OSPAR COMMISSION

Implementation Report of PARCOM Recommendation 91/4 Report from Germany

Radioactive Substances Series

2011

OSPAR Convention

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

Convention OSPAR

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

Contents

1 Introduction

At its 2004 meeting in La Rochelle, France, the OSPAR Radioactive Substances Committee (RSC) established 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 about the German nuclear installations is given for the six year period from 2003 to 2008.

In Chapter 2, general information on the implementation of BAT / BEP (**Best Available Technology / Best Environmental Practice**) in national legislation / regulation is provided. The compilation includes the legal background, dose limits, the calculational procedure to derive discharge and emission limits, monitoring programmes and the form of reporting. For power reactors the discharges and emissions are given in absolute values and also normalised to the annual electrical power generation compared to the UNSCEAR ranges. Furthermore the annual effective doses for the water pathway and the air pathway are calculated and compared to the national dose limit. In accordance with the common usage within the OSPAR Convention, the term “emission” is used for gaseous releases and the term “discharge” for liquid releases.

In **Annexes 1, 2** and **3** all required information concerning the nuclear power plants, the nuclear fuel fabrication and enrichment plants and the research and development facilities are documented in tabular form.

2 General information

2.1 Implementation of BAT / BEP in German legislation and regulation

This section gives an overview over the legislation and regulations that are applied within this implementation round. In special, **figure 1** shows the hierarchy of national rules, regulations and standards and the degree of bindingness in Germany.

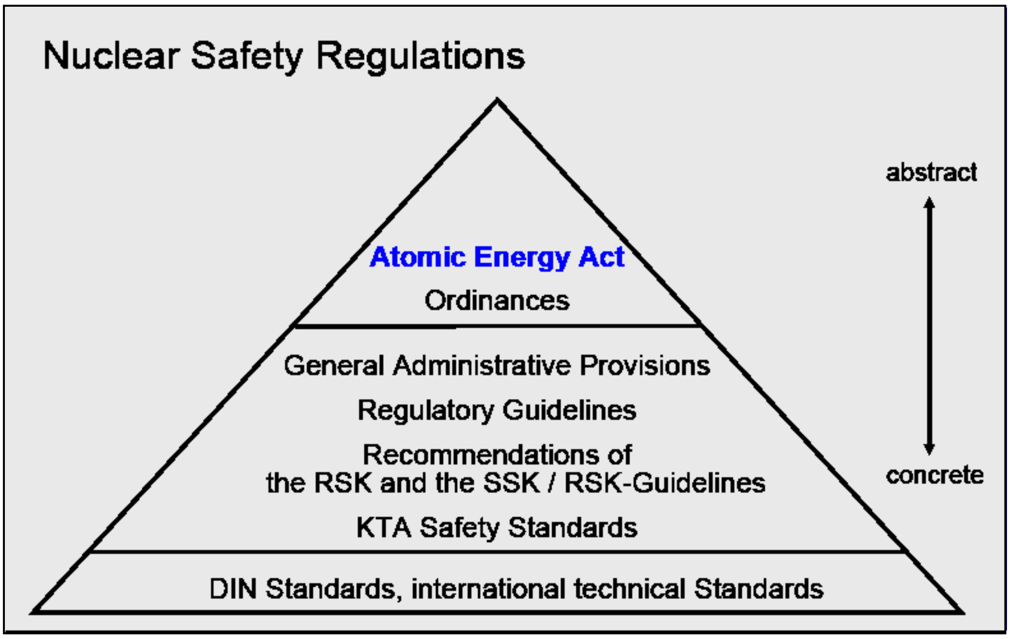

Figure 1 Nuclear safety regulations in Germany

Laws

Atomic Energy Act (Atomgesetz, AtG)

The Atomic Energy Act was promulgated on 23 December 1959 and has been amended several times. The purpose of the Atomic Energy Act as amended in 2002 is:

- to cease the use of nuclear energy for the commercial production of electricity in a structured manner and to ensure on-going operation until the date of discontinuation,
- to protect life, health and property against the hazards of nuclear energy and the detrimental effects of ionising radiation and
- to provide for the compensation for any damage and injuries incurred.

Furthermore, the Atomic Energy Act ensures that the Federal Republic of Germany meets its international obligations in the field of nuclear energy and radiation protection. The Atomic Energy Act includes the general national regulations for protective and preventive measures, radiation protection, disposal of radioactive waste and irradiated fuel elements in Germany and is the basis for associated ordinances.

According to Section 7 of the Atomic Energy Act, a licence is required for the construction, operation or any other holding of a stationary installation for the production, treatment, processing or fission of nuclear fuel, or for materially altering such an installation or its operation. A licence may only be granted if the licensing prerequisites stated in Section 7 Article 2 of the Atomic Energy Act are fulfilled. These are:

- there are no known facts giving rise to doubts as to the reliability of the applicant and of the persons responsible for the erection and management of the installation and the supervision of its operation, and the persons responsible for the erection and management of the installation and the supervision of its operation have the requisite qualification.

- it is assured that the persons who are otherwise engaged in the operation of the installation have the necessary knowledge concerning the safe operation of the installation, the possible hazards and the protective measures to be taken.
- the necessary precautions have been taken in the light of the state of the art in science and technology to prevent damage resulting from the erection and operation of the installation.
- the necessary financial security has been provided to comply with the legal liability to pay compensation for damage.
- The necessary protection has been provided against disruptive action or other interference by third parties.
- The choice of the site of the installation does not conflict with overriding public interests, in particular in view of its environmental impacts.

Ordinances

Radiation Protection Ordinance (Strahlenschutzverordnung, StrlSchV)

For more details regarding the legal regulations, the Atomic Energy Act includes authorisations for issuing ordinances. In Germany these ordinances requires the approval by the *Bundesrat* (Federal Council). The *Bundesrat* is a constitutional body of the Federation in which the governments of the *Länder* (Federal States) are represented. One of the prominent ordinances in Germany is the Radiation Protection Ordinance in which the principles of radiation protection, dose limits, requirements for the organisation of radiation protection, personal monitoring, environmental monitoring, accident management, design against incidents and accident planning values are regulated.

Dose limits for nuclear installations

In Germany the limit for the effective dose to members of the public resulting from practices is 1 mSv per calendar year (§ 46 StrlSchV). This limit applies to all practices from which an individual is exposed. The dose limit is set in accordance with both the recommendations of the International Commission on Radiological Protection (ICRP) and the EU Basic Safety Standards Directive 96/29 EURATOM.

Dose limits for the exposures resulting from discharges and emissions of nuclear installations are specified in § 47 StrlSchV.

1. Effective dose	0.3 mSv per calendar year
2. Organ dose for gonads, uterus, bone marrow (red)	0.3 mSv per calendar year
3. Organ dose for colon, lungs, stomach, bladder, breast, liver, oesophagus, thyroid, other organs or tissues unless specified in 2. or 4.	0.9 mSv per calendar year
4. Organ dose for bone surface, skin	1.8 mSv per calendar year

The dose limits apply separately for discharges and emissions. Discharges and emissions from other nuclear installations must be taken into acount.

