OSPAR COMMISSION

Assessment of the 4th Round of Reporting on the Implementation of PARCOM Recommendation 91/4 on Radioactive Discharges

Radioactive Substances Series

2008

OSPAR Convention

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention") was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. It has been ratified by Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Sweden, Switzerland and the United Kingdom and approved by the European Community and Spain.

Convention OSPAR

La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998. La Convention a été ratifiée par l'Allemagne, la Belgique, le Danemark, la Finlande, la France, l'Irlande, l'Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d'Irlande du Nord, la Suède et la Suisse et approuvée par la Communauté européenne et l'Espagne.

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Executive Summary

This report confirms that the OSPAR Contracting Parties' commitment to use 'Best Available Technology' (BAT), to 'minimize and, as appropriate, eliminate 'radioactive pollution from nuclear industries, has been successfully translated into both the legal and operational systems used to regulate radioactive discharges from the most significant nuclear industries in the OSPAR region. There have also been indications of a general downward trend in radioactive discharges, which suggests that the objective of this commitment is being met.

This report provides an overview of an assessment of the 4th round of reporting on the implementation of PARCOM Recommendation 91/4 on radioactive discharges, that contains the above mentioned commitment on the application of BAT. The objective was to review information provided in the Contracting Parties' reports on the implementation of this recommendation in order to:

- assess the effectiveness of the implementation of BAT in nuclear facilities by each Contracting Party and overall;
- conclude on Contracting Parties' implementation, including identification of abatement techniques adopted and consideration of whether these constitute BAT;
- assess the effectiveness of measures taken to implement BAT and to make recommendations for the next reporting round.

The focus of this report was on consideration of BAT; information on discharge trends was derived from a previous OSPAR Commission report[1].

From information provided, it was possible to conclude that, in general:

- BAT is implemented in Contracting Parties' national legislation and regulations;
- operational management systems are in place to prevent, eliminate or reduce liquid waste;
- the abatement techniques applied for liquid effluent are consistent with international reports on best practice; and,
- there have been reductions in radioactive discharges and some evidence that reductions arise from actions taken to reduce discharges rather than differences in throughput.

Detailed recommendations to enhance the value of the next round of reporting were provided, including:

- further development of the reporting Guidelines and associated BAT performance indicators to facilitate their consistent use and encourage information exchange on: BAT documentation and decision-making; the use of environmental targets, and on specific radionuclides, e.g. tritum and C-14;
- consideration of the way in which aerial emissions in general and discharges from decommissioning operations in particular should be considered.

[1] First Periodic Evaluation of Progress towards the Objective of the OSPAR Radioactive Substances Strategy (OSPAR, 2006)

1 Introduction

1.1 Background

In PARCOM Recommendation 91/4 on Radioactive Discharges, the Contracting Parties to the Paris Convention agreed

"*To respect the relevant Recommendations of international organizations and to apply the Best Available Technology to minimize and, as appropriate, eliminate any pollution caused by radioactive discharge from all nuclear industries, including research reactors and reprocessing plants, into the marine environment*."

Furthermore, Contracting Parties agreed to present a statement on progress made in applying such technology every four years.

The OSPAR Commission published a report on the implementation of PARCOM Recommendation 91/4 on Radioactive Discharges in 2003, which provided a summary of the 3rd round of reporting (OSPAR, 2003a). This report concluded that the criteria necessary to establish Best Available Technology (BAT) were, to some extent, missing, although the use of BAT/BEP indicators marked substantial progress towards allowing a balanced evaluation to be made. To support this process, revised Guidelines for the Submission of Information about, and Assessment of, the Application of BAT in Nuclear Facilities were developed (OSPAR, 2004); a copy of these guidelines is provided as Annex 1.

This report provides an assessment of the 4th round of reporting on the implementation of PARCOM Recommendation 91/4, including comparison with the revised guidelines (2004-03). The following Contracting Parties reported during this round; slight differences in the reporting period arise from the annual rotation of reporting at successive meetings of the Radioactive Substances Committee (RSC).

Table 1: Contracting Parties Reporting in 4th Round and Reporting Periods

	Reporting period		Reporting period
Belgium	1998 - 2005	Portugal[2]	
Denmark[1]		Spain	1998 - 2003
France	1999 - 2004	Sweden	1998 - 2003
Germany	1999 - 2004	Switzerland	1999 - 2004
The Netherlands	1998 - 2003	United Kingdom	1998 - 2003
Norway	1999 - 2004		

More detailed information may be obtained from the national implementation reports referenced in Annex 2, which are generally available from the OSPAR website[1]. These reports include *inter alia* general information regarding national arrangements for the implementation of BAT and site-specific details of radioactive waste management processes, abatement technologies, discharge and environmental monitoring information and data.

[2] It was agreed that the reports from Denmark and Portugal be included in this assessment, although representatives of these Contracting Parties were not in attendance at the Radioactive Substances Committee meeting to present them. These reports therefore do not appear on the OSPAR website.

The OSPAR Radioactive Substances Strategy (OSPAR, 2003b), as amended at the second Ministerial meeting of the OSPAR Commission in 2003, provides that:

"…the objective of the Commission with regard to radioactive substances, including waste, is to prevent pollution of the maritime area from ionizing radiation through progressive and substantial reductions of discharges, emissions and losses of radioactive substances, with the ultimate aim of concentrations in the environment near background levels for naturally occurring radioactive substances and close to zero for artificial radioactive substances. In achieving this objective, the following issues should, inter alia, be taken into account:

- *Legitimate uses of the sea;*
- *Technical feasibility;*
- *Radiological impacts on man and biota*."

The First Periodic Evaluation of Progress towards the Objective of the OSPAR Radioactive Substances Strategy was published in 2006 (OSPAR, 2006). This includes a detailed statistical analysis of the discharge trends for each Contracting Party for each industry sector; this information also has relevance to this report, as outlined below.

1.2 Objectives and Approach

The objectives and approach for this assessment were primarily based on recommendations developed during the Radioactive Substances Committee meeting 2008 (RSC 2008). The objectives were to:

- assess the effectiveness of the implementation of BAT in nuclear facilities by each Contracting Party and overall (with focus on BAT);
- conclude on Contracting Parties' implementation, including identification of abatement techniques adopted and consideration of whether these constitute BAT;
- assess the effectiveness of measures taken to implement BAT and to make recommendations for the next implementation reporting round.

Within the time and resources available to undertake this assessment, it was agreed that the focus should be on a consideration of the implementation of BAT, rather than a detailed consideration of discharge trends, or environmental monitoring information and data.

Information relating to:

- national procedures for the implementation of BAT; and
- radioactive discharges and waste management processes and abatement techniques;

used by individual Contracting Parties has been gathered from a review of both a compilation of national reports on PARCOM 91/4, provided by the OSPAR Secretariat, and the individual implementation reports (listed in Annex 2).

Information regarding discharge trends has been obtained solely from the information presented in the First Periodic Evaluation of Progress towards the Objective of the OSPAR Radioactive Substances Strategy (OSPAR, 2006).

1.3 Structure of this report

Following this introduction, Section 2 provides a discussion of Contracting Parties' compliance with reporting requirements and guidelines. Section 3 deals with the effectiveness of Contracting Parties' implementation of BAT, taking account of national arrangements, systems and abatement technologies in place and their effectiveness in delivering reductions in discharges. Conclusions and recommendations for future reporting are provided in Section 4. There are three annexes: Annex 1 is the Guidelines for the Submission of Information about, and Assessment of, the Application of BAT in Nuclear Facilities; Annex 2 is a list of national implementation reports submitted in the 4th round of reporting; and Annex 3 is a summary of site-specific information on systems and abatement techniques in use at the Contracting Parties' nuclear facilities.

2 Compliance with Reporting Requirements and Guidelines

2.1 The Guidelines

The Guidelines for Submission of Information about, and the Assessment of, he Application of BAT in Nuclear Facilities (herein after "the Guidelines") are provided as Annex 1. Some of the key requirements are summarised here for ease of reference.

General information regarding the implementation of BAT in national legislation or regulation is required, with a focus on new legislation in place since the previous round of reporting. In addition, specific information regarding each nuclear facility is also requested including: systems in place to reduce, prevent or eliminate discharges of radioactive substances to the marine environment and the nature and efficiency of abatement systems. These requirements are supported by Appendix I of the Guidelines, which includes a template for recording the management and abatement systems in place. Information on liquid discharges; emissions to air of concern for the marine environment; environmental monitoring programmes and concentrations in water, sediment and fish and dose assessment information, are also required. A number of BAT/BEP indicators are identified related to:

- systems in place to reduce, prevent or eliminate discharges of radioactive substances;
- decontamination or abatement factors or other measures of the efficiency of abatement systems;
- downward trends in discharges, environmental concentrations and critical group doses;
- relevance of the environmental monitoring programme and target values.

