Radioactive Substances Series

Implementation Report of PARCOM Recommendation 91/4 by Germany

OSPAR Commission
2006

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.

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.

ISBN 1-905859-37-6
ISBN 978-1-905859-37-5

Publication Number: 299/2006

contents

1. Introduction

At its 2004 meeting in La Rochelle, France, the OSPAR Radioactive Substances Committee established, on a trial basis, revised "Guidelines for the submission of information on the assessment of the application of Best Available Technology (BAT) in nuclear facilities" (RSC 04/6/1). In this report the requested information for German nuclear installations is given. The report covers the six-year period 1999-2004 inclusive.
In the second chapter, general information on implementation of BAT/BET in national legislation, dose limits/constraints, monitoring programmes, discharge limits, reporting and the methodology for the assessment of the radiation dose is provided. The subsequent annexes 1, 2 and 3 give type of facility, location, production, discharges, emissions, dose to public, normalised data and waste management of nuclear power stations, nuclear fuel facilities and research facilities, respectively. For each installation, the emissions and discharges (note that emission is used for gaseous releases and discharge for liquid releases, in accordance with the normal usage within the OSPAR Convention) are given in absolute values and normalised according to actual output as compared to the UNSCEAR ranges and individual doses as compared to the national dose limit.

2. General information

2.1 Implementation of BAT/BET in German legislation and regulation

This section considers the legislation and regulations that are new or changed since the latest implementation round.

Authorisations of nuclear installations are issued on the basis of the Nuclear Energy Act (Atomgesetz) and the Radiation Protection Ordinance (Strahlenschutzverordnung). This legislation provides the framework for standards, guidelines and objectives in the field of production of nuclear energy and application of nuclear techniques. According to application of BAT/BEP in nuclear facilities, the fundamentals of the legislation are:

- 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.

For nuclear installations in Germany, 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)". The safety standard series KTA 3601-3606 contains requirements for technical standards in "Activity Control and Activity Management". Within the context of discharges into water, the safety standard KTA 3603 provides technical requirements and detailed information on techniques for "Facilities for the Treatment of Radioactively Contaminated Water in Nuclear Power Plants". The corresponding regulation for emissions into the atmosphere is KTA 3605: "Treatment of Radioactively Contaminated Gases in Nuclear Power Stations with Light Water Reactors". In addition to the requirements for the design of the systems, these safety standards also contain requirements concerning absolute reliability in terms of safety, regular testing and maintenance of the installed systems.

Furthermore, the guidelines KTA 1503 and 1504 give instructions on discharge monitoring, which specify type of sampling, sample treatment, time periods of sampling, radionuclides considered, detection limits, reporting, etc.

Additional regulations are issued by the "Deutsches Institut für Normung (DIN)" containing further requirements affecting the treatment of radioactive effluents, such as retention factors for filter systems. DIN 24 184, for example, requires the use of aerosol filters with a minimum retention factor of 99,97 % (Class S).

The safety standards issued by the KTA and the DIN are reviewed on a regular basis every five years.

2.2 Other basis for national legislation/regulation

The German policy in this field is based on international conventions, on Euratom Directives and on recommendations of appropriate international bodies like the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA).

2.3 Dose constraints/limits for nuclear installations

The dose limit applied within Germany for members of the general public is 1 mSv per year. This limit is cumulative for all artificial sources an individual is exposed to. The level is set in accordance with both the recommendations of the ICRP and the EU Basic Safety Standards Directive (96/26 Euratom).

Dose limits resulting from radioactive discharges and emissions of nuclear installations are specified in the Radiation Protection Ordinance for aerial and liquid releases each:

a.	individual effective dose, partial body dose for gonads, uterus and red bone marrow	0,3 mSv/y
b.	partial body dose of all organs and issues unless under 1. or 3.	0,9 mSv/y
c.	partial body dose of bone surface and skin	1,8 mSv/y

Emissions and discharges from other nuclear installations must be taken into account.

2.4 Discharge limits

The annual limits for discharges and emissions are specified for a nuclear facility in such a way that the resulting doses to the reference person shall not exceed 0,3 mSv per year on either pathway (see 2.3). This applies to normal operation as well as to decommissioning of nuclear facilities. The nuclear facilities are licensed to discharge a limited amount of tritium and of beta-gamma emitters excluding tritium. The resulting doses for these radionuclides are calculated and totalled, and this total should not exceed 0,3 mSv. For more than one installation at the same site, the total discharges shall not exceed the mentioned dose limit.

The models used to estimate the radiation exposure for a reference person caused by radioactive effluents of nuclear power plants are described in the General Administration Provision to § 47 of Radiological Protection Ordinance (Allgemeine Verwaltungsvorschrift zu § 47 Strahlenschutzverordnung). The dose is calculated at the most unfavourable receiving points, taking into account the relevant exposure pathways and living habits, e.g. the consumption rates of different foodstuffs. On the basis of these assumptions and parameters used in the models, the radiation exposure to individuals can not be underestimated.

2.5 Monitoring programmes of discharges and environmental concentrations of radionuclides

If radioactive material is discharged to air, water or soil it must be ensured that:

- an uncontrolled release is avoided,
- the discharged radioactivity is as low as practicable, and
- the discharge is monitored and is reported to the competent authority at least once a year, specifying its nature and activity.

The basic requirement for emission monitoring is converted into measurement programmes. These are specified in the regulatory guideline on emission and environmental monitoring (Richtlinie zur Emissions- und Immissionsüberwachung kerntechnischer Anlagen, REI). In the general part of the guideline the objectives and the basics of emission and environmental monitoring are stated and the requirements applicable to all nuclear installations are explained. In the appendices the different measurement programmes are listed according to the type of nuclear installation.

Appendix A of the regulatory guideline REI pertains to nuclear power plants and refers to the corresponding KTA safety standards with respect to the monitoring of emissions. Safety standard KTA 1503.1 deals with monitoring the discharge of radioactive materials through the vent stack of nuclear power plants in the case of operating conditions and KTA 1503.2 in the case of design basis accidents. The corresponding requirements for measurements regarding the monitoring of discharges with water are specified in KTA 1504.

The emission surveillance programme specified in the regulatory guideline REI is carried out by the operator of the nuclear facility under his own responsibility. These measurement results are then submitted to the supervisory authority (see also §§ 2.6 and 2.7). The environmental programme is undertaken by the operators and by governmental laboratories. A continuous surveillance of actual plant parameters is performed with the remote monitoring system for nuclear power plants (KFÜ) [3-54]. A selection of measured variables from

- operation;
- monitoring of emissions;

- monitoring of environmental concentrations of radionuclides; and
- meteorology

are transmitted online to the competent supervisory authority of the German states (Länder). This system is in operation at all times during operating conditions and design basis or severe accidents as far as the corresponding instruments are suited for, and still available under these conditions.

In addition to the site-oriented surveillance of nuclear power plants described above, a nation-wide system, the so-called Integrated Measurement and Information System for the Surveillance of Environmental Radiation (IMIS), was installed in accordance with the Precautionary Radiation Protection Act. IMIS is intended to provide data on the radiation level in the entire region of the Federal Republic of Germany. Parts of this system have been in operation since the late fifties. Even slight changes in environmental radiation are quickly and reliably detected and evaluated by this system, making it possible to give early warnings to the public if so required. IMIS is permanently in routine operation. In the event of increased values the Federal Ministry for the Environment will cause IMIS to switch from routine to intense operation which means measurements and samples will be taken more frequently.

2.6 National authority responsible for supervision of discharges

All licensing and supervision activities concerning construction and operation of nuclear facilities is carried out by the regulatory authority of the federal state (*Land*), in which the facility is located. This is also the case for authorisation of radioactive discharges to the environment. These authorities of the federal states are controlled by the Ministry for the Environment of the Federal Republic of Germany to ensure harmonized criteria of authorisation and supervision in the country.

2.7 Nature of inspection and quality assurance of surveillance programme

The nuclear installations are inspected several times per year by the licensing authorities. To verify that the facilities comply with the emission surveillance programme, independent experts of the authority take random double samples for measurements at special laboratories. The environmental programme is undertaken by the operators and by governmental laboratories. Operators laboratories undertake analyses in accordance with procedures set down in Implementation Documents published by the Federal Ministry for the Environment. Quality control procedures also involve regular calibration of detectors and yearly comparison exercises with other laboratories. All laboratories have secondary standards traceable to primary standards. Therefore, the quality of environmental and discharge sample measurement, and the assessment of impact of discharges and emissions on members of the general public is based not only on the work of the operators but also on a national system of regulators, governmental bodies and independent advisors.

2.8 Radiation doses to the general public - methodology

The Federal Office for Radiation Protection (BfS) calculates yearly the radiation dose for the general public from all nuclear facilities of Germany. These calculations are based on discharge data measured by the operators and the general administrative provision pertaining to section 47 of the Radiation Protection Ordinance on "Calculation of the Radiation Exposure by Radioactive Discharges during Normal Operation of Nuclear Power Plants". This regulation defines, *inter alia*:

- Transfer factors soil/plants, plants/beef, water/fish, water/riverbank sediment, water/milk and water/beef;
- Procedures for calculation of activity concentrations of radionuclides in air, drinking water, fish, meat, plants, milk, river water and river bank;
- Consumption rates for adults and children for drinking water, milk, fish, meat, vegetables, fruit, cereals and potatoes;
- Dose factors for internal and external exposure for organs and effective dose; and
- Exposure pathways for adults and children (1 year) for the calculation of internal and external radiation exposure.

Dose calculations for intakes of radionuclides are based on methodology dose coefficients in the relevant ICRP publications.

2.9 National reporting

The results of discharge measurements performed by operators are reported to the supervisory authority and are available generally through operators annual reports. The discharge records from the nuclear power plants are summarised in Table 1.

Table 1. Reporting of discharges to the national authorities based on analyses of waste water samples from the discharge tanks of nuclear power stations

Radionuclides	Sampling time	Reporting
γ-radionuclides	Week	monthly
H-3	3 month	quarterly
Sr-89/90	3 month	quarterly
Total-α-activity	3 month	quarterly
Fe-55	Year	annually
Ni-63	Year	annually

The annual discharges from nuclear installations of Germany are published by the Ministry of Environment in the report "Environmental Radioactivity and Radiation Exposure" (Umweltradioaktivität und Strahlenbelastung).

2.10 International reporting

Germany submits annually to EURATOM and OSPAR a report on liquid discharges from nuclear installations based on Article 35 of the EURATOM Treaty and of OSPAR Convention, respectively.

3. Nuclear Power Plants (NPP)

Nuclear power currently accounts for about 30% of Gemany‘s electric energy consumption. The nuclear power stations are located at 18 river sites, 16 of which are in the OSPAR catchment. There are 13 operational power reactors, 10 of which are pressurized water reactor stations, there 3 are boiling water reactors. There are a further 7 reactor stations that have been shut down and are now in various stages of decommissioning.

The discharge data are given both for operational and shutdown reactor sites. The activity concentrations of radionuclides in non human biota of river water are so low that it is not possible to detect them.

The information to be submitted in accordance with the BAT Guidelines is given in Annex 1 referring to nuclear power plants. Only those installations that were in operation for most of the reporting cycle between 1999 and 2004 and were not shut down due to final decommissioning, are listed in the Annex.

For each installation, the information as defined in BAT Guidelines is given in tabular form:

- Name of facility
- Type of facility
- Date commissioned
- Location
- Installed electrical generation capacity
- Electricity generation
- Shut-down year
- Annual emissions and discharges, absolute and normalised according to actual output as compared to the UNSCEAR ranges
- Individual dose as compared to the national dose limits
- Waste treatment

The determination of individual dose covers all radionucildes discharged to the environment.

3.1 Sources of liquid effluent

The main sources of radioactive liquid effluent are reactor operations and small leaks from the reactor itself, associated plant and the laundry. The principal radionuclides arising in liquid waste are tritium and, to a much lesser degree, activation and fission products. See Annex 1.

3.2 Liquid effluent treatment

See Annex 1.

3.3 Nuclide libraries

The radionuclides which to be monitored are stipulated by Kerntechnischer Ausschuss (KTA). The detection of radionuclides (specific alpha, beta and gamma emitters) in air and water is described in the documents KTA 1503 and KTA 1504, respectively.

3.4 Environmental Impact

The environmental programme in the vicinity of nuclear power stations is described in the regulatory guideline on emission and environmental control (REI). The analyses of environmental samples (river water, plants, milk, meat, fish, soil) show that there are no detectable α- and β-activity concentrations (excluding tritium) referring to radioactive discharges from NPP. Tritium discharges from pressurised water reactors can increase the tritium concentrations in surface water of small rivers by 10 Bq/l (e.g. river Ems).

3.5 Trends in discharge over the 1999-2004 period and summary evaluation

Most stations have been operating steadily throughout this period, so liquid discharges have been fairly constant. For tritium, the range for normalised discharges from the stations is 0,32-22 TBq/GWa (average value 10 TBq/GWa) with no discernible trend; for beta/gamma emitters excluding tritium, the range is 0 - 0,6 GBq/GWa (mean value 0,14 GBq/GWa) with decreasing tendency.

Comparison of normalised liquid discharges from each nuclear power plant with the UNSCEAR ranges shows that:

	UNSCEAR ranges of normalised discharges	
	BWR	PWR
Tritium, TBq/GWa	2,5 - 25	7,9 - 80
Non-Tritium, GBq/GWa	11 - 115	14 - 140

- Tritium discharges from boiling water reactors are **below** the levels of the ranges.
- Tritium discharges from pressurised water reactors are **below** the level of the ranges or **at the lower end** of the ranges.
- Non-tritium discharges into water are always **far below** the level of the ranges for all reactors.

Most important, and applicable to all nuclear installations, is the dose criterion. Calculations made under conservative assumptions show that the maximum effective doses to the population in the vicinity of all nuclear installations are well below the national limits.

The low levels of radioactivity discharges and emissions from all nuclear power stations and low levels of radiation exposure in general show that the best available technology is being applied in Germany.

