interlab Comparison	IRMM	Bilberry powder	^{40}K, ^{90}Sr, ^{137}Cs
2011	EC Interlab Comparison	IRMM	Mineral water	^{226}Ra, ^{228}Ra, ^{234}U, ^{238}U
2011	IAEA-TEL-2011-04	IAEA	Water and soil	Gamma emitters
2010	RADPAST 01-06-2010	NKS	Sediment	Gamma emitters
2010	IAEA-CU-2010-03	IAEA	Soil	Radium
2010	Env Rad PTE 2010	NPL	Water	Gamma emitters, ^{3}H, ^{14}C, ^{41}Ca, ^{55}Fe, ^{63}Ni, ^{90}Sr, ^{99}Tc, ^{129}I, Ra, Pu, Np, Am, Cm
2010	EC Interlab Comparison	IRMM	Soil	NORM
2008	GEOTRACES	LDEO, USA	Seawater	^{90}Sr, ^{137}Cs, Pu, Am
2007	LUCIA	NKS	Sewage sludge and water	^{131}I, ^{111}In
Nearly annually	HELCOM MORS intercomparison	HELCOM MORS group	Seawater	^{90}Sr, ^{137}Cs