Annual Limits for Discharges and Emissions and the Radiation Exposure of Members of the Public

The annual limits for the discharges and emissions of a nuclear facility are specified in such a way that the dose limits of § 47 StrlSchV which are listed above are not exceeded during normal operation and decommissioning. The models, their parameter values and additional assumptions are described in the General Administrative Provision (AVV) to § 47 StrlSchV. The dose to members of the public is calculated under the assumptions that the individual permanently stays at the most unfavourable location and exclusively consumes foodstuffs produced at another most unfavourable location. AVV to § 47 StrlSchV defines, *inter alia:*

- Transfer parameters (transfer factors, concentration ratios etc.) quantifying the transport of radionuclides into foodstuffs, including human milk and sediment,
- Procedures for calculation of activity concentrations of radionuclides in air, soil, freshwater, foodstuffs, including human milk and sediment,
- Consumption rates for six age groups for all relevant categories of foodstuff including drinking water and human milk,
- Dose coefficients and dose rate coefficients for internal and external exposure for organs and effective dose, and
- Exposure pathways to be considered for the six age groups for the calculation of internal and external radiation exposure.

The dose coefficients for internal exposure are taken from the relevant ICRP publications and the EU Basic Safety Standards Directive 96/29 EURATOM.

The Federal Office for Radiation Protection (BfS) calculates the annual radiation exposure of members of the general public for all nuclear facilities in Germany. These calculations are based on discharge and emission data measured by the operators, the actual meteorological conditions applying the models, parameter values and assumptions of the AVV to § 47 StrlSchV as described above. The calculated doses should be considered as upper limits of the actual exposure, a consequence of the conservative character of the AVV to § 47 StrlSchV.

Regulatory Guidelines

Guideline on Emission and Environmental Monitoring (Richtlinie zur Emissions- und Immissionsüberwachung, REI)

The Guideline on Emission and Environmental Monitoring (REI) specifies the requirements for discharge and emission monitoring and contains mandatory measurement programmes. The general part of the guideline explains the objectives and the basics of discharge, emission and environmental monitoring as well as the requirements applicable to all nuclear installations. The specific measurement programmes according to the type of the nuclear installation are compiled in the appendices. The discharge and emission monitoring programme specified in the regulatory guideline REI is carried out by the operator of the nuclear facility under his own responsibility. The measurement results are then submitted to the national authority.

Monitoring of radioactive discharges and emissions from nuclear power plants

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 discharges and emissions. Safety standard KTA 1503.1 deals with monitoring the emission 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. In addition to the monitoring equipment of the licensee there are also special equipment belonging to the competent authority, e. g. within the exhaust stack, that enable a remote and independent monitoring by the supervisory authority via KFÜ (Remote Monitoring System for Nuclear Power Plants) data network. Furthermore the balancing measurements by the licensee of the weekly, monthly, quarterly and yearly water and air samples are regularly checked by an independent organisation. The amount of control measurements for gamma-, alpha- and beta-emitters are clearly defined in REI. A brief overview to the regulations for the monitoring of radioactive discharges and emissions from nuclear facilities is presented in **figure 2**.

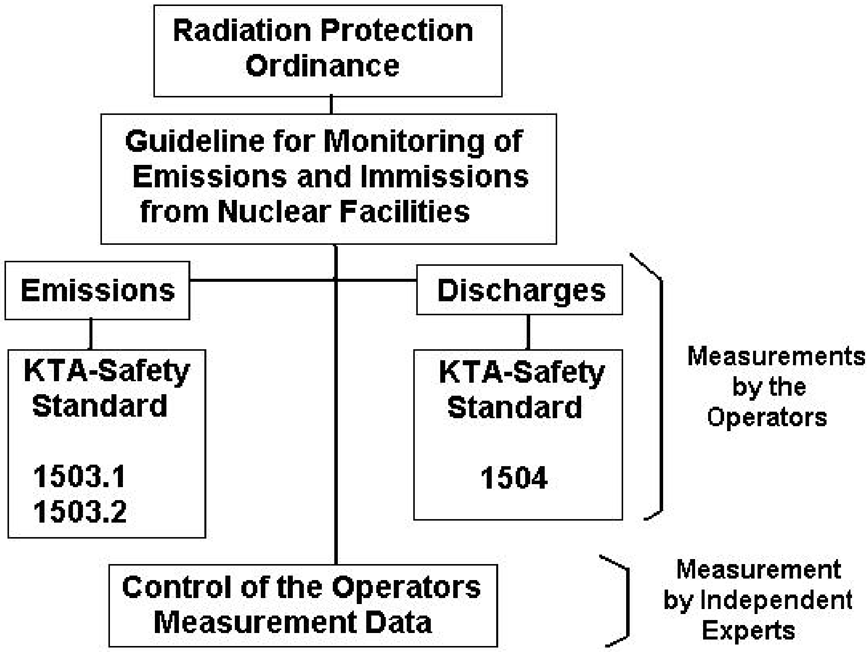

Figure 2 Regulations for the monitoring of radioactive discharges and emissions

Monitoring of radioactive discharges and emissions from the nuclear power plants to the surveillance

The environmental monitoring programme of nuclear power plants, nuclear fuel fabrication plants and facilities for interim storage and final disposal of nuclear fuel are specified in the appendices of REI. These programmes are carried out prior to commissioning and during operation conditions both by licensee and by the independent organisation. In order to be able to detect an increase of radioactivity with respect to the natural background in the vicinity of nuclear installations, a measurement of background radiation is required for a two-year period prior to commissioning. The extent of this programme depends on the measurements to be performed during operating conditions. In addition REI specifies at what time and to what extent which monitoring measures can be discontinued and which must continue to be performed after a final shutdown of the nuclear facility. The required surveillance programmes must take every exposure path into consideration that could lead to a radiation exposure of a human being. The samples and measurements are defined in such a way that all relevant dose contributions from direct irradiation, inhalation and ingestion are covered during operating conditions and design basis accidents or severe accidents.

The radiation measurement programme is performed under the authority of the licensee. The majority of these programme are discontinuous measurements on samples taken over more or less extended time periods. A continuous surveillance of actual plant parameters is performed with KFÜ. In that case, selected measured variables asured variables from

- operation,
- monitoring of emissions,
- monitoring of environmental concentrations of radionuclides and
- meteorology

are permanently transmitted online to the competent supervisory authority of the Federal State (*Bundesland*).

In addition to the site-oriented surveillance and monitoring of nuclear power plants described above, a nationwide system, commonly known as Integrated Measurement and Information System (IMIS) was installed in accordance with the Precautionary Radiation Protection Act (Strahlenschutzvorsorgegesetz, StrVG) for monitoring environmental radioactivity. IMIS, which is operated by the BfS, permanently monitors the radioactivity in all important environmental media in the whole territory 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.

Safety Standards, KTA

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)”. In special, the safety standard series KTA 3601-3606 contain 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 “Surveillance of the discharge of gaseous and particulate bound radioactive substances”, KTA 1504 “Surveillance of the discharge of liquid radioactive substances” and KTA 1507 “Surveillance of the discharge of radioactive substances from research reactors” give instructions on discharge and emission monitoring, which specify type of sampling, sample treatment, time periods of sampling, radionuclides considered, detection limits, reporting, etc.

Conventional technical standards, DIN

Furthermore conventional technical standards, in particular the national standards of the German Institute for Standardisation (DIN) and also the international standards of ISO and IEC, are applied just as they are in the design and operation of all technical installation, as far as the conventional standards correspond to the state of the art in science and technology. DIN EN 1822-1, for example, requires the use of aerosol filters with a minimum retention factor of 99.97 % (Class H12).