This report takes account of the first three indicators, with a focus on the first two. A detailed consideration of the relevance of the established environmental monitoring programmes and targets was beyond the scope of this review.

2.2 Compliance with the Guidelines

The Contracting Parties that have a nuclear industry submitted implementation reports (listed in Annex 2).

Information was generally presented within the overall format of the Guidelines. However, as in the previous round of reporting, not all of the Contracting Parties submitted all of the information requested. A brief summary of the content of the national implementation reports, in comparison to key headings in the Guidelines is provided in Table 2. A more detailed interpretation of the information referred to in the first three columns (the focus of this report) is provided in Section 3.

Table 2 demonstrates that the reports from Denmark and Portugal would need significant modification to comply with the Guidelines.

The reports provided by individual Contracting Parties have different strengths. For example, the reports by France, Spain and Sweden make use of the Appendix I format to provide detailed information on the characteristics of abatement techniques, and France and Sweden refer explicitly to the BAT/BEP indicators. The UK report provides detailed information on the review of decision-making related to the choice of abatement technologies for some sites, and the report from Germany makes reference to national documentation on BAT that may provide a useful basis for future review.

Table 2: Summary of Information included in Contracting Parties' Implementation Reports related to Guideline Headings

Contracting Party	General	Discharges				Environmental		Radiation Doses	
	Implementation in legislation[1]	Systems to reduce discharges	Efficiency of abatement systems[2]	Comparisons (trends & international)	Trends in aerial emissions[3]	Monitoring programmes	Environmental concentrations	Critical group doses	Targets
Belgium	(✓)	✓		✓	✓	✓	✓	✓	
Denmark	(✓)								
France	✓	✓	✓	✓		✓	✓	✓	
Germany	✓	✓	(✓)	✓	✓	✓		✓	
Netherlands	(✓)	✓	(✓)	✓	✓	✓	✓	✓	✓
Norway	(✓)	✓		✓		✓	✓	✓	✓
Portugal							✓	✓	
Spain	✓	✓	✓	✓		✓	✓	✓	
Sweden	✓	✓	✓	✓	✓	✓	✓	✓	✓
Switzerland	(✓)	✓	✓	✓		✓	✓	✓	✓
UK	✓	✓	(✓)	✓	✓	✓	✓	✓	✓

[1] (✓) in this column indicates that information is incomplete, as explained in more detail in Section 4.1.
[2] (✓) in this column indicates that information on the efficiency of abatement systems is incomplete, as demonstrated in Section 3 and Annex 3.
[3] In some cases this information was not provided as it was not considered relevant to the marine environment.

This information is in accordance with the conclusions of the Radioactive Substances Committee, outlined in Summary Records of their meetings, and given below.

Following presentation of the national implementation reports, the RSC agreed, subject to the reservation of Ireland[3], that with respect to the implementation of PARCOM Recommendation 91/4:

- Contracting Parties had fulfilled the reporting requirements[4];
- The reports were in line with the Guidelines ;
- The information presented included indications that BAT had been applied in the nuclear installations of the Contracting Parties.

[3] The application of BAT was one of the matters in dispute between Ireland and the UK in the context of the MOX Plant case before the UNCLOS Annex VII Tribunal. In the circumstances, Ireland did not believe it would be appropriate to state its views on the reports presented with regard to the application of BAT.

[4] Two Contracting Parties (Denmark and Portugal) did not attend the RSC to present their reports; the RSC was therefore not in a position to make a decision on these reports but it was agreed that these reports should be taken into account in this assessment report.

3 Effectiveness of Implementation of BAT

As outlined in Section 1.2, there are three key elements involved in this assessment of the effectiveness of the implementation of BAT:

- National arrangements for the implementation of BAT;
- The systems and abatement technologies in place and the extent to which they may be considered to constitute BAT;
- The effectiveness of these arrangements and techniques in delivering reductions in discharges.

Each of these issues is considered in turn in the following sections.

3.1 National Arrangements for Implementation of BAT

The Guidelines require national implementation reports to include general information on the implementation of BAT in national legislation and regulation. This information was reviewed. Some general conclusions are provided for each Contracting Party. However, it should be noted that the Guidelines suggest that the focus of the implementation reports should be on legislation introduced since the previous round of reporting. The level of detail provided, and conclusions arising, may therefore be influenced by differing interpretations of this requirement and focus.

3.1.1 Belgium

The Royal Decree of 20 July 2001 (General Regulations for the Protection of the population, workers and the environment against the dangers of Ionising Radiation - GRPIR) implements European Directives and the recommendations of ICRP Publication 60, and thus will include the requirement for optimisation of protection. However, the way in which this legislation addresses optimisation of protection and the application of BAT is not specified.

3.1.2 Denmark

Danish legislation and regulations are based on international principles of radiation protection and derived from Euratom Directives. However, no specific information is provided on the way in which the principles of optimisation or BAT are implemented within these requirements.

3.1.3 France

The French Nuclear Safety Authority has established new regulatory provisions to cover modifications of discharge authorisations and requirements for technical improvements from the operator. Authorised limits are set to be as low as technically and economically possible, and require the operator continuously to optimise treatment and waste processes by using the best available techniques at an acceptable cost. Furthermore, the French authorities are currently analysing a study of processes and effluent treatment measures to reduce liquid radioactive discharges from COGEMA - La Hague that they have requested. The information provided in the summary information available in English suggests that technical advances in effluent treatment methods and approaches have been reviewed and may lead to improvements which would be presented in the next round of implementation of PARCOM 91.

3.1.4 Germany

German policy is based on international conventions and recommendations. Existing legislation provides for:

- avoidance of unnecessary radiation exposure to the public,
- avoidance of unnecessary contamination of humans and the environment, and
- minimisation of radiation exposure and contaminations taking into account the state of scientific and technological advancement.

In addition, the state of scientific and technological advancement, taking into account the BAT, is defined in technical guidelines, such as safety standards, issued by the "Kerntechnischer Ausschuß (KTA)". Additional regulations are issued by the "Deutsches Institut für Normung (DIN)" containing requirements affecting the treatment of radioactive effluents, including retention factors for filter systems. The safety standards issued by the KTA and the DIN are reviewed on a regular basis every five years. Thus, the processes for establishing and reviewing BAT appear to be well established.

3.1.5 The Netherlands

The Nuclear Energy Act incorporates the three principles of radiological protection. The terms BAT/BEP are not explicitly referred to in the Nuclear Energy Act, although BAT/BEP are considered to be implemented in the Dutch national regulation by the application of the optimisation (or ALARA) principle. Information is not, however, provided on the approach applied to review and apply national and. international developments in technology or practices.

3.1.6 Norway

Norwegian policy is based on internationally accepted principles for radiation protection. Discharge authorisations explicitly require the use of Best Available Techniques (BAT). When issuing authorisations for nuclear installations, Norwegian practice is to focus on BAT, the ALARA and precautionary principles. No detailed information is, however, provided.

3.1.7 Portugal

No information provided.

3.1.8 Spain

Spanish legislation and regulations require that facilities generating radioactive wastes must be provided with adequate treatment and removal systems and that every reasonable effort is made, from the generation of wastes to the operation of the effluent treatment systems, to reduce releases and to keep the radiological impact as low as is technically and economically feasible. A Continuous Safety Assessment Programme (CSA) is required that takes account of progress in technology (BAT) and the operational experience. Licensees are also required to perform a Periodic Safety Review (PSR) programme on a ten yearly basis to *inter alia* evaluate the applicability to the facility of developments in new generation plants. Thus, the processes for establishing and reviewing BAT appear to be well established.

3.1.9 Sweden

The primary legislation, the Radiation Protection Act, includes a requirement that radiation protection shall be in reasonable accordance with technical and methodological development, and shall be improved as technological and methodological development permits (i.e. that BAT shall be applied although the term is not used *per se*). Other relevant codes and regulations explicitly identify BAT as a means for achieving the goal of preventing, eliminating or reducing the impact on health and the environment of human activities, and target levels are established that are considered to relate to BAT. Thus, the processes for establishing and reviewing BAT appear to be well established.

3.1.10 Switzerland

The Swiss Federal Act and Ordinance on Radiological Protection has been based on the recommendations of the ICRP Publication 60. In addition, the Swiss Federal Nuclear Safety Inspectorate's regulatory guidelines include the BAT/BEP requirement, according to the terms of the OSPAR Convention. More detailed information on the way in which this requirement is implemented is not provided.

3.1.11 United Kingdom

The regulation of radioactive waste discharges and disposals in the UK is governed by two optimisation concepts: Best Practicable Environmental Option (BPEO) and Best Practicable Means (BPM). The BPEO is about global optimisation, with respect to environmental impact, while BPM focuses on processes and individual waste streams. In practice, the common regulatory understanding in the UK is that if an identified BPEO is put into effect using BPM, an operator can confidently claim that BAT has been applied. Together, these concepts, and the way in which they are incorporated within the process of regular authorisation review, place a continuous pressure for improvement on operators which is consistent with the objectives of BAT. Thus, the processes for establishing and reviewing BAT appear to be well established.

