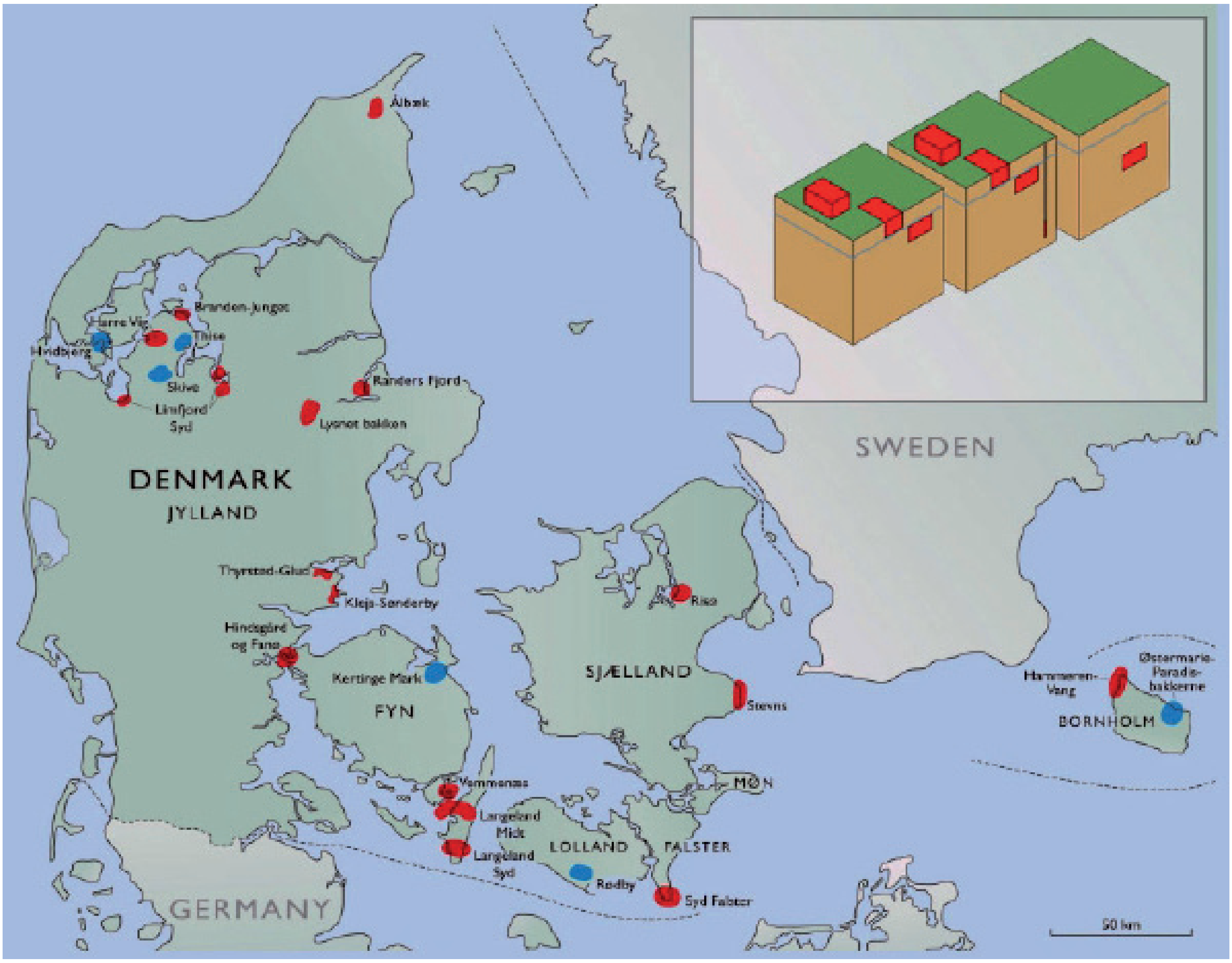
Sundhedsstyrelsen
National Board of Health



Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

2011

FOURTH NATIONAL REPORT FROM DENMARK

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive waste Management – National Report from Denmark

National Board of Health (Sundhedsstyrelsen)
National Institute of Radiation Protection
Knapholm 7
2730 Herlev
Denmark

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Contents

Section A. Introduction

Denmark signed the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management 29 September 1997, the day it opened for signature. The Convention was accepted 3 September 1999 by letter from the Ministry of Foreign Affairs to the International Atomic Energy Agency (IAEA). Until further notice the Convention does not apply for the autonomous territories Greenland and the Faroe Islands.

The present report is the Danish National Report for the Fourth Review Meeting to the Convention. The meeting takes place 14-23 May 2012 at IAEA headquarters, Vienna. As described in the Guidelines regarding the Form and Structure of National Reports, (INFCIRC/604 rev. 1, 19 July 2006) duplication within the reporting, including repetition of former reports, should be avoided. At the same time it is stated that the report should be a stand-alone report. Consequently, Denmark has in this report decided to focus on what is considered highlights and new developments since the National Report from the Third Review Meeting. However, the present situation will, if considered necessary from a stand-alone report point of view, be stated briefly under each paragraph, even if there has been no development since the last meeting. Readers wishing a more detailed description of the Danish practices and understanding of the development before 2009 will find the former reports as well as the questions and answers submitted via the homepage for the Joint Convention[1].

Main developments since the 2009 meeting fall within the following areas of work: 1) the decommissioning of the peripheral equipment of Danish research reactor 3 (DR 3), 2) decontamination of the Hot Cell facility and 3) the process leading to establishment of a final repository for LILW (Low and Intermediate Level Waste). Below, the current status of the decommissioning process is summarised briefly.

DR 1 (Danish Reactor 1) is now fully decommissioned and released from regulatory control. DR 2 is as of 2008 also fully decommissioned, but the reactor building has not been released from regulatory control, as it will be used for handling and storage purposes in connection with the decommissioning of the Hot Cell facility and of DR 3. With respect to DR 3, the fuel elements are removed, decommissioning of auxiliary systems is in progress, and a plan for the complete decommissioning to »green field« was submitted for approval by the National Regulatory Authorities in August 2011. The contamination of the Hot Cell facility has been characterised further and isolated hotspots have been removed prior to the actual decontamination of the cell interiors, which is still in planning.

With the long-term aim to establish a Danish repository for radioactive waste, a “Basis for Decision” describing how to proceed with the project was prepared and forwarded to the Government in the fall of 2008. It was subsequently discussed and endorsed by Parliament. As planned in the “Basis for Decision”, three preliminary studies have focussed on: a) Pre-feasibility study for final disposal of radioactive waste. Disposal concepts. b) Radiation doses from the transport of radioactive waste to a future repository in Denmark – A model study, and c) Low- and intermediate level radioactive waste from Risø, Denmark. Location studies for potential disposal areas.. These studies were finalised in May 2011.

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[1] http://www-ns.iaea.org/conventions/waste-jointconvention.htm

The present report also considers the issues raised in the Rapporteur's Report for Denmark at the 2009 meeting, where the following themes were highlighted as challenges:

- Technical challenges: Hot Cell decontamination and dismantling of the inner parts of DR 3.
- Management solution for remaining minimal amounts of spent fuel.
- LILW disposal follow up (selection of option, siting, etc.).
- Forecasting the need of staff and maintaining necessary staff during the decommissioning period and qualifying staff for future employment.

The report is prepared by the National Institute of Radiation Protection under the National Board of Health, in co-operation with Danish Decommissioning (DD) and the Nuclear Division under the Danish Emergency Management Agency. It is concluded in the report, that Denmark meets all obligations of the Convention.

Section B. Policies and Practices

No new developments. Please refer to the previous National Reports[2].

The policy and practice for radioactive waste management is to collect, characterize, manage and store all Danish radioactive waste under safe and secure conditions in dedicated storage facilities under responsibility of Danish Decommissioning.

The availability of adequate financial resources is assured also in the future, inasmuch as Danish Decommissioning is government property under the administration of the Danish Ministry of Science, Innovation and Higher Education. Thus the financial capacity to maintain and if necessary improve the safety of facilities for spent fuel and radioactive waste management in accordance with the regulatory requirements is ensured.

[2] National Reports from Denmark:

Joint Convention Report 2003.pdf

Joint Convention Report 2005.pdf

Joint Convention Report 2008.pdf

Section C. Scope of Application

As Contracting Party to the Joint Convention Denmark has declared that:

- Reprocessing is not part of the spent fuel management.
- Waste that contains only naturally occurring radioactive materials is not radioactive waste for the purpose of the Convention.
- Spent fuel or radioactive waste within military or defence programmes is not spent fuel or radioactive waste for the purpose of the Convention.

However, waste that contains only naturally occurring radioactive materials as well as radioactive waste from the Danish military or defence programmes, is managed identical to the radioactive waste described in this report, as this kind of waste is covered by the legislative and regulatory system mentioned in section E.

Section D. Inventories and Lists

Article 32. Reporting

D.1 Spent fuel management facilities

There is no new development regarding spent fuel. The present situation is described below.

There are no spent fuel management facilities in Denmark subject to the Convention. However, minor amounts of spent fuel are stored, under safe and secure conditions with appropriate surveillance, at the storage facilities for radioactive waste at Danish Decommissioning. Special precautions for heat generation and dissipation are not necessary for these materials. An inventory of the stored spent fuel is given in Table 1.

Table 1. Inventory of spent fuel. Activities as of January 2008.

Spent fuel	Storage facility	Material	Mass/ Volume	Activity
Spent fuel from DR 1	DR 3 building complex	Solution of 20% enriched uranyl sulphate in light water	15.8 l	112 GBq fission products 4 GBq actinides
Experimentally irradiated spent fuel of power reactor type	The Centralvej Storage	Uranium oxide pellets mostly in zircalloy tube	233 kg	703 TBq fission products 32 TBq actinides

D.2 Radioactive waste management facilities

An overview of Danish Decommissioning nuclear facilities and associated buildings is given in Figure 1, and listed in Table 2. Since the last report to the Convention, permission to use an extension to The Intermediate Storage was given by the Regulatory Authorities in December 2010. The extension is a 12 m addition towards the West, identical in design to the existing building, yielding an extra 244 m^2 of storage area.

The extended Low Level Waste Storage taken into use in 2008 accommodates approximately 1,200 drums of LILW-SL (Table 2). The storage also comprises a facility for repackaging of corroded and old drums. The repackaged drums eventually get transferred to The Intermediate Storage, maintaining the total number of drums stored in the Low Level Waste Storage is at a constant level.

Following inspection and approval by the Nuclear Regulatory Authorities ultimo 2005, the Radiological Characterization Lab (A-lab) for sampling and characterisation of materials from facilities, buildings, and areas has undergone external audit of quality assurance according to DS/EN ISO 9001: 2008 in 2010

In 2006 the Clearance Laboratory (F-lab) for decommissioning waste was approved by the Nuclear Regulatory Authorities with respect to a restricted and well defined amount and type of decommissioning waste. There are no restrictions on the amount or type of decommissioning waste for handling in F-lab after the independent accreditation of the lab in 2007.