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

2.2 National authority responsible for supervision of discharges and emissions

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

2.3 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 their own laboratories. All the samples will be analysed in accordance to the procedure manuel for monitoring of radioactive substances in the environment and external radiation (“Messanleitungen für die Überwachung radioaktiver Stoffe in der Umwelt und externer Strahlung”) published by the Federal Ministry of Environment, Nature Conservation and Nuclear Safety.

To ensure a high quality standard of the operators’ measurements, the guideline “Kontrolle der Eigenüberwachung von kerntechnischen Anlagen” was issued by the state authority. This guideline lists the measurements which has to be performed by independent experts, preferably by an official institution, as the

Federal Office for Radiation Protection (BfS). The guideline in special is classified in three major sections, which include:

- the routine measurement program,
- intercomparison measurements during the operation starting phase and
- quality control by round-robin tests.

The procedures of the routine measuring program and intercomparison measurements for quality assurance are essentially identical with the measurements required by KTA 1503.1 and KTA 1504. 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.

2.4 National reporting

The results of measured and balanced discharges and emissions determined by the operators of the nuclear facilities are reported to the national authority and are published by the Ministry of Environment, Nature Conservation and Nuclear Safety in the report “Environmental Radioactivity and Radiation Exposure” (“Umweltradioaktivität und Strahlenbelastung”). The radionuclides to be considered, the detection limits as well as the sampling and reporting period are summarised in **table 1** for the discharges and in **table 2** for the emissions.

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	detection limit	Sampling time	Reporting
γ-radionuclides	$1 \cdot 10^3$ Bq·m^{-3} (Co-60)	week	monthly
H-3	$4 \cdot 10^4$ Bq·m^{-3}	month	quarterly
Sr-89/Sr-90	$5 \cdot 10^2$ Bq·m^{-3}	3 months	quarterly
Total-α-activity	$2 \cdot 10^2$ Bq·m^{-3}	3 months	quarterly
Fe-55	$2 \cdot 10^3$ Bq·m^{-3}	year	annually
Ni-63	$2 \cdot 10^3$ Bq·m^{-3}	year	annually

Table 2 Reporting of emissions to the national authorities based on analyses of air samples (gaseous and particulate)

Radionuclides	detection limit	Sampling time	Reporting
radioactive noble gases	$5{\cdot}10^{2}$ Bq·m^{-3} (Xe-133) $1{\cdot}10^{4}$ Bq·m^{-3} (Kr-85)	24 hours	quaterly
radioactive iodine	$2{\cdot}10^{-2}$ Bq·m^{-3} (I-131)	week	quaterly
radioactive particulates	$3{\cdot}10^{-2}$ Bq·m^{-3} (Cs-137)	week	quaterly
α-radionuclides	$5{\cdot}10^{-3}$ Bq·m^{-3} (Am-241)	3 months	quaterly
Sr-89/Sr-90	$1{\cdot}10^{-3}$ Bq·m^{-3}	3 months	quaterly
H-3	$1{\cdot}10^{2}$ Bq·m^{-3}	3 months	quaterly
C-14	$1{\cdot}10^{9}$ Bq / quarter	3 months	quaterly

2.5 International reporting

Germany submits annually to EURATOM the discharges and emissions and to OSPAR the discharges from nuclear installations based on Article 35 of the EURATOM Treaty and of the OSPAR convention, respectively.

2.6 Summary

According to the application of BAT / BEP to nuclear facilities, the aims of all the mentioned legislations are

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

3 Nuclear Power Plants (NPP)

The nuclear power stations currently supply about 25 % of Germany's electrical energy consumption. The nuclear power stations which are in the OSPAR catchment are shown in **figure 3**. There are thirteen operational nuclear power plants, ten of which are pressurised water reactors and three are boiling water reactors. Furthermore there are seven power plants which have been already shutdown and are now in various stages of decommissioning.

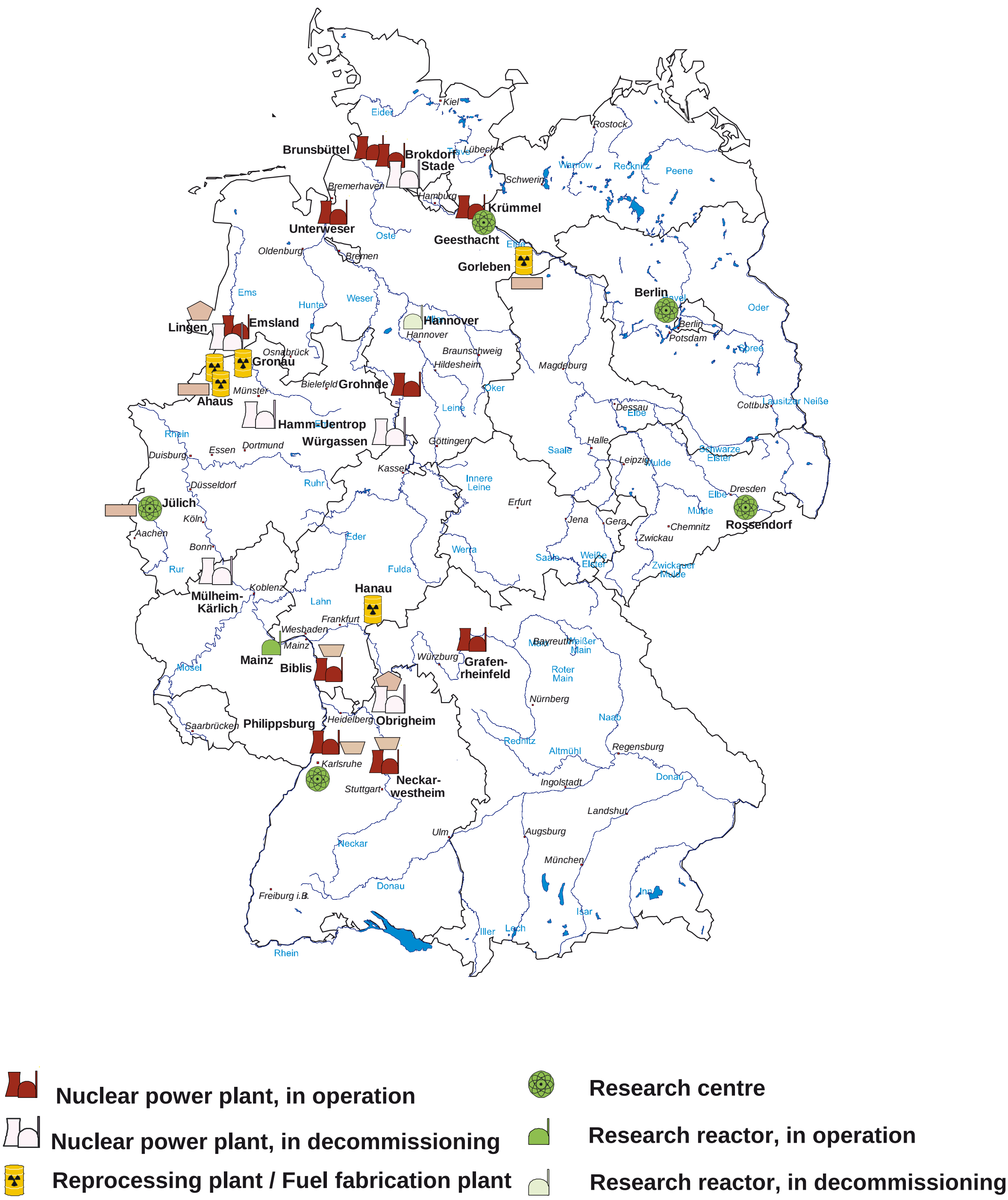

Figure 3 German nuclear facilities which are in the OSPAR catchment

The discharge and emission data are given for the operational and for the shutdown nuclear power plants in accordance with the BAT Guidelines in **Annex 1**. For each installation the information is documented in tabular form:

- the name of the site,
- the type of facility,
- the location,
- the year of commissioning,
- the year of shut down (if applicable),
- the year of decommissioning (if applicable),
- the annual electric power generation of power reactors,
- the discharges and emissions,
- the dose to members of the public and
- the waste management (provided by the operators).

