OSPAR CONVENTION FOR THE PROTECTION OF THE MARINE ENVIRONMENT OF THE NORTH EAST ATLANTIC

MEETING OF THE RADIOACTIVE SUBSTANCES COMMITTEE (RSC)

BERN, SWITZERLAND: 19-22 FEBRUARY 2007

Implementation Report of PARCOM Recommendation 91/4 on Radioactive discharges

Presented by Denmark

In the context of the fourth round of implementation reporting of PARCOM Recommendation 91/4, RSC is invited to examine the attached report from Denmark, to reach conclusions on the implementation by Denmark of Recommendation 91/4 and to agree on its publication.

IMPLEMENTATION REPORT

on

PARCOM Recommendation 91/4 on Radioactive Discharges

Presented by Denmark

January, 2007

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1. Introduction

1. The present report is the Danish contribution to the 4th round of implementation reporting in relation to PARCOM Recommendation 91/4.

2. General Information

2. In Denmark the basic legislation governing nuclear activities is contained in a number of Acts and Orders and Regulations governing the nuclear area.

3. Danish regulations and legislation are based on international accepted principles for radiation protection from appropriate international bodies like the International Commission on Radiological Protection (ICRP) and International Atomic Energy Agency (IAEA), and Euratom Directives.

4. The Risoe National Laboratory carries out the environmental monitoring programme.

5. The responsible Danish Authorities in relation to radioactive questions are the National Institute of Radiation Hygiene and the Danish Emergency Management Agency, the Nuclear Division.

6. Denmark reports discharges and environmental data from the Risoe research facility to EURATOM, OSPAR and HELCOM.

3. Decommissioning of the Research and Development facilities – Risø

3.1 Introduction

7. The following description is based on "Decommissioning in Denmark", Kurt Lauridsen.

8. Risø National Laboratory (RNL) was established in the late 1950'es as a Danish research centre for preparing the introduction of nuclear energy in Denmark. Three research reactors and a number of supporting laboratories were built. However, Denmark has not yet built any nuclear power plants, and in 1980 the Danish Parliament decided that nuclear power should no longer be an option in the national energy planning. The facilities at RNL thus are the only nuclear facilities in Denmark. Subsequent to the Parliament's decision the research at RNL related to nuclear power was reduced and the utilisation of the facilities concentrated on other applications, such as basic materials research, isotope production and silicon transmutation doting. Already in 1975 one of the reactors had been taken out of service for economical reasons and the activities moved to the 10 MW materials test reactor, DR 3. Furthermore, in 1989 the hot cell facility was closed, and over the next four years it was partly decommissioned.

9. The Laboratory is located about 6 km north of the city of Roskilde (about 40 km west of Copenhagen) at the shore of Roskilde Fjord as shown in Figure 1.

Figure 1 Aerial photograph of Risø National Laboratory. Reactor DR 2 can be seen in the foreground. DR 3 is situated at the left hand side of the peninsula. DR 1 is hidden to the far right in the picture.

3.2 Planning for decommissioning

10. As part of Risø's strategic planning in 2000 it was taken into account that the largest research reactor, DR 3, was approaching the end of its useful life, and that the decommissioning question was becoming relevant. Since most of the other nuclear activities at Risø depended on DR 3 being in operation, it was decided to decommission all nuclear facilities at Risø National Laboratory once the reactor had been closed. Therefore, a project was started with the aim to produce a survey of the technical and economical aspects of the decommissioning of the nuclear facilities. The survey should cover the entire process from termination of operation to the establishment of a "green field"[1], giving an assessment of the manpower and economical resources necessary and an estimate of the amounts of radioactive waste that must be disposed of. The planning and cost assessment for a final repository for radioactive waste was not part of the project. Such a repository is considered a national question, because it will have to accommodate waste from other applications of radioactive isotopes, e.g. medical or industrial.

11. In September 2000 Risø's Board of governors decided that DR 3 should not be restarted after an extended outage. The outage was caused by the suspicion of a leak in the primary system of the reactor, and followed after the successful repair of a leak in a drainpipe earlier in the year. Extensive inspection of the reactor tank and primary system during the outage showed that there was not any leak, but at the same time some corrosion was revealed in the aluminium tank. According to the inspection consultant the corrosion called for a more frequent inspection of the tank. Therefore, the management judged that the costs of bringing the reactor back in operation and running it would outweigh the benefits from continued operation in the remaining few years of its expected lifetime.