4. Nuclear fuel fabrication and enrichment plants

Uranium enrichment is carried out at URENCO's Gronau site. For the enrichment the technology of gas centrifuges is used. The total-α-activity yearly discharged by waste water is very low (approximately 10 000 Bq/y and less). The impact on the environment can not be detected. The highest dose for the reference person in the vicinity of the enrichment plant is less than 0,1 □Sv/y.

The Advanced Nuclear Fuels GmbH operates the facility in Lingen, which fabricates nuclear fuel for light water reactors by converting uranium hexafluoride (UF_6) to uranium dioxide (UO_2) using the dry conversion process, pressing and sintering the UO_2 powder into pellets, sealing the pellets in fuel rods, and assembling the rods into fuel elements. There is no radioactive waste water by the production process. Radioactive discharges into environment can not be detected.

The nuclear fuel fabrications plants in Hanau have been shut down in 1995. In last years buildings and production areas were decontaminated. Individual facilities and parts of the site were already released from nuclear regulatory control. Termination of all the decommissioning activities is scheduled for 2005/2006. The total-α-discharges continuously decreased from 0,0003 TBq in 1995 to 0,000008 in 2004. The highest dose for the reference person in the vicinity of the nuclear fuel plant is less than 0,1 □Sv/y.

For each installation, the information as defined in BAT Guidelines is given in tabular form:

- Name of facility
- Type of facility
- Capacity, U processed
- Date commissioned
- Location
- Receiving water
- Annual emissions and discharges, absolute and normalised
- Individual dose as compared to the national dose limits
- Waste treatment

4.1 Sources of liquid effluent

See Annex 2.

4.2 Liquid effluent treatment

See Annex 2.

4.3 Environmental impact

The environmental programme in the vicinity of plants is described in the regulatory guideline REI. The analyses of environmental samples (river water, plants, milk, meat, fish, soil) show that there are no detectable α- and β-activity concentrations referring to radioactive discharges from nuclear fuel plants.

4.4 Trends in discharge over the 1999-2004 period and summary evaluation

Downward trend is noted for α-discharges in liquid effluent from Hanau. The α-discharge level of Gronau is very low and constant throughout this period (approx. 1E04 Bq/a). Total-α-activity in liquid effluent from Lingen is below detection limits.

5. Research and Development Facilities

There are five sites of research and development facilities in Germany described as former nuclear research centres. The facilities at these sites carry out scientific and commercial programmes in nuclear field. In Berlin, Geesthacht and Jülich are installed reactors with thermal capacity of 10 MW, 5 MW and 23 MW respectively. The reactors in Karlsruhe and Rossendorf have been shut down and are currently undergoing decommissioning. All 5 centres are located at an inland site.

The highest dose (22 µSv/y) was calculated for a reference person in the vicinity of Rossendorf. This theoretical value is caused by radioactive discharges into a very small rivulet. The water flow is there only 0,02 m^3 per second. The calculated dose in the vicinity of all other research centres is less than 1 µSv/y. Activity concentrations in non human biota caused by radioactive discharges from the facilities were not detectable.

For each installation, the information as defined in BAT Guidelines is given in tabular form:

- Name of facility
- Type of facility
- Reactor capacity
- Date commissioned/ decommssioned
- Location

- Receiving water
- Annual emissions and discharges, absolute and normalised
- Individual dose as compared to the national dose limits
- Waste treatment

5.1 Sources of liquid effluent

See Annex 3.

5.2 Liquid effluent treatment

See Annex 3.

5.3 Environmental impact

The environmental programme in the vicinity of plants is described in the regulatory guideline REI. The analyses of environmental samples (river water, plants, milk, meat, fish, soil) from the region of Geesthacht, Jülich, HMI and Rossendorf show that there are no detectable α- and β-activity concentrations referring to radioactive discharges from these facilities. Tritium discharges from Karlsruhe are responsible for tritium concentrations of up to 600 Bq/l in surface water of a small lake near the river Rhine.

5.4 Trends in discharge over the 1999-2004 period and summary evaluation

The sum of total beta activity and tritium discharged over the period 1999 to 2004 from all research and development facilities in Germany show a decreasing tendency from 0,001 TBq in 1999 to 0,0002 TBq in 2004. This temporal trend is mainly caused by the Research Centre in Karlsruhe and in Geesthacht. The data of Annex 3 show that the sum of total alpha activity discharged has a very low level over the period 1999 to 2004. There is no increasing or decreasing trend. The fluctuations were caused by discharge variations from former Nuclear Research Centre in Rossendorf.

Annex 1: Nuclear Power Plants

1. Site Characteristics

Name of facility	Biblis A					
Type of facility	PWR					
Date commissioned	1974					
Location	Germany					
Receiving water	Rhine					
	1999	2000	2001	2002	2003	2004
Installed electrical generation capacity, MW(e)	1204					

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
Cr-51						
Mn-54	6,4E+04	2,1E+05	7,5E+04	5,7E+04		
Co-57						
Co-58	1,1E+06	1,7E+06	1,2E+06	4,2E+06	5,5E+05	3,7E+05
Co-60	2,3E+07	5,8E+07	3,7E+07	9,3E+07	4,8E+07	2,2E+07
Fe-55		9,5E+06	5,5E+06	9,2E+06	6,1E+06	
Fe-59						
Ni-63						
Zn-65		1,1E+05				
Sr-89						
Sr-90						
Zr-95				5,8E+05		
Nb-95	2,9E+05					
Ru-103						
Ru-106			1,2E+06			
Ag-110m	3,2E+05	4,4E+05	3,0E+05	1,0E+07		3,7E+05
Te-123m	5,4E+07	4,7E+07		8,0E+07	2,5E+07	1,0E+07
Sb-124	2,2E+07	2,0E+07	1,6E+07	6,4E+07	2,4E+07	8,9E+06
Sb-125	3,7E+05	1,7E+06	3,4E+06	2,7E+07	1,2E+07	5,9E+06
I-131	2,5E+05	1,3E+06	2,4E+07		1,7E+05	4,2E+05
Cs-134	8,0E+05	1,7E+06	1,5E+05	3,8E+05	9,8E+05	
Cs-137	2,9E+06	5,9E+06	1,2E+06	1,1E+07	1,4E+07	2,7E+06
Ba-140			5,7E+06			
La-140				1,2E+06		
Ce-141		2,4E+05				
Ce-144						
Other nuclides	6,3E+06	1,7E+07			2,4E+06	
Total activity excluding H-3	1,1E+08	1,6E+08	9,6E+07	3,0E+08	1,3E+08	5,1E+07

	1999	2000	2001	2002	2003	2004
Total activity excluding H-3	1,1E+08	1,6E+08	9,6E+07	3,0E+08	1,3E+08	5,1E+07
Authorised annual limit, Bq/a	1,1E+11					
% of annual limit	0,101	0,150	0,087	0,273	0,121	0,046
Normalised to capacity, GBq/GWa	0,092	0,137	0,080	0,250	0,111	0,042
H-3	1,6E+13	1,6E+13	7,7E+12	1,7E+13	1,5E+13	1,7E+13
Authorised annual limit, Bq/a	3,0E+13					
% of annual limit	53	52	26	57	51	58
Normalised to capacity, TBq/GWa	13,0	12,9	6,4	14,1	12,5	14,3
Total Alpha-activity						

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
H-3	2,4E+11	5,1E+11	1,5E+11	4,8E+11	4,8E+11	1,1E+11
Normalised to capacity, GBq/GWa	2,0E+02	4,2E+02	1,2E+02	4,0E+02	4,0E+02	9,1E+01
C-14	3,0E+11	3,7E+11	7,4E+10	3,1E+11	3,2E+11	1,3E+11
Normalised to capacity, GBq/Gwa	2,5E+02	3,1E+02	6,1E+01	2,6E+02	2,7E+02	1,1E+02

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway						
Annual effective dose (mSv)	0,00010	0,00010	0,00010	0,00020	0,00015	0,00019
% of dose limit	0,03	0,03	0,03	0,07	0,05	0,06
Air-pathway						
Annual effective dose (mSv) (1)	0,0005	0,0010	0,0003	0,0004	0,0010	0,0015
% of dose limit	0,02	0,03	0,01	0,01	0,03	0,05

(1) including Biblis B

1. Site Characteristics

Name of facility	Biblis B					
Type of facility	PWR					
Date commissioned	1976					
Location	Germany					
Receiving water	Rhine					
	1999	2000	2001	2002	2003	2004
Installed electrical generation capacity, MW(e)	1300					

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
Cr-51		7,4E+05	8,8E+04			
Mn-54		1,1E+05		4,8E+04	6,2E+05	
Co-57			2,2E+06			
Co-58	9,2E+05	9,9E+05	1,4E+08	1,6E+06	6,4E+06	5,4E+06
Co-60	2,7E+07	1,5E+07		9,7E+07	7,8E+07	1,7E+07
Fe-55			1,6E+05		6,8E+06	
Fe-59						
Ni-63				1,1E+07	5,7E+06	
Zn-65				2,6E+05		
Sr-89						
Sr-90				5,4E+05		
Zr-95						
Nb-95	2,2E+06	7,2E+04		1,6E+05		
Ru-103						
Ru-106			7,5E+05		3,4E+06	
Ag-110m		4,8E+05	1,8E+07	4,7E+06	7,4E+05	2,2E+06
Te-123m	8,5E+06	1,4E+07	2,4E+07	1,9E+07	3,7E+07	1,0E+07
Sb-124	2,1E+08	1,5E+07	7,7E+06	1,9E+07	5,6E+07	2,2E+07
Sb-125	1,8E+07	2,9E+06	3,6E+07	2,1E+07	7,4E+07	1,2E+07
I-131	8,9E+05	4,0E+07	3,3E+06	2,8E+05	4,9E+06	2,8E+06
Cs-134	4,7E+06	1,3E+05	1,2E+07	1,2E+07	8,9E+06	
Cs-137	2,3E+07	2,3E+06		3,6E+07	7,2E+07	2,3E+06
Ba-140			1,1E+06			
La-140						
Ce-141		1,5E+05				
Ce-144						
Other nuclides	3,7E+06	1,1E+08	1,5E+07	1,3E+06		1,0E+07
Total activity excluding H-3	3,0E+08	2,0E+08	2,6E+08	2,2E+08	3,5E+08	8,5E+07

	1999	2000	2001	2002	2003	2004
Total activity excluding H-3	3,0E+08	2,0E+08	2,6E+08	2,2E+08	3,5E+08	8,5E+07
Authorised annual limit, Bq/a	1,1E+11					
% of annual limit	0,274	0,179	0,237	0,204	0,322	0,077
Normalised to capacity, GBq/GWa	0,232	0,152	0,200	0,172	0,273	0,065
H-3	1,6E+13	1,5E+13	1,1E+13	1,5E+13	1,4E+13	1,1E+13
Authorised annual limit, Bq/a	3,0E+13					
% of annual limit	54	50	37	51	47	36
Normalised to capacity, TBq/GWa	12,3	11,3	8,5	11,5	10,8	8,2
Total Alpha-activity						

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
H-3	1,8E+11	2,7E+11	2,1E+11	1,9E+11	1,8E+11	1,9E+11
Normalised to capacity, GBq/GWa	1,4E+02	2,1E+02	1,6E+02	1,5E+02	1,4E+02	1,5E+02

C-14	1,0E+11	4,0E+11	1,6E+11	2,0E+11	4,1E+11	3,0E+11
Normalised to capacity, GBq/GWa	7,7E+01	3,1E+02	1,2E+02	1,5E+02	3,2E+02	2,3E+02

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway Annual effective dose (mSv)	0,00010	0,00010	0,00010	0,00020	0,00015	0,00013
% of dose limit	0,03	0,03	0,03	0,07	0,05	0,04
Air-pathway Annual effective dose (mSv) (1)	0,0005	0,0010	0,0003	0,0004	0,0010	0,0015
% of dose limit	0,02	0,03	0,01	0,01	0,03	0,05

(1) including Biblis A

4. Origin of waste arising: primary coolant cycle

5. Waste treatment: filtration, ion-exchange procedures

6. Waste management:

a) Procedures used to minimise the production of waste:
- Quality and design of fuel elements.
- Permanent monitoring of primary coolant.
- Operation mode and coolant chemistry to avoid damage of fuel elements.
- Reduction of the mobilisation of corrosion and activation products by means of coolant chemistry.

b) Improvements in waste treatment:
- Filtration and evaporation of waste waters.

Further information:

Longer terms of stand still in 1995/1996 (Biblis A, due to licensing procedure).

a)
- Tritium emissions are below the range indicated.
- Tritium discharges are within the range indicated.

- Non-Tritium discharges are below the range indicated.

b) No significant trends identifiable.

c) No particularly high or low values.

d) No additional measures planned.