Remark: for the determination of the effective dose, all radionuclides discharged to the environment are considered

3.1 Sources of liquid effluent

The main sources of radioactive discharges are the 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

The liquid effluent treatment is given in Annex 1.

3.3 Nuclide libraries

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

3.4 Environmental impact

The environmental program in the vicinity of nuclear power stations is described in REI. The analyses of environmental samples (river water, plants, milk, meat, fish, soil) show that there are no detectable alpha- and beta-activity concentrations (excluding tritium) referring to radioactive discharges from the nuclear power plants. The environmental annual measurement data are documented in "Environmental Radioactivity and Radiation Exposure" published annualy by the German Ministry of Environment, Nature Conservation and Nuclear Safety.

3.5 Trends in discharges and emissions in the period from 2003 to 2008 and evaluation

Discharges and Emissions

Most of the nuclear power plants have been operating continuously throughout this period, hence the releases have been nearly constant (see **figures 4 to 7** releases from boiling water reactors and **figures 8 to 11** releases from pressurised water reactors).

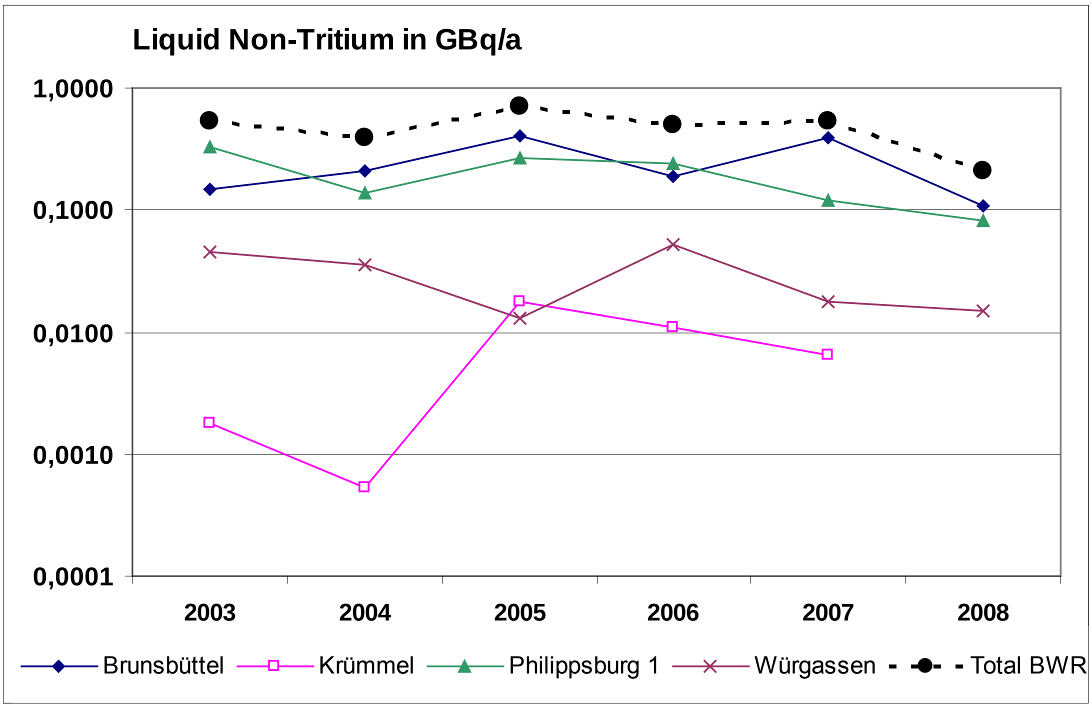

Figure 4 Discharges of liquid Non-Tritium from German boiling water reactors

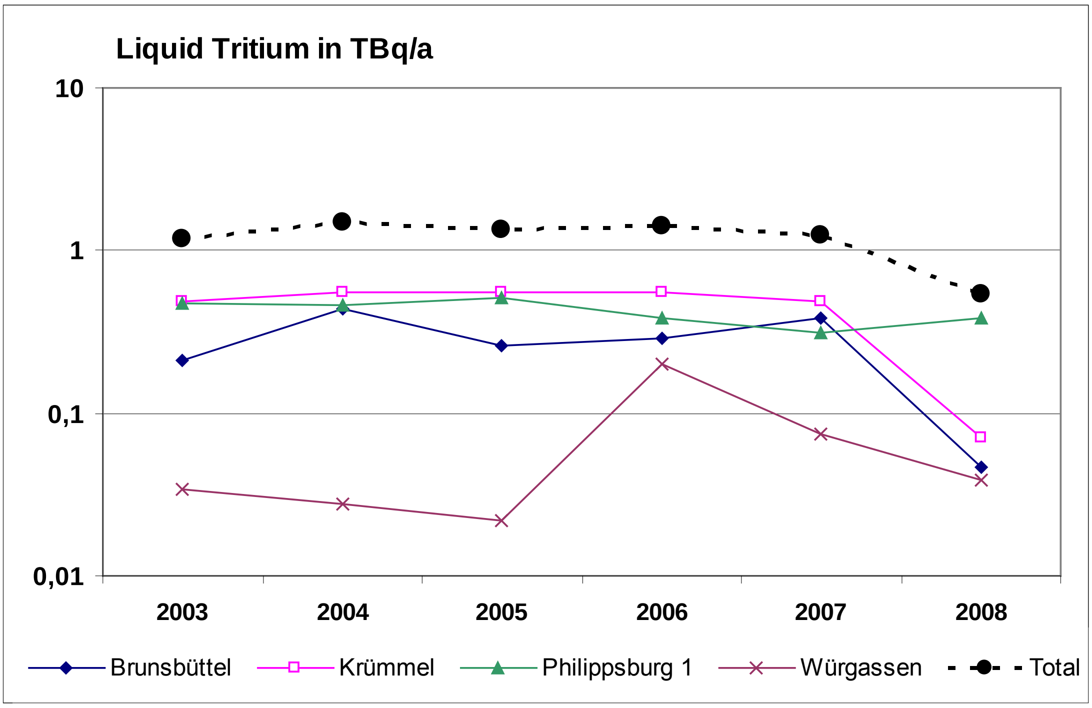

Figure 5 Discharges of Tritium from German boiling water reactors

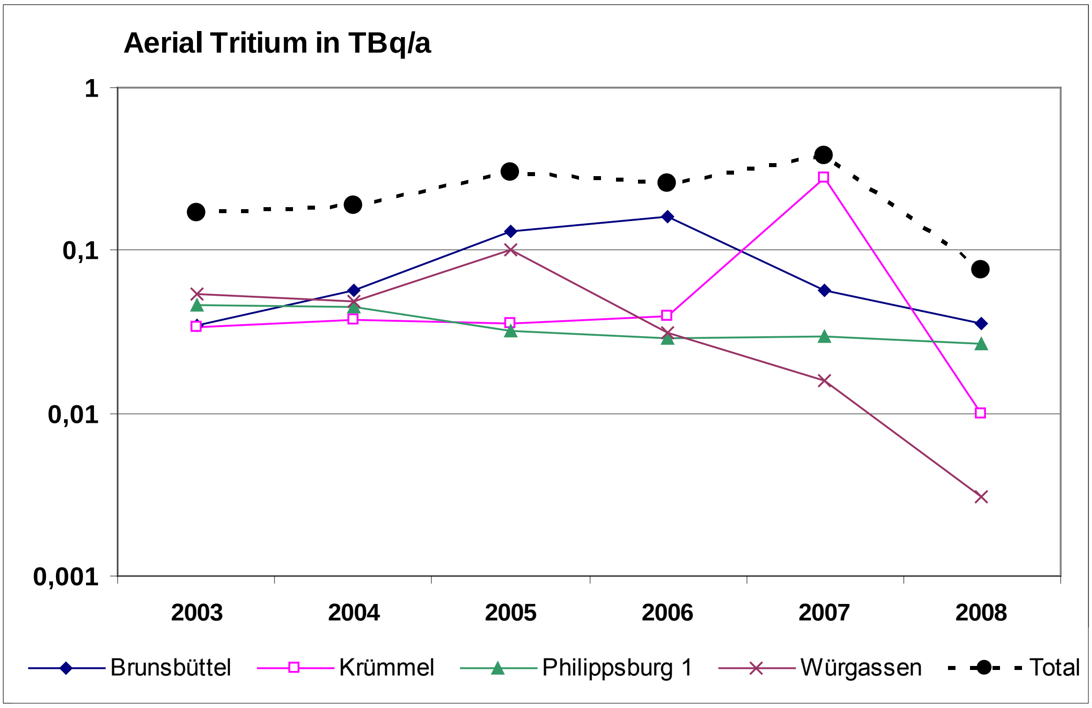

Figure 6 Emissions of Tritium from German boiling water reactors

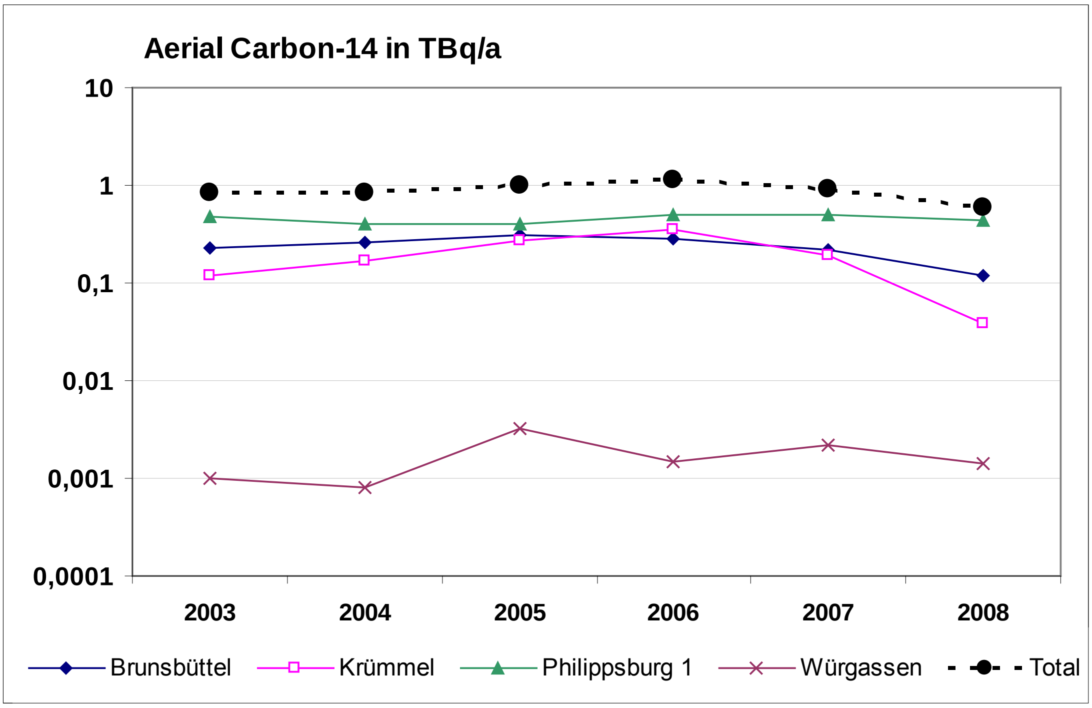

Figure 7 Emissions of Carbon-14 from German boiling water reactors

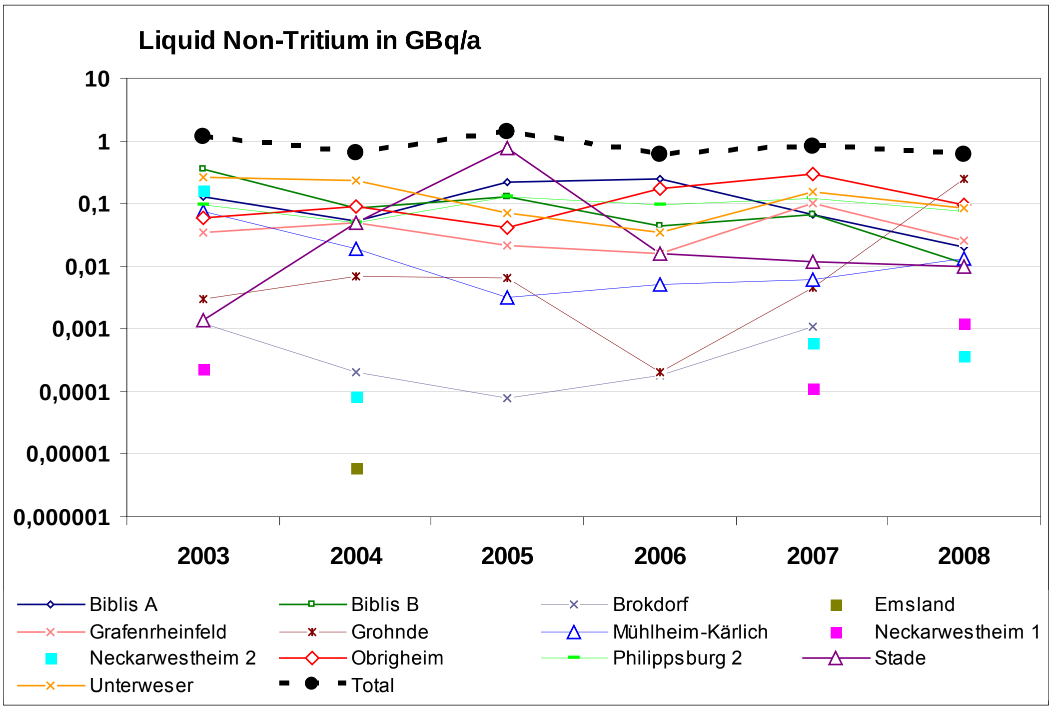

Figure 8 Discharges of liquid Non-Tritium from German pressurised water reactors