Since the publication of the previous National Reports the waste flows have developed considerably with respect to both amounts and routes. A significant amount of waste has passed the clearance criteria and has been released from regulatory control since the F-lab went into operation.

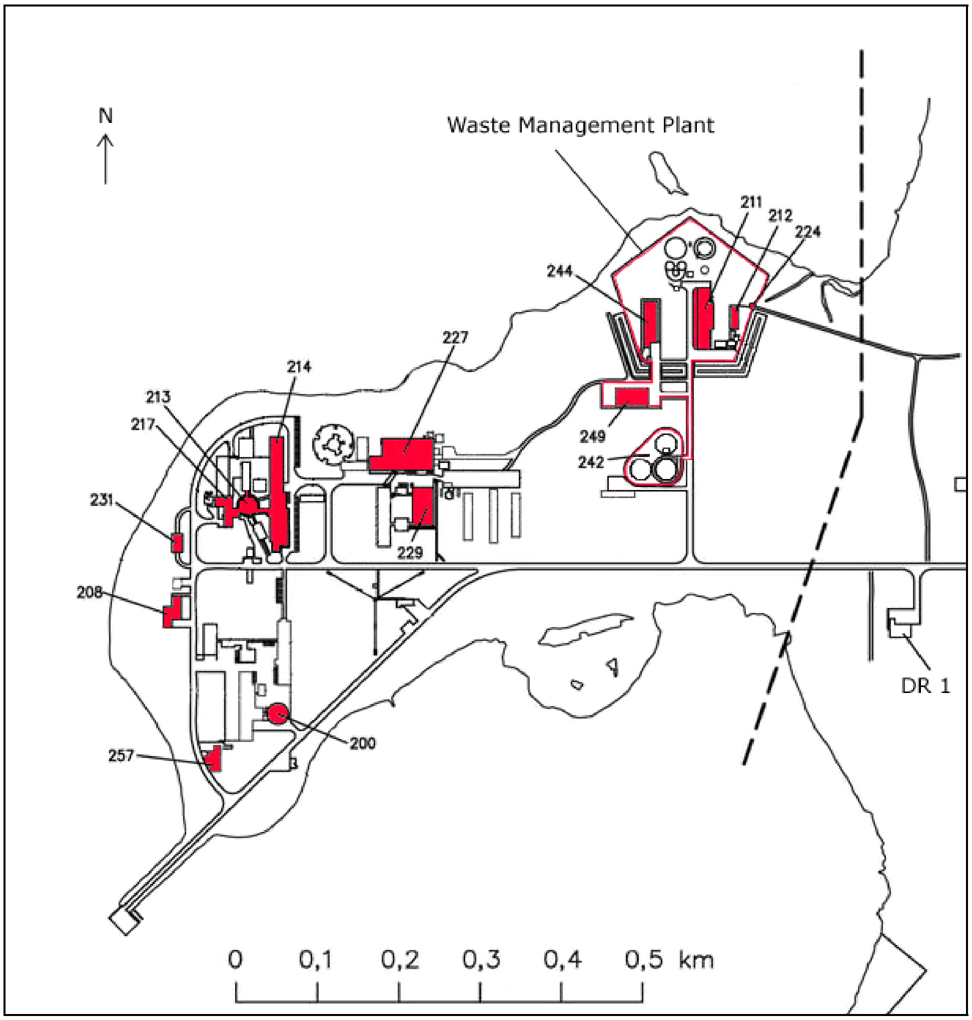

Figure 1. Nuclear facilities and associated buildings at Danish Decommissioning. Names of buildings in Danish as well as English are listed in Table 2. Danish names refer to nomenclature used in previous reports. The stippled line delineates the evacuation zone of DD to the West (left).

An inventory of radioactive waste subject to the Convention is given in Table 3 for conditioned waste and in Table 4 for unconditioned waste. Table 5 shows recently produced operational and secondary waste (not decommissioning waste) as well as unconditioned waste received from external producers.

The amount of unconditioned waste stored at The Intermediate Storage (Table 4) has risen substantially, mainly due to the decommissioning of DR 2 and DR 3, but also as a consequence of cleanup of areas on top of the Hot Cells and from the fact that decommissioning waste containing both short and long lived radioisotopes is placed at The Intermediate Storage. The inventory of conditioned radioactive LILW-SL waste stored at The Low Level Waste Storage remains essentially unchanged compared to previous years (Table 3), because repackaged drums were placed in The Intermediate Storage.

Table 2. List of buildings at Danish Decommissioning

Building	Danish designation (used in previous reports)	English designation
200	H-hallen (DR 2, reaktorhal)	DR 2 Reactor Containment Hall
208	Aktivt Laboratorium	Radiological Characterization Lab (A-lab)
211	Behandlingsstationen	Waste Management Plant, Main Building
212	Tromlelager	Drum Storage (w. drum press)
213	DR 3, reaktorhal	DR 3 Reactor Containment Hall
214	DD kontor, AH-hal	DD Offices, DR 3 Active Handling Hall
217	DR 3, driftsbygning	DR 3 and Decontamination Cabinet
224	Lager for radioaktive væsker	Radioactive Liquids Storage
227	Hot Cell og Fiberlab	Hot Cells / Materials Research Laboratory
229	Teknologihallen	Fuel Fabrication Plant
231	Centralvejslager	The Centralvej Storage (irradiated spent fuel)
242	Tailingsbassiner	Tailings and Ore
244	Lager for Lavaktivt Affald	Low Level Waste Storage
249	Mellemlager og Bufferlager	The Intermediate Storage
257	Frigivelseslaboratorium	Clearance Laboratory (F-lab)

Table 3. Inventory of conditioned radioactive waste stored at DD, classified as low and intermediate level waste - short lived (LILW-SL).

Storage facility	Volume (m^3)	Activity (TBq)
Low Level Waste Storage	1,200	5

Table 4. Inventory of unconditioned radioactive waste stored at DD, classified as low and intermediate level waste - long lived (LILW-LL).

Storage facility	Mass (tons)	Activity (TBq)
Drum Store and The Centralvej Storage	~127	430*
Taillings and ore	4,800	0.1
The Intermediate Storage	772	4**

** Including 18 TBq LL β/γ-emitters and 4 TBq α-emitters*
** Estimated ultimo September 2011

Table 5. Unconditioned waste produced/received (decommissioning waste not included).

Year	2008	2009	2010
Operational waste and secondary waste (tons)	0,2	1,5	1,2
Waste received from external waste producers (tons)	2,8	1,7	3,8

D.3 Nuclear facilities under decommissioning

Challenges highlighted in the 2009 Rapporteur's Report were the decontamination of Hot Cells and the dismantling of the inner parts of DR 3. The decommissioning is proceeding and in the following a brief status of already completed work, as well as an account of progress with ongoing decommissioning work, is given.

The smallest reactor DR 1 is fully decommissioned and the building has been released for other non-nuclear purposes. Also DR 2 is fully decommissioned, but the reactor building has not been released from regulatory control, as the reactor building and building crane are used for handling of large/heavy objects from the decommissioning of DR 3. The secondary cooling system of DR 3 has been removed and a final decommissioning plan for DR 3 has been submitted to the Regulatory Authorities.

According to the plan for decommissioning of Hot Cells, approved by the authorities in early 2008, the decontamination work is going through a public tender phase and contamination levels have been further characterized. Isolated "hotspots" within the cells were identified in this process and have been removed subsequently.

The status of decommissioning of nuclear facilities at the Risoe peninsula is given in Table 6 and described in further detail for the Hot Cells and DR 3 in the subsections below.

Table 6. Nuclear facilities under decommissioning (updated August 2011).

Nuclear facility	Type	Taken out of operation	Decommissioning status
DR 1	Small homogeneous 2 kW reactor mainly used for educational purposes	2001	Fully decommissioned and released from regulatory control in 2006.
DR 2	5 MW research reactor of the open pool type	1975	Reactor fully decommissioned, but the building is used for storage and handling of DR 3 waste objects prior to final release from regulatory control.
DR 3	10 MW heavy water research reactor of the PLUTO type	2000	Fuel elements removed. Method of dismantling selected. Final decommissioning plan submitted to Regulatory Authorities. Secondary cooling system and structures dismantled. Decommissioning of peripheral systems ongoing.
Hot Cells	Facility for post irradiation investigations of nuclear fuel	1989	The decommissioning plan was approved by the authorities in spring 2008 and characterization of contamination and removal of “hotspots” carried out in summer 2010.
Fuel fabrication	Fuel fabrication facilities for DR 2 and DR 3	2002	Decommissioning to »green field« is under planning. Equipment removed. Certain contamination- and radiation risk zones down-graded.

D.3.1 Danish Reactor 1

After regulatory approval of the specific decommissioning plan in mid 2004, DR 1 was successfully dismantled and demolished in 2005. On the basis of a detailed final decommissioning report[3] presented by Danish Decommissioning in late 2005, the Nuclear Regulatory Authorities finally released the building and area from regulatory control in 2006. A further summary of the decommissioning process for DR 1 including the findings of a lessons learned study is available in the Third National Report to the Convention[4].

D.3.2 Danish Reactor 2

After regulatory approval of the specific decommissioning plan in late 2005, DR 2 was successfully dismantled and demolished from 2006 to early 2008 (Figure 3). A final decommissioning report was submitted by Danish Decommissioning to the Regulatory Authorities for approval in October 2008[5]. As a consequence of the anticipated use of the building for handling and storage of large waste objects from the dismantling of DR 3, the building and surrounding area will not be released from regulatory control until the final stages of the decommissioning of DR 3.

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[3] Decommissioning of DR1.pdf

[4] Joint Convention Report 2008.pdf

[5] Decommissioning of DR2.pdf

DR 2 was a 5 MW open pool type research reactor. It was operational for only 16 years and was permanently shut down in 1975. Dismantling of auxiliary systems and sealing of the reactor block/top shielding were carried out in the late 70's. Following a detailed radiological characterisation during the years 2000-2003, a total amount of 175 t of radioactive primary waste was generated for storage and 421 t was released from regulatory control.

In October 2009, Danish Decommissioning summarised a "lessons learned" report for the decommissioning process for DR 2. Key experiences concerning choice of equipment and procedures were noted and have been incorporated into the decommissioning plans for the Hot Cells and DR 3. In terms of human resources, the project manager and lead health physicist have transferred from DR 2 to the Hot Cell decommissioning project, ensuring knowledge base transfer. Essential lessons learned from the decommissioning of DR 2 are listed below:

- Down-sizing of concrete blocks from the biological shield and metal structures (lead, aluminium, steel) within the biological shield was efficiently accomplished using wire saws, hydraulic cutters and plasma cutting techniques.
- The need to confine dust generated by removal of graphite blocks and from cutting of the concrete biological shield showed that temporary, sub-ambient pressure tented volumes are efficient in limiting dust migration. The experience is relevant for the proposed grit blasting approach for removal of surface contamination inside the Hot Cells as well as removal of the biological shield on DR 3.
- Wire cutting of shot concrete was not successful and alternatives have to be sought in future decommissioning projects.
- The tendency for constant air monitoring units to fail due to the intense production of aerosols when using plasma-cutting equipment has proven problematic.
- The consistent use of standardised document formats for all documentation related work has increased transparency of the work process and contributed to the quality assurance.
- Frequent meetings at all staff levels ensured equal and updated information levels contributing to the safety and efficiency of the decommissioning process.
- Use of transmitting dosimeters were of limited value due to difficulties with transmission through great thicknesses of concrete and other radiation shielding structural elements.