1. Site Characteristics

Name of facility	Brokdorf
Type of facility	PWR
Date commissioned	1986
Location	Germany
Receiving water	Elbe

	1999	2000	2001	2002	2003	2004
Installed electrical generation capacity, MW(E)	1392					

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
Cr-51						
Mn-54						
Co-57						
Co-58						
Co-60	7,7E+05	2,1E+06	6,5E+05		1,3E+05	1,4E+05
Fe-55			4,8E+06			
Fe-59						
Ni-63						
Zn-65						
Sr-89						
Sr-90						
Zr-95						
Nb-95						
Ru-103						
Ru-106						
Ag-110m						
Te-123m	1,2E+05			2,4E+04		
Sb-124						
Sb-125		4,4E+04	1,1E+05			
I-131				1,3E+06	3,8E+04	
Cs-134	2,9E+06	6,7E+05	1,4E+06	9,3E+04	8,2E+04	
Cs-137	3,1E+06	1,2E+06	6,8E+06	1,3E+06	9,3E+05	6,3E+04
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides	6,8E+04			2,1E+06		
Total activity excluding H-3	6,9E+06	4,0E+06	1,4E+07	4,8E+06	1,2E+06	2,0E+05

	1999	2000	2001	2002	2003	2004
Total activity excluding H-3	6,9E+06	4,0E+06	1,4E+07	4,8E+06	1,2E+06	2,0E+05
Authorised annual limit, Bq/a	5,5E+10					
% of annual limit	0,013	0,007	0,025	0,009	0,002	0,000
Normalised to capacity, GBq/GWa	0,005	0,003	0,010	0,003	0,001	0,000
H-3	1,8E+13	2,1E+13	2,0E+13	1,8E+13	1,8E+13	1,6E+13
Authorised annual limit, Bq/a	3,5E+13					
% of annual limit	50	59	57	51	51	44
Normalised to capacity, TBq/GWaa	12,6	14,9	14,4	12,9	12,9	11,1
Total Alpha-activity						

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
H-3	3,2E+11	3,8E+11	3,6E+11	2,5E+11	3,9E+11	2,9E+11
Normalised to capacity, GBq/GWa	2,3E+02	2,7E+02	2,6E+02	1,8E+02	2,8E+02	2,1E+02
C-14	3,0E+11	3,7E+11	2,8E+11	3,3E+11	3,7E+11	2,9E+11
Normalised to capacity, GBq/GWa	2,2E+02	2,7E+02	2,0E+02	2,4E+02	2,7E+02	2,1E+02

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway						
Annual effective dose (mSv)	< 0,0001	< 0,0001	< 0,0001	0,00010	0,00010	< 0,0001
% of dose limit	< 0,03	< 0,03	< 0,03	0,03	0,03	< 0,03
Air-pathway						
Annual effective dose (mSv)	0,0003	0,0006	0,0006	0,0006	0,0010	0,0005
% of dose limit	0,01	0,02	0,02	0,02	0,03	0,02

4. Origin of waste arising: primary coolant cycle and attached systems

5. Waste treatment: filtration, ion-exchange procedures,evaporation, combustion, collection

6. Waste management:

a) Procedures used to minimise the production of waste:

- Quality and design of fuel elements.
- Operation mode to avoid damage of fuel elements.
- Special operation mode in the case of damaged fuel elements.

b) Improvements in waste treatment:

- Permanent monitoring of operations.
- Due to adherence to the minimisation obligation, emissions and discharges are kept as low as possible.

Further information:

a) Emissions and discharges are at the lower end or below the ranges indicated.

b) No significant trends identifiable.

c) No particularly high or low values.

d) Current operations do not require additional measures to reduce discharges.

1. Site Characteristics

Name of facility	Brunsbüttel					
Type of facility	BWR					
Date commissioned	1976					
Location	Germany					
Receiving water	Elbe					
	1999	2000	2001	2002	2003	2004
Installed electrical generation capacity, MW (e)	806					

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
Cr-51	9,1E+06	5,7E+06	1,2E+07		1,3E+05	4,3E+05
Mn-54	3,4E+07	1,8E+07	2,3E+07	2,7E+07	7,3E+06	1,2E+07
Co-57						
Co-58	1,2E+07	8,1E+06	1,0E+07	1,2E+06	3,0E+05	1,8E+06
Co-60	1,6E+08	7,8E+07	7,9E+07	7,7E+07	4,1E+07	4,2E+07
Fe-55	2,8E+07	3,4E+07	1,1E+08	1,9E+08	7,0E+07	1,1E+08
Fe-59	3,3E+06	3,6E+05	1,6E+06			3,8E+05
Ni-63	5,6E+06	5,7E+06	5,2E+06	6,6E+06	1,0E+07	1,0E+07
Zn-65	9,4E+07	2,7E+07	1,5E+07	9,5E+06	3,6E+06	1,9E+07
Sr-89	3,4E+05	2,6E+05	1,4E+05	7,1E+04	1,2E+04	5,4E+04
Sr-90	9,5E+05	3,7E+05	2,9E+05	2,0E+05	1,3E+05	1,2E+05
Zr-95			7,3E+04			
Nb-95	1,7E+05	3,8E+04	2,3E+05	8,8E+03		
Ru-103						
Ru-106	2,9E+05			5,8E+05		
Ag-110m	7,2E+04	1,3E+05		9,2E+04		
Te-123m						
Sb-124	5,4E+05	1,3E+04	1,6E+05			4,7E+04
Sb-125	1,2E+06		1,3E+04	2,5E+04	2,3E+05	
I-131	3,4E+05			2,4E+06		2,8E+04
Cs-134	7,9E+05	5,7E+04	2,3E+04		4,8E+04	3,0E+04
Cs-137	3,5E+07	3,0E+07	2,5E+07	2,7E+07	1,3E+07	1,2E+07
Ba-140						
La-140						
Ce-141						3,6E+04
Ce-144						
Other nuclides						
Total activity excluding H-3	3,9E+08	2,1E+08	2,8E+08	3,4E+08	1,5E+08	2,1E+08

	1999	2000	2001	2002	2003	2004
Total activity excluding H-3	3,9E+08	2,1E+08	2,8E+08	3,4E+08	1,5E+08	2,1E+08
Authorised annual limit, Bq/a	1,9E+11					
% of annual limit	0,210	0,112	0,152	0,185	0,079	0,114
Normalised to capacity, GBq/GWa	0,482	0,256	0,350	0,424	0,181	0,263
H-3	2,6E+11	3,5E+11	3,1E+11	1,3E+11	2,1E+11	4,4E+11
Authorised annual limit, Bq/a	3,7E+13					
% of annual limit	1	1	1	0	1	1
Normalised to capacity, TBq/GWa	0,3	0,4	0,4	0,2	0,3	0,5
Total Alpha-activity						

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
H-3	7,5E+10	8,1E+10	8,3E+10	4,4E+10	3,5E+10	5,7E+10
Normalised to capacity, GBq/GWa	9,3E+01	1,0E+02	1,0E+02	5,5E+01	4,3E+01	7,1E+01
C-14	2,7E+11	2,6E+11	3,2E+10	1,7E+11	2,3E+11	2,6E+11
Normalised to capacity, GBq/GWa	3,3E+02	3,2E+02	4,0E+01	2,1E+02	2,9E+02	3,2E+02

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway						
Annual effective dose (mSv)	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001
% of dose limit	< 0,03	< 0,03	< 0,03	< 0,03	< 0,03	< 0,03
Air-pathway						
Annual effective dose (mSv)	0,0020	0,0020	0,0020	0,0010	0,0020	0,0020
% of dose limit	< 0,03	0,07	0,07	0,03	0,07	0,07

4. Origin of waste arising: reactor core with water and steam cycles

5. Waste treatment:

a) Waste water:
- ion-exchange procedures and evaporation for waste water

b) exhaust air:
- filtration and hold-up loop for exhaust air

6. Waste management:

1. Procedures used to minimise the production of waste:
   - Quality and design of fuel elements.
   - Operation mode to avoid damage of fuel elements.

2. Improvements in waste treatment:
   - Permanent monitoring of operations.
   - Due to adherence to the minimisation obligation, emissions and discharges are kept as low as possible.

Further information:

a) Emissions and discharges are below the ranges indicated.

b) No significant trends identifiable.

c) No particularly high or low values.

d) Current operations do not require additional measures to reduce discharges.

1. Site Characteristics

Name of facility	Emsland					
Type of facility	PWR					
Date commissioned	1988					
Location	Germany					
Receiving water	Ems					
	1999	2000	2001	2002	2003	2004
Installed electrical generation capacity, MW(e)	1363					

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
Cr-51						
Mn-54			1,5E+04			
Co-57						
Co-58		3,0E+04	6,5E+04			
Co-60			2,6E+04	8,1E+03		
Fe-55						
Fe-59						
Ni-63						
Zn-65						
Sr-89						
Sr-90						
Zr-95			2,0E+04			
Nb-95						
Ru-103						
Ru-106						
Ag-110m						
Te-123m		4,4E+04	1,4E+04	9,4E+03		6,0E+03
Sb-124						
Sb-125		3,2E+04				
I-131						
Cs-134						
Cs-137						
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides						
Total activity excluding H-3	0,0E+00	1,1E+05	1,4E+05	1,8E+04	0,0E+00	6,0E+03

	1999	2000	2001	2002	2003	2004
Total activity excluding H-3	0,0E+00	1,1E+05	1,4E+05	1,8E+04	0,0E+00	6,0E+03
Authorised annual limit, Bq/a	3,7E+10					
% of annual limit	0,000	0,000	0,000	0,000	0,000	0,000
Normalised to capacity, GBq/GWa	0,000	0,000	0,000	0,000	0,000	0,000
H-3	1,7E+13	1,3E+13	1,8E+13	1,5E+13	1,3E+13	1,8E+13
Authorised annual limit, Bq/a	3,5E+13					
% of annual limit	49	37	51	43	37	51
Normalised to capacity, TBq/GWa	12,5	9,5	13,2	11,0	9,5	13,2
Total Alpha-activity						

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
H-3	2,5E+12	1,6E+12	1,5E+12	1,4E+12	1,6E+12	1,3E+12
Normalised to capacity, GBq/GWa	1,8E+03	1,2E+03	1,1E+03	1,0E+03	1,2E+03	9,5E+02

C-14	7,0E+11	3,2E+11	3,6E+11	4,0E+11	4,8E+11	2,6E+11
Normalised to capacity, GBq/GWa	5,1E+02	2,3E+02	2,6E+02	2,9E+02	3,5E+02	1,9E+02

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway						
Annual effective dose (mSv)	0,00050	0,00040	0,00160	0,00080	0,00120	0,00160
% of dose limit	0,17	0,13	0,53	0,27	0,40	0,53
Air-pathway						
Annual effective dose (mSv)	0,0008	0,0005	0,0005	0,0007	0,0010	0,0004
% of dose limit	0,27	0,17	0,17	0,23	0,33	0,13

4. Origin of waste arising: reactor core with water and steam cycles

5. Waste treatment:

a) Waste water:
- ion-exchange procedures and evaporation for waste water

b) Exhaust air:
- filtration and hold-up loop for exhaust air

6. Waste management:

a) Procedures used to minimise the production of waste:
- Quality and design of fuel elements.
- Operation mode to avoid damage of fuel elements.

b) Improvements in waste treatment:
- Permanent monitoring of operations.
- Due to adherence to the minimisation obligation, emissions and discharges are kept as low as possible.

Further information:

a) Emissions and discharges are below the ranges indicated.

b) No significant trends identifiable.

c) No particularly high or low values.

d) Current operations do not require additional measures to reduce discharges.

1. Site Characteristics

Name of facility	Grafenrheinfeld					
Type of facility	PWR					
Date commissioned	1981					
Location	Germany					
Receiving water	Main					
	1999	2000	2001	2002	2003	2004
Installed electrical generation capacity, MW(e)	1345					

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
Cr-51						
Mn-54	1,8E+04	9,5E+04				3,2E+04
Co-57						
Co-58	4,8E+06	2,7E+06	1,9E+05	3,1E+05	3,0E+06	6,1E+06
Co-60	1,9E+07	3,1E+07	1,7E+07	1,9E+07	2,0E+07	2,9E+07
Fe-55					5,7E+06	6,0E+06
Fe-59						
Ni-63						
Zn-65						
Sr-89						
Sr-90						
Zr-95			3,8E+05		1,1E+06	8,7E+05
Nb-95	4,8E+05	2,9E+05	6,5E+05	1,7E+05	2,5E+06	2,6E+06
Ru-103						
Ru-106						
Ag-110m		1,0E+05	2,6E+05	2,6E+05		6,6E+05
Te-123m	3,2E+06	6,3E+06	1,9E+06	2,0E+06	6,1E+05	1,1E+06
Sb-124	4,8E+06	8,8E+05	2,9E+05	3,5E+05	3,4E+05	5,7E+05
Sb-125		4,3E+05				
I-131		1,2E+06				
Cs-134		1,2E+06	6,8E+04	1,6E+05		2,8E+05
Cs-137		9,0E+05	8,3E+04	8,5E+05	1,0E+06	1,5E+06
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides			8,6E+06			1,2E+05
Total activity excluding H-3	3,2E+07	4,5E+07	2,9E+07	2,3E+07	3,4E+07	4,9E+07

	1999	2000	2001	2002	2003	2004
Total activity excluding H-3	3,2E+07	4,5E+07	2,9E+07	2,3E+07	3,4E+07	4,9E+07
Authorised annual limit, Bq/a	5,5E+10					
% of annual limit	0,058	0,082	0,053	0,042	0,062	0,088
Normalised to capacity, GBq/GWa	0,024	0,034	0,022	0,017	0,025	0,036
H-3	1,4E+13	1,6E+13	1,6E+13	2,1E+13	2,2E+13	1,7E+13
Authorised annual limit, Bq/a	4,1E+13					
% of annual limit	35	38	39	52	54	42
Normalised to capacity, TBq/GWa	10,7	11,5	11,9	15,6	16,4	12,6
Total Alpha-activity						

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
H-3	2,7E+11	3,6E+11	3,2E+11	2,5E+11	1,9E+11	2,1E+11
Normalised to capacity, GBq/GWa	2,0E+02	2,7E+02	2,4E+02	1,9E+02	1,4E+02	1,6E+02
C-14	5,0E+10	5,8E+10	5,0E+10	2,6E+11	3,7E+11	3,2E+11
Normalised to capacity, GBq/GWa	3,7E+01	4,3E+01	3,7E+01	1,9E+02	2,8E+02	2,4E+02

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway						
Annual effective dose (mSv)	0,00020	0,00020	0,00050	0,00060	0,00070	0,00053
% of dose limit	0,07	0,07	0,17	0,20	0,23	0,18
Air-pathway						
Annual effective dose (mSv)	0,0003	0,0004	0,0003	0,0010	0,0005	0,0002
% of dose limit	0,10	0,13	0,10	0,33	0,17	0,07

4. Origin of waste arising: primary cooling system

5. Waste treatment: ion-exchange, evaporation, aerosol filters, activated carbon filters

6. Waste management:

To avoid radioactive discharges as far as possible the following measures are taken:

a) Procedures used to minimise the production of waste:

- Deployment of high quality fuel elements, based on scientific and technological know-how.
- Implementation of an operation mode geared towards maintaining fuel element integrity.
- Regular checks of fuel elements and fuel rods to monitor the quality and the state of the elements.

b) Improvements in waste treatment:

- To avoid activity concentrations to build up, about 10% of the primary cooling contents are permanently routed through ion exchangers.
- By employing evaporation systems, waste water from the controlled area is almost completely freed from radioactive components, before it is released into the receiving body (Main river).