12. The closure of DR 3, of course, accentuated the need for decommissioning planning and for the results of the above-mentioned project. By the end of February 2001 the project report [1] was published. The study

[1] In this context "green field" means a situation where facilities and areas are free released to other use without any radiological restrictions. Thus clean buildings and equipment may be re-used for other purposes than nuclear.

was followed by other studies in order to prepare a proposal for legislative action by the parliament to provide funding for the decommissioning. Among other aspects, possible decommissioning strategies were evaluated. Two overall strategies were considered, (1) an irreversible entombment where the nuclear facility is covered by concrete and thereby transformed into a final repository for low- and medium level waste, and (2) decommissioning to 'green field' where all buildings, equipment and materials that cannot be decontaminated below established clearance levels are removed. The entombment option was rejected rather quickly as not being acceptable, among others for ethical reasons ("each generation should take care of its own waste"). Instead, three different decommissioning scenarios were considered with 'green field' as the end point, but with different durations, viz. 20, 35 and 50 years, respectively.

12. After thorough preparations, including an Environmental Impact Assessment, the Danish parliament in March 2003 gave its approval to funding the decommissioning of all nuclear facilities at Risø National Laboratory to "green field" within a period of time up to 20 years. The decommissioning is to be carried out by a new organisation, Danish Decommissioning (DD), which is independent of Risø National Laboratory, thus avoiding any competition for funding between the decommissioning and the continued research activities at Risø.

3.3 Description of the nuclear facilities

13. The nuclear facilities include three research reactors (DR 1, DR 2 and DR 3), a Hot Cell Facility and a Waste Management Plant with storage facilities. The activity content in each of the nuclear facilities has been estimated from both measurements and calculations and the results are shown in Table I with reference to the year 2000.

Table 1 Estimated activity in the nuclear facilities at Risø National Laboratory in 2000 [1].

Nuclear facility	β-/γ-activity [GBq]	α-activity [GBq]
Storage facility for high-radiation waste	700,000	30,000
Storage hall for waste drums	4,800	-
Waste Management Plant	8,500	10
Research reactor DR 3 (excl. fuel)	200,000	-
Hot Cell plant	3,000	100
Research reactor DR 1 (incl. fuel)	100	5
Research reactor DR 2	60	-
Cellar DR 2 (tritium in heavy water from DR 3)	3,000,000	-

14. Tritium in the heavy water from reactor DR 3 constitutes the largest single activity at the nuclear facilities as can be seen in Table 1, but it is, however, a very low-toxic radionuclide. The major potential radiological risks would arise during the decommissioning of reactor DR 3 and the Hot Cells, although the potentially largest doses could arise from exposure to waste in the storage facility for high-radiation waste. However, this waste is safely contained in steel drums and the probability for being exposed is, therefore, rather low.

15. The major characteristics of each of the nuclear facilities at Risø are briefly presented in the following paragraphs. A more detailed description of these facilities can be found in [1].

3.4 Research reactor DR 1

16. DR 1, shown in Figure 2, was a 2 kW thermal homogeneous solution type reactor, which used 20% enriched uranium fuel and light water as moderator. The first criticality was obtained in August 1957. During the first 10 years of operation the reactor was used for neutron experiments and thereafter mainly for educational purposes. In the autumn of 2000 it was decided to close the operation of the reactor, subsequent to the closure of DR 3.

The reactor core consisted of a spherical steel vessel containing about 15 litres of uranyl sulphate dissolved in light water. Around the core there was a graphite reflector contained in a steel tank and a biological shield made of heavy concrete. The reactor had various irradiation facilities. Two stainless steel control rods containing boron carbide controlled the reactor. In addition to these major reactor components there were connecting pipes, recombiner, lead shield, cooling coil etc.

17. The main part of the activity was concentrated in the fuel solution. During 43 years of operation it has consumed less than 1 gram of ^{235}U out of a total amount of 984 grams. The recombiner, the connecting pipes and the core tank were the most active components due to mainly ^{137}Cs deposited on the inner surfaces (and small amounts of actinides). Small amounts of long-lived activation products such as ^{14}C, ^{60}Co, ^{63}Ni, ^{133}Ba, ^{152}Eu and ^{154}Eu were left in the different construction parts, mainly in the core tank, the reflector tank and the concrete shield surrounding the graphite reflector.

18. DR 1 was decommissioned in 2004-05 and the building given back to Risø National Laboratory for non-nuclear applications [3].