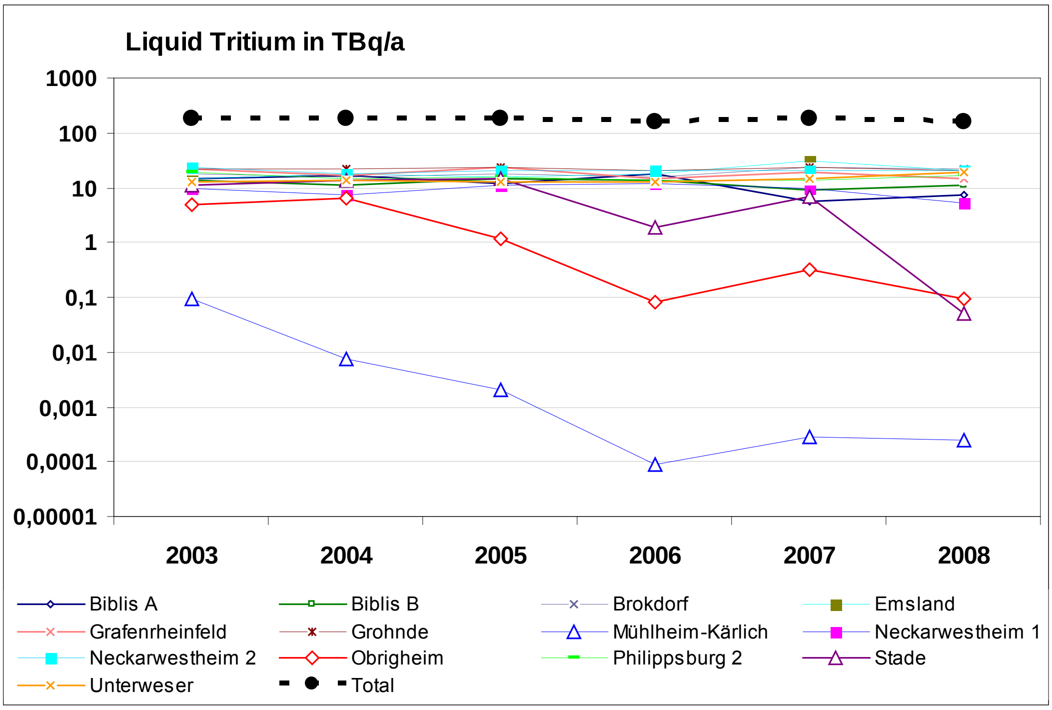

Figure 9 Discharges of Tritium from German pressurised water reactors

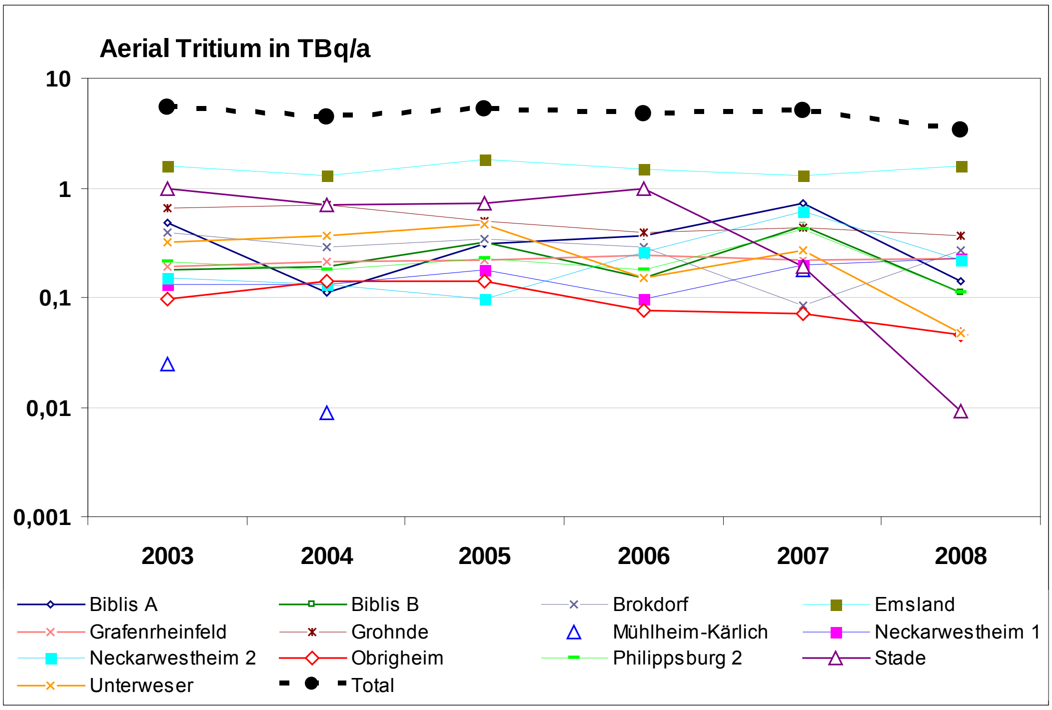

Figure 10 Emission of Tritium from German pressurised water reactors

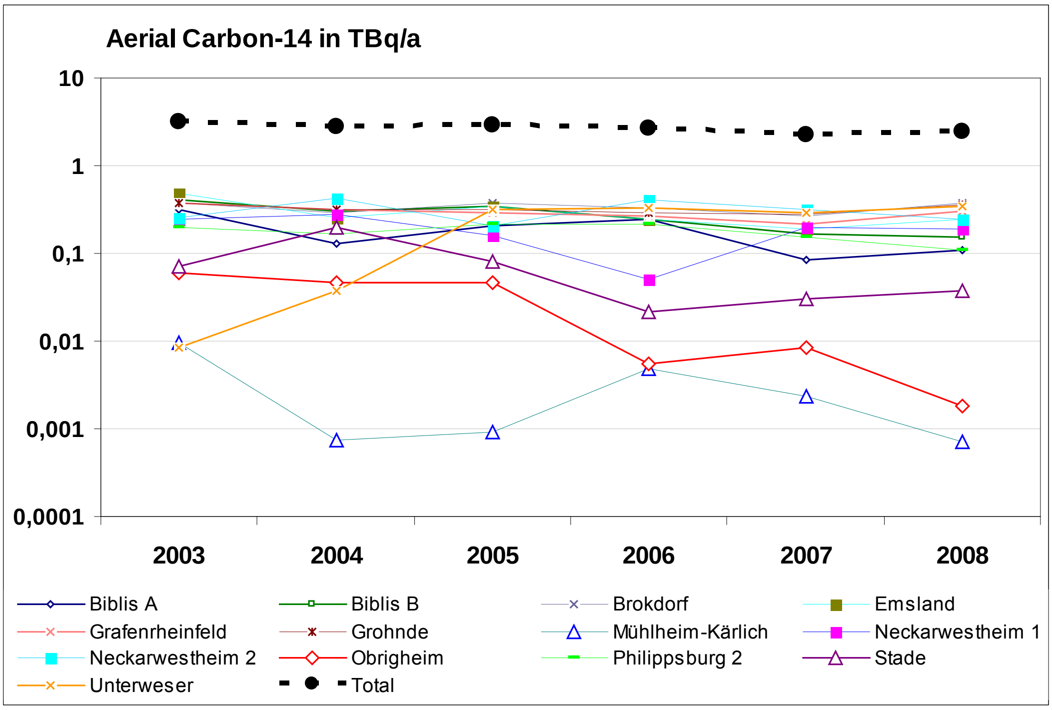

Figure 11 Emission of Carbon-14 from German pressurised water reactors

Normalised Discharges and Emissions

Normalised releases have been compiled annually for each nuclear power plant by calculating the amount of discharges and emissions per net electrical output. These normalised discharges and emissions can be compared to the mean value for all nuclear power plants of the same type published by UNSCEAR 2000. The ranges corresponding to a factor of ten around the mean values based on the data of the period from 1990 to 1997 are given in **table 3**. In **figures 12 to 19** the normalised discharge and emission data are plotted and compared to the UNSCEAR values.