Figure 2. Cleaned up DR 2 reactor hall and floor with a removable concrete lid where the reactor once protruded the deck to the basement. Inset shows DR 2 reactor after removal of peripheral units.

D.3.3 Danish Reactor 3 (DR 3)

DR 3 was a 10 MW, heavy water moderated research reactor of the PLUTO type. It was in operation from 1960 to early 2000, and was shut down permanently in the year 2000. A final plan for decommissioning of DR 3 was designed by Danish Decommissioning based on an extensive review of methods potentially to be employed. The plan takes into account comments supplied by group of international experts asked to review the chosen procedure. The decommissioning plan was submitted to the Regulatory Authorities in summer 2011 and is currently under review. Already completed dismantling operations, with high similarity to routine maintenance operations or assembling/disassembling of various experimental rigs, include:

- Spent fuel from DR 3 has been transferred to the jurisdiction of USA according to an agreement with the US Department of Energy

- Dismantling of experimental set-up frames and housing, back-up power units, cooling systems and CCA operational and maintenance area, as well as redundant offices.
- Storage of dismantled CCA, isotope rigs, instrumentation.
- Preservation of circuits and auxiliary systems (safe condition).
- Construction of appropriate shielding in forthcoming decommissioning areas.
- Demolition of cooling tower foundation (cooling tower dismantled previously).
- Tapping and desiccation of heavy water system.

In the planning phase of decommissioning for DR 3, the spatial distribution of the γ-radiation fields from the neutron activated inner parts of the reactor were evaluated using Monte Carlo code based on measured and calculated activities in various construction parts. In Figure 3, an example of the calculated dose rates at various heights over an open reactor tank are illustrated. In combination with estimated working hours in different radiation fields, the exposure of workers involved in decommissioning the inner construction parts of the reactor was evaluated. The outcome of this study was incorporated in the criteria for method selection in the final decommissioning plan for DR 3.

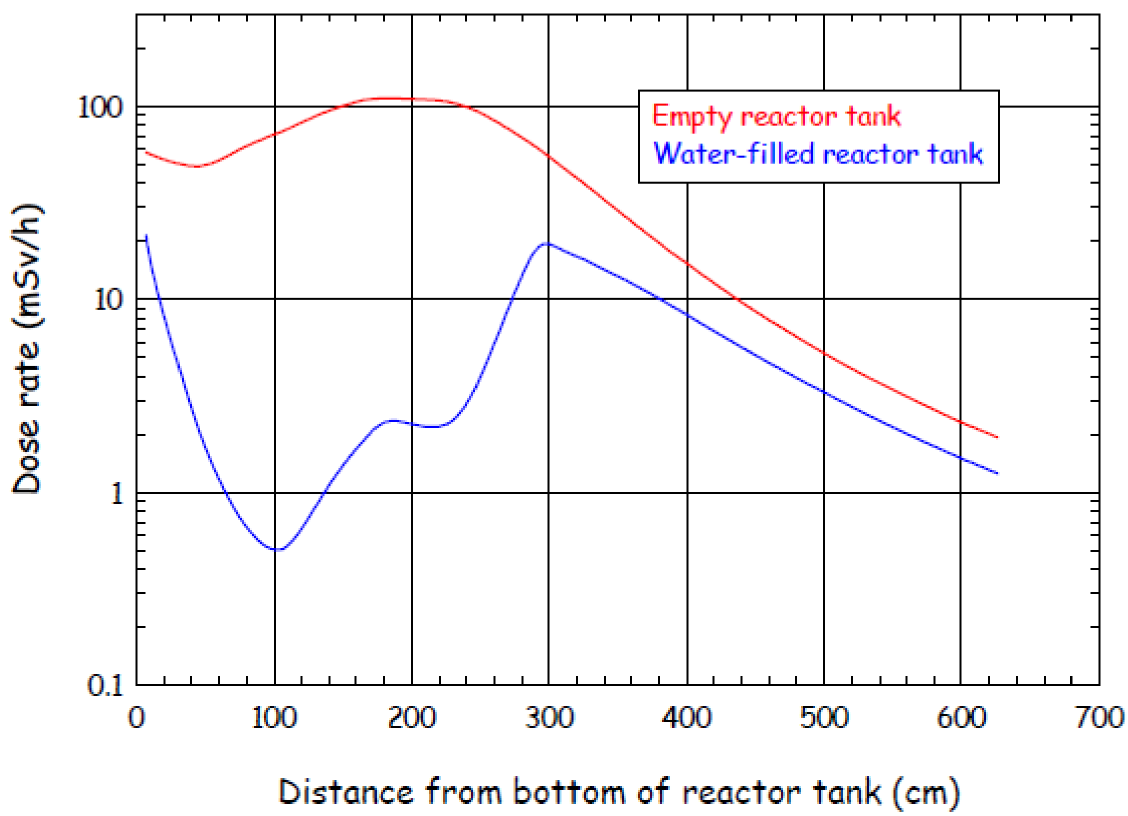

Figure 3. Dose rate from the inner parts of the reactor as a function of vertical distance above the bottom of the reactor tank. The dose rate is calculated at the centerline of an empty reactor tank and a water-filled reactor tank. Source: Danish Decommissioning.

Decommissioning of DR 3 is divided into a number of phases. Phase 1; dismantling and removal of the remaining peripheral systems (cooling systems, experimental set-ups, and electrical systems) has been ongoing since submission of the previous national report and is scheduled to be completed before end 2011.

Phase 1 comprises the three decks; basement, 1st floor and top deck. The top deck was cleared in 2009. Cleanup of the 1st floor was completed in 2010 with the removal of the last research set-up; the so-called “horizontal silicon facility”. Emptying the basement deck, which includes the control room, is scheduled to be completed by the end of 2011.

Figure 4. (left) DR 3, horizontal silicon facility; (right) secondary cooling systems.

Phase 2 includes the dismantling of the components in the heavy water plant room commencing late 2011 and continuing during first quarter of 2012.

Phase 3, commencing in 2012, covers the dismantling and removal of the inner reactor parts. Prior to submission of the actual decommissioning plan for DR 3, Danish Decommissioning carried out a major analysis of various plausible methods to accomplish the internal parts, as recommended by the international panel of experts associated with the decommissioning of the Danish nuclear facilities.
The purpose of the analysis was to provide an overview of possible methods - systematically scrutinized with respect to a number of critical issues, such as: appliance of well known and proven technical solutions, health physics, conventional safety, waste packaging and minimization of generated secondary waste. The analysis was submitted to the Nuclear Regulatory Authorities for preliminary assessment in order to screen out potentially unacceptable methods prior to the development of a more detailed decommissioning plan.

A modelled example of the chosen method for access and dismantling of the reactor tank interior is shown in Figure 5.

Phase 4, demolition of the reactor block and buildings will mark the completion of the project.”

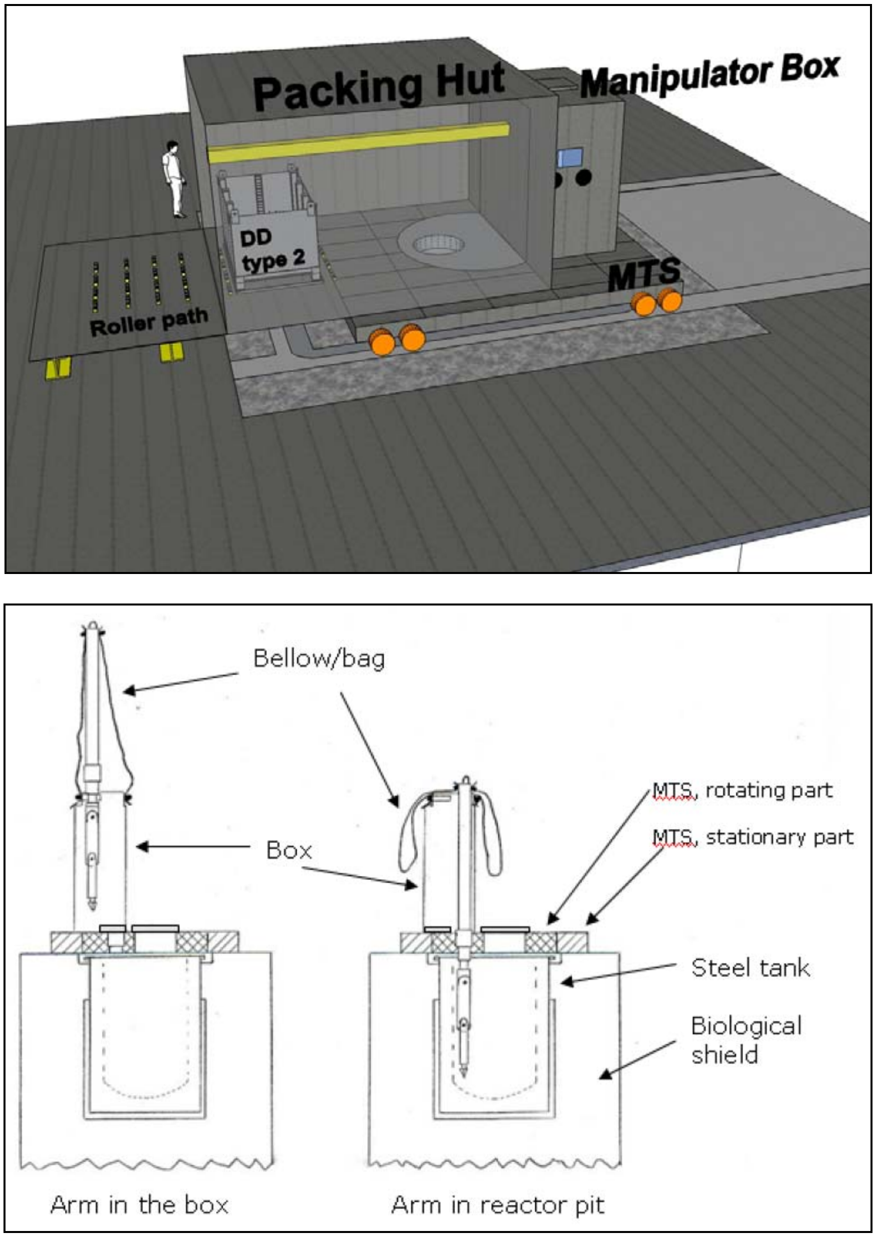

Figure 5. Model of intended setup of Moveable Top Shield (MTS), manipulator box and packing hut on top of DR 3. The lower section of the figure shows the suggested operation of the robotic tool arm.
Source: Danish Decommissioning.