- Exhaust air from the controlled area passes through filters (aerosol filters and activated carbon filters), which offer maximum technical separation standards. Depending on the functionalities of the installation (filters employed in case of incidents, filters employed on demand), activated carbon filters are changed if the loading is 1% or 10%.

Further information:

a) The values for radioactive discharges in exhaust air and waste water show, that
  - in exhaust air tritium is considerably below the minimum value of the corresponding range.
  - in waste water tritium is considerably below the average value of the corresponding range.
  - Non-Tritium is considerably below the minimum value of the corresponding range.

b/c) Significant upward and downward trends have not been recorded. Fluctuations between the individual annual discharge values are to be contributed to the different types of work covered by the individual annual reviews (more or fewer openings and clean-ups of systems).

d)
  – The clean-up and hold-up procedures used (clean-up of the primary coolant cycle with ion-exchange resins, clean-ups of waste water by employing evaporation systems, filtering of exhaust air with aerosol filters and activated carbon filters) are still the best available state-of-the-art technology. Short or medium term improvements are thus not necessary.
  – With the help of internal operating guidelines, training for the staff and differentiated preparatory work, radioactive discharges are kept as low as possible.

1. Site Characteristics

Name of facility	Grohnde
Type of facility	PWR
Date commissioned	1984
Location	Germany
Receiving water	Weser

	1999	2000	2001	2002	2003	2004
Installed electrical generation capacity, MW(e)	1430					

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
Cr-51						
Mn-54			9,5E+04			
Co-57						
Co-58		4,7E+05	4,2E+05	7,9E+05		
Co-60	3,8E+06	8,9E+06	2,8E+06	1,0E+07	1,8E+06	4,4E+06
Fe-55		6,9E+06	5,2E+06	8,8E+06		
Fe-59						
Ni-63				1,1E+06		
Zn-65						
Sr-89	8,8E+05					
Sr-90		1,3E+07				
Zr-95						
Nb-95		9,7E+05			3,4E+04	
Ru-103						
Ru-106						
Ag-110m			8,4E+05	6,4E+04		2,6E+05
Te-123m	3,7E+05	1,6E+06	4,3E+06	3,3E+05	2,0E+05	9,8E+05
Sb-124	5,8E+04	1,3E+06	4,9E+05	2,9E+05	1,8E+05	
Sb-125						
I-131		3,8E+06		1,2E+05	4,7E+05	1,1E+06
Cs-134				2,7E+04	4,4E+04	
Cs-137		9,4E+04	1,3E+05	1,1E+06	9,2E+04	3,3E+04
Ba-140				8,3E+05		
La-140		3,9E+05				
Ce-141					8,0E+04	5,3E+04
Ce-144				5,7E+05	1,9E+05	
Other nuclides						
Total activity excluding H-3	5,1E+06	3,7E+07	1,4E+07	2,4E+07	3,1E+06	6,8E+06

	1999	2000	2001	2002	2003	2004
Total activity excluding H-3	5,1E+06	3,7E+07	1,4E+07	2,4E+07	3,1E+06	6,8E+06
Authorised annual limit, Bq/a	5,5E+10					
% of annual limit	0,009	0,068	0,026	0,044	0,006	0,012
Normalised to capacity, GBq/GWa	0,004	0,026	0,010	0,017	0,002	0,005
H-3	1,9E+13	1,7E+13	1,3E+13	1,8E+13	2,2E+13	2,2E+13
Authorised annual limit, Bq/a	4,8E+13					
% of annual limit	39	35	27	38	46	47
Normalised to capacity, TBq/GWa	13,1	11,9	9,1	12,6	15,4	15,7
Total Alpha-activity	8,7E+05					

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
H-3	2,6E+11	5,2E+11	3,8E+11	5,8E+11	6,6E+11	6,9E+11
Normalised to capacity, GBq/GWa	1,8E+02	3,6E+02	2,7E+02	4,1E+02	4,6E+02	4,8E+02

C-14	3,3E+11	4,0E+11	2,6E+11	3,6E+11	3,8E+11	3,1E+11
Normalised to capacity, GBq/GWa	2,3E+02	2,8E+02	1,8E+02	2,5E+02	2,7E+02	2,2E+02

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway						
Annual effective dose (mSv)	0,00020	0,00020	0,00030	0,00040	0,00040	1,00045
% of dose limit	0,07	0,07	0,10	0,13	0,13	333,48
Air-pathway						
Annual effective dose (mSv)	0,0003	0,0005	0,0003	0,0006	0,0009	0,0007
% of dose limit	< 0,03	0,17	0,10	< 0,03	0,30	0,23

4. Origin of waste arising: primary coolant cycle

5. Waste treatment: filtration, ion-exchange procedures within mixed-bed filters, evaporation, decantation, centrifugation

6. Waste management:

a) Procedures used to minimise the production of waste:
- Administrative requirements.
- Protection of the equipment against leaking.
- Preventive maintenance.
- Monitoring of leakages.

Further information:

a) Tritium emissions are below the corresponding range.

b) Tritium discharges are at the lower end of the corresponding range.

c) Non-Tritium discharges are far below the respective range.

b/c) No significant trends identifiable.

d) Separator / decanter for contaminated laundry drains and sludges.

1. Site Characteristics

Name of facility	Krümmel
Type of facility	BWR
Date commissioned	1983
Location	Germany
Receiving water	Elbe

	1999	2000	2001	2002	2003	2004
Installed electrical generation capacity, MW(e)	1316					

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
Cr-51						
Mn-54		3,6E+05	9,6E+05	6,6E+05		
Co-57						
Co-58						
Co-60	1,9E+06	9,8E+05	9,3E+06	6,5E+06	1,8E+06	5,3E+05
Fe-55						
Fe-59				1,4E+05		
Ni-63						
Zn-65			3,8E+06	3,0E+05		
Sr-89						
Sr-90						
Zr-95						
Nb-95						
Ru-103						
Ru-106						
Ag-110m						
Te-123m						
Sb-124						
Sb-125						
I-131		5,6E+05	1,2E+07	2,3E+06		
Cs-134						
Cs-137						
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides						
Total activity excluding H-3	1,9E+06	1,9E+06	2,6E+07	9,9E+06	1,8E+06	5,3E+05

	1999	2000	2001	2002	2003	2004
Total activity excluding H-3	1,9E+06	1,9E+06	2,6E+07	9,9E+06	1,8E+06	5,3E+05
Authorised annual limit, Bq/a	5,0E+10					
% of annual limit	0,004	0,004	0,052	0,020	0,004	0,001
Normalised to capacity, GBq/GWa	0,001	0,001	0,020	0,008	0,001	0,000
H-3	3,5E+11	5,0E+11	4,3E+11	6,1E+11	4,8E+11	5,6E+11
Authorised annual limit, Bq/a	1,9E+13					
% of annual limit	2	3	2	3	3	3
Normalised to capacity, TBq/GWa	0,3	0,4	0,3	0,5	0,4	0,4
Total Alpha-activity						

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
H-3	3,9E+10	3,5E+10	4,1E+10	3,8E+10	3,4E+10	3,7E+10
Normalised to capacity, GBq/GWa	3,0E+01	2,7E+01	3,1E+01	2,9E+01	2,6E+01	2,8E+01
C-14	4,8E+11	3,6E+11	2,5E+11	9,8E+10	1,2E+11	1,7E+11
Normalised to capacity, GBq/GWa	3,6E+02	2,7E+02	1,9E+02	7,4E+01	9,1E+01	1,3E+02

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway						
Annual effective dose (mSv)	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001
% of dose limit	< 0,03	< 0,03	< 0,03	< 0,03	< 0,03	< 0,03
Air-pathway						
Annual effective dose (mSv)	0,0030	0,0020	0,0020	0,0010	0,0010	0,0020
% of dose limit	1,00	0,67	0,67	0,33	0,33	0,67

4. Origin of waste arising: reactor core with water and steam cycles

5. Waste treatment:

a) Waste water:
- ion-exchange procedures, decantation and evaporation

b) Exhaust air:
- filtration and hold-up loop

6. Waste management:

a) Procedures used to minimise the production of waste:
- Quality and design of fuel elements.
- Operation mode to avoid damage of fuel elements.

b) Improvements in waste treatment:
- Permanent monitoring of operations.
- Due to adherence to the minimisation obligation, emissions and discharges are kept as low as possible.

Further information:

a) Emissions and discharges are below the ranges indicated.

b) No significant trends identifiable.

c) No particularly high or low values.

d) Current operations do not require additional measures to reduce discharges.

1. Site Characteristics

Name of facility	Mülheim-Kärlich					
Type of facility	PWR					
Date commissioned	1986					
Location	Germany					
Receiving water	Rhine					
	1999	2000	2001	2002	2003	2004
Installed electrical generation capacity, MW(e)	1302					

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
Cr-51						
Mn-54						
Co-57						
Co-58						
Co-60	6,4E+06	8,1E+06	8,3E+06	1,7E+07	5,5E+07	1,1E+07
Fe-55						
Fe-59						
Ni-63	4,2E+05		3,0E+06	1,3E+07	1,9E+07	7,9E+06
Zn-65						
Sr-89						
Sr-90						
Zr-95						
Nb-95						
Ru-103						
Ru-106						
Ag-110m						
Te-123m						
Sb-124						
Sb-125						
I-131						
Cs-134						
Cs-137					3,8E+05	
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides						
Total activity excluding H-3	6,8E+06	8,1E+06	1,1E+07	3,0E+07	7,4E+07	1,9E+07

	1999	2000	2001	2002	2003	2004
Total activity excluding H-3	6,8E+06	8,1E+06	1,1E+07	3,0E+07	7,4E+07	1,9E+07
Authorised annual limit, Bq/a	6,0E+10					
% of annual limit	0,011	0,014	0,019	0,050	0,124	0,032
Normalised to capacity, GBq/GWa	0,005	0,006	0,009	0,023	0,057	0,015
H-3	9,0E+09	1,1E+11	5,3E+09	1,4E+10	9,3E+10	7,3E+09
Authorised annual limit, Bq/a	5,0E+13					
% of annual limit	0	0	0	0	0	0
Normalised to capacity, TBq/GWa	0,0	0,1	0,0	0,0	0,1	0,0
Total Alpha-activity						

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
H-3	2,9E+10	1,7E+10	1,9E+09		2,5E+10	8,8E+09
Normalised to capacity, GBq/GWa	2,2E+01	1,3E+01	1,5E+00	0,0E+00	1,9E+01	6,8E+00
C-14	5,1E+08			3,0E+10	9,7E+09	7,3E+08
Normalised to capacity, GBq/GWa	3,9E-01	0,0E+00	0,0E+00	2,3E+01	7,5E+00	5,6E-01

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway						
Annual effective dose (mSv)	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001
% of dose limit	< 0,03	< 0,03	< 0,03	< 0,03	< 0,03	< 0,03
Air-pathway						
Annual effective dose (mSv)	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001
% of dose limit	< 0,03	< 0,03	< 0,03	< 0,03	< 0,03	< 0,03

4. Origin of waste arising: primary cooling system

5. Waste treatment:

a) Primary cooling system:
- Cleaning and degassing of the primary coolant in a by-pass loop.

b) Waste water:
- Treatment of waste waters by ion-exchange procedure, evaporation, silting filtration, floc precipitation.

c) Exhaust air:
- Treatment of exhaust air by employing filters for aerosols and iodine.
- Retention of noble gases by employing a hold-up line.

6. Waste management:

Procedures used to minimise the production of waste:

Adherence to specified operation modes to minimise damage to fuel elements and thereby the amount of radioactivity in the coolant.

Further information: At present no further measures planned.