Figure 2 DR 1 prior to decommissioning

3.5 Research reactor DR 2

19. DR 2 was a pool-type, light water moderated and -cooled reactor with a thermal power level of 5 MW. The reactor went critical for the first time in December 1958. It was used mainly for isotope production and neutron scattering experiments. It was closed in October 1975 and partially decommissioned. After the final shut down, the spent fuel elements were shipped back to the US. The reactor block and the cooling system was sealed and the reactor hall was used for other purposes until 1997, when a pre-decommission study was commenced. During its 5905 days of operation the integrated thermal power of DR 2 was 7938 MWd. Figure 3 shows a cut-away drawing of DR 2.

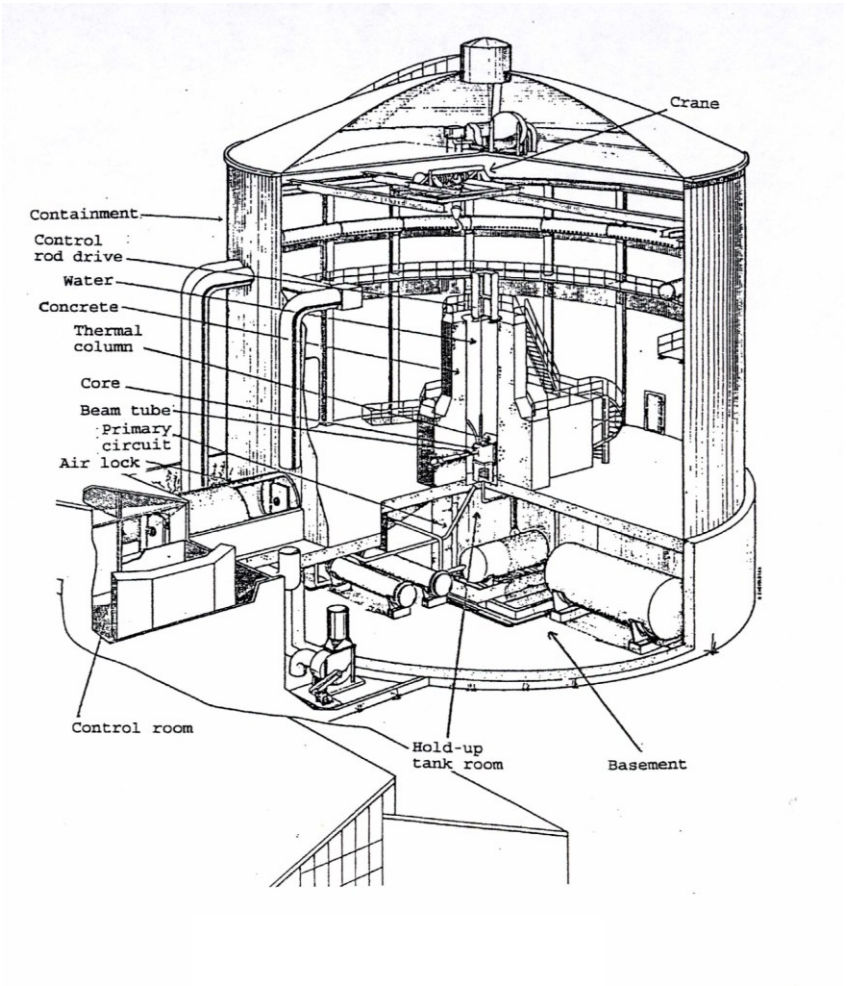

Figure 3 Cut-away drawing of DR 2

20. The reactor block is made of ordinary and heavy concrete and contains the reactor tank made of aluminium and a lead shield surrounding the core position. A graphite thermal column is situated next to the core position. The reactor tank is 8 metres in height and 2 metres in diameter. The primary cooling system including the heat exchangers is made of aluminium.

21. The major part of the residual activity in the reactor components is located in the stainless steel components and to some extent in the beam plugs and heavy concrete shield. The radionuclide activity is found in the following parts of the reactor system: reactor tank (^{60}Co), heavy concrete shield (^{133}Ba, $^{152+154}$Eu), beryllium reflector elements (^{10}Be), thermal column graphite ($^{152+154}$Eu, ^{14}C), beam plugs (^{60}Co), guide tubes and S-tubes (^{60}Co), and the primary cooling system (^{60}Co, ^{137}Cs).