3.2 Systems and Abatement Techniques to Reduce Discharge

The Guidelines require site-specific information on systems and abatement techniques in place to reduce, prevent or eliminate discharges of radioactive substances to the marine environment (2.1 and 2.2 and Appendix I of the Guidelines). Appendix I of the Guidelines includes a list of abatement techniques from the OECD/NEA report on Effluent Release Options from Nuclear Installations (OECD, 2003), as follows:

- Delay tanks
- Chemical precipitation
- Centrifuging
- Hydrocylone
- Cross-flow filtration
- Ion exchange
- Osmosis
- Ultrafiltration

3.2.1 Systems and Abatement Techniques in place in Contracting Parties

A compilation of the site-specific information on systems and abatement techniques, included in the Contracting Parties' implementation reports (listed in Annex 2) is provided in Annex 3. A summary is provided in Table 3 and in the discussion that follows. It should be noted, however, that the identification of BAT, at a site-specific and process level, is a complex task which is beyond the scope of this assessment. This is a high level review of the systems and abatement techniques, to determine whether they are appropriate and generally in line with industry best practice – and by extension likely to be consistent with BAT.

Table 3: Systems and Abatement Techniques in Place in Contracting Parties (see Annex 3)

	Fuel Enrichment and Fabrication	Nuclear Power Generation and Decommissioning	Reprocessing	Research and Development
Belgium	Not applicable	Segregation. Filtration of low active effluents. Ion-exchange and evaporation. Decay storage.	Not applicable	Segregation, sedimentation and evaporation. Cementation of residues and bitumenisation before storage.
Denmark	No information			
France	Not applicable[5]	Minimization at source, filtration, evaporation and demineralisation.	Continuous review of developments regarding evaporation, concentration and vitrification. Chemical treatment.	No information
Germany	No discharge water from fabrication plant. At the enrichment plant dry conversion processes used. Minimization of waste by design and process. Filtration and evaporation.	Minimization and segregation, filtration, evaporation, ion-exchange and centrifugal systems. Representative decontamination factors provided.	Not applicable	Delay storage, ion-exchange and evaporation processes for higher concentrations. Representative decontamination factors provided.
The Netherlands	Distillation, precipitation or sedimentation followed by filtration and deposition. Recovered uranium is reused. Delay storage for short-lived nuclides.	Minimization of waste, ion-exchange. Storage and further distillation and filtration of sludge. Decontamination factors are provided.	Not applicable	Minimization, distillation and decay storage. Segregation and sedimentation, flocculation and pH adjustment, membrane filtration, centrifugation and drying.

5 No plants located in the OSPAR area.

	Fuel Enrichment and Fabrication	Nuclear Power Generation and Decommissioning	Reprocessing	Research and Development
Norway	Not applicable	Not applicable	Not applicable	Delay storage, sedimentation, filtration and purification by ion exchange and evaporation.
Portugal	No information			
Spain	Centrifugation filtration and delay.	Minimization of waste. Delay, filters, evaporators. Demineralization and filtration. Detailed site-specific information on effectiveness of different treatment techniques provided.	Not applicable	No information
Sweden	No information	Segregation. Low-level liquids discharged without treatment. Higher levels: particle filtration or ion exchange or evaporation. Decontamination factors provided.	Not applicable	No information
Switzerland	Not applicable	Centrifugation and evaporation, in conjunction with chemical precipitation. Decontamination factors provided.	Not applicable	Diffusion through membranes with pressure difference.
United Kingdom	Fuel enrichment: segregation, ion exchange and decay storage. Fuel fabrication: management options to reduce discharges or their impact, e.g. ban on use of uranium ore concentrates containing elevated levels.	The management of fuel ponds to minimize corrosion of fuel, including temperature control and anion concentrations in ion exchange plant. Ion exchange and anion removal, sand pressure filtration, various filters. Some decontamination factor information provided.	Vitrification of highly active liquid. Options for low active effluent streams include: pH controls, flocculation and ion exchange, ultrafiltration and encapsulation of residue; evaporation and decay; sand pressure filters, pH control and counterflow with CO_2; incineration.	Very low activity wastes, pH adjustment only. Otherwise decay storage, flocculation and dynasand filtration. Ion-exchange is used where Cs-137 loading warrants. Evaporation of small volume effluents is also undertaken. Decontamination factors provided.

In addition, a number of Contracting Parties reported on recent developments in abatement systems or processes, which are summarised below:

- France (COGEMA – La Hague): Recent developments include the replacement of pulsed columns or mixer-settlers by centrifugal extractors in Workshop R4, resulting in lower degradation of solvent and less effluent. There is continuous purification of solvents and treatment by distillation under vacuum.
- Sweden (Ringhals 2): A pilot plant was developed for cross-flow filtration in combination with different absorbers and resins. This plant handles operational effluents, giving rise to a DF >100. It is, however, unable to handle the large volumes of liquid arising during transient shut-down situations.
- Switzerland (Beznau), improvement of the system by use of nanofiltration was planned to be operational in 2007.
- United Kingdom (Sellafield): During this reporting period, a comprehensive review of the control of discharges of Tc-99 was undertaken, which included consideration of abatement options, potential process changes, impact assessment, storage options and costs. As a consequence, an approach to reduce discharges of this nuclide was developed involving the diversion of material to vitrification.

3.2.2 Contracting Parties' Systems Abatement Techniques and BAT

As outlined in the NEA Expert Group on Effluent Release Options (OECD, 2003), it is important to note that BAT relates both to the technologies used and the way in which the nuclear facility is designed, built, maintained, operated and decommissioned. The efficiency of plant processes may be optimised during design and construction but, once a facility is built, there are generally fewer opportunities to change the design of processes such that, for existing plants, there is generally a greater focus on abatement technology. Nevertheless, operational management systems to prevent, eliminate or reduce liquid waste are an important element of the application of BAT. Contracting Parties generally acknowledged that such systems were in place.

Some examples of the general types of abatement techniques available for liquid discharges, identified in the NEA report, are given in Table 4. This table demonstrates that different types of treatment option are available, depending on the physical and chemical properties of the liquid waste stream.

Table 3 demonstrates that the abatement techniques, identified in the NEA report and Table 4, have been employed by Contracting Parties individually or in combination to optimise the removal of particular materials and nuclides from the liquid effluents. Furthermore, it may be seen from Table 3 that there is a significant level of similarity among the systems and abatement processes and techniques applied in nuclear facilities in the Contracting Parties. This level of agreement, together with the national processes in place to implement BAT, provides a strong indication that international best practice – and by extension BAT – is being applied.

Table 4: Examples of Available Abatement Techniques for Liquid Discharges and their Application (OECD, 2003)

Techniques	Application
Chemical precipitation	Chemical treatment of aqueous solution, e.g. application of alkali, with resulting co-precipitation of nuclides from solution. Filtration and ion exchange to remove particulates from liquid effluents. DFs from combined approach typically 10^3 - 10^6
Physical separation (centrifuging and cross-flow filtration)	Insoluble contaminants, e.g. corrosion products and metal oxides. Efficiency depends on particle size.
Reverse osmosis, ultra-filtration and evaporation	Used to remove very low levels of contaminants as final stage before discharge of liquid effluent. Reverse osmosis and ultrafiltration rely on passing relatively clean effluents through a sensitive permeable membrane under pressure. Together with ambient temperature evaporation, very low discharges result.

Tables 3 and 4 also indicate that combinations of techniques may be and are being used to achieve high decontamination factors. A report of an IAEA Co-ordinated Research Project on Combined Methods for Liquid Radioactive Waste Treatment, published in 2003 (IAEA, 2003), also recognised that the treatment of radioactive liquid effluents often involves a number of steps (such as filtration, precipitation, sorption, ion exchange, evaporation and/or membrane separation). In particular, the value of using combined multi-stage processes for wastes with complex composition (e.g. from reprocessing, secondary wastes from decontamination operations, organic radioactive sludges and spent ion exchange resins) is recognised. The evaporation and fractional condensation treatment of boric acid solutions, resulting from PWR operations in operation at Doel power plant in Belgium, is noted as a particular example. Other examples of multi-stage plants exist in other Contracting Parties.

The inflexibility in the design of older nuclear plants, which were constructed in the 1950s and 1960s when permitted standards for environmental protection were different, is also noted in the NEA report (OECD, 2003). This inflexibility leads to higher abatement costs under operational and decommissioning situations, where recycling and recovery has not been ‘designed-in’. Given that both the ALARA and BAT principles include an allowance for economic and social considerations, considerations of cost and feasibility (and projected lifetime of the plant in question) will inevitably influence decisions on what constitutes BAT, particularly in relation to early nuclear facilities that are now drawing to the end of their operational life, or which are undergoing decommissioning.