1. Site Characteristics

Name of facility	Neckarwestheim 1
Type of facility	PWR
Date commissioned	1976
Location	Germany
Receiving water	Neckar

	1999	2000	2001	2002	2003	2004
Installed electrical generation capacity, MW(e)	840					

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
Cr-51						
Mn-54						
Co-57						
Co-58	4,2E+04					
Co-60	5,0E+05	6,5E+04	5,1E+05	4,6E+05		
Fe-55						
Fe-59						
Ni-63						
Zn-65						
Sr-89			1,1E+05			
Sr-90			6,2E+04			
Zr-95						
Nb-95						
Ru-103						
Ru-106						
Ag-110m						
Te-123m	4,4E+05	2,2E+05			2,3E+05	
Sb-124	8,9E+05	1,5E+06	7,0E+05			
Sb-125						
I-131						
Cs-134						
Cs-137						
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides						
Total activity excluding H-3	1,9E+06	1,8E+06	1,4E+06	4,6E+05	2,3E+05	0,0E+00

	1999	2000	2001	2002	2003	2004
Total activity excluding H-3	1,9E+06	1,8E+06	1,4E+06	4,6E+05	2,3E+05	0,0E+00
Authorised annual limit, Bq/a	1,9E+10					
% of annual limit						
Normalised to capacity, GBq/GWa						
H-3	6,7E+12	8,7E+12	9,5E+12	1,2E+13	1,0E+13	7,4E+12
Authorised annual limit, Bq/a	1,9E+13					
% of annual limit	36	47	51	65	54	40
Normalised to capacity, TBq/GWa	8,0	10,4	11,3	14,3	11,9	8,9
Total Alpha-activity	3,3E+05		2,6E+05			

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
H-3	1,3E+11	1,1E+11	1,2E+11	1,2E+11	1,3E+11	1,3E+11
Normalised to capacity, GBq/GWa	1,5E+02	1,3E+02	1,4E+02	1,4E+02	1,5E+02	1,5E+02
C-14	2,4E+11	2,4E+11	1,7E+11	2,3E+11	2,5E+11	2,8E+11
Normalised to capacity, GBq/GWa	2,9E+02	2,9E+02	2,0E+02	2,7E+02	3,0E+02	3,3E+02

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway						
Annual effective dose (mSv)	0,00011	0,00014	0,00035	0,00044	0,00037	0,00024
% of dose limit	0,04	0,05	0,12	0,15	0,12	0,08
Air-pathway						
Annual effective dose (mSv)	0,0005	0,0010	0,0005	0,0010	0,0010	0,0015
% of dose limit	0,17	0,33	0,17	0,33	0,33	0,50

1. Site Characteristics

Name of facility	Neckarwestheim 2					
Type of facility	PWR					
Date commissioned	1988					
Location	Germany					
Receiving water	Neckar					
	1999	2000	2001	2002	2003	2004
Installed electrical generation capacity, MW(e)	1365					

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
Cr-51				1,2E+07		
Mn-54	2,4E+05					
Co-57						
Co-58	2,8E+04	1,2E+05		1,7E+06		
Co-60	2,5E+06	1,9E+06	1,9E+05	1,7E+07	1,6E+06	8,2E+04
Fe-55	4,3E+06			8,1E+06		
Fe-59						
Ni-63				1,0E+07		
Zn-65						
Sr-89		1,8E+05				
Sr-90						
Zr-95						
Nb-95		1,3E+05	2,7E+05	3,1E+04	1,3E+05	
Ru-103						
Ru-106						
Ag-110m				1,9E+05		
Te-123m				4,0E+07	9,7E+06	
Sb-124	3,3E+06	1,1E+06		3,2E+06	1,5E+06	
Sb-125	5,3E+05	1,4E+06		6,4E+07	5,3E+06	
I-131					1,9E+05	
Cs-134	1,1E+07			1,7E+06		
Cs-137	1,4E+07	1,8E+05	1,1E+05	1,4E+07	3,0E+05	
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides					1,4E+08	
Total activity excluding H-3	3,6E+07	5,0E+06	5,7E+05	1,7E+08	1,6E+08	8,2E+04

	1999	2000	2001	2002	2003	2004
Total activity excluding H-3	3,6E+07	5,0E+06	5,7E+05	1,7E+08	1,6E+08	8,2E+04
Authorised annual limit, Bq/a	6,0E+10					
% of annual limit	0,060	0,008	0,001	0,287	0,265	0,000
Normalised to capacity, GBq/GWa	0,026	0,004	0,000	0,126	0,116	0,000
H-3	1,7E+13	1,1E+13	9,5E+12	1,7E+13	2,3E+13	1,8E+13
Authorised annual limit, Bq/a	7,0E+13					
% of annual limit	24	16	14	24	33	25
Normalised to capacity, TBq/GWa	12,5	8,1	7,0	12,5	16,8	13,0
Total Alpha-activity						

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
H-3	2,6E+11	2,5E+11	1,4E+11	2,0E+11	1,5E+11	1,3E+11
Normalised to capacity, GBq/GWa	1,9E+02	1,8E+02	1,0E+02	1,5E+02	1,1E+02	9,5E+01

C-14	2,7E+11	3,9E+11	2,6E+11	2,2E+11	2,6E+11	4,2E+11
Normalised to capacity, GBq/GWa	2,0E+02	2,9E+02	1,9E+02	1,6E+02	1,9E+02	3,1E+02

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway						
Annual effective dose (mSv)	0,00027	0,00018	0,00035	0,00063	0,00084	0,00066
% of dose limit	0,09	0,06	0,12	0,21	0,28	0,22
Air-pathway						
Annual effective dose (mSv)	0,0005	0,0010	0,0005	0,0010	0,0010	0,0015
% of dose limit	0,17	0,33	0,17	0,33	0,33	0,50

4. Origin of waste arising: primary cooling system

5. Waste treatment: evaporation, ion-exchange

6. Waste management:

In line with applicable rules and regulations, directives and operational manuals

a) Procedures used to minimise the production of waste:
- Leak tightness of fuel elements.
- Cleaning of the primary cooling system.
- Waste processing.

b) Improvements in waste treatment:
- Evaporation with a high degree of decontamination.

Further information:
- Tritium emissions to the atmosphere are at the minimum.
- Tritium discharges to water are at the average.
- Non-Tritium discharges to water are significantly below the minimum.

1. Site Characteristics

Name of facility	Obrigheim
Type of facility	PWR
Date commissioned	1968
Location	Germany
Receiving water	Neckar

	1999	2000	2001	2002	2003	2004
Installed electrical generation Capacity, MW(e)	357					

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
Cr-51	8,2E+06	2,6E+06		2,7E+06		2,8E+06
Mn-54	1,8E+06	5,0E+06	7,6E+05	1,9E+05	7,4E+05	5,6E+05
Co-57						
Co-58	2,3E+07	4,2E+07	2,0E+07	1,4E+07	7,1E+06	4,5E+07
Co-60	1,1E+08	1,8E+08	2,8E+07	1,1E+07	1,2E+07	1,0E+07
Fe-55	1,7E+07	5,9E+07	1,6E+07	6,9E+06	1,8E+07	6,9E+06
Fe-59						
Ni-63	1,8E+08	2,8E+08	2,3E+07	9,9E+06	8,6E+06	1,2E+07
Zn-65		1,4E+06				1,9E+05
Sr-89	9,0E+04	2,5E+05	1,6E+05			
Sr-90	1,8E+05	4,2E+05	1,9E+05			
Zr-95	2,9E+05					
Nb-95	1,7E+06					
Ru-103						
Ru-106						
Ag-110m	7,2E+07	5,5E+07	1,4E+07	9,9E+06	7,5E+06	5,7E+06
Te-123m	3,7E+05	7,6E+05	6,7E+05	1,1E+06	1,9E+05	
Sb-124	7,8E+05	4,1E+06	1,1E+06		2,2E+06	5,4E+06
Sb-125	7,8E+05			3,1E+05		
I-131		6,2E+05				
Cs-134	8,9E+05	2,8E+07	4,2E+06	1,7E+05	1,6E+05	4,8E+05
Cs-137	1,1E+07	6,6E+07	7,7E+06	3,9E+06	3,0E+06	2,8E+06
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides						
Total activity excluding H-3	4,3E+08	7,3E+08	1,2E+08	6,0E+07	5,9E+07	9,2E+07

	1999	2000	2001	2002	2003	2004
Total activity excluding H-3	4,3E+08	7,3E+08	1,2E+08	6,0E+07	5,9E+07	9,2E+07
Authorised annual limit, Bq/a	3,0E+10					
% of annual limit	1,423	2,436	0,386	0,200	0,198	0,308
Normalised to capacity, GBq/GWa	1,196	2,047	0,324	0,168	0,167	0,259
H-3	6,1E+12	5,5E+12	5,4E+12	5,9E+12	4,9E+12	6,3E+12
Authorised annual limit, Bq/a	1,8E+13					
% of annual limit	34	31	30	33	27	35
Normalised to capacity, TBq/GWa	16,9	15,4	15,1	16,5	13,7	17,6
Total Alpha-activity			4,3E+04		2,9E+04	

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
H-3	1,3E+11	1,3E+11	9,8E+10	9,8E+10	9,8E+10	1,4E+11
Normalised to capacity, GBq/GWa	3,6E+02	3,6E+02	2,7E+02	2,7E+02	2,7E+02	3,9E+02

C-14	4,7E+10	8,4E+10	5,6E+10	6,2E+10	6,0E+10	4,7E+10
Normalised to capacity, GBq/GWa	1,3E+02	2,4E+02	1,6E+02	1,7E+02	1,7E+02	1,3E+02

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway						
Annual effective dose (mSv)	0,00020	0,00020	0,00030	0,00030	0,00020	0,00028
% of dose limit	0,07	0,07	0,10	0,10	0,07	0,09
Air-pathway						
Annual effective dose (mSv)	0,0020	0,0040	0,0050	0,0100	0,0080	0,0040
% of dose limit	0,67	1,33	1,67	3,33	2,67	1,33

4. Origin of waste arising: primary coolant cycle

5. Waste treatment: filtration, ion-exchange procedures, evaporation

6. Waste management:

In line with applicable rules and regulations, directives and operation manuals

Procedures used to minimise the production of waste:

- Leak tightness of fuel elements.
- Specialized operation modes for fuel elements.
- Cleaning of the primary cooling cycle.
- Waste processing.
- Ozone laundry system for contaminated clothing.

Further information:

All values are minimum values, with the exception of tritium discharges to water, where the values recorded are the average values.

1. Site Characteristics

Name of facility	Philippsburg 1					
Type of facility	BWR					
Date commissioned	1979					
Location	Germany					
Receiving water	Rhine					
	1999	2000	2001	2002	2003	2004
Installed electrical generation capacity, MW(e)	912					

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
Cr-51	1,6E+07	1,5E+07	1,6E+06	1,1E+07	1,4E+07	4,9E+06
Mn-54	7,8E+06	1,0E+07	8,1E+06	1,2E+07	2,1E+07	6,8E+06
Co-57						
Co-58	3,2E+06	7,3E+06	4,0E+06	4,7E+06	1,1E+07	6,3E+04
Co-60	9,5E+07	7,7E+07	6,3E+07	8,4E+07	1,1E+08	3,5E+07
Fe-55	2,9E+07	1,6E+07	1,7E+07	4,0E+07	4,0E+07	3,2E+07
Fe-59						
Ni-63	3,1E+07				8,1E+07	
Zn-65	2,8E+07	2,2E+07	2,5E+07	3,4E+07	3,8E+07	2,6E+07
Sr-89	9,5E+05					4,3E+06
Sr-90	3,4E+05					
Zr-95						
Nb-95						
Ru-103						
Ru-106						
Ag-110m	1,4E+07	1,6E+05		1,6E+05	8,0E+05	9,5E+05
Te-123m						
Sb-124						
Sb-125						1,8E+05
I-131	4,2E+07	5,3E+06	1,5E+05	8,8E+06		2,3E+07
Cs-134	1,1E+06		2,4E+05	1,1E+05	4,9E+05	7,5E+05
Cs-137	1,8E+07	4,7E+06	7,9E+06	5,5E+06	1,0E+07	3,1E+06
Ba-140						2,3E+06
La-140						3,0E+06
Ce-141						1,0E+06
Ce-144						
Other nuclides						
Total activity excluding H-3	2,9E+08	1,6E+08	1,3E+08	2,0E+08	3,3E+08	1,4E+08

	1999	2000	2001	2002	2003	2004
Total activity excluding H-3	2,9E+08	1,6E+08	1,3E+08	2,0E+08	3,3E+08	1,4E+08
Authorised annual limit, Bq/a	1,5E+11					
% of annual limit	0,191	0,105	0,085	0,134	0,218	0,096
Normalised to capacity, GBq/GWa	0,314	0,173	0,139	0,220	0,358	0,158
H-3	5,9E+11	4,8E+11	6,5E+11	4,6E+11	4,7E+11	4,6E+11
Authorised annual limit, Bq/a	1,8E+13					
% of annual limit	3	3	4	3	3	3
Normalised to capacity, TBq/GWa	0,6	0,5	0,7	0,5	0,5	0,5
Total Alpha-activity	2,1E+06					

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
H-3	5,5E+10	5,2E+10	4,8E+10	3,5E+10	4,6E+10	4,2E+10
Normalised to capacity, GBq/GWa	6,0E+01	5,7E+01	5,3E+01	3,8E+01	5,0E+01	4,6E+01
C-14	6,2E+11	5,0E+11	5,3E+11	5,5E+11	4,8E+11	4,1E+11
Normalised to capacity, GBq/GWa	6,8E+02	5,5E+02	5,8E+02	6,0E+02	5,3E+02	4,5E+02

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway						
Annual effective dose (mSv)	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001
% of dose limit	< 0,03	< 0,03	< 0,03	< 0,03	< 0,03	< 0,03
Air-pathway						
Annual effective dose (mSv)	0,0035	0,0035	0,0035	0,0035	0,0035	0,0025
% of dose limit	1,17	1,17	1,17	1,17	1,17	0,83

1. Site Characteristics

Name of facility	Philippsburg 2					
Type of facility	PWR					
Date commissioned	1984					
Location	Germany					
Receiving water	Rhine					
	1999	2000	2001	2002	2003	2004
Installed electrical generation capacity, MW(e)	1042					

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
Cr-51			1,3E+06	9,6E+06		
Mn-54	4,8E+05	1,4E+06	4,5E+06	3,4E+06	3,8E+04	2,2E+05
Co-57	8,9E+04	1,1E+05	4,7E+04		6,7E+04	
Co-58	5,3E+06	4,3E+06	8,5E+06	4,2E+06	1,8E+06	2,8E+05
Co-60	3,7E+07	5,0E+07	8,1E+07	7,1E+07	1,8E+07	7,9E+06
Fe-55	3,8E+07	1,3E+07	6,5E+07	3,0E+07	1,4E+07	6,2E+06
Fe-59						
Ni-63	1,4E+08	7,2E+07	9,6E+07	7,5E+07	1,6E+07	8,0E+06
Zn-65		1,7E+05	1,8E+07	1,1E+06		2,7E+05
Sr-89	2,9E+05					
Sr-90	9,5E+04					
Zr-95		9,3E+05	1,8E+05	3,9E+04		
Nb-95	2,1E+05	1,6E+06	1,4E+06	6,7E+05	2,4E+05	3,9E+04
Ru-103					3,8E+04	1,3E+05
Ru-106						
Ag-110m	4,8E+06	5,0E+06	7,9E+06	3,4E+06	1,0E+06	5,4E+05
Te-123m	6,9E+05	4,2E+05	6,9E+05	1,7E+05	1,1E+06	
Sb-124	9,9E+06	3,7E+06	9,1E+06	8,9E+06	3,7E+06	2,2E+06
Sb-125	2,9E+06	1,7E+06	7,2E+06	4,0E+06	2,5E+06	7,0E+05
I-131	8,1E+06	3,5E+07	5,9E+05	2,0E+07		7,9E+05
Cs-134	4,2E+07	2,9E+07	3,0E+07	2,3E+07	8,3E+06	2,6E+06
Cs-137	1,5E+08	1,3E+08	1,6E+08	1,4E+08	2,6E+07	1,9E+07
Ba-140						
La-140						
Ce-141	5,2E+04			2,5E+05	8,0E+04	2,9E+05
Ce-144	3,7E+05		3,4E+05	2,1E+05	5,9E+05	
Other nuclides						
Total activity excluding H-3	4,4E+08	3,5E+08	4,9E+08	3,9E+08	9,3E+07	4,9E+07