Dismantling of the reactor tank interior: Once the top seal plug of the reactor tank has been removed, a Movable Top Shield (MTS) is positioned on the reactor top to seal off the reactor tank volume. The Packing Hut based on top of the MTS enables insertion of a robotic tool arm into the reactor tank through the circular opening in the MTS. The opening is located in a rotating part of the MTS such that access to all parts of the reactor tank is facilitated. When not in use, the robotic arm can be retracted and left in stand by position inside a sealed box resting on the MTS.

D.3.4 Hot Cells

The Hot Cells facility was in active use during the period 1964 – 1989. The facility consists of 6 inter-connected concrete cells, each equipped with master-slave manipulators and lead glass windows. Each cell could be isolated from the next by means of a steel door and could be individually accessed from the back through of a set of airtight seal-doors enclosing a concrete plug mounted on a rail system to facilitate plug removal.

The Hot Cells were used for post-irradiation examination of fuel pins irradiated in the DR 3 reactor, the Halden reactor in Norway and other reactors. Power reactor fuel pins, including plutonium enriched pins, from several foreign reactors have been examined. All kinds of non-destructive and destructive physical and chemical examinations were performed in the facility. In addition, various radiotherapy sources – mainly Co-60 sources - were produced.

As a result of the cutting and destructive testing of irradiated fuel and other irradiated material, dust containing fission and activation products was released in the cells and settled on workbenches and other surfaces. Hence, Sr-90 and Cs-137 as well as a number of transuranic α-emitters are still present in the cells. In addition, the work with Co-60 radiotherapy sources resulted in a number of Co pellets being dropped and not retrieved again, appearing as hot spots on workbenches and floors.

In 2007, characterisation of the cells was carried out from the top of the cells, and from paint samples scraped off the inside of plugs extending through the concrete walls. These data, along with older measurements from 1990, were used to develop a project plan for the decommissioning of the facilities. The project plan was approved by the National Regulatory Authorities in the spring of 2008. Prior to the actual decommissioning work, a new ventilation system for the Hot Cells was established with a pressure cascade design to prevent migration of material from more contaminated areas into the surrounding zones. A total of nine ventilation units enable 5 pressure regimes to be maintained and all exhausts pass through dedicated filtered outlets.

In 2009 and 2010, the area on top of the Hot Cells was cleared of equipment and parts left there during earlier partial decommissioning of the Hot Cell facility. Objects with simple geometries were decontaminated and subsequently released from regulatory control through measurements in the Clearance Laboratory. A number of cleaned objects still await clearance based on gamma spectrometric measurements in the Clearance Laboratory. Meanwhile, the material is stored in The Intermediate Storage.

The Co-60 hotspots were located using remotely operated collimated radiation detectors in conjunction with video cameras. Five sources with dose rates from 50 to 250 mSv/h were identified, and after a number of rehearsals in a 1:1 mock-up of part of the cells, the objects were removed by means of a vacuum hose system fed through the horizontal plugs on the cell front. 14 persons took part in the operation and all individual doses were below 10 µSv.

In July 2011, the accessibility of Hot Cell number 6 was tested, and after extensive practice on a full scale mock-up (Figure 6), a 5 minute entry was conducted by staff wearing pressurised full body suits (Figure 6). During entry, a number of smaller objects were removed and smear tests of floors were performed. The cell interior dimensions were also verified to ensure that the remote controlled equipment which will be used for decontamination of the cell interior will fit inside the cells and through cell doors. 4 persons took part in the entry and received a collective dose of 11 μSv and a maximum individual dose of 9 μSv.

The intention is to decontaminate the Hot Cell interior steel clad walls by means of remotely controlled grit blasting. The concrete structure, once released from regulatory control, will be left as an integral part of the building structure. The process of acquiring the remotely operated grit blasting equipment has resulted in extensive delays to the project due to legislative complications associated with EU public tender regulations. Projected deadline for conclusion of the decontamination of the Hot Cell interior is now the end of 2012.

Figure 6. (top left) The operating hall with the front of the six concrete cells and newly installed ventilation systems; (top right) Full scale mock-up of Hot Cell no. 6 used for training of hotspot removal and first entry. (bottom left) tent and airtight seal-door access to a single cell used during the 2011 entrance (bottom right).

D.4 International expertise and decommissioning

Two representatives of the Nuclear Regulatory Authorities and Danish Decommissioning participate in the IAEA International Project on Use of Safety Assessment Results in Planning and Implementation of Decommissioning of Facilities Using Radioactive Material (FaSa). The project builds on the experience from the International Project on Evaluation and Demonstration of Safety for Decommissioning of Nuclear Facilities (DeSa) and is aimed at providing recommendations on the use of the safety assessment methodology developed in the DeSa project.

Section E. Legislative and Regulatory System

Article 18. Implementing measures

Article 19. Legislative and regulatory framework

The Danish legislation for radioactive waste and spent fuel management is unchanged. A list of relevant Acts, Orders etc. in force by 14 October 2011 is given in Annex 1.

Article 20. Regulatory body

Please refer to the previous National Reports[6].

The National Regulatory Authorities has expanded the technical resource base into the areas of clean laboratory management, air handling systems and isotope chemistry through one new recruitment. This action was taken in order to meet increased demands for regulatory competence during decommissioning of the Hot Cells and DR 3.

[6] National Report from Denmark,2003, 2005 and 2008:

Joint Convention Report 2003.pdf

Joint Convention Report 2005.pdf

Joint Convention Report 2008.pdf

Section F. Other General Safety Provisions

F.1 Responsibility of the licence holder

Article 21. Responsibility of the licence holder

The only Danish waste management facility subject to the convention is located at the Risoe peninsula and is licensed to and operated by Danish Decommissioning.

As written in previous national reports the Nuclear Installations Act (Section E) assigns the prime responsibility for the safety of a nuclear installation to the licence holder. The related requirements are determined and administered by the Nuclear Regulatory Authorities by means of so-called 'Operational Limits and Conditions'.

As the decommissioning of the nuclear facilities at the Risoe peninsula is ongoing, the Operational Limits and Conditions have to be changed progressively. Hence, minor changes have occurred since the last national report, mainly through a minor relaxation in monitoring and emergency preparedness provisions.

Article 22. Human and financial resources

The responsibility for operation and decommissioning of the nuclear facilities, as well as continued waste management at the Waste Management Plant was transferred to Danish Decommissioning from the Risoe National Laboratory in 2003. The staff assigned to the decommissioning process and for operating the Waste Management Plant was reassigned to Danish Decommissioning assuring qualified and adequate human resources needed for safety related activities during the decommissioning and the operating lifetime of the Waste Management Plant.

The Operational Limits and Conditions for Danish Decommissioning states that every employee at any level in the organisation shall maintain adequate training and instruction necessary to comply with the requirements of the position, in full accordance with the safety provisions prescribed by the Nuclear Regulatory Authorities. As Danish Decommissioning is subject to minor, but continuous staff adjustments and replacements, training courses, seminars, and more extensive classes are therefore undertaken in order to ensure both an adequate level of qualification as well as transfer of relevant experience from skilled members of the staff.

For Danish Decommissioning the availability of adequate financial resources is also assured, inasmuch as the organization is subordinated the Danish Ministry of Science, Innovation and Higher Education. Thus the financial provisions to support the safety of facilities for radioactive waste management are in place.

Forecasting the need of staff and maintaining necessary staff during the decommission period and qualifying staff for future employment was noted as a challenge in the Rapporteur's Report. As Denmark is a non-nuclear country with little or no focus on maintaining adequate training courses etc. in ionizing radiation and radiation protection, adequate and qualified human resources have been made available by internal courses and seminars throughout the period since the Third Review Meeting.

As previously mentioned the Nuclear Regulatory Authorities has increased its staff concerned with decommissioning and waste management by one employee, in order to ensure adequate human resources upon entering the final stages of decommissioning of the Hot Cell and DR 3 facilities.

Article 23. Quality assurance

An important precondition for obtaining the Nuclear Regulatory Authorities final approval for decommissioning was that Danish Decommissioning attained quality certification in accordance with the ISO 9001 standard. Danish Decommissioning was certified in June 2004. Since then the quality assurance system for the entire process of decommissioning, including all radioactive waste management has been based on the DS/EN ISO 9001. The system is inspected biannually by Danish Standards (DS) and every third year a complete audit of all certified functions is conducted. This was carried out twice in 2010 and again confirmed the validity of the certification. All audit reports are available to the Regulatory Authorities.

In addition, specially trained personnel at Danish Decommissioning regularly conduct internal audits as required by the standard. For instance, in 2010 the number of internal audits was 12. With respect to the functions delivered by the Radiation Research department at the Risoe National Laboratory for Sustainable Energy, Danish Decommissioning carries out second-party audits in order to determine the appropriateness and effectiveness of contracting laboratories. These audit reports are also available to the regulatory authorities.

In 2005 the Nuclear Regulatory Authorities also required an independent accreditation of the Clearance Laboratory (F-lab) in order to assure compliance with International Standards. In order to facilitate accreditation of the relevant functions, F-lab was initially allowed to operate under a limited approval, specifying in detail the material which could be subject to clearance measurements prior to a formal independent accreditation.

In May 2007 F-lab was accredited by the Danish Accreditation and Metrology Fund (DANAK) according to the ISO 17025 standard on general requirements for the competence of testing and calibration laboratories. The accreditation (DANAK No. 488) is specified for the: Measurement of radioactivity and content of radionuclides as well as determination of clearance index for solid items and waste with respect to clearance. F-lab is now subject to routine inspections by DANAK, the latest in 2010.

In 2006, Danish Decommissioning established a computerized Waste Documentation System with bar code identification, in order to ensure proper documentation of inventory as well as real time documentation of spatial location of any characterised waste item. This, as well as the use of colour-coded waste, waste containers and waste routes, has successfully minimized the number of waste handlings and waste destination errors. Moreover the Waste Documentation System simplifies tracking down potential errors occurring despite the system. The integrity of the system is verified every 6 months by correspondence checks between inventory lists and actual storage contents.

Finally, in accordance with the quality assurance system various parts of the waste handling equipment, especially at the Waste Management Plant, have been refurbished in order to ensure a continuous safe and adequate waste handling. A new glove box for operating the drum press was installed and taken into use by 2010.

Article 24. Operational radiation protection

In accordance with the Nuclear Installations Act (1962) Danish Decommissioning is subject to Operational Limits and Conditions, which set out regulations covering all aspects of decommissioning, including administrative structure, project planning and management, detailed operation planning, quality assurance, characterization of radioisotope inventory, operational radiation protection, safety assessment, environmental impact assessment and documentation.

The general principles for operational radiation protection in relation to decommissioning are similar to those applied during operation of the facilities. The operational radiation protection program must comply with the regulations given in Operational Limits and Conditions for Danish Decommissioning. Accordingly, the mandatory radiation surveillance programs cover all relevant decommissioning operations, and the received doses are reported to the Nuclear Regulatory Authorities in normal as well as abnormal situations.