22. DR 2 is being decommissioned 2006-08.

3.6 Research reactor DR 3

23. DR 3 was a 10 MW tank type reactor with heavy water as moderator and coolant and a graphite reflector. It is of the DIDO/PLUTO family designed in the UK. The reactor went critical for the first time in January 1960 and since then was operated in a 4-week-cycle with 23 days of continuous operation and 5 days of shut down. It was finally shut down in September 2000 and had its last operation in April 2000. After the final shut down the fuel elements have been removed and shipped to the US and the heavy water has been stored in stainless steel drums (about 15,000 litres).

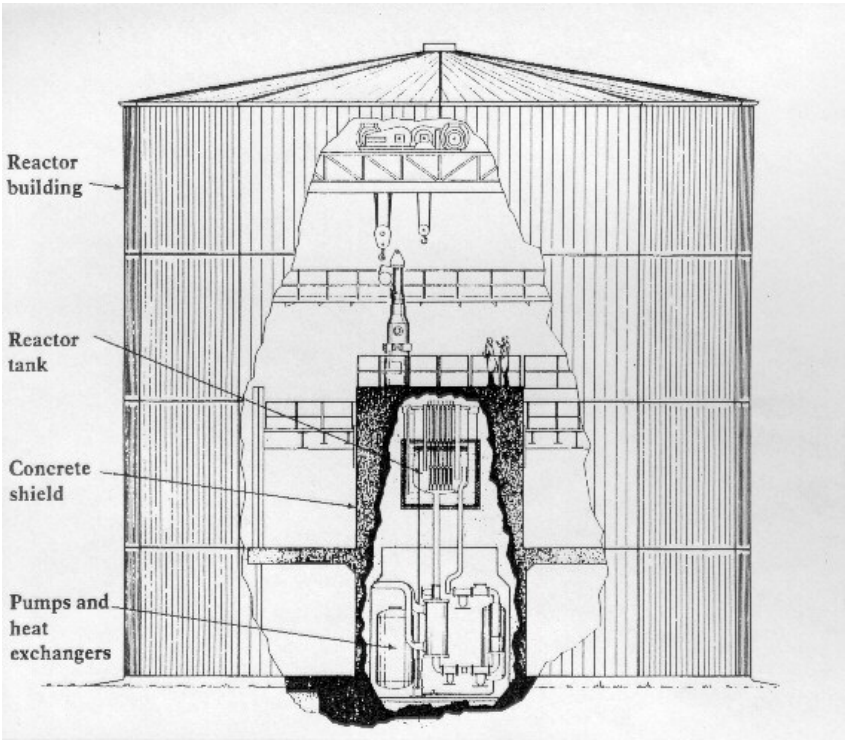

Figure 4 Cut-away drawing of DR 3

24. The reactor was used for materials testing, beam experiments, isotope production and silicon transmutation doting. The main reactor components are: reactor aluminium tank, primary cooling system (steel), graphite reflector, steel reflector tank, lead shield and biological shield (heavy concrete). The coarse control arms (cadmium contained in stainless steel) are stored outside the reactor in a storage facility for high radiation waste. The auxiliary systems are still in place, but are presently undergoing modification or being removed.

25. The major activity will be found in the following reactor components: reactor aluminium tank, graphite reflector, reactor steel tank, top shield, lead shield, biological shield, coarse control arms, irradiation rigs, and experimental facilities. The main components have a total weight of about 1000 tons and nearly all the residual activity will be found here, approximately 200 TBq of semi long-lived and long-lived radionuclides (year 2000). The tritium activity in the heavy water is about 3,000 TBq.

3.7 Hot Cell facility

26. The Hot Cell facility was commissioned in 1964 and operated until 1989. The six concrete cells have been used for post-irradiation examination of irradiated fuel of various kinds, including plutonium-enriched fuel pins. All kinds of non-destructive and destructive physical and chemical examinations have been performed. In addition, various sources for radiotherapy - mainly ^{60}Co - have been produced from pellets irradiated in DR 3. Following a partial decommissioning of the Hot Cell facility from 1990 to 1994 only a row of six concrete cells remains as a sarcophagus inside the building. The remaining part of the building has been released and is now being used for other purposes.