	1999	2000	2001	2002	2003	2004
Total activity excluding H-3	4,4E+08	3,5E+08	4,9E+08	3,9E+08	9,3E+07	4,9E+07
Authorised annual limit, Bq/a	5,5E+10					
% of annual limit	0,801	0,633	0,894	0,718	0,170	0,089
Normalised to capacity, GBq/GWa	0,423	0,334	0,472	0,379	0,090	0,047
H-3	1,8E+13	1,8E+13	1,3E+13	1,6E+13	1,9E+13	1,5E+13
Authorised annual limit, Bq/a	4,8E+13					
% of annual limit	38	38	27	33	40	30
Normalised to capacity, TBq/GWa	17,3	17,3	12,5	15,4	18,2	14,0
Total Alpha-activity						

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
H-3	1,1E+12	5,4E+11	3,0E+11	2,9E+11	2,1E+11	1,8E+11
Normalised to capacity, GBq/GWa	1,1E+03	5,2E+02	2,9E+02	2,8E+02	2,0E+02	1,7E+02

C-14	1,8E+11	1,9E+11	2,9E+11	2,2E+11	2,0E+11	1,7E+11
Normalised to capacity, GBq/GWa	1,7E+02	1,8E+02	2,8E+02	2,1E+02	1,9E+02	1,6E+02

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway						
Annual effective dose (mSv)	< 0,0001	< 0,0001	0,00016	0,00019	0,00024	0,00017
% of dose limit	< 0,03	< 0,03	0,05	0,06	0,08	0,06
Air-pathway						
Annual effective dose (mSv)	0,0035	0,0035	0,0035	0,0035	0,0035	0,0025
% of dose limit	1,17	1,17	1,17	1,17	1,17	0,83

4. Origin of waste arising: primary coolant cycle and attached systems

5. Waste treatment:

a) Waste water:

- Radioactive waste water is separated and collected according to its concentration of activity and the level of chemical contamination and is then treated according to its degree of contamination.
- Highly contaminated water will be subject to evaporation. In case of low chemical contamination (low-degree of conductivity) it is cleaned by means of ion-exchangers.
- Water which is hardly contaminated but strongly chemically polluted (laundry effluents for instance) are processed by means of centrifugal systems, which consist of a decanter and a separator.
- Depending on the concentration of activity and the composition of nuclides, decontamination factors are 10^5 to 10^6 in case of evaporation and between 1 and 100 in case of centrifugation.

b) Exhaust air:

- By using activated carbon filters radionuclides within the exhaust are partially absorbed, while there is simultaneously a delay over time. Due to this procedure Xe-nuclides are almost totally retained. Kr-nuclides too are almost totally retained with the exception of Kr-85. The long-lived but not particularly relevant Kr-85 is fully released.

6. Waste management:

Procedures used to minimise the production of waste by following preventive measures are taken to avoid generation of radioactive waste as a result of damaged fuel elements:

- Permanent application of quality assurance measures with regard to fuel element design, fuel element construction and fuel element production at the manufacturers' site and through monitoring by the contractor and the regulatory authority.
- Handling of fuel elements according to detailed manual constructions, to avoid the risk of damaging fuel elements. Tools such as cranes, load limitors etc. are designed to meet higher requirements than other tools.
- Technical and administrative measures during operations to avoid damage to fuel elements. Automatic, electronic control mechanisms used to monitor the reactor ensure for KKP1 and KKP2 that fuel elements are not overloaded. Apart from this, an additional administrative (manual-based) and computer-based special operation mode for fuel elements will be provided for KKP1. The respective function is provided for KKP2 by means of electronic surveillance equipment.
- Regular inspection of selected fuel elements with the objective of identifying potential initial damage by means of visual inspection, eddy-current testing and, in particular, by measuring the thickness of the corrosion layer.
- Regular monitoring of activity concentration in the primary coolant to early identify damage to fuel elements during operation and to be able to take measures geared towards avoiding the potential release of activity and thus generation of radioactive waste if the plant is taken out of operation. These operational measures include, for example, opening of the reactor closure head at a late point in time, check of all fuel elements in the core for potential leakage and thus exclusion of damaged fuel elements from the next operational cycle.

Further information:

a)
- Non-tritium discharges into water are far below the level of the ranges published by UNSCEAR
- Tritium emissions into the atmosphere and liquid tritium discharges are below the level of the ranges or at the lower end of the ranges.

b/c) Significant upward and downward trends or peaks and dips have not been recorded.

d) Current operations do not require additional measures to reduce discharges.

1. Site Characteristics

Name of facility	Stade
Type of facility	PWR
Date commissioned	1972
Location	Germany
Receiving water	Elbe

	1999	2000	2001	2002	2003	2004
Installed electrical generation capacity, MW(e)	672					

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
Cr-51						
Mn-54	1,2E+05	1,1E+05	2,3E+05			5,2E+05
Co-57	2,0E+04					
Co-58	3,3E+06	4,5E+06	3,1E+06	4,9E+04		5,4E+04
Co-60	1,1E+07	9,3E+06	9,1E+06	3,3E+06	3,1E+05	2,4E+07
Fe-55	1,0E+06	1,3E+06	4,9E+06	1,5E+06		1,2E+07
Fe-59				8,8E+04		
Ni-63	7,2E+06	6,2E+06	5,9E+06	3,7E+06		4,3E+06
Zn-65				5,9E+04		
Sr-89		2,3E+04				
Sr-90	3,0E+04	7,9E+04	2,5E+04			
Zr-95	9,0E+04		1,5E+05			
Nb-95		3,7E+05	2,9E+05		9,2E+04	
Ru-103						
Ru-106						
Ag-110m	5,6E+06	3,4E+06	6,8E+06	2,3E+06	1,5E+05	4,8E+06
Te-123m	2,7E+06	2,5E+06	1,7E+06	2,5E+05	5,2E+05	1,3E+06
Sb-124	4,1E+06	4,6E+06	8,1E+06	5,4E+05	4,8E+04	4,7E+04
Sb-125	2,7E+05					
I-131						
Cs-134	9,3E+04					
Cs-137	6,8E+06	5,5E+06	6,5E+06	1,9E+06	2,8E+05	1,2E+06
Ba-140						
La-140						
Ce-141	3,9E+04		1,4E+05			
Ce-144						
Other nuclides						
Total activity excluding H-3	4,3E+07	3,8E+07	4,7E+07	1,4E+07	1,4E+06	4,8E+07

	1999	2000	2001	2002	2003	2004
Total activity excluding H-3	4,3E+07	3,8E+07	4,7E+07	1,4E+07	1,4E+06	4,8E+07
Authorised annual limit, Bq/a	1,85E+11					
% of annual limit	0,023	0,020	0,025	0,007	0,001	0,026
Normalised to capacity, GBq/GWa	0,064	0,056	0,070	0,020	0,002	0,072
H-3	3,0E+12	2,4E+12	5,1E+12	3,3E+12	1,1E+13	1,4E+13
Authorised annual limit, Bq/a	4,81E+13					
% of annual limit	6	5	11	7	23	29
Normalised to capacity, TBq/GWa	4,4	3,6	7,6	4,9	16,4	20,5
Total Alpha-activity	2,7E+04					1,9E+04

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
H-3	5,3E+11	5,5E+11	7,3E+11	6,5E+11	1,0E+12	6,9E+11
Normalised to capacity, GBq/GWa	7,9E+02	8,2E+02	1,1E+03	9,7E+02	1,5E+03	1,0E+03
C-14	1,9E+11	9,1E+10	1,5E+11	9,5E+10	7,2E+10	2,0E+11
Normalised to capacity, GBq/GWa	2,8E+02	1,4E+02	2,2E+02	1,4E+02	1,1E+02	3,0E+02

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway						
Annual effective dose (mSv)	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001
% of dose limit	< 0,03	< 0,03	< 0,03	< 0,03	< 0,03	< 0,03
Air-pathway						
Annual effective dose (mSv)	0,00050	0,00030	0,00050	0,00040	0,00040	0,00090
% of dose limit	0,17	0,10	0,17	0,13	0,13	0,30

4. Origin of waste arising: primary coolant cycle and attached systems

5. Waste treatment: filtration, ion-exchange procedures, decantation, evaporation

6. Waste management

a) Procedures used to minimise the production of waste:
- Quality and design of fuel elements.
- Chemical set-up of the major coolant.
- Smooth operation modes to avoid damage fuel elements or to minimise the impact of damaged fuel elements.

b) Improvements in waste treatment:
- Permanent monitoring of operations.
- Due to adherence to the minimisation obligation, emissions and discharges are kept as low as possible.

Further information:

a) Discharges are at the lower end or below the ranges indicated.

b) No significant trends identifiable.

c) No particularly high or low values.

d) Current operations do not require additional measures to reduce discharges.

1. Site Characteristics

Name of facility	Unterweser					
Type of facility	PWR					
Date commissioned	1978					
Location	Germany					
Receiving water	Weser					
	1999	2000	2001	2002	2003	2004
Installed electrical generation capacity, MW(e)	1320					

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
Cr-51				6,5E+05		
Mn-54		2,0E+06	1,3E+05	1,1E+06	2,0E+06	3,6E+06
Co-57						
Co-58		1,1E+07		5,0E+06	1,6E+06	1,4E+07
Co-60	2,5E+07	1,4E+08	2,9E+07	1,3E+08	1,9E+08	1,3E+08
Fe-55				2,7E+07	2,6E+07	2,3E+07
Fe-59						
Ni-63				2,2E+07	2,2E+07	1,1E+07
Zn-65						
Sr-89						
Sr-90						
Zr-95				2,5E+06	5,7E+05	
Nb-95		8,2E+04		4,9E+06	1,4E+06	4,2E+05
Ru-103				1,2E+04		
Ru-106						
Ag-110m		1,9E+07	1,9E+05	3,2E+06	8,3E+04	
Te-123m	1,5E+07	3,5E+07	2,3E+07	9,1E+07	9,1E+06	7,5E+06
Sb-124	2,8E+07	4,3E+08	2,1E+07	6,4E+07	2,9E+06	3,6E+07
Sb-125		7,0E+06	1,2E+07	2,2E+07	1,2E+07	1,6E+06
I-131	5,9E+05	1,7E+06				
Cs-134		2,0E+07	2,0E+06	9,5E+04	5,2E+05	
Cs-137	1,4E+06	8,8E+07	1,2E+07	9,3E+06	8,2E+06	2,1E+06
Ba-140						
La-140	1,4E+05					
Ce-141						
Ce-144			3,8E+05			
Other nuclides		1,1E+07		3,1E+06		
Total activity excluding H-3	7,1E+07	7,7E+08	1,0E+08	3,9E+08	2,8E+08	2,3E+08

	1999	2000	2001	2002	2003	2004
Total activity excluding H-3	7,1E+07	7,7E+08	1,0E+08	3,9E+08	2,8E+08	2,3E+08
Authorised annual limit, Bq/a	7,4E+10					
% of annual limit	0,096	1,037	0,135	0,521	0,373	0,307
Normalised to capacity, GBq/GWa	0,054	0,581	0,076	0,292	0,209	0,172
H-3	7,7E+12	1,6E+13	1,6E+13	1,2E+13	1,3E+13	1,4E+13
Authorised annual limit, Bq/a	3,5E+13					
% of annual limit	22	47	45	34	37	41
Normalised to capacity, TBq/GWa	5,9	12,5	12,1	9,1	9,8	11,0
Total Alpha-activity						

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
H-3	4,4E+11	3,3E+11	3,1E+11	4,2E+11	3,2E+11	3,6E+11
Normalised to capacity, GBq/GWa	3,3E+02	2,5E+02	2,3E+02	3,2E+02	2,4E+02	2,7E+02
C-14	3,7E+10	5,6E+10	6,0E+10	6,9E+10	8,5E+09	3,8E+10
Normalised to capacity, GBq/GWa	2,8E+01	4,2E+01	4,5E+01	5,2E+01	6,4E+00	2,9E+01

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway						
Annual effective dose (mSv)	< 0,0001	< 0,0001	0,00020	0,00010	0,00010	0,00014
% of dose limit	< 0,03	< 0,03	0,07	0,03	0,03	0,05
Air-pathway						
Annual effective dose (mSv)	0,00020	0,00030	0,00050	0,00050	< 0,0001	0,00030
% of dose limit	0,07	0,10	0,17	0,17	< 0,03	0,10

4. Origin of waste arising: primary coolant cycle and attached systems

5. Waste treatment:

a) Primary coolant cycle:
- filtration, ion-exchange procedures, degassing, evaporation

Waste water from the controlled area:
- collection, silting filtration, evaporation

6. Waste management:

a) Procedures used to minimise the production of waste:
- Quality and design of fuel elements.
- Operation mode to avoid damage of fuel elements.
- Special programmes in case of damage fuel elements.

b) Improvements in waste treatment:
- Continuous monitoring of operations.
- In line with the minimisation obligation, emissions and discharges are kept as low as possible.