With respect to personnel at contractor level, it is the responsibility of Danish Decommissioning to ensure that all relevant personnel are instructed to the necessary level, in order to accomplish the assignments properly in terms of health physics and radiological safety. Contractor level instructions are typically on the order of three hours in total.

F.2 Discharge

Releases of radioactive materials from the Waste Management Plant are primarily liquid and derive from the radioactive wastewater distillation plant which conducts the distillate to the inactive waste water system which again is led into Roskilde Fjord.

Since the reactors were taken out of operation, the release of tritium to Roskilde Fjord has been reduced by almost two orders of magnitude and is now around 102 GBq/y as shown in Figure 7. The minor increase from 2003 to 2004 is due to cleanup in connection with operation of the distillation column. The relatively high discharges in 2006 and 2007 were caused by an erroneous washing process in late 2006 leading to the increased discharges to Roskilde Fjord in late 2006 and early 2007. The procedure described in the quality management system has been adjusted to avoid recurrence. Since 2008, the release of tritium has declined steadily to the lowest level yet recorded. The main reason for this is related to the desiccation of the concrete in DR3. To dry out the concrete, the facility has been actively ventilated. As the concrete has gradually dried out, progressively less tritium-bearing water has been be extracted for treatment at the Waste Management Plant.

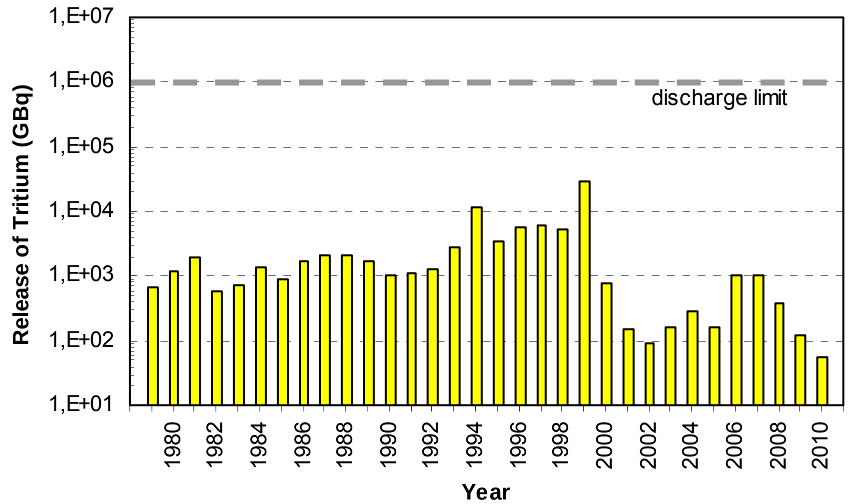

Figure 7. Annual release of tritium into Roskilde Fjord from the Waste Management Plant.

The annual release of dissolved gross β/γ-activity has generally been stable since the reactors were taken out of operation and was less than 0.1 GBq in 2010. Most of this is the naturally occurring K-40. The annual releases, which mainly can be attributed to distillation waste water and overflow from the tailing basins, are shown in Figure 8.

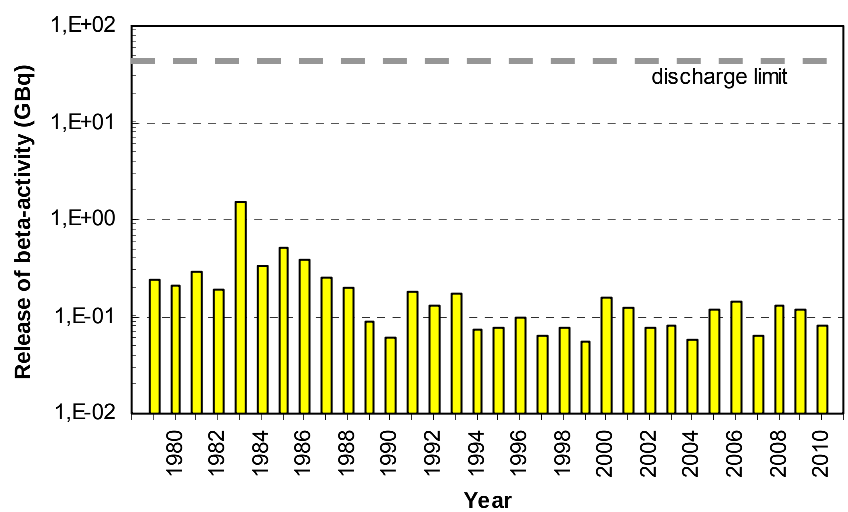

Figure 8. Annual release of gross ß/γ-activity into Roskilde Fjord from the Waste Management Plant.

Article 25. Emergency preparedness

Sector based responsibility is fundamental for the Danish emergency preparedness and, wherever possible, the Danish nuclear emergency preparedness system is based on organisations and preparedness arrangements already in force for other purposes with the adequate amendments regarding special matters within the nuclear area. A thorough revision of the nationwide nuclear emergency preparedness plan is ongoing in 2011 and a revised plan is expected to be implemented in 2012.

F.3 Decommissioning

Article 26. Decommissioning

F.3.1 Doses from the decommissioning of DR 1

The decommissioning of DR 1 was finalised in late 2005. A final account of doses from the decommissioning of DR 1 was given in the third report to the Joint Convention.

In summary, DD personnel received a total collective dose slightly above 1 person-mSv and the highest individual dose was 0.3 mSv. Finger dose meters for two technicians performing a dismantling task in particularly hot areas were 0.85 mSv and 0.35 mSv, respectively.

All staff from the external contractors who carried out the concrete demolition wore TL dose meters and delivered urine samples before the demolition work started and after its completion. No doses were recorded and there were no signs of intake of radionuclides during the work.

F.3.2 Doses from the decommissioning of DR 2

Decommissioning of DR 2 was finalised during spring 2008. An account of doses and surveillance techniques from this undertaking was reported in the final decommissioning report for DR 2. Staff from Danish Decommissioning received a collective dose of 1.6 person-mSv and staff from the external contractors who carried out the demolition of concrete received a collective dose of 3.2 person-mSv. The maximum individual doses for internal and external staff were 0.6 and 1.1 mSv, respectively.

F.3.3 Doses from the decommissioning of DR 3 and Hot Cells

The maximum effective individual and collective doses can not be accounted for on the basis of each facility. This is because several workers perform duties in both facilities and hence accumulate doses on more locations. The maximum effective individual and collective doses for both DR 3 and Hot Cells for 2009 are 0.4 mSv and 1.6 person-mSv, respectively. Corresponding values for 2010 are 0.54 mSv and 1.7 person-mSv, respectively.
Following requests from National Regulatory Authorities, yearly reports of maximum dose rates registered on walls separating the Hot Cell facility from the adjacent DTU-Risoe Materials Research Laboratories are submitted. In 2009 and 2010, no dose rates higher than 0.3 μSv/h were registered.

Section G. Safety of Spent Fuel Management

Article 4. General safety requirements

Article 5. Existing facilities

Article 6. Siting of proposed facilities

Article 7. Design and construction of facilities

Article 8. Assessment of safety of facilities

Article 9. Operation of facilities

Article 10. Disposal of spent fuel

As a consequence of the decision taken by the Danish Parliament in 1985, there are, at present, no considerations or plans for taking any kind of nuclear reactors into operation in Denmark. Thus, there are no plans for siting, designing, constructing or operating spent fuel facilities or for systematic disposal of spent fuel. Spent fuel from the research reactors DR 2 and DR 3 has been transferred to USA's jurisdiction according to an agreement with the US Department of Energy.

The only exemption from this is the less than 1 kg of spent fuel from the research reactor DR 1 and about 233 kg of experimentally produced and irradiated spent fuel of power reactor type remaining from post-irradiation investigations in the former Hot Cells. This amount of spent fuel is stored under safe and secure conditions awaiting a decision on the final management. The storage does not give rise to any discharges of radioactive materials to the environment and hence no exposure of the public.

Finding a solution for the spent fuel was mentioned as a challenge in the 2009 Rapporteur's report for Denmark. Denmark has since the Third Review Meeting been searching for an international solution regarding the spent fuel in question, but until now this effort has proven unsuccessful. If an international solution cannot be found, the option for Denmark will be to dispose this spent fuel in the planned Danish repository for low and intermediate level waste. The spent fuel is therefore considered part of the overall waste volume, which is being taken into account in the planning for establishing a final repository for Danish low and intermediate level waste; see section H for further details.

Section H. Safety of Radioactive Waste Management

Article 11. General safety requirements

Article 12. Existing facilities and past practices

Article 13. Siting of proposed facilities

Article 14. Design and construction of facilities

Article 15. Assessment of safety of facilities

At Danish Decommissioning, all radioactive waste related to the decommissioning activities as well as all other radioactive waste produced in Denmark is stored under safe and secure conditions in one of the following facilities: the Low Level Waste Storage, The ‘Centralvej’ Storage, the Drum Storage, the Intermediate Storage, Radioactive Liquids Storage or Tailings and Ore.

Inspections of waste storage facilities by the Nuclear Regulatory Authorities are routinely carried out with 6 to 12 month intervals. Furthermore, the quantity of internal audits that the operator has to report to the authorities was increased prior to the previous national report (2008). The improved internal audits sustain the safety; not only due to the inspections, but also due to the improved focus on the waste management system in general.

Since the Third National Report, The Intermediate Storage has after approval by the nuclear regulatory authorities been expanded to include a further 244 m^2. Additionally, a new glove box assembly as well as an evaporator unit for liquid organic radioactive waste has been installed at the Waste Management Plant.

H.1 Establishing a final repository for low and intermediate level waste

The establishment of a final repository was highlighted as one of the challenges for Denmark in the 2009 Rapporteur’s Report. An account of the progress and status of the project is given below.

The Danish Parliament agreed in March 2003 to initiate the preparation of a ‘Basis for Decision’ for the establishment of a Danish disposal facility for LILW.

The ‘Basis for Decision’ describes the background, requirements and scope of the project to the decision makers and stakeholders, taking legal aspects, foreign experiences and the amount and type of waste to be deposited into account. It also suggests various design solutions and describes a way forward for the siting process including stakeholder involvement.

The 'Basis for Decision' was finalised by a cross-ministerial Working Group[7] in late 2008 and submitted to the Danish Parliament. It was subsequently discussed by the Danish Parliament in 2009 and all parties supported initiation of the recommended process, of which initial the step was the preparation of three preliminary studies on: repository concept, waste transport and siting.

A detailed account of legal aspects, waste inventory, safety principles and criteria, preliminary studies and the site selection process is given below together with a brief account of the next phase.

H.1.1 Legal aspects

The national and international legal aspects relevant for a repository are presented in the 'Basis for Decision'. It is concluded by the Working Group that the national regulation is adequate for establishing a final repository. However, it should be considered to establish a specific licensing procedure for the repository.

With regard to international legal recommendations and obligations such as those of IAEA, it is the explicit Danish policy to commit to these.