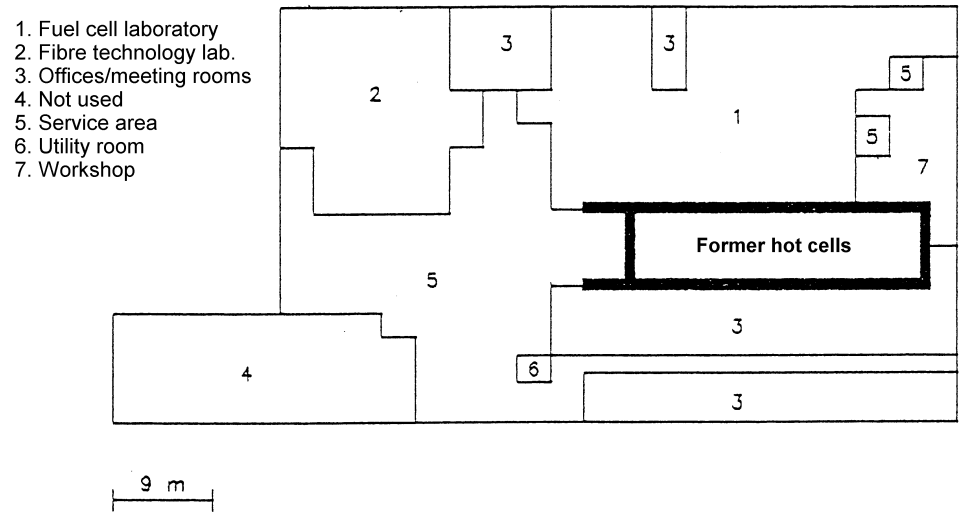

Figure 5 Sketch of the partly decommissioned Hot Cell facility

27. The dimensions of the interior of the six cells are: 39 metres in length, 4 metre in width and 5 meters in height. The cells are shielded by approximately 2 metres of concrete walls with lead glass windows. The cells are lined inside with steel plates and a conveyor belt, and parts of the ventilation systems still remain. Only long-lived fission products and actinides remain in the cells together with some small activated Co-pellets. Alpha- and gamma-spectrometric analyses of smear samples and dose rate measurements have shown that the major part of the activity, i.e. more than 90% is found in the concrete cells No 1 - 3. The total activity in the cells (1993) is about 3,000 GBq β-/γ-activity (mainly ^{137}Cs and ^{90}Sr) and about 100 GBq of actinides.

3.8 Waste Management Plant with storage facilities

28. The waste management plant is responsible for the collection, conditioning and storage of radioactive waste from the laboratories and the nuclear facilities at Risø as well as from other Danish users of radioactive materials. No final disposal of radioactive waste has taken place in Denmark and all waste units produced since 1960 are presently stored in three interim storage facilities at the Risø site.

The decommissioning of the Waste Management Plant will not take place until the decommissioning of the other nuclear facilities has been completed and a suitable substitute for the plant has been provided. After decommissioning of the nuclear facilities there will still be a need for a system for treatment of radioactive waste in Denmark, because radioactive isotopes will still be used in medicine, industry and research.

3.9 References

1. Lauridsen, K. (Editor), Decommissioning of the nuclear facilities at Risø National Laboratory. Descriptions and cost assessment. Risø-R-1250(EN). ISBN 87-550-2844-6. Risø National Laboratory, February 2001. Available as a PDF-file at the Internet address: http://www.risoe.dk/rispubl/SYS/ris-r-1250.htm

2. http://www.risoe.dk

3. Decommissioning of DR 1. Final report. DD-18(EN). Danish Decommissioning, January 2006. http://www.dekom.dk/publikationer/Decommissioning_of_DR1_-_Final_Report/

4. Discharge monitoring

Table 2 Discharges from the Waste Management Plant

Year	Yearly discharges at Waste Management Plant TBq released per annum	
	Gross beta	Tritium
2001	1,3E-04	1,5E-01
2002	2,5E-04	8,9E-02
2003	9,0E-05	1,6E-01
2004	1,1E-04	2,9E-01
2005	1,18E-04	1,64-01

29. After all three Danish research reactors have been taken out of operation and the process of decommissioning has started, the discharge limits and the reporting obligations set in the Operational limits and Conditions have been revised. The annual discharges reported are now exclusively from the Waste Management Plant.

30. Discharge limit for H-3: 1,000 TB per year and discharge limit for Gross beta: 0,2 TBq per year. Additionally reporting required at discharges of H-3 above 2 TBq in one month. Additionally reporting required at discharges of Gross beta above 0,3E-03 TBq in one month.