Over recent years, a lot of work has been devoted on abatement techniques for tritium and carbon 14 in the liquid effluents by OSPAR experts. A relevant IAEA report, published in 2004, demonstrated that techniques are available to remove these radionuclides (IAEA, 2004), although there were also indications that their use may be influenced by the limited scale of operations, high operating costs and that no qualified safe conditioning is available for their disposal. Implementation reports of the Contracting Parties do not mention that any abatement techniques have been implemented for tritium and carbon 14 in the liquid effluents discharged by the nuclear industry (light water reactor NPP and reprocessing plants.

3.3 The Effectiveness of BAT in reducing Liquid Discharges

The following conclusions on the change in discharges from nuclear facilities in the Contracting Parties are included in the First Periodic Evaluation of Progress towards the Objective of the OSPAR Radioactive Substances Strategy (OSPAR, 2006). In that report, discharge trends for nuclear facilities were identified relative to total-α, total-β, Cs-137, Tc-99 and Pu-239 and Pu-240 activity (as appropriate) in the baseline period 1995-2001, using a range of statistical trend analysis techniques[6].

3.3.1 Belgium

Although there have been reductions in the levels of discharge from the nuclear power sector, in the period 2002-2004 when compared with the baseline average (OSPAR, 2006), these reductions are not statistically significant. There is evidence of reductions in discharge levels from the research and development (R & D) sector, in 2002-2004, which are statistically significant.

3.3.2 Denmark

Discharges from the R & D sector were around, or a little above, the baseline average, but statistical tests suggest that there has not been a statistically significant increase.

3.3.3 France

There is clear evidence of statistically significant reductions in the discharges of total-β and some evidence of reductions in discharges of Cs-137 from the nuclear power sector since the baseline period, in the period 2002-2004 (OSPAR, 2006). There is clear evidence of statistically significant reductions in the total-β and Cs-137 discharges, and some evidence for reductions in total-α and plutonium discharges, from the reprocessing sector. These reductions are considered to result from actions taken to reduce discharges rather than differences in throughput. There is no evidence of reductions in discharges of radioactive substances from the R & D installation at Fontenay-aux-Roses, which has stopped operating since 1995 and only processes decommissioning liquid effluents and radioactive wastes. For the installation at Saclay, there is no evidence of reductions in discharges of total-α, but there is some evidence of reductions in discharges of other radionuclides.

3.3.4 Germany

There is some evidence for a reduction in the total-β and Cs-137 discharges from the nuclear power sector, but they are not statistically significant. The nuclear fuel enrichment and production plants in Germany demonstrate a reduction in total-α discharges of more than an order of magnitude. There is evidence of a reduction in levels of total-β discharges from the R & D sector which is statistically significant.

3.3.5 The Netherlands

Total-β and Cs-137 discharges from the nuclear power sector are an order of magnitude below the baseline average. There is some evidence for reductions in discharges, but these are not statistically significant. There is evidence for a statistically significant reduction in total-β discharges, but not in total-α discharges

[6] The information on statistical significance has been taken from the First Periodic Evaluation of Progress towards the Objective of the OSPAR Radioactive Substances Strategy (OSPAR 2006). The application of statistical analyses and the choice of baseline elements and times have not been reviewed as part of this assessment. The extent to which these factors might influence the absolute and relative performance of different Contracting Parties is therefore not known.

from the fuel enrichment plant (Almelo). There has been a statistically significant reduction in the levels of discharges of total-α activity from the R & D sector but no statistically significant trend in the discharge of total-β activity from this sector.

3.3.6 Norway

It was not possible to draw any clear conclusions from the data for the R & D sector, except that there is no clear evidence of any increase.

3.3.7 Portugal

It was not possible to draw any conclusions from the data regarding whether there had been any change in discharges from the R & D sector.

3.3.8 Spain

There is clear evidence of statistically significant reductions in total-β discharges and some evidence of reductions in Cs-137 discharges from the nuclear power sector. The total-α discharges from the nuclear fuel production facility (Juzbado) have remained fairly constant.

3.3.9 Sweden

There is evidence of statistically significant reductions in total-β discharges and some evidence of a reduction of Cs-137 discharges (which are nearly an order of magnitude lower than the baseline average) from the nuclear power sector.

3.3.10 Switzerland

There is some evidence for a reduction in the discharges of total-β and Cs-137, from the nuclear power sector. No conclusions could be drawn regarding the trend in total-α discharges from the R & D sector, although there is evidence of a statistically significant reduction in total-β discharges.

3.3.11 United Kingdom

There is no evidence of a statistically significant change in levels of discharges from the nuclear power sector. There was, by 2004 (the end of the reporting period), no evidence of a reduction in the levels of total-α, total-β and Tc-99 discharges from the fuel enrichment and fuel fabrication plants in the UK, though significant reductions have been observed since 2004. The total-β and Tc-99 discharges from reprocessing for the end of the reporting period (2004) are below the baseline average, giving an indication of a relevant reduction. There was also some fluctuation in the Cs-137 discharges over the period but statistical tests suggest that the reductions are not significant. Discharges of total-α and plutonium isotopes from reprocessing indicate an increase, relative to the baseline. However, a simple comparison gives no indication of a relevant increase. The Student's t-test suggests this increase is statistically significant, while the Mann-Whitney statistic does not confirm this. The levels of discharges in 2002-2004 from the R & D sector are an order of magnitude lower than the average for the baseline period. However, the lower brackets of the baseline are negative such that no clear conclusions could be drawn for the R & D sector, except that there is no evidence of any statistically significant increase.

4 Conclusions and Recommendations

The overall conclusion of this assessment is that the national implementation reports, presented to the RSC, indicate that BAT has been implemented in the Contracting Parties' legal and regulatory systems and that operational systems and techniques are in place to minimize or eliminate radioactive discharges from nuclear facilities. This conclusion is in agreement with that of the RSC, outlined in Section 2.2. A more detailed discussion of these conclusions and recommendations for consideration in the next round of reporting follow.

4.1 Conclusions

The Contracting Parties' implementation reports indicate that arrangements are generally in place for implementation of BAT in the national legislation and regulations related to the nuclear industry[7]. However, some Contracting Parties appear to rely on the application of the radiological protection principle of optimisation (or ALARA) alone. Although closely related, the ALARA and BAT principles are focused on different endpoints; ALARA is directly related to dose and health impact, while BAT is focused on the application of processes and technology to control discharge. Application of BAT may be considered to imply a greater emphasis on continuing reviews to determine the 'best' processes than is necessarily the case with ALARA, while ALARA implies a greater allowance for the holistic assessment of risk. However, these observations depend upon the way in which the terms ALARA and BAT are interpreted and applied by the Contracting Parties. There is not always sufficient information to determine whether the continuing review processes, implicit in the BAT principle, are implemented and if they are also part of the ALARA principle, as it is applied in practice.

In their national reports, Contracting Parties generally acknowledged that operational management systems are in place to prevent, eliminate or reduce liquid waste. Such systems are an essential element of the application of BAT. In addition, the abatement techniques, identified in the NEA and IAEA reports, on available liquid effluent options, have been employed by Contracting Parties individually or in combination to remove particular materials and nuclides (except tritium and carbon 14) from the liquid effluents. For tritium and carbon 14 (two nuclides which require particular attention according to Bremen agreement), implementation reports of the Contracting Parties do not mention that any abatement technique has been implemented for tritium and carbon 14 in the liquid effluents discharged by the nuclear industry. There is a significant level of agreement in the processes being employed, which provides a strong indication that international best practice – and by extension BAT – is being applied.

The First Periodic Evaluation of Progress towards the Objective of the OSPAR Radioactive Substances Strategy provides evidence that there have been statistically significant reductions in the discharge of indicator materials and some evidence, for example in relation to the reprocessing sector in France, that these

7 With the exception of Portugal for which no information was available.

reductions arise from actions taken to reduce discharges rather than differences in throughput.

4.2 Recommendations for next round of reporting

There was not always sufficient information on which to judge the adequacy of national or facility procedures to implement BAT or the way in which BAT considerations are included within operational optimisation. It would be useful if Contracting Parties were encouraged to provide more information regarding regulatory and operational processes in place to review and update technological and other developments. Furthermore, documentation on established management and work practices in place to reduce discharge at source could be improved.

The BAT/BEP indicators in the guidelines are not consistently used. It would be easier to assess and compare Contracting Parties' implementation of BAT if the use these indicators more applied more directly. Their use in summary form could also be encouraged (see for example the report by Sweden). There would also be value considering of whether more guidance should be provided on the interpretation of the BEP concept and associated indicators. The application of normalized discharges in this context may also warrant further consideration.