H.1.2 Waste types and waste amounts

The Danish radioactive waste is of variable origin, type and composition. It originates partly from previous nuclear research and the decommissioning of the related facilities and partly from common Danish users of radioactive materials, e.g. the industry, health and research sectors. In 2008, Danish Decommissioning estimated the types and amounts of waste to be deposited in a Danish repository. These estimates, which have not changed since are shown in Table 6.

Table 6. Estimated total volume (rounded) of conditioned waste to be deposited in a Danish repository.

Waste type	Volume (m^3)
Waste from decommissioning	2,100
Low activity waste (existing)	2,000
Intermediate activity waste (existing)	540
Special waste	180
Tailings and contaminated concrete	1,100

As the decommissioning is ongoing, the final amount of decommissioning waste is not exactly known. Hence, the volume of decommissioning waste is a preliminary estimate. The special waste can be separated into the following types: 233 kg of experimentally irradiated uranium, 4.9 kg 19.9 % uranium in a 15.8 l solution equivalent to approximately 975 g U-235 in total, ~20 pcs. of larger alpha-sources, 1.2 kg of irradiated uranium, originally in solution, now solidified in concrete, and 2,000 kg of non-

[7] The Working Group is chaired by the Ministry of Health and Prevention and consists of relevant members from various departments, agencies and operators under the Ministry of Health and Prevention, Ministry of Science, Innovation and Higher Education, Ministry of the Environment, Ministry of Climate and Energy and the Ministry of Defence.

irradiated uranium. The tailings and contaminated concrete listed in Table 6 are remains from uranium extraction research carried out in the 1970's and 80's.

At present the total activity of the waste in Table 6 is about 1.400 TBq out of which the special waste constitutes approx. 800 TBq. In Figure 9, the activities of the various waste categories are presented.

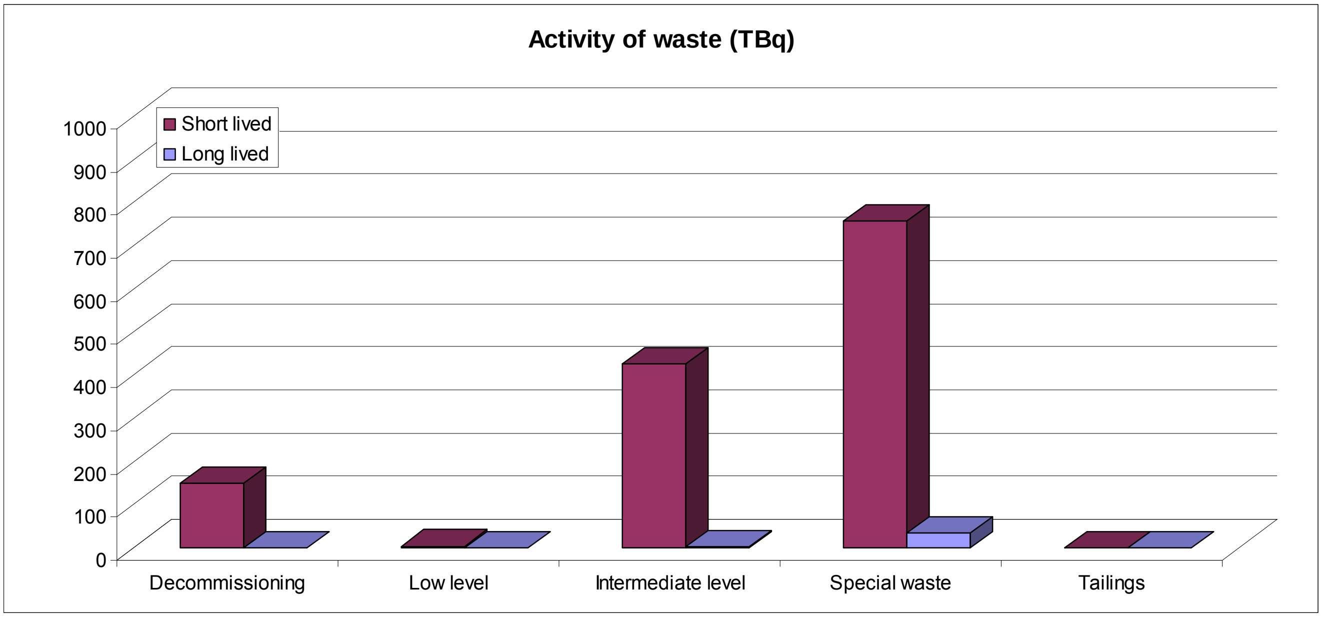

Figure 9. Activity of the various waste types as of 2008.

H.1.3 General principles for the protection of humans and the environment

An important step in the preparation of the "Basis for Decision" has been to develop the 'Fundamental principles for safety and environmental protection'. These fundamental principles describe the framework with which all the work related to the repository must comply. It is the Danish policy to follow the recommendations and standards from IAEA, ICRP and other relevant international organisations.

Based on the recommendations by IRCP and the IAEA safety standards, Denmark has established 4 principles for all work related to the establishing of a repository for LILW:

> ***Protection of humans and the environment***
> *Radioactive waste shall be managed in such a way as to secure an acceptable level of protection for humans and the environment.*
>
> Any exposure of humans much be kept as low as reasonably achievable taking into consideration economical and societal factors. Radiation can harm all living creatures, not just humans. Radiation protection therefore also includes plants, animals and the environment in general. A final repository must be designed so as to ensure that it does not pose a risk to the biological diversity.

Protection beyond national borders
Radioactive waste shall be managed in such a way as to assure that possible effects on human health and the environment beyond national borders will be taken into account.

It is based on the premise that a country has a duty to act responsibly and, as a minimum, not to impose effects on human health and the environment in other countries more detrimental than those which have been judged acceptable within its own borders.

Protection of future generations
Radioactive waste shall be managed in such a way that predicted impacts on the health of future generations will not be greater than relevant levels of impact that are acceptable today. Likewise, radioactive waste shall be managed in such a way that will not impose undue burdens on future generations.

Consideration for future generations is of fundamental importance in the management of radioactive waste. This principle is derived from an ethical concern for the health and environment of future generations, as well as a principle that the generations that receive the benefits of a practice should bear the responsibility to manage the resulting waste.

The legal framework
Radioactive waste shall be managed within an appropriate national legal framework including clear allocation of responsibilities and provision for independent regulatory functions.

The responsibilities of each party or organization involved should be clearly allocated for all radioactive waste management activities that take place in a country. Separation of the regulatory function from the operating function is required to guarantee independent review and overseeing of radioactive waste management activities.

H.1.4 Safety criteria and safety analyses

The general principles described above have been transformed into actual quantitative criteria for the protection of humans. During the lifetime of a repository various requirements for radiation protection for workers and individuals in the population are determined based on the ICRP principles of justification, optimisation and dose limitation.

During the operational period, the requirements shall be similar to the existing dose limits and dose constraints in the present Danish legislation: worker dose limit is set at 20 mSv/y and dose limits of 1 mSv/y with a reference dose (dose constraint) for nuclear installations of 0.1 mSv/y for individual members of the population. After closure, the general dose constraint is set at 0.01 mSv per year with regard to the expected development of the repository. This is equal to the clearance criteria in the Danish legislation and acknowledges the principle that future generations should be protected at the same level as the present generation. The dose constraint is equal to that applicable for material released from regulatory control and hence not considered radioactive.

In addition, there is a dose constraint for potential isolated incidents, such a minor earthquakes and intrusion, of 1 mSv per year. The recommended safety criteria for the repository are presented in the table below.

Table 7. Recommended safety criteria (dose constraints) for individual members of the public.

Period	Scenario	Reference dose, mSv per year
Operational period	Normal operation	0.1
After closure	Expected development	0.01
	Potential incidents	1

An incident, that is very unlikely or where the consequences are so destructive that dispersal of LILW is a minor problem, is not included above (e.g. meteor impact and a major earthquake).

The early safety assessments will be of a more conceptual type, using general data that are available. As the process evolves and more site specific knowledge is gathered, the safety assessments will become increasingly more detailed and a thorough safety case can be established. During the process there will be a close integration between the outcome of the safety assessments and the design of the engineered barriers.

H.1.5 Preliminary studies

The first phase of establishing a final repository for the complete inventory of the Danish radioactive waste included three preliminary studies, covering:

1. *Pre-feasibility study for final disposal of radioactive waste. Disposal concepts.*
   Identification of suitable conceptual designs of a final repository based on the waste properties and including requirements on dimensions, construction, surface/subsurface location and surrounding geology, as well as cost estimates.
2. *Radiation doses from the transport of radioactive waste to a future repository in Denmark – A model study*
   Assessment of the risk associated with transport of the waste from its present location at the Risoe-site to the future repository site. The assessment includes an analysis of whether the risks limit the site selection.
3. *Low- and intermediate level radioactive waste from Risø, Denmark. Location studies for potential disposal areas.*
   Selection of approximately 20 areas in Denmark where the repository potentially can be sited, based primarily on geological suitability and groundwater conditions.

The studies were conducted in parallel. The studies were completed and delivered to the ministerial working group responsible for the overall process of establishing a repository in Denmark, in May 2011.

H.1.5.1 Pre-feasibility study for final disposal of radioactive waste. Disposal concepts.

The purpose of the preliminary study was to identify suitable conceptual designs of a final repository and to outline a set of criteria for these designs and for the future site of the repository. In addition, the total cost of establishing a repository, i.e. the cost of site investigations, construction, operation and closure, monitoring, etc was evaluated. The study[8] was conducted by Danish Decommissioning.

The conceptual designs considered for the complete inventory of Danish radioactive waste according to the 'Basis for Decision' were:

- a near surface repository (above or below the surface to a depth of 30 m)
- a near surface repository (above or below the surface to a depth of 30 m) combined with a borehole for the long-lived waste
- a medium depth repository placed at 30 to 100 m below the surface.

These are illustrated in Figure 10.