Further information:

a) Discharges and emissions are to be found at the lower end or below the ranges indicated.

b) No significant trend identifiable.

c) No particularly high or low values.

d) Adherence to the obligation to minimise emissions and discharges during operation does not make it necessary to take any additional measures.

1. Site Characteristics

Name of facility	Würgassen					
Type of facility	BWR					
Date commissioned / shut down	1971 / 1995					
Location	Germany					
Receiving water	Weser					
	1999	2000	2001	2002	2003	2004
Installed electrical generation capacity, MW(e)	670	670	-	-	-	-

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
Cr-51						
Mn-54	1,5E+04					
Co-57						
Co-58						
Co-60	6,3E+07	2,6E+07	3,6E+07	3,4E+07	2,7E+07	1,5E+07
Fe-55						
Fe-59						
Ni-63						
Zn-65						
Sr-89						
Sr-90	4,4E+05		1,7E+05	3,1E+05	1,1E+06	7,8E+05
Zr-95						
Nb-95						
Ru-103						
Ru-106						
Ag-110m						
Te-123m						
Sb-124						
Sb-125	3,7E+07					
I-131						
Cs-134						
Cs-137	3,7E+07	1,7E+07	1,5E+07	1,5E+07	1,7E+07	2,0E+07
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides						
Total activity excluding H-3	1,4E+08	4,3E+07	5,1E+07	4,9E+07	4,5E+07	3,5E+07

	1999	2000	2001	2002	2003	2004
Total activity excluding H-3	1,4E+08	4,3E+07	5,1E+07	4,9E+07	4,5E+07	3,5E+07
Authorised annual limit, Bq/a	6,0E+10					
% of annual limit	0,680	1,700	0,196	0,176	0,163	0,284
Normalised to capacity, GBq/GWa	0,609	1,522	0,176	0,157	0,146	0,254
H-3	4,4E+11	3,3E+11	3,5E+10	3,8E+10	1,4E+10	1,3E+10
Authorised annual limit, Bq/a	1,0E+13					
% of annual limit	0	0	0	0	0	0
Normalised to capacity, TBq/GWa	0,0	0,0	0,0	0,0	0,1	0,0
Total Alpha-activity	7,2E+04			5,5E+05	7,2E+05	3,3E+05

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
H-3	3,6E+09	3,0E+09	1,4E+10	6,2E+10	5,4E+10	4,9E+10
Normalised to capacity, GBq/GWa	5,4E+00	4,5E+00	2,1E+01	9,3E+01	8,1E+01	7,3E+01
C-14	2,7E+08	1,3E+09	1,4E+09	1,9E+09	1,0E+09	7,9E+08
Normalised to capacity, GBq/GWa	4,0E-01	1,9E+00	2,1E+00	2,8E+00	1,5E+00	1,2E+00

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway Annual effective dose (mSv)	0,00010	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001
% of dose limit	0,03	< 0,03	< 0,03	< 0,03	< 0,03	< 0,03
Air-pathway						
Annual effective dose (mSv)	0,00010	0,00020	0,00020	0,00030	0,00020	0,00010
% of dose limit	0,03	0,07	0,07	0,10	0,07	0,03

4. Origin of waste arising: primary coolant cycle and old contaminations (shut down in 1995)

5. Waste treatment: filtration, ion-exchange procedure, destillation

6. Waste management:

- Permenant monitoring of operations.
- Due to adherence to the minimisation obligation, emissions and discharges are kept as low as possible.

Further information:

a) Emissions and discharges are below the ranges indicated.

b) Downward trend for both tritium and total activity excluding tritium.

c) No particularly high or low values.

d) Decommissioning of the nuclear power plant.

Annex 2: Nuclear Fuel Fabrication and Enrichment Plants

1. Site Characteristics

Name of facility	Gronau
Type of facility	Nuclear fuel fabrication (uranium enrichment)
Capacity, U	1800 t/a
Date commissioned	1985
Location	Gronau
Receiving water	Vechte. Ijsselmeer

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
Total Alpha-activity	7,3E+03	1,0E+04	1,0E+04	2,3E+03	1,5E+04	1,4E+03
Authorised annual limit, Bq/a	7,4E+05	7,4E+05	7,4E+05	7,4E+05	7,4E+05	7,4E+05
% of annual limit	1,0	1,4	1,4	0,3	2,0	0,2

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
Total Alpha-activity	4,9E+04	4,5E+04	4,6E+04	4,7E+04	5,4E+04	2,6E+04

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway						
Annual effective dose (mSv)	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001
% of dose limit	< 0,03	< 0,03	< 0,03	< 0,03	< 0,03	< 003

4. Origin of waste arising: decontamination of UF_6-components, UF_6-container cleaning, media from traps for UF_6/HF

5. Waste treatment: filtration, evaporation

6. Waste management:

a) Procedures used to minimise the production of waste:
- a. Protection of UF_6-system against leaking.
- b. Utilization of vacuum systems.
- c. Minimisation of radioactive discharges by recycling residual waste.
- d. Recovery / reuse of cleaned auxiliary substances.
- e. Utilization of maintenance free gas centrifuges.

b) Improvements in waste treatment:
- a. At present there are no further measures planned.

Further information:

b/c) Since the plant has been taken into operation in 1985, discharges into air and water have practically been constantly low.

d) Additional measures are not planned.

1. Site Characteristics

Name of facility	Hanau
Type of facility	Different facilities for nuclear fuel fabrication (PWR, MOX)
Capacity, U	1350 t/a
Date commissioned/ decommisioned	1969/ 1996
Location	Hanau
Receiving water	Main

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
Total Alpha-activity	2,0E+08	1,7E+08	1,5E+08	1,3E+08	3,7E+07	
Authorised annual limit, Bq/a	1,5E+10	1,5E+10	1,5E+10	1,5E+10	1,5E+10	1,5E+10
% of annual limit	1,3	1,1	1,0	0,9	0,2	0,0

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
Total Alpha-activity						

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway						
Annual effective dose (mSv)	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001
% of dose limit	< 0,03	< 0,03	< 0,03	< 0,03	< 0,03	< 0,03

4. Origin of waste arising:

a) Waste water:
- There is no discharge of waste water from MOX fuel element production.
- Waste water is arising from wet-chemical conversion of uraniumhexafluoride to uraniumoxide in the production of uranium fuel elements.

b) Exhaust air:
- Exhaust air from the production of fuel elements contains radioactive substances in the form of uranium and plutonium compounds.

5. Waste treatment:

a) Waste water:
- Chemical treatment of waste water

b) Exhaust air:
- Filtration of exhaust air

6. Waste management:

a. Procedures used to minimise the production of waste:
- Filtration of the exhaust air from the glove boxes, where uranium and plutonium are processed.
- Further filtration of the exhaust air in the stack.

- Discharges of radioactive waste water arising from uranium fuel production are treated by chemical procedures.
- Process water from MOX fuel element production is treated in a waste treatment plant and stored in concreted waste bundles.

Further information:

- The production of MOX fuel elements had been stopped in 1991.
- The production of uranium fuel elements finished in the year 1996.
- The nuclear fuel element factory was shut down.

1. Site Characteristics

Name of facility	Lingen
Type of facility	Nuclear fuel fabrication (LWR)
Capacity, U	400 t/a
Date commissioned	1979
Location	Lingen
Receiving water	Ems

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
Total Alpha-activity	not detectable					
Authorised annual limit, Bq/a	220 g uranium					
% of annual limit	-	-	-	-	-	-

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
Total Alpha-activity	not detectable					

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway Annual effective dose (mSv)	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001
% of dose limit	< 0,03	< 0,03	< 0,03	< 0,03	< 0,03	< 0,03

4. Origin of waste arising:

a) Waste water:

- There is no discharge of water into outside water from the fuel production plant. In other words: radioactive substances cannot be released in this way.

b) Exhaust air:

- Exhaust air from the production process and building ventilation system may contain radioactive substances in the form of uranium compounds.

5. Waste treatment:

a) Exhaust air from the production process:

- Before exhaust air from production sites is released to the environment through a stack, it is cleaned with the help of strippers and two filtration systems for suspended substances.

b) Exhaust air from the building ventilation system:

- Exhaust air from those areas in which open uranium is available is cleaned by means of two filtration systems for suspended substances before it is released into the air via a stack.

6. Waste management:

The following principles apply to the design and the operation of the air ventilation system:

- Air pressure in the working areas and in those areas in which open uranium is processed or handled is lower than that of other working areas and the environment.
- To avoid an increase in pressure in the production area, exhaust air fans and supply air fans are sealed against each other: an exhaust air fan must be in operation before a supply air fan can be started.
- In case of an outage of the power supply network the exhaust air fan is supplied by an independent stand-by system.
- Distributors attached at a higher level ensure that internal air is routed to the floor and that air from clean areas is routed to potentially contaminated areas.
- The difference in pressure is regularly controlled at each suspended substances filter.
- To guarantee the functionalities of the air ventilation and the exhaust air system major components are checked at regular intervals:
    - the non-existence of uranium in exhaust airducts for exhaust air from processing
    - each suspended substances filter before installation
    - factors for retaining at the second level of filtration
    - potential leaking in filter seals
    - direction of air-flows within the building
    - the functionalities of the power supply stand-by system
    - air sampling systems at exhaust air stacks.
- Exhaust air is permanently controlled by the operator and simultaneously by an independent measuring organisation (monitoring of emissions).
- Parallel to the monitoring of emissions at the exhaust air stacks, there is continuous monitoring for uranium deposition in the environment (monitoring of immissions).
- Operation, maintenance, checks and control measurements are based on approved and controlled procedures.

Annex 3: Research and Development Facilities

1. Site Characteristics

Name of facility	GKSS Geesthacht
Type of facility	Different research and development facilities including 2 reactors
Reactor capacity	5 MW / 15 MW
Date commissioned	1958 / 1963
Date decommissioned	- / 1991
Location	Geesthacht
Receiving water	Elbe

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
Cr-51	5,3E+06		2,4E+05	6,7E+05		
Mn-54	1,1E+06	7,6E+04	5,2E+05	3,3E+05	1,9E+04	
Co-58	3,8E+04					
Co-60	1,8E+08	6,6E+07	7,1E+07	5,1E+07	7,3E+06	4,9E+06
Fe-59						
Zn-65	1,1E+07	8,4E+05	2,7E+06	8,0E+05	6,6E+04	
Sr-89	8,0E+05	2,1E+05	3,6E+05	5,0E+05	5,0E+04	2,5E+04
Sr-90	3,4E+06	1,2E+06	9,7E+05	2,4E+06	5,9E+05	5,4E+05
Zr-95				1,2E+05		
Nb-95				1,3E+05		
Ru-103	3,5E+05		8,9E+04			
Ru-106						
Ag-110m			7,3E+04			
Te-123m				1,9E+04		
Sb-124	1,6E+06		3,8E+05	9,2E+04		
Sb-125	7,5E+05					
I-131				7,9E+04		
Cs-134	2,6E+05	4,3E+05	1,3E+05			
Cs-137	1,3E+08	1,3E+08	4,3E+07	1,1E+08	3,3E+07	1,7E+07
Ba-140				7,6E+04		
La-140	1,3E+05			7,2E+04		
Ce-141	4,2E+05			2,4E+05		
Ce-144	2,9E+05		1,1E+06	9,5E+05		
Other nuclides	4,2E+05		1,9E+04	3,7E+05		
Total activity excluding H-3	3,4E+08	1,9E+08	1,2E+08	1,7E+08	4,1E+07	2,2E+07
Authorised annual limit, Bq/a	1,9E+10	1,9E+10	1,9E+10	1,9E+10	1,9E+10	1,9E+10
% of annual limit	1,8	1,0	0,6	0,9	0,2	0,1
H-3	9,3E+09	2,8E+09	7,8E+09	4,2E+09	2,0E+08	1,6E+08
Authorised annual limit, Bq/a	5,6E+10	5,6E+10	5,6E+10	5,6E+10	5,6E+10	5,6E+10
% of annual limit	17	5	14	8	0	0
Total Alpha-activity	4,9E+04	5,6E+04	7,2E+04	6,9E+04	1,7E+04	1,6E+04

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
H-3	5,5E+10	4,9E+10	2,7E+11	1,1E+11	9,8E+10	9,0E+10
C-14	3,8E+08	2,8E+08	1,4E+09	2,0E+08	6,2E+08	8,5E+08

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway						
Annual effective dose (mSv)	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001
% of dose limit	< 0,03	< 0,03	< 0,03	< 0,03	< 0,03	< 0,03

4. Origin of waste arising: primary coolant cycle

5. Waste treatment: filtration, ion-exchange procedures

6. Waste management:

a. Procedures used to minimise the production of waste:

- Tightness of fuel elements by corrosion resistant cladding (AlMg-alloy) and special surface treatment.

b. Improvements in waste treatment:

- Sedimentation, neutralisation and evaporation of waste water.

Further information:

Future in-process measures: concentration of waste water by reverse osmosis and/or evaporation.

1. Site Characteristics

Name of facility	Hahn-Meitner-Institut (HMI) Berlin
Type of facility	Different research and development facilities including 1 reactor
Reactor capacity	10 MW
Date commissioned	1973
Location	Berlin
Receiving water	Havel

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
Total activity excluding H-3	2,4E+05	5,5E+05	2,8E+05	7,0E+05	1,2E+06	1,2E+06
Authorised annual limit, Bq/a	1)	1)	1)	1)	1)	1)
% of annual limit	-	-	-	-	-	-
H-3	2,8E+07	5,8E+07	5,8E+08	7,0E+08	1,4E+09	6,6E+08
Authorised annual limit, Bq/a	1)	1)	1)	1)	1)	1)
% of annual limit	-	-	-	-	-	-
Total Alpha-activity						
Authorised annual limit, Bq/a	1)	1)	1)	1)	1)	1)
% of annual limit	-	-	-	-	-	-

1) There is no authorised annual limit. The acitivity concentration of waste water must have drinking water quality (see section 47 of the German Radiation Protection Ordinance).