Experience of techniques or processes being considered or adopted in one Contracting Party may be of relevance to another. There would therefore be value in encouraging greater levels of on-going information exchange on BAT between Contracting Parties. For example, exchange of information regarding the use of codes and handbooks in Germany and the application of environmental targets in Sweden would be potentially valuable. In addition, more detailed information regarding BAT decisions (including information on unsuccessful trials and the reasons why given techniques were not applied in some situations) would be useful. While it is recognised that there may be commercial or other constraints on the exchange of information, valuable information of this sort was included in the UK implementation report (e.g. in relation to Sellafield).

A significant and increasing number of nuclear facilities are undergoing or will shortly undergo decommissioning in many Contracting Parties. There would be value in considering whether there are particular issues relating to the control of discharges during decommissioning, that warrant separate consideration of operational and decommissioning sites (as in the report by the UK)[8]. The processes for considering the implications of BAT with respect to the choice of decontamination and decommissioning techniques will be increasingly relevant in the future. This may include considerations such as: scheduling of waste treatment plant operation and decommissioning operations, and assessments of total and discharge rates.

Many Contracting Parties did not provide information on aerial emissions on the basis that they were not relevant to the marine environment, for example due to distance from the coast. It was also noted that studies had indicated that aerial emissions did not make a significant contribution to concentrations of radionuclides in the marine environment. The context and scope of the request for information

[8] Ireland believes that this recommendation is not appropriate in a review on the BAT reports. It was argued that it merits discussion at the RSC rather than as part of this report.

on atmospheric emissions should therefore be clarified before the next round of reporting. It may be appropriate to request information on aerial emissions and associated abatement techniques only where they are likely to have a direct impact on liquid discharges. For example, the control of atmospheric emissions of C-14 is a particular example identified in the implementation reports of both France and the UK.

The abatement techniques for tritium and carbon-14 in liquid effluents have also been the subject of discussion and there may be value in reviewing the extent to which there is agreement on the definition of BAT with regard to the abatement of these radionuclides among Contracting Parties, as part of the next round of reporting.

5 References

IAEA (2003), Combined Methods for Liquid Radioactive Waste Treatment, Final Report of a Coordinated Research Project 1997-2001, IAEA-TECDOC-1336, IAEA, Vienna, Austria.

IAEA (2004), Management of Waste Containing Tritium and Carbon-14, Technical Reports Series No. 421, IAEA, Vienna, Austria.

OECD Nuclear Energy Agency (2003), Effluent Release Options from Nuclear Installations, Technical Background and Regulatory Aspects, NEA, Radiation Protection Series, Paris, France.

OSPAR (2003a), Implementation of PARCOM Recommendation 91/4 on Radioactive Discharges. ISBN 1-904426-21-2.

OSPAR (2003b), Radioactive Substances Strategy (Agreement no. 2003-21).

OSPAR (2004), Guidelines for Submission of Information about, and the Assessment of, the Application of BAT in Nuclear Facilities (2004-03) (Annex 1).

OSPAR (2006), First Periodic Evaluation of Progress towards the Objective of the OSPAR Radioactive Substances Strategy, Report No. 302/2006.

6 Annexes

Annex 1: Guidelines for the submission of information about, and assessment of, the application of BAT in nuclear facilities (2004-03)

Annex 2: National Implementation Reports

Annex 3: Summary of site-specific information on abatement techniques

Annex 1: Guidelines for the Submission of Information about, and assessment of, the Application of BAT in Nuclear Facilities (2004 – 03)

Guidelines for the Submission of Information about, and the Assessment of, the Application of BAT in Nuclear Facilities

(Reference number: 2004-03)

Replaces agreement 1999-11

GENERAL INFORMATION

INFORMATION TO BE SUBMITTED
Implementation of BAT/BEP in terms of the OSPAR Convention in national legislation/regulation - New legislation since latest implementation round National regulatory concepts, e.g. what is considered as BAT and how BAT is being applied by each Contracting Party. **Dose constraints/limits for nuclear facilities** Rationale for setting dose constraints/limits **Discharge limits** Rationale for setting discharge limits **Monitoring programmes of environmental concentrations of radionuclides** **Environmental norms and standards (other than dose standards for humans, e.g. standards for drinking water)** **National authority responsible for supervision etc. of discharges** **Nature of inspection and surveillance programmes**

SITE -SPECIFIC INFORMATION: 1. SITE CHARACTERISTICS

INFORMATION TO BE SUBMITTED
1.1 Name of site **1.2 Type of facility** E.g. power plant (PWR, BWR, GCR, AGR), reprocessing plant, fuel fabrication plant, waste treatment plant, etc., or a combination of these (number of units of each type) **1.3 Year for commissioning/licensing/decommissioning** Specified for the main installations within the site **1.4 Location** **1.5 Receiving waters and catchment area, including, where relevant, information on water flow of receiving rivers** **1.6 Production** Installed electrical effect and annual electrical output for the last six years (power reactors) Tonnes U processed (reprocessing and fuel fabrication plants) Thermal effect (research reactors) Other relevant data (e.g. for waste treatment plants) **1.7 Other relevant information**

SITE-SPECIFIC INFORMATION: 2. DISCHARGES

OBJECTIVE	INFORMATION TO BE SUBMITTED	BAT/BEP INDICATOR
Discharges to the marine environment, as well as emissions of concern to the marine environment, are limited through application of technical and managerial practices in accordance with Article 2, 3 (b) (i), as well as Appendix 1 on BAT/BEP of the OSPAR Convention	**2.1** System(s) in place to reduce, prevent or eliminate discharges of radioactive substances to the marine environment, as well as emissions of radioactive substances of concern to the marine environment according to the list in Annex 5. In particular, systems taken into operation during the reporting period (or decided to be taken into operation) should be reported as well as changes in management of waste treatment (for example use of other waste streams), or processes that reduce discharges or emissions should be reported.	Relevant systems in place (Annex 1).
	2.2 Efficiency of *abatement* systems in terms of, e.g., retention times and distribution between waste streams destined for discharge and waste streams destined for disposal *according to Annex 5.*	The decontamination (or abatement) factor or other measure of efficiency of abatement systems (Annex 1).
	2.3 Annual liquid discharges: • nuclide specific data as given in the OSPAR Annual Report on Liquid Discharges with possible additional radionuclides from EC reporting requirements • data on beta emitters (excluding tritium), tritium and alpha emitters (normalised data with regard to net electrical output (power reactors) or tonnes U processed (reprocessing plants and fuel fabrication plants). Factors influencing the normalisation should be reported); Data for at least the last six years should be submitted.	Downward trends in absolute and normalised discharges Comparison with values of similar installations world-wide, based on the most recent compilations published by OSPAR, UNSCEAR or EC
	2.4 Emissions to air of concern for the marine environment. Only nuclides with half-life >30 days should be considered, however, as a minimum, information on tritium, C-14 and I-129 should be submitted. Data for at least the last six years.	Downward trends

SITE-SPECIFIC INFORMATION: 2. DISCHARGES *(Continued)*

OBJECTIVE	INFORMATION TO BE SUBMITTED	BAT/BEP INDICATOR
Discharges to the marine environment, as well as emissions of concern to the marine environment, are limited through application of technical and managerial practices in accordance with Article 2, 3 (b) (i), as well as Appendix 1 on BAT/BEP of the OSPAR Convention	**2.5** Systems for quality assurance of: • performance of retention systems etc. • data management.	Relevant and reliable systems are in place
	2.6 Site specific target discharge values.	Relevance of target and closeness to target value
	2.7 Any relevant information not covered by the requirements specified above.	
	2.8 Explanations for lack of data or failure to meet BAT/BEP indicators, as well as, when appropriate, a description of on-going or planned activities.	
		SUMMARY EVALUATION: **A BALANCED EVALUATION OF THE CP'S ABILITY TO ACHIEVE THE OBJECTIVE, TAKING INTO ACCOUNT** • The BAT/BEP indicators listed above • Data completeness • Causes for deviations from indicators • Uncertainties • Other information

SITE-SPECIFIC INFORMATION : 3. ENVIRONMENTAL IMPACT

OBJECTIVE	INFORMATION TO BE SUBMITTED	BAT/BEP INDICATOR
Marine ecosystems shall be protected, in accordance with Article 2, 1 (a), of the OSPAR Convention.	**3.1** *Concentrations of radionuclides of concern in representative samples of water, sediment and fish. Data for at least the last six years.*	Development of environmental quality criteria is a part of the OSPAR Strategy with Regard to Radioactive Substances. Such criteria may be used as a BAT/BEP indicator Downward trends
	3.2 Environmental monitoring programme, frequency of sampling, organisms and or other types of environmental samples considered.	The environmental monitoring programme is relevant, taking sample types, frequencies and the local environment into account
	3.3 Systems for quality assurance of environmental monitoring.	Relevant and reliable systems are in place
	3.4 Any relevant information not covered by the requirements specified above.	
	3.5 Explanations for lack of data or failure to meet BAT/BEP indicators, as well as, when appropriate, a description of on-going or planned activities.	
		SUMMARY EVALUATION: **A BALANCED EVALUATION OF THE CP'S ABILITY TO ACHIEVE THE OBJECTIVE, TAKING INTO ACCOUNT** • The BAT/BEP indicators listed above • Data completeness • Causes for deviations from indicators • *Uncertainties* • Other information