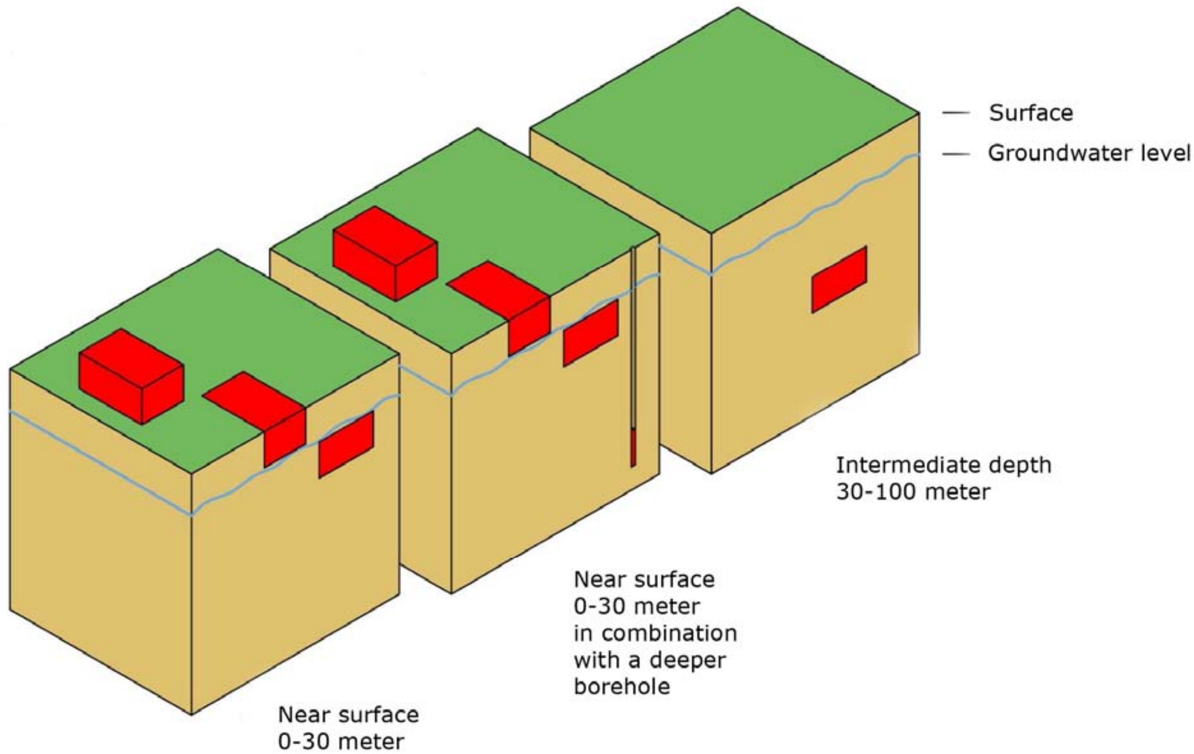

Figure 10. Conceptual designs of a final repository for the complete inventory of Danish radioactive waste. Source Danish Decommissioning.

[8] Pre-feasibility study for final disposal of radioactive waste. Disposal concepts

To assess the suitability of the above described repository designs for the complete inventory of Danish radioactive waste as shown in Table 6, the following has been performed:

- A preliminary model of each of the above conceptual designs.
- Generic safety assessments of each conceptual design.
- Cost evaluation of each conceptual design.

The preliminary models included analyses of: construction, construction materials, capacity, waste conditioning, option of reversibility, etc., as well as a visualisation of the repository. The following figure shows an example of a preliminary model of a repository.

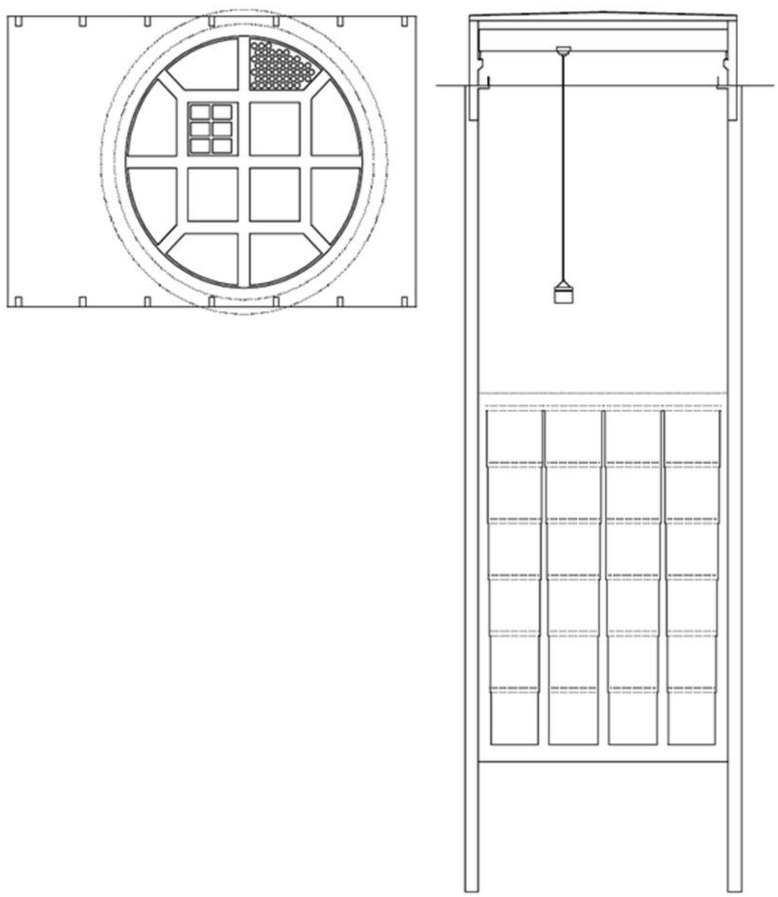

Figure 11. Example of a preliminary model of a final repository. Ground plan and cross section of a repository designed as a shaft operated from ground level. No scale is provided; the design is scalable within the boundaries set by the generic design specifications. Source Danish Decommissioning.

The generic safety assessments included risk analysis related to the activities of the different periods in the overall life time of the repository. The main activities included a) placement of the waste in the repository, b) operation and c) a passive period after closure of the repository. The generic safety assessments also included assessments of the potential impact on a reference person due to long term release of radioactive substances from the repository.

The basis for the generic safety assessments was the preliminary design of the repository types, including an assessment of the consequences of reversibility on the design and cost of establishing a repository. Generic geologies, topography and relevant recipients of groundwater potentially impacted by the repository, were used in the generic safety assessment with typical parameter values for Denmark. Generic geologies had to be used, as the site of the future repository is not yet known. The geologies selected for the generic safety assessments were fat tertiary clay, moraine clay and similar clay types, limestone and crystalline basement rock. The generic safety assessments were performed for each of the repository types in a typical Danish environment, and included typical Danish intake of food.

The results of this preliminary study showed that all three repository concepts can be applied. However, compared to subsurface repositories, more extensive technical measures must be taken to isolate the radioactive materials in a near surface repository in order to ensure highly restricted access as well as to confine the radioactive materials within the repository.

The study demonstrates that the total cost of establishing a repository is roughly estimated to be in the range of 40 to 80 mio. € depending on the choices made, including the repository design, construction, reversibility, etc.

H.1.5.2 Radiation doses from the transport of radioactive waste to a future repository in Denmark – A model study

The purpose of the second preliminary study was to investigate the risk of transporting the complete inventory of Danish radioactive waste from the Risoe-site, to a future repository and to assess whether the risk of transportation would limit the site selection. The study[9] was conducted by the National Institute of Radiation Protection.

Transport of the national inventory of radioactive waste must comply with national regulation based on international guidelines from the International Atomic Energy Agency (IAEA). The study thus presumed that the transport would occur by the use of appropriate packages conforming to the IAEA requirements on content limits for packages and conveyances, as well as performance and maintenance standards for package designs.

The transport could be performed by road, sea, rail or air or a combination of these. However, a preliminary feasibility study of the safety, practicability and cost of all transport modes showed that the transport by rail and air should be rejected. This preliminary study was therefore focused on the transport by road and sea.

[9] Radiation doses from the transport of radioactive waste to a future repository in Denmark – A model study

The estimation of the risk associated with the transport was done by developing conceptual models which were fed into the modelling tool RADTRAN used by e.g. the U.S. Department of Energy and IAEA. The transport of the complete inventory of Danish radioactive waste was modelled to take place as either a) 250 road transports by trucks with trailers or b) at sea, in 10 transports on a barge or coaster to a harbour in the vicinity of the future repository followed by 250 road transports by trucks with trailers.

The modelling accounted for radiation doses for incident free transports as well as for accident situations. It also allotted the probabilities of accidents to occur at various severities. To do this, the model made use of a comprehensive set of input parameters including: waste type, chemical and physical properties of the waste, activity and dose rate, package type, vehicle type and dimension, route characteristics, as well as crew members, bystanders and the population density along the route. It further handled accident scenarios with different types of packages. The overall probability of an accident to occur was obtained from Danish statistical analysis of the traffic, while the characteristics of the accident in relation to the radioactive material was obtained from countries having developed detailed models of such accidents.

The results of this preliminary study showed that the modelled radiation doses from the transport of radioactive waste to a future repository in Denmark would be small both when considering incident free transports and in the event of a potential accident. The study thus demonstrated that the risk associated with road and sea transport pose limitation on the future selection of a repository site. From a safety perspective transport by road as well as sea were deemed feasible modes of transport.

H.1.5.3 Low- and intermediate level radioactive waste from Risø, Denmark. Location studies for potential disposal areas

The purpose of the third preliminary study was to select approximately 20 areas in Denmark in which a site could be located that potentially can host a repository for the complete inventory of Danish radioactive waste. The study[10] was conducted by the Geological Survey of Denmark and Greenland (GEUS).

The geology of the future repository site must contribute to the confinement of the radioactive materials by ensuring that any migration of the radioactive substances will be minimal. To do so, the geological conditions of the area surrounding the repository must be homogeneous and have a low permeability.

Thus the criteria for selecting the repository areas were:

- The host rock must be homogeneous and low-permeable from the surface, or close to the surface, to a depth as large as possible. Hence high-permeable sediments such as sand and gravel should not be present.
- The stratigraphy must allow the host rock to surround the repository entirely, which requires appropriate rock bodies extending to large horizontal as well as vertical dimensions.

[10] Low- and intermediate level radioactive waste from Risø, Denmark. Location studies for potential disposal areas

Besides these criteria, the following have also been applied:

- Groundwater is the primary source of drinking water in Denmark and the entire country has been surveyed with respect to drinking water supplies. Any concern of radionuclides migrating from a future repository into a drinking water reservoir is undesirable and therefore present and future drinking water reservoir areas have been disregarded.
- Areas designated for nature conservation have been disregarded.
- There are few non-populated areas in Denmark and therefore populated areas must be included as candidates for a future repository site. However, highly populated areas such as towns and cities have been disregarded.
- Areas with increased risk of flooding as well as areas with increased risk of future flooding due to climate changes should be avoided.

The study has been a desktop study, using only existing data leaving detailed field investigations to a later phase. Future field investigations of the areas might therefore reveal unexpected occurrences that make an area unsuitable for a future repository.

This preliminary study has resulted in the initial selection of 22 suitable areas (Figure 12).

Figure 12. The 22 potential areas in Denmark for a future repository for the Danish radioactive waste. The marking in blue shows the six areas of particular interest. Source: GEUS.

H.1.5.4 Presentation of the preliminary studies.

With the conclusion of the three preliminary studies, a summarizing report[11] in Danish was prepared. This report recommended further focus on 6 areas of interest in particular, based on the geological suitability of these areas. The 6 areas are shown with a blue marking in Figure 11.

The preliminary studies were presented in May 2011 by the responsible Minister (Minister of Interior and Health) to all political parties represented in the Danish parliament and all parties expressed continued support to proceed with the project as planned.