Table 3 UNSCEAR ranges of normalised releases (period from 1990 to 1997)

	UNSCEAR ranges of normalised releases (period from 1990 to 1997)	
	Boiling water reactor (BWR)	Pressurised water reactor (PWR)
Liquid Non-Tritium, GBq/GWa	8.5 - 85	4.3 – 43
Liquid Tritium, TBq/GWa	0.29 – 2.9	6.5 - 65
Aerial Tritium, TBq/GWa	0.28 – 2.8	0.74 – 7.4
Aerial Carbon-14, TBq/GWa	0.081 – 0.81	0.35 – 3.5

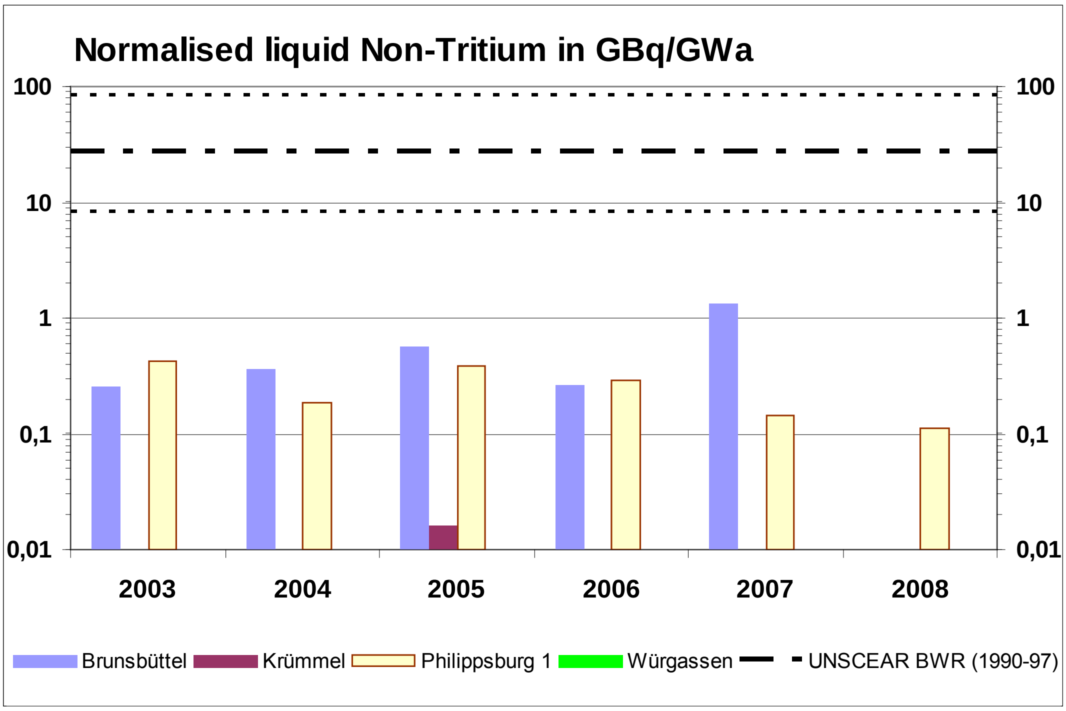

Figure 12 Liquid Non-Tritium data normalised to the net electrical output on an annual basis and comparison to the UNSCEAR values for BWR listed in **table 3**.

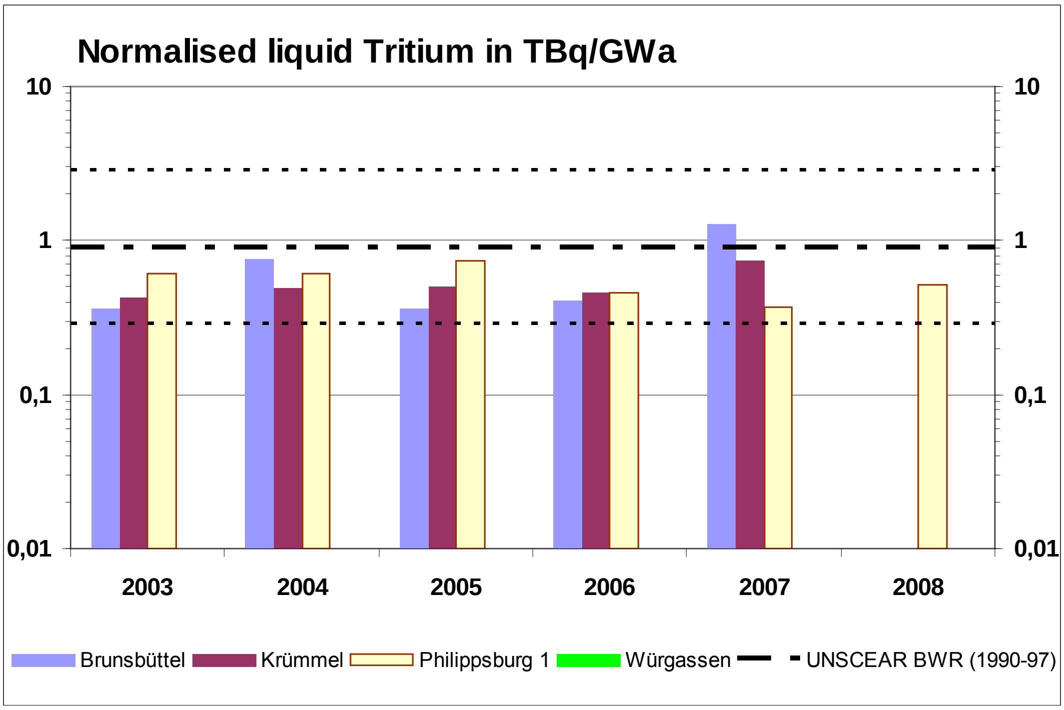

Figure 13 Liquid Tritium data normalised to the net electrical output on an annual basis and comparison to the UNSCEAR values for BWR listed in **table 3**.