SITE-SPECIFIC INFORMATION: 4. RADIATION DOSES TO THE PUBLIC

OBJECTIVE	INFORMATION TO BE SUBMITTED	BAT/BEP INDICATOR
Human health shall be protected, in accordance with Article 2.1 (a) of the OSPAR Convention.	**4.1** Average annual effective dose to individuals within the critical group(s) via the marine exposure pathway(s), and caused by current discharges. Data should be submitted for the last six years.	Downward trend
	4.2 Total exposures (i.e. including those from emissions and historic discharges/emissions).	The exposure is well within the constraint (or similar), provided the constraint gives reasonable allowance for other practices so that the annual effective dose from all practices is kept below 1 mSv
	4.3 The definition of the critical group(s), including information on age distribution, size and other relevant information, and on whether the critical group is real (identified) or hypothetical. **4.4** Information on exposure pathway(s) considered, and whether these are treated individually or collectively.	The critical group is relevant, taking local conditions and habits, as well as the exposure situation, into account
	4.5 Basis for methodology to estimate doses (models, actual measurements, and verification of data, as appropriate).[9] **4.6** Site-specific factors for significant nuclides, used to estimate the dose to critical group members from discharge values.	The dose estimates are reliable and sufficiently realistic
	4.7 Site specific target annual effective dose.	Relevance of target and closeness to target value
	4.8 Systems for quality assurance of processes involved in dose estimates.	Relevant and reliable system is in place
	4.9 Any relevant information not covered by the requirements specified above.	
	4.10 Explanations for lack of data or failure to meet BAT/BEP indicators, as well as, when appropriate, a description of on-going or planned activities.	

[9] If this information is general for the nuclear sector and/or part of a statutory programme, this information may be entered under GENERAL INFORMATION

		SUMMARY EVALUATION: **A BALANCED EVALUATION OF THE CP'S ABILITY TO ACHIEVE THE OBJECTIVE, TAKING INTO ACCOUNT** • The BAT/BEP indicators listed above • Data completeness • Causes for deviations from indicators • *Uncertainties* • Other information

Appendix 1

System(s) in place to reduce, prevent or eliminate discharges and their efficiency

Abatement systems[10] and management (according to 2.1 and 2.2).

Abatement system/ Management	Into operation (Year)		Efficiency of abatement system		Comments
	Existing	**Planned**	**Decontamination Factor**	**Other measure of efficiency**	
Discharges:					
delay tank(s)					
chemical precipitation					
centrifuging					
hydrocyclone					
cross-flow filtration					
ion exchange					
osmosis					
ultrafiltration					
..other….					
..other….					
Emissions:					
electrostatic precipitation					
cyclone scrubbing					
chemical adsorption					
HEPA filtration					
cryogenics					
..other….					
..other….					
***Changes in management or processes**:*					
……					
……					

10 The examples on abatement techniques are taken from the recently published OECD/NEA report "Effluent release options from nuclear installations".

Annex 2: National Implementation Reports

Unless otherwise specified, the reports listed below are available from the OSPAR website[11]:

Publication No. 341/2007: Implementation reporting of PARCOM Recommendation 91/4: Belgian Implementation Report, OSPAR Commission 2007.

RSC 07/5/2-E, Implementation Report of PARCOM Recommendation 91/4 on Radioactive Discharges, Presented by Denmark[12].

Publication No. 298/2006: Rapport National Français de mise en œuvre de la Recommandation PARCOM 91/4 sur les rejets radioactifs, Commission OSPAR 2006.

Publication No. 299/2006: Implementation report of PARCOM Recommendation 91/4 by Germany, OSPAR Commission 2006.

Publication No. 2005/238: Report on Information about, and the Assessment of, the Application of BAT in Nuclear Facilities, The Netherlands' Report, OSPAR Commission 2005.

Publication No.300/2006: PARCOM Recommendation 91/4 on Radioactive Discharges: Norway's Report on the Implementation of PARCOM Recommendation 91/4 on Radioactive Discharges, OSPAR Commission 2006.

RSC 07/5/3-E, Implementation Report of PARCOM Recommendation 91/4 on Radioactive Discharges, Presented by Portugal[13].

Publication No. 342/2007: PARCOM Recommendation 91/4 on Radioactive Discharges: Spanish Implementation Report, OSPAR Commission 2007.

Publication No. 2005/240: Swedish Report on Implementation of PARCOM Recommendation 91/4 on Radioactive Discharges, OSPAR Commission 2005.

Publication No. 301/2006: Implementation Report of PARCOM Recommendation 91/4 by Switzerland, OSPAR Commission 2006.

Publication No. 2005/241: The Application of BAT in UK Nuclear Facilities Report, UK's Report on the Implementation of PARCOM Recommendation 91/4), OSPAR Commission 2005.

[11] http://www.ospar.org in the Publications section (as part of the Radioactive Substances Series)
[12] Not available on the OSPAR website.
[13] Not available on the OSPAR website

Annex 3: Summary of Site-Specific Information on Abatement Techniques

A summary of information compiled from Contracting Parties' implementation reports is summarised on the following table. Empty cells imply that no information was provided. The information for France was derived solely from the Compiled information provided by the Secretariat[14].

[14] The full implementation report was not available in English and review of the report in French was beyond the scope of this assessment.

Country	Name	Type of Facility	Liquid Effluent Treatment	Effectiveness	Gaseous Discharge Treatment	Particular Developments
Belgium						
	Doel	Nuclear Power, PWR	Segregation of waste waters from different sources; ion-exchange procedures, filtration and evaporation of waste waters. Tritium is condensed and released as liquid fraction. After treatment, effluents are diluted by secondary waters and tertiary cooling waters. The concentrate phase is conditioned as solid concrete waste.		Storage, continuously monitored and filtered. Where action levels are exceeded, releases are passed through HEPA filters. Filters and active carbon cartridges (for trapping iodine) are analysed weekly.	
	Tihange	Nuclear Power, PWR	Recyclable elements are collected in respective units then filtered, demineralised (anionic, cationic and mixed bed resins) degassed and evaporated. Filtrate is stored and residue solidified by cementation. For non-recyclable effluents, low activities are filtered while higher activities also subject to evaporation and ion exchange. Effluents are sent to a storage tank prior to release.		Continuously monitored; Effluents from hydrogenous circuits are sent to storage/decay tanks. When action levels exceeded releases are by-passed through HEPA filters. Filters and active carbon cartridges (for trapping iodine) are analysed weekly.	
	Fleurus	Research and Development	Liquid wastes sent to Mol-Dessel			

Country	Name	Type of Facility	Liquid Effluent Treatment	Effectiveness	Gaseous Discharge Treatment	Particular Developments
	Mol-Dessel	Research and Development	Belgoprocess management of liquid wastes; different types of liquid waste are differentiated. Effluents are treated by sedimentation in decantation tank; the particulate phase is sent to a storage tank, for other sedimentation/decantation mechanisms. Evaporation is also used, depending on activity. Residues are conditioned by cementation and bitumenisation before storage. Higher level solids are vitrified.		HEPA filtration.	
Denmark						
	Riso	Research and Development (decommissioning)				
France						
	Belleville	Nuclear Power, PWR	EDF Strategy: is to reduce the production of effluents at the source and to optimize the collection and the processing of liquid waste. Liquid effluents are selectively collected according to			Set-up of an organization dedicated to effluent management, reinforced during refuelling outages. Sharing of good practices between power plants.

Country	Name	Type of Facility	Liquid Effluent Treatment	Effectiveness	Gaseous Discharge Treatment	Particular Developments
	Cattenom	Nuclear Power, PWR	4 categories (floor drains, service effluents, chemical effluents, process drains) in order to direct them towards the treatment best adapted to their characteristics (filtration, evaporation, demineralisation)			Improvement of leakage detection and identification.
	Chinon	Nuclear Power, PWR				
	Chooz	Nuclear Power, PWR				
	Civaux	Nuclear Power, PWR				
	Dampiere-en-Burly	Nuclear Power, PWR				
	Fassenheim	Nuclear Power, PWR				
	Flamanville	Nuclear Power, PWR				
	Golfech	Nuclear Power, PWR				
	Gravelines	Nuclear Power, PWR				
	Le Blayais	Nuclear Power, PWR				
	Nogent-sur-Seine	Nuclear Power, PWR				
	Paluel	Nuclear Power, PWR				
	Penly	Nuclear Power, PWR				
	Saint Laurent	Nuclear Power, PWR				
	La Hague	Reprocessing	evaporation, distillation, filtration and chemical precipitation			Continuous approach to review technical and economic developments regarding evaporation, concentration and vitrification for management of discharges. Workshop R4: Replacement of pulsed columns or mixer-settlers by centrifugal extractors, resulting in lower degradation of solvent and less effluent.