[11] Forstudier til slutdepot for lav- og mellemaktivt affald – sammendrag indeholdende hovedkonklusionerne og anbefalinger fra tre parallelle studier

Following presentation to the political parties, the studies were presented for the media and for municipality officials from the five municipalities hosting the six areas of interest (two of the selected areas are within the same municipality). Moreover, one of the municipalities arranged a public meeting, where the preliminary studies were presented and where citizens could raise questions regarding the studies and of the project as a whole.

H.1.6 Future phases in the project of establishing a final repository

With the conclusion of the preliminary studies, vicinity studies are to be initiated covering the six areas of interest. The vicinity studies will focus on how a repository may affect its vicinity with regard to societal and spatial planning issues. The studies will serve to further discriminate the areas and where possible, more precisely identify suited sites for the repository within the areas.

All socioeconomic aspects, including planning acts at local, regional and state level will be taken into account in the vicinity studies. Hearings for municipalities, local communities and other stakeholders will be arranged. In addition, the prerequisites for eventual further geological field investigations in the six selected areas have been determined. Pending the outcome of the above investigations, the number of candidate areas is expected to be reduced. Should the vicinity studies show that none of the six areas are suitable for a LILW repository, the scope of studies will be widened to include some or all of the remaining designated areas.

When these studies are concluded, a plan and a budget that reserves relevant areas and ensures funding for the subsequent field investigations will be prepared and presented to the Danish Parliament for approval.

At this stage in the project, detailed field investigations and environmental impact assessments will be performed. Safety assessments will include information from the field investigations. As these investigations are costly, they are expected to cover only 2-3 areas, although at least two areas must be investigated thoroughly.

The next stage in the project will be to design the repository in detail and to make the safety case. Prior to that however, plans that ensure the continuation of the project will be presented to the Danish Parliament for approval.

In the Parliamentary decision from 2003 it was stated, that it is of utmost importance to make the process open and transparent. Hence, stakeholder involvement and information is a major issue in the process. Besides the presentations of the preliminary studies, two hearings regarding the ‘Basis for Decision’ have been held and a leaflet describing the project has been produced. Moreover, there are plans of public hearings and a high degree of stakeholder involvement in the coming phases of the project.

Article 16. Operation of facilities

There have been no new developments in the general operation of the waste management facilities since the last report to the convention. However, there has been the following development with regard to the handling and storage of waste:

- A new type of steel container has been developed in order to improve the management of the decommissioning waste. The use of this steel container has been approved for interim storage by the Regulatory Authorities in 2008.
- The Intermediate Store, which is the storage facility mainly used for decommissioning waste, was expanded by 244 m^2 in 2010.
- General upgrade of technical installations for the radioactive waste management, e.g. new control and surveillance units for the wastewater treatment, new equipment for waste separation and new storage facility for radioactive liquids.

Article 17. Institutional measures after closure

No new development. Please refer to the second National Report, 2005[12].

[12] Joint Convention Report 2005.pdf

Section I. Transboundary movement

Article 27. Transboundary movement

The European Council has adopted Directive 2006/117/EURATOM of 20 November 2006 on the supervision and control of shipments of radioactive waste and spent fuel. Denmark implemented this directive in a new Order no. 1175 of 25 December 2008 replacing Order no. 969 of 13 December 1993 on international transfer of radioactive waste. The new directive and the Order cover all shipments of radioactive waste and spent fuel, whether it is intended for disposal or for reprocessing.

The National Institute of Radiation Protection has in the period from the last Review Meeting consented 17 transboundary movements between EU-countries, but only with Denmark as a country of transit.

Section J. Disused sealed Sources

Disused sealed sources are occasionally but rarely found in metal scrap. To date, the radioactive sources are detected by means of portal monitoring systems typically installed at major scrap yards rather than in surveys. Monitoring systems are thus recommended in advisory material distributed to the scrap dealers.

Surveys are however still being performed and have been conducted on a more regular basis since 2010. The surveys are typically carried out by the National Institute of Radiation Protection using a portable Canberra Falcon 5000 mobile germanium detector and Thermo Scientific FH40 G-X equipped with large (FHZ 502 P) NaI scintillation probes. Surveys are occasionally conducted in co-operation with the Nuclear Division, Danish Emergency Management Agency, who operates a car-mounted mobile 1028-channel gamma multichannel analyser system equipped with a 4L NaI(Tl) detector, position logger and automated alarm features.

A specific strategy on the scrap area is in preparation. In this regard contacts have been made to the Danish association of recycling industries in order to establish a more detailed understanding of the scrap flow and thereby identify the most effective ways to prevent or detect orphan sources. Points of action include: a) A more specific regulation on the handling of material activated by accelerators/electron accelerators, b) further advice on portal detection devices at major scrap yards serving as collection points for minor scrap dealers, c) attendance at annual meetings in the association.

Finally, it is anticipated that implementation in Denmark of Council Regulation (EU) No 333/2011 of 31 March 2011, which establish criteria determining when certain types of scrap metal cease to be waste will cause an increased attention on, and monitoring of, radioactivity in metal waste, thereby - eventually – leading to an overall reduction of unwanted doses to persons.

Figure 13. Car-mounted mobile 1028-channel gamma multichannel analyser system equipped with a 4L NaI(Tl) detector, position logger and automated alarm features.

Section K. Planned Activities to Improve Safety

K.1 Planned national activities

The National Institute of Radiation Protection is presently developing a new and improved database incorporating several new elements that will advance the control with radioactive sources in Denmark and on Danish territory.

Applying national interface standards for IT-integration the database is intended to connect to the Danish Central Business Register (CVR), which contain primary data on all public and private businesses in Denmark. This will enable a proactive and early action by the authorities in case of bankruptcy and discontinuation of companies possessing radioactive sources. It is anticipated that potential third party dismantling of facilities can be avoided before removal of the radioactive sources.

K.2 International co-operation

Examples of what has been done in the past to improve safety through international co-operation are given below. This participation in international co-operation is planned to continue in the future and is as such part of the planned activities to improve safety.

International co-operation is becoming more and more important both on the international scene for obvious reasons, but also on the national scene as one of several means to react to the challenge of the diminishing competences and knowledge in several relevant fields for the safety of spent fuel and radioactive waste management. Being a small country without a nuclear power programme this is even more important for Denmark. As a consequence Denmark participates with its limited resources in many international groups in order to follow, understand and take part in the evolution of the safety of nuclear fuel and radioactive waste management. The international co-operation is essential for both the Nuclear Regulatory Authorities and the operators of nuclear installations and both have taken actively part in this for many years.

In the IAEA context, Denmark has taken active part in the development of the IAEA Safety Standards with representation in three Committees (RASSC, WASSC, TRANSSC) since 2005. Denmark has also offered officers for IAEA Reviews and Appraisals in other Member States, e.g. providing the Team Leader for the Integrated Regulatory Review Service (IRRS) mission to Australia in 2007 and its follow-up in late 2011. Finally both the operator and regulator representatives from Denmark have taken part in the international project on the Evaluation and Demonstration of Safety during Decommissioning of Nuclear Facilities (DeSa) with the finalised Danish decommissioning project of the Danish research reactor DR 1 being one of the test cases selected for the second phase of the DeSa Project. Both parties also participate in the International Project on Use of Safety Assessment in the Planning and Implementation of Decommissioning of Facilities using Radioactive Material (FaSa). The project builds on the experience from the International Project on Evaluation and Demonstration of Safety for Decommissioning of Nuclear Facilities (DeSa) and is aimed at providing recommendations on the use of the safety assessment methodology developed in the DeSa project.

In the Euratom context, Denmark has for many years been actively engaged in EU working groups preparing EU legislation or given advice on the implementation of EU legislation in EU Member States, especially within the Euratom Article 31 Group of Experts. Since 2007, the two Danish Nuclear Regulatory Authorities have been represented in the European Nuclear Safety Regulators Group (ENSREG), which is an independent authoritative expert body composed of senior officials from national regulatory or nuclear safety authorities from all 27 member states in the EU. ENSREG, which was originally established as the European High Level Group on Nuclear Safety and Waste Management, aims to maintain and further improve the safety of nuclear installations and the safety of the management of spent fuel and radioactive waste.

Co-operation between the Nordic countries has been on-going for many decades, and has been focusing on the development of common Nordic principles and strategies, as well as day-to-day operational collaboration between the authorities. An example of this is the very close harmonisation in nuclear and radiological emergency planning and preparedness.

To seek continuous improvement in the Danish arrangements for the nuclear and radioactive waste safety, the Danish Nuclear Regulatory Authorities have jointly decided to set up a plan to undertake a self assessment, based on all or parts of the elements in the self assessment methodology used in the preparation of an IAEA International Regulatory Review Service (IRRS) mission. Such a self assessment will also constitute a part of the follow-up on the adopted working programme for the European High Level Group on Nuclear Safety and Waste Management.

Section L. Annexes

Annex A. Danish Legislation – Spent Fuel and Radioactive Waste

The Danish legislation listed below is in force per 14 October 2011. The legislation is available in Danish at the web site of the National Institute of Radiation Protection: www.sis.dk.

Acts:

- Act No. 94 of 31 March 1953 on use etc. of radioactive materials.
- Act No. 170 of 16 May 1962 on nuclear installations.

Ministerial Orders:

- Ministry of the Interior (now Ministry of Defence) Order No. 278 of 27 June 1963 on protective measures against accidents in nuclear installations (atomic installations) etc. with amendments in Order No. 502 of 1 October 1974.
- Ministry of the Environment (now Ministry of Health and Prevention) Order No. 574 of 20 November 1975 on precautionary measures for the use etc. radioactive substances.
- Ministry of the Interior and Health (now Ministry of Health and Prevention) Order No. 192 of 2 April 2002 on exemptions from Act on the use of radioactive substances.

Operational Limits and Conditions issued by the Nuclear Regulatory Authorities (The Nuclear Division under the Danish Emergency Management Agency and the National Institute of Radiation Protection under the National Board of Health):

- Operational Limits and Conditions for Danish Decommissioning.
- Operational Limits and Conditions for Risø National Laboratory.

Orders from the National Board of Health (National Institute of Radiation Protection):

- National Board of Health Order No. 154 of 6 March 1990 on smoke detectors and consumer products containing radioactive materials with amendments in Orders No. 547 of 23 July 1993 and No. 793 of 19 October 1999.

- National Board of Health Order No. 546 of 23 June 1993 on transfer of radioactive materials.
- National Board of Health Order No. 663 of 12 July 1994 on outside workers, who are exposed to ionizing radiation in a CE-country with amendments in Order no. 824 of 31 October 1997.
- National Board of Health Order No. 823 of 31 October 1997 on dose limits for ionizing radiation.
- National Board of Health Order No. 954 of 23 October 2000 on the use of unsealed radioactive sources in hospitals, laboratories etc.
- National Board of Health Order No. 993 of 5 December 2001 on transport of radioactive materials.
- National Board of Health Order No. 985 of 11 July 2007 on sealed radioactive sources.
- National Board of Health order no. 1175 of 5 December 2008 on international transfer of radioactive waste and spent nuclear fuel.

WWW.SIS.DK

National Board of Health, Denmark
- National Institute of Radiation Protection