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
H-3	4,6E+10	5,0E+10	6,3E+10	9,5E+10	9,0E+10	7,9E+10
C-14	2,0E+09	1,6E+09	2,0E+09	2,3E+09	2,1E+09	2,8E+09

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway						
Annual effective dose (mSv)	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001
% of dose limit	< 0,03	< 0,03	< 0,03	< 0,03	< 0,03	< 0,03

4./5. Origin of waste arising / Waste treatment:

All the contaminated waste water that is generated in the Hahn-Meitner-Institut is collected centrally in a transfer tank. The discharges are released into the municipal sewerage system with the limit values of Article 46 (4) of the Radiation Protection Ordinance being observed. (This limit is set at a concentration of 10^{-2} times the annual limit of intake for ingestion per cubic meter of waste water.) The discharges given therefore subsume the releases from all the facilities in the Institute, including those of the reactor.

Only negligible quantities of low-contaminated waste water are generated by the operation of the BER II research reactor. These are released via the State Collecting Facilitiy for radioactive waste, meaning that BER II does not release any separate discharges via the water route.

Part of the flow of the reactor's primary coolant water is continuously cleaned by ion-exchange filters. No discharges occur in this process. Intermittently ion-exchange resins occur as radioactive waste. The secondary coolant cycle and the coolant tower cycle are monitored and are free of activity.

The radioactive waste delivered to the State Collecting Facility for radioactive waste comes from research, industry and medicine. The physical and chemical properities of the various types of waste differ accordingly. Emissions and discharges can arise from the treatment and storage of these wastes.

6. Waste management:

a) Procedures used to minimise the production of waste:

The fuel elements used in BER II are MTR elements with a current U-235 enrichment of 90% (in future 20%). Within the fuel plates the fuel is thightly enclosed on all sides by the cladding material by means of roll cladding. The manufacturing process ensures a metallurgical link between the fuel and the cladding material. The surface of the fuel plates is checked for freedom from contamination after the manufacturing process.The transfer of fission products from the fuel plate into the basin water is therefore minimal, due to the design. The discharge of radioactive substances from the fuel elements into the basin water is effectively monitored by means of continuous measurements of the dose rate at the basin surface and by the means of regular sampling of the basin water.

In order to reduce the volume of the waste at the State Collecting Facility, the waste is evaporated, compacted or enclosed in cement after sorting. Incineration is not carried out in Berlin. A practice introduced recently is the recycling of sources containing tritium.

b) Improvements in waste treatment:

Since 1993 BER II has been operated with a so-called "warm layer". A heated layer of purified water is applied to the surface of the reactor basin water, which clearly reduces the transfer of fission and activation products from the surface of the reactor basin water into the hall atmosphere - and thus into the exhaust air. This measure has no effect on tritium emissions; but since tritium is not decisive for the dose (at the most unfavourable point of impact in the vicinity of the installation) in the case of BER II, this measure contributed to a reduction of the dose in 1993/94 compared to 1992 (first year after recommissioning).

This and the quality assurance measures practised for some considerable time in the manufacture of fuel elementss at BER II (see above) are the best available technology to be applied at a research reactor of the pool type. Further measures to reduce emissions - such as the installation of activated carbon filters in addition to the existing aerosol filters - cannot be justified due to the low level of emissions.

Further information:

The tritium and non-tritium emissions and discharges are very low.

1. Site Characteristics

Name of facility	Jülich Research Centre (KfA)
Type of facility	Different research and development facilities including 3 reactors
Reactor capacity	10 MW / 15 MW / 23 MW
Date commissioned	1962 / 1966 / 1962
Date decommissioned	1885 / 1988 / -
Location	Jülich
Receiving water	Rur

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
Co-60	3,7E+06	1,2E+06	2,9E+06		7,5E+05	1,0E+06
Sr-89						
Sr-90	7,5E+07	4,4E+07	1,6E+07	2,3E+07	2,9E+07	3,6E+07
I-131	6,9E+06	4,5E+06	5,8E+06	3,2E+06	2,1E+05	2,1E+06
Cs-137	5,3E+06	4,5E+06	1,3E+07	6,0E+06	3,9E+06	3,5E+06
Other nuclides						
Total activity excluding H-3	1,6E+08	1,3E+08	2,8E+08	1,7E+08	1,2E+08	1,2E+08
Authorised annual limit, Bq/a	7,6E+09	7,6E+09	7,6E+09	7,6E+09	7,6E+09	7,6E+09
% of annual limit	2,1	1,7	3,7	2,2	1,6	1,5
H-3	2,1E+11	1,4E+11	4,4E+11	3,4E+11	8,0E+11	4,2E+11
Authorised annual limit, Bq/a	1,1E+13	1,1E+13	1,1E+13	1,1E+13	1,1E+13	1,1E+13
% of annual limit	2	1	4	3	7	4
Total Alpha-activity	not detected					
Authorised annual limit, Bq/a	1,0E+08	1,0E+08	1,0E+08	1,0E+08	1,0E+08	1,0E+08
% of annual limit	-	-	-	-	-	-

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
H-3	2,0E+12	5,0E+10	6,3E+10	9,5E+10	9,0E+10	3,5E+12
C-14	1,9E+10	1,6E+09	2,0E+09	2,3E+09	2,1E+09	3,2E+11

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway						
Annual effective dose (mSv)	0,0006	0,0004	0,0008	0,0008	0,0023	0,0011
% of dose limit	0,21	0,15	0,28	0,27	0,77	0,37

4. Origin of waste arising:

At the Jülich Research Centre radioactive emissions to air and water are mainly caused by handling open radioactive materials in various facilities or laboratories.

a) Waste water:
- Radioactive waste water is collected in 25 drain tanks, the contents of which are then centrally collected.

b) Exhaust air:
- Emissions into the exhaust air originate from 17 different facilities.

5. Waste treatment:

a) Waste water:

Radioactivity in waste water is reduced by
- higher storage times for short-lived nuclides.
- evaporation in the case of higher concentrations.

b) Exhaust air:

As far as exhaust air is concerned radioactive emissions are reduced by
- delayed emissions of short-lived nuclides.
- using aerosol filters of level S.
- routing exhaust air through activated carbon filters.

Further information:
- The radiation exposition calculated on a per annum basis varies due to the different volumes of radioactive materials handled and due to different weather patterns.

1. Site Characteristics

Name of facility	Research Centre Karlsruhe (FZK)
Type of facility	Different research and development facilities, pilot reprocessing plant
Reactor capacity	44 MW / 58 MW / 20 MW
Date commissioned	1961 / 1965 / 1971
Date decommissioned	1981 / 1984 / 1991 / 1990 (pilot reprocessing plant)
Location	Karlsruhe
Receiving water	Rhine

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
C-14	4,0E+08					
Co-60	1,2E+05		1,5E+05	3,7E+04	5,7E+05	1,1E+06
Sr-89	1,5E+06		1,0E+06			
Sr-90	2,7E+07	1,2E+07	1,1E+07	8,7E+06	1,3E+07	8,9E+06
Cs-137	1,9E+07	1,4E+07	5,4E+06	7,9E+06	1,0E+07	9,0E+06
Pu-241	8,3E+06	1,1E+06				
Total activity excluding H-3	4,5E+08	2,7E+07	1,9E+07	1,7E+07	2,3E+07	1,9E+07
Authorised annual limit, Bq/a	3,2E+11	3,2E+11	3,2E+11	3,2E+11	3,2E+11	2,3E+11
% of annual limit	0,1	0,0	0,01	0,01	0,01	0,0
H-3	1,2E+13	1,5E+12	6,9E+11	1,2E+12	4,3E+11	9,3E+11
Authorised annual limit, Bq/a	1,5E+14	1,5E+14	1,5E+14	1,5E+14	1,5E+14	1,5E+14
% of annual limit	8,0	1,0	0,5	0,8	0,3	0,6
Pu-238	9,4E+04	9,8E+04				
Authorised annual limit, Bq/a	1,1E+09	1,1E+09	1,1E+09	1,1E+09	1,1E+09	1,1E+09
% of annual limit	0,01	0,01	0,00	0,00	0,00	0,00
Pu-239 + 240	6,7E+05	5,4E+04				
Authorised annual limit, Bq/a	9,6E+08	9,6E+08	9,6E+08	9,6E+08	9,6E+08	9,6E+08
% of annual limit	0,07	0,01	0,00	0,00	0,00	0,00

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
H-3	3,1E+12	3,8E+12	1,5E+12	9,3E+11	9,0E+11	9,8E+11
C-14	6,9E+10	6,6E+10	1,9E+10	2,8E+10	2,6E+10	2,3E+10

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway						
Annual effective dose (mSv)	0,0370	0,0052	0,0004	< 0,0001	< 0,0001	< 0,0001
% of dose limit	12,3	1,7	0,1	< 0,03	< 0,03	< 0,03

4. Origin of waste arising:

At the Research Centre Karlsruhe radioactive emissions to air and discharges to water are mainly caused by the handling of open radioactive materials in various facilities and laboratories. Contributions arise also by the decommissioning of the research reactors and the pilot reprocessing plant.

5. Waste treatment:

a) Waste water:

- The radioactive waste water is first collected in tanks, which are installed in 26 collecting stations next to the place of waste water generation. When the measured activity concentrations are higher than the maximum permissable values, the waste water is transferred into the decontamination plant, where the radioactivity is reduced by evaporation with a decontamination factor of 10^4.
- In the clarification plant for chemical waste water the liquid effluents from the collecting stations and from the decontamination plant are mixed with chemical waste waters free from radioactivity, clarified in a multistage process and, finally, collected in three end basins before discharged into the mains canal.

b) Exhaust air:

- The radioactive emissions to air are released through a total of 43 exhaust air vents and stacks with heights between 5 m and 100 m. Compared to nuclear power plants, the releases from these facilities exhibit greater variability both in terms of activity composition and release rates.
- Radioactive aerosol emissions are reduced by
  - HEPA-filters with decontamination factors of 10^2 to 10^3 (in all facilities).
  - off-gas scrubbers (only in the solid waste incineration plant and in the reprocessing plant for vessel off-gas).
- Radioactive iodine emissions are reduced by activated charcoal beds or silver-impregnated molecular sieves (in the reprocessing plant for vessel off-gas and, if applicable, in decontamination facilities).

Further information:

- The variations in emissions and discharges as well as in the resulting radiation exposures are due to different volumes of radioactive materials handled as result of changes in the research and development programs and the progress in the decommissioning of nuclear facilities.

1. Site Characteristics

Name of facility	Verein für Kernverfahrenstechnik und Analytik Rossendorf e.V.
Type of facility	Former nuclear research centre; reactors are now closed
Reactor capacity	
Date commissioned	1957
Location	Rossendorf
Receiving water	Elbe

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	1999	2000	2001	2002	2003	2004
C-14	4,4E+06	4,7E+05	2,3E+06	3,3E+06	6,9E+05	1,0E+06
Mn-54						
Co-58		1,8E+04				
Co-60	2,4E+06	5,8E+05	4,5E+06	8,2E+06	1,1E+06	5,9E+06
Cs-137	2,0E+06	8,9E+05	9,5E+05	1,6E+06	7,7E+05	1,6E+06
Ce-144						
Eu-152		5,1E+04		3,4E+04		
Sr-90	5,7E+05	1,5E+06	1,8E+06	7,9E+06	1,0E+06	8,3E+05
Total activity excluding H-3	9,4E+06	3,5E+06	4,1E+06	1,2E+06	1,7E+06	9,3E+06
Authorised annual limit, Bq/a	2,3E+08	2,3E+08	2,3E+08	2,3E+08	2,3E+08	2,3E+08
% of annual limit	4,1	1,5	1,78	0,52	0,74	4,1
H-3	6,6E+09	8,1E+08	1,1E+10	4,3E+10	2,1E+10	1,5E+11
Authorised annual limit, Bq/a	4,0E+11	4,0E+11	4,0E+11	4,0E+11	4,0E+11	4,0E+11
% of annual limit	2	0	3	11	5,3	38
Total Alpha-activity	4,8E+05	4,7E+05	9,9E+04	6,8E+05	5,2E+05	3,8E+05
Authorised annual limit, Bq/a	1,0E+06	1,0E+06	1,0E+06	1,0E+06	1,0E+06	1,0E+06
% of annual limit	48	47	10	68	52	38

Annual aerial emissions, Bq/a

	1999	2000	2001	2002	2003	2004
H-3	4,7E+10	4,5E+10	3,0E+10	3,0E+10	9,5E+09	7,4E+09
C-14	5,3E+09	7,0E+09	2,9E+09	3,9E+09	4,7E+09	3,2E+09

3. Radiation Doses to the Public

	1999	2000	2001	2002	2003	2004
Water-pathway Annual effective dose (mSv)	0,005	0,003	0,006	0,013	0,006	0,023
% of dose limit	1,6	1,1	1,8	4,3	2,0	7,6

4. Origin of waste arising:

At the Rossendorf Research Centre radioactive emissions to air and water are mainly caused by handling open radioactive materials in various facilities or laboratories.

a) Waste water:
- Radioactive waste water is collected in 11 drain tanks.

b) Exhaust air:
- The radioactive emissions to air are released through a total of 14 exhaust air vents and stacks with heights up to 50 m. Compared to nuclear power plants, the releases from these facilities exhibit greater variability both in terms of activity composition and release rates.

5. Waste treatment:

a) Waste water:

Radioactivity in waste water is reduced by
- higher storage times for short-lived nuclides.
- Ion exchange and evaporation in the case of higher concentrations.

b) Exhaust air:

As far as exhaust air is concerned radioactive emissions are reduced by
- delayed emissions of short-lived nuclides.
- using aerosol filters of level S.
- routing exhaust air through activated carbon filters.

Further information:
- The radiation exposition calculated on a per annum basis varies due to the different volumes of radioactive material handled and due to different weather patterns.