Country	Name	Type of Facility	Liquid Effluent Treatment	Effectiveness	Gaseous Discharge Treatment	Particular Developments
						Continuous purification of solvents, concentration by evaporation and vitrification.
	Fontenay-aux-Roses	Research and Development				R&D facilities operations stopped in 1995
	Saclay	Research and Development				
Germany						
	Biblis A	Nuclear Power, PWR	Filtration and Ion-exchange			Filtration and evaporation of waste waters
	Biblis B	Nuclear Power, PWR	Filtration, ion-exchange			Filtration and evaporation of waste waters
	Brokdorf	Nuclear Power, PWR	Filtration, Ion-exchange, evaporation, combustion, collection			Permanent monitoring
	Brunsbüttel	Nuclear Power, BWR	Ion-exchange and evaporation		Filtration and hold-up loop	
	Grafenrheinfeld	Nuclear Power, PWR	Ion-exchange, evaporation.		Aerosol filters, activated carbon filters	10% primary cooling content permanently routed through ion exchange; evaporation effective in reducing radioactive component of discharge; clean-up and hold-up procedures BAT

Country	Name	Type of Facility	Liquid Effluent Treatment	Effectiveness	Gaseous Discharge Treatment	Particular Developments
	Grohnde	Nuclear Power, PWR	Filtration, Ion-exchange within mixed-bed filters, evaporation, decantation, centrifugation			
	Hamm	Nuclear Power, THTR				
	Kahl	Nuclear Power, BWR				
	Krümmel	Nuclear Power, BWR	Ion-exchange, evaporation, decantation		Filtration and hold-up loop	
	Geesthacht	Research and Development	Filtration and Ion-exchange			
	Lingen/Emsland	Nuclear Power, PWR	Ion-exchange and evaporation		Filtration and hold-up loop	Permanent monitoring
	Lingen	Nuclear Power, BWR				
	Lingen	Fuel fabrication	No discharge of water		Filtration	
	Mülheim-Kärlich	Nuclear Power, PWR	Ion-exchange, evaporation, silting filtration, floc precipitation		Filters for aerosols and iodine; retention of noble gases by hold-up line	
	Neckarwestheim 1	Nuclear Power, PWR	Evaporation and Ion-exchange			Evaporation with high degree of decontamination
	Neckarwestheim 2	Nuclear Power, PWR	Evaporation and Ion-exchange			Evaporation with high degree of decontamination
	Obrigheim	Nuclear Power, PWR	Filtration, Ion-exchange, evaporation			
	Philippsburg 1	Nuclear Power, BWR	Separation according to concentration; high activity liquids subject to evaporation, low levels treated by Ion-exchange.	Evaporation: 10^5-10^6. Centrifugation 1 - 100.	Activated carbon filters	

Country	Name	Type of Facility	Liquid Effluent Treatment	Effectiveness	Gaseous Discharge Treatment	Particular Developments
			Chemically polluted stream (e.g. laundry) processed by centrifugal systems (consisting of decanter and separator)			
	Philippsburg 2	Nuclear Power, PWR				
	Rheinsberg	Nuclear Power, PWR				
	Stade	Nuclear Power, PWR	Filtration, Ion-exchange, decantation, evaporation			
	Rodenkirchen-Unterweser	Nuclear Power, PWR	Primary coolant: filtration, Ion-exchange, degassing, evaporation. Waste water: collection, silting filtration, evaporation.			Continuous monitoring
	Würgassen/Beverungen	Nuclear Power, BWR	Filtration, ion-exchange, distillation			
	Karlsruhe	Research and Development (decommissioning)	Collection in tanks, where higher than maximum permissible values, decontamination by evaporation	10^4 (evaporation)	HEPA filters, off-gas scrubbers (in solid waste incineration plant and reprocessing plant); Iodine emissions treated by activated charcoal beds or silver impregnated molecular sieves.	

Country	Name	Type of Facility	Liquid Effluent Treatment	Effectiveness	Gaseous Discharge Treatment	Particular Developments
	Gronau	Fuel enrichment	Filtration and evaporation			
	Hanau	Fuel fabrication (decommissioning)	Unspecified chemical treatment		Filtration (unspecified)	
	Karlstein	Fuel fabrication				
	HMI Berlin	Research and Development	Central collection tank then discharge to sewerage system (< 0.01 ALI for ingestion). Some proportion treated by ion-exchange			Warm layer to reduce fission and activation product transfer into hall atmosphere.
	Jülich	Research and Development	Delay storage in tanks where appropriate; Evaporation for higher concentrations		Delayed emission, aerosol filters, activated carbon filters.	
	Rossendorf	Research and Development (Decommissioning)	Delay storage in tanks where appropriate; Ion-exchange and evaporation for higher concentrations		Delayed emission, aerosol filters, activated carbon filters.	
The Netherlands						
	Borssele	Nuclear Power, PWR	Ion-exchange (primary coolant water), saturated resin is transferred to solid waste system following storage in tank; distillation of samples from tank (dependent upon activity);	Distillation 10^4 (except for tritium).		Chemicals added to primary coolant to prevent corrosion. Monitoring of leakage of fuel pellets.

Country	Name	Type of Facility	Liquid Effluent Treatment	Effectiveness	Gaseous Discharge Treatment	Particular Developments
			filtration of sludge. Residues transferred to solid waste system and cemented.			
	Doodewaard	Nuclear Power, BWR	Ion-exchange (primary coolant water), saturated resin is transferred to solid waste system following storage in tank; evaporation of samples from tank (dependent upon activity); filtration of sludge. Sedimentation; residues transferred to solid waste system and immobilized by cementation.			
	Almelo	Fuel enrichment	Distillation (dependent on activity) with residue transfer to the solid waste system and discharge of distillate to public sewer system (after routine checks on activity); precipitation/sedimentation of wash water from cylinder decontamination. The sediment is filtered and deposited into special vessels. Recovered uranium is reused. Storage for		Not relevant to marine compartment (not directly located at the sea or lake).	

Country	Name	Type of Facility	Liquid Effluent Treatment	Effectiveness	Gaseous Discharge Treatment	Particular Developments
			decay of short-lived nuclides			
	Delft	Research and Development	Processes and end-of-pipe measures applied: collection of waste in batches, minimization of dilution and mixing; distillation of waste water (exceeding 37 kBq/m^3 beta/gamma), ion exchange (primary coolant), storage and decay if possible, monitoring of leakage of fuel pellets.		Not relevant to marine compartment.	
	Petten	Research and Development	Separation of radioactive and non-radioactive effluents including sedimentation basins, membrane filtration units, centrifugation of sludges, sludge drying units. Waste water treatment methods: collection and storage, flocculation and pH adjustment, processing by			

Country	Name	Type of Facility	Liquid Effluent Treatment	Effectiveness	Gaseous Discharge Treatment	Particular Developments
			removal and drying sediments; dried sludges and sediments transferred in barrels to decontamination building and transportation to COVRA.			
Norway						
	Halden	Research and Development	Filtration, ion exchange and evaporation, delay and sedimentation in tanks.			
	Kjeller	Research and Development	Large storage tanks, delay for short-lived nuclides, filtration and purification by ion exchange and evaporation.		No emissions to air relevant to marine environment.	
Portugal						
	Campus de Sacavém	Research and Development				
Spain						

Country	Name	Type of Facility	Liquid Effluent Treatment	Effectiveness	Gaseous Discharge Treatment	Particular Developments
	Almaraz	Nuclear Power, PWR	Primary system wastes processed by boric acid recovery and coolant clean up system comprising retention tanks, filters, evaporators. Slurries are transferred to solid waste system. Condensed effluent are subject to demineralisation and filtration before decay tank and discharge.	See separate tables. Filtration 98% for particles; ion exchange 100 for anions, 10 for Cs, Rb, 100-1000 for others; boron recovery 2 for Cs, Rb 10 for other	Decay tanks, filtration (coarse, HEPA and carbon bed). Condensed vapour formed in catalytic recombination drained to liquid treatment stream.	
	Jose Cabrera	Nuclear Power, PWR	High activity liquids treated by ion exchange (5 filter demineralisers) and evaporation. Storage tanks allow choice of discharge volume and time.	Mixed Ion exchange: 1 for noble gases, Cs, Mo and 10 for other nuclides except iodine. Cationic exchanger 10 for Cs, Y, Mo. Evaporator DF 10^6 for liquids except I and B; 10^5	Storage tanks, filtration for particles and iodine (course, HEPA and charcoal beds)	The evaporator was replaced in order to achieve higher DFs; management options including change of ion exchange resins before saturation, use of dry decontamination processes

Country	Name	Type of Facility	Liquid Effluent Treatment	Effectiveness	Gaseous Discharge Treatment	Particular Developments
				for gases; 10^3 I and B.		
	Trillo	Nuclear Power, PWR	Primary circuit treated in chemical and volume control system, where gases are removed. Ion exchange (removal of fission products) and evaporator (recover boric acid). Storage and treatment system. This includes hold-up tanks conditioning for precipitation, control of pH, evaporation and filtration (latter not used), condensate demineralised.		Catalytic recombination to convert hydrogen to water is condensed and removed, delay, charcoal beds and retention for decay of noble gases. Particle filters (coarse and HEPA) and charcoal beds.	Policies to minimize production of wastes and specific actions including reuse of liquids.
	Juzbado	Fuel fabrication	Floor cleaning water treated by centrifugation (to remove suspended particles) filtration and delay (as required).			Substitution of outdoor pipes to reduce likelihood of leakage, cover bottom of outdoor pond (where effluents stored prior to discharge).
Sweden						

Country	Name	Type of Facility	Liquid Effluent Treatment	Effectiveness	Gaseous Discharge Treatment	Particular Developments
	Barsebäk	Nuclear Power, BWR	Ion exchange in reactor cleaning circuit; ion exchange filters for condensate, mechanical and ion exchange filters for separation of particulate and ionogenic contaminants in waste water. Evaporation plant if fuel failure occurs.	Cross-flow filtration DF 1-2; ion exchange 2-10	Recombiners, sand tanks for retention of noble gases in process gases, carbon and HEPA filters.	Modernisation of waste treatment systems in 2001, valves, piping and sampling equipment and computer controls installed.
	Ringhals 1-4	Nuclear Power, PWR & BWR	Segregation according to chemical composition and activity, low-level liquids discharged without further treatment. Particle filtration or ion exchange; evaporation to recycle boron in PWR units.	Particle filtration DF 2-4; ion exchange DF 10-50, cross-flow filtration (unit 2) >100	Recombiners in unit 1. Increased delay and reduction in noble gases.	In 2002, R&D pilot plant for cross-flow filtration in combination with different absorbers and resins in operation in unit 2. Handles operational effluents but cannot handle large volumes in shut-down transient situation. DF >100
Switzerland						
	Beznau	Nuclear Power, PWR	Centrifugation and, if necessary, chemical precipitation.	Chemical precipitation factor up to 100		Improvement of system by nanofiltration planned to be operational in 2007.
	Gösgen	Nuclear Power, PWR	Evaporation. The condensate is sampled and, if required, treated with bitumen	Evaporation concentration reduction 100-10000		

Country	Name	Type of Facility	Liquid Effluent Treatment	Effectiveness	Gaseous Discharge Treatment	Particular Developments
	Leibstadt	Nuclear Power, BWR	Centrifugation and evaporation	Evaporation concentration reduction 1000-10000		
	Mühlberg	Nuclear Power, BWR	Centrifugation and ion exchange	Combined reduction by factor of 100		
	Paul Scherrer Institute	Research and Development	Diffusion through membranes with pressure difference.	Concentration reduction factor of 1000		
United Kingdom						
Operational Magnox	Chapelcross	Nuclear Power, GCR	2 stage filter system		HEPA, charcoal iodine absorbers	Magnox; Pond fuel management - corrosion of magnox cladding minimised by careful pond management; low anion concentrations in ion exchange plant, temperature control, actions to prevent mechanical damage.
	Dungeness A	Nuclear Power, GCR	Ion exchange (including caesium removal unit) and anion removal, sand pressure filtration, ceramic filters	CRU 60-98%; SCRU 90%	Candle filters and iodine bed (emergency use only), HEPA	Dungeness A: Magnox dissolution plant dissolves inactive debris in carbonic acid, leaving active residue, sand bed filtration.
	Oldbury	Nuclear Power, GCR	Ion exchange (IONSIV and caesium removal unit) and sand pressure filtration		Charcoal iodine absorbers (emergency), HEPA filters on	

Country	Name	Type of Facility	Liquid Effluent Treatment	Effectiveness	Gaseous Discharge Treatment	Particular Developments
					contaminated ventilation system	
	Sizewell A	Nuclear Power, GCR	Sand pressure filtration, IONSIV on pond water.		Charcoal iodine absorbers (emergency), ceramic filters on blowdown, glass fibre and HEPA filters on contaminated ventilation	
	Wylfa	Nuclear Power, GCR	FilTore, radial filtration device		Charcoal iodine absorbers (emergency), sintered metal filters on blowdown and HEPA on contaminated ventilation systems.	
Operational AGR	Dungeness B	Nuclear Power, AGR	AGR (operational): Particulate and sand pressure filter and ion exchange resins and mixed bed units (Hinkley Point B), chemical controls to prevent corrosion.			AGR: Pond water management - pond water is within a closed circuit; leaking fuel elements placed in water-tight containers. Treated in active effluent treatment plants.
	Hartlepool	Nuclear Power, AGR				
	Heysham 1	Nuclear Power, AGR				
	Heysham 2	Nuclear Power, AGR				
	Hinkley Point B	Nuclear Power, AGR				
	Hunterstone B	Nuclear Power, AGR				
	Torness	Nuclear Power, AGR				
Operational PWR	Sizewell B	Nuclear Power, PWR				

Country	Name	Type of Facility	Liquid Effluent Treatment	Effectiveness	Gaseous Discharge Treatment	Particular Developments
Transitional Magnox	Bradwell	Nuclear Power, GCR	Sand pressure filter and ion exchange - caesium removal unit (ion exchange) IONSIV		Iodine charcoal beds, candle filters on blow down, roll filter for shield cooling and HEPA for contaminated ventilation system.	
	Hinkley Point A	Nuclear Power, GCR	Ion exchange (IONSIV, CRU) and sand pressure filtration		Charcoal iodine absorbers, sintered candle assemblies with quartz fibre candles on blowdown stack, roll filter on shield cooling air, HEAP on contaminated ventilation system.	
Decommissioning Magnox	Berkeley	Nuclear Power, GCR	Sand pressure filter		HEPA on contaminated ventilation system, gas scrubber on incinerator	
	Hunterston A	Nuclear Power, GCR	Sand pressure filter, ion exchange plant		HEPA	
	Trawsfynydd	Nuclear Power, GCR	Sand pressure filter and ion exchange - caesium removal unit (ion exchange) IONSIV		HEPA	

Country	Name	Type of Facility	Liquid Effluent Treatment	Effectiveness	Gaseous Discharge Treatment	Particular Developments
Other Nuclear Fuel Cycle Facilities	Sellafield	Reprocessing	Vitrification of highly active liquid, diversion of future MAC arisings to vitrification, removal of nuclides in EARP and encapsulation; treatment of low active streams in EARP (pH and floccation and ion exchange, ultrafiltration and encapsulation of residue), SETP (evaporation and decay) and SIXEP (regenerable sand pressure filters, pH and counterflow with CO2; ion exchange columns) ; treatment of organic solvent in STP, incineration of lubricating oil.	EARP: DF > 1000 for alpha and > 10 beta		Review of options for dealing with Tc-99 arising from treatment of Medium Active Concentrate (diversion to vitrification where possible). This will also reduce discharges of Sr-90 and Cs-137. C-14 scrubbers of atmospheric emissions with increase in liquid discharge; removal of iodine by precipitation with iron salts
	Calder Hall	Nuclear Power, GCR	Included in Sellafield discharge			
	Capenhurst	Fuel enrichment	Segregation, ion exchange and decay storage			
	Springfields	Fuel fabrication	Recirculation to remove uranium			Ban on processing uranium ore concentrates containing above average levels of thorium.
Research and Development	Dounreay	Research and Development (decommissioning)	Filtration, ion-exchange where Cs-137 loading warrants(e.g. from sodium coolant destruction process, which commenced during the reporting period);			Construction of Low Level Liquid Effluent Treatment Plant - for monitoring prior to discharge.

Country	Name	Type of Facility	Liquid Effluent Treatment	Effectiveness	Gaseous Discharge Treatment	Particular Developments
			evaporation of small effluents from small-scale operations.			
	Harwell	Research and Development	Low active liquors held in delay tanks; treatment involves flocculation (precipitation of alpha and beta activity) followed by dynasand filters for removal of particulates. The filtrate is sampled for suitability for discharge. Slurries are removed to a settling tank prior to cementation.	Alpha removal DF 10-20; Beta removal 3-5		
	Windscale	Research and Development	Filtration			
	Winfrith	Research and Development	No treatment except pH adjustment			

New Court
48 Carey Street
London WC2A 2JQ
United Kingdom

t: +44 (0)20 7430 5200
f: +44 (0)20 7430 5225
e: secretariat@ospar.org
www.ospar.org

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