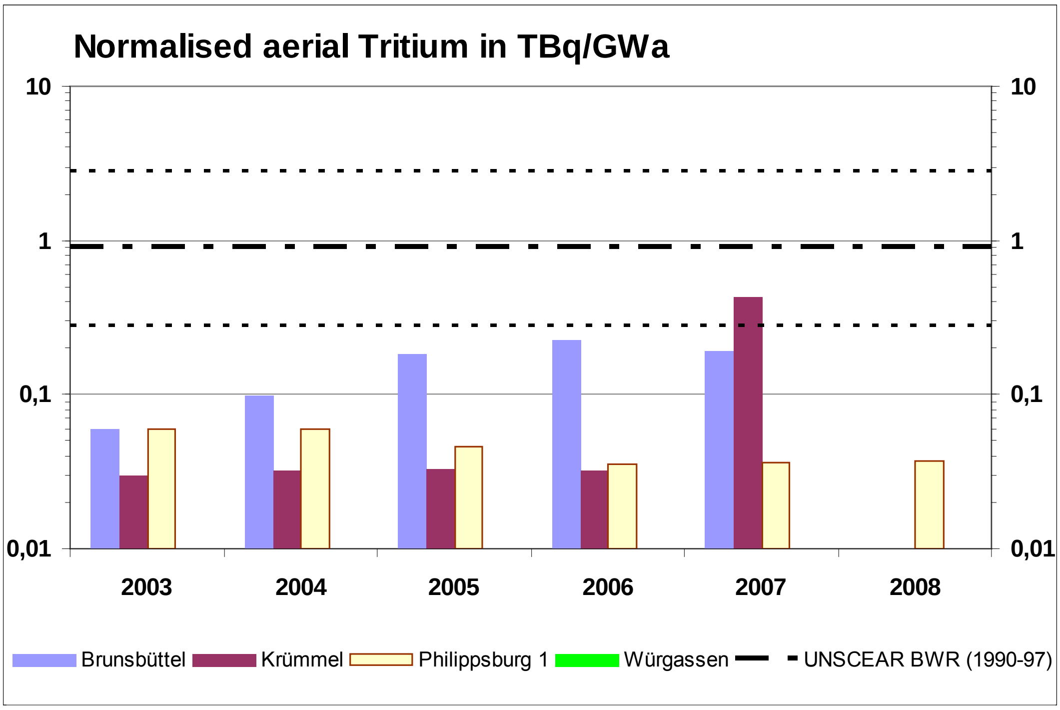

Figure 14 Aerial Tritium data normalised to the net electrical output on an annual basis and comparison to the UNSCEAR values for BWR listed in **table 3**.

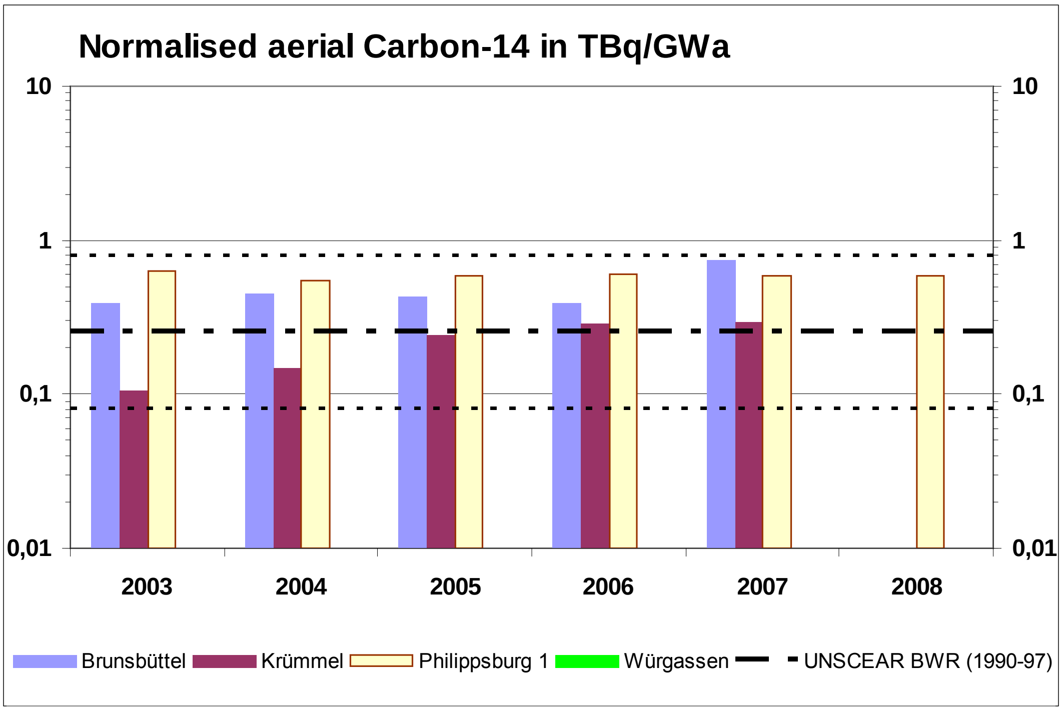

Figure 15 Aerial Carbon-14 data normalised to the net electrical output on an annual basis and comparison to the UNSCEAR values for BWR listed in **table 3**.

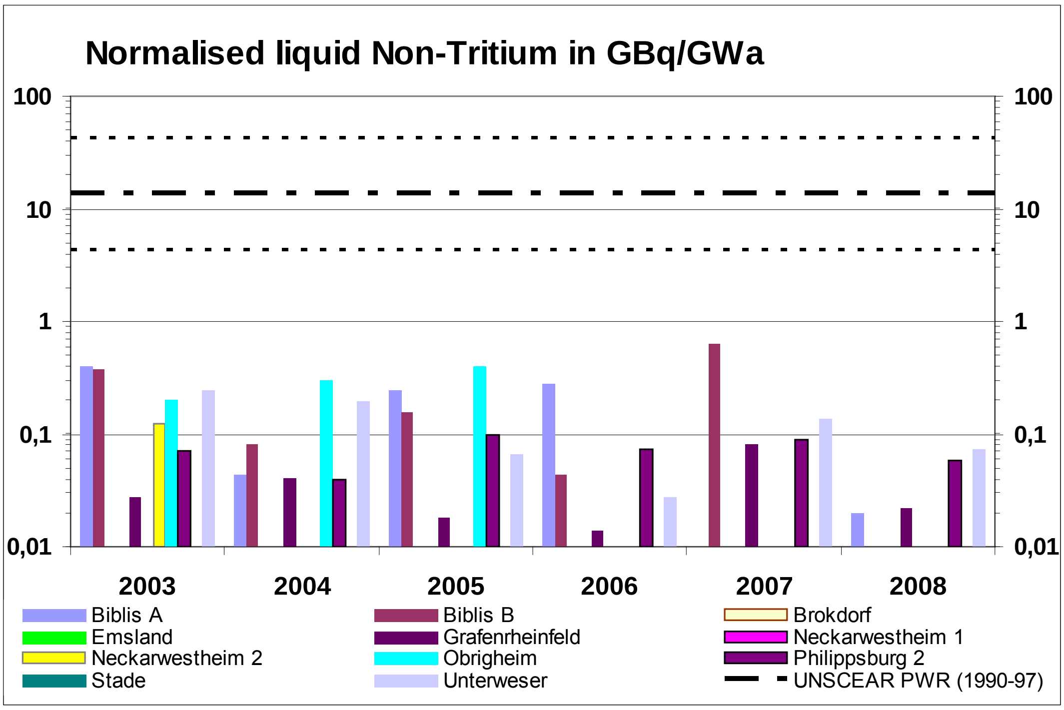

Figure 16 Liquid Non-Tritium data normalised to the net electrical output on an annual basis and comparison to the UNSCEAR values for PWR listed in **table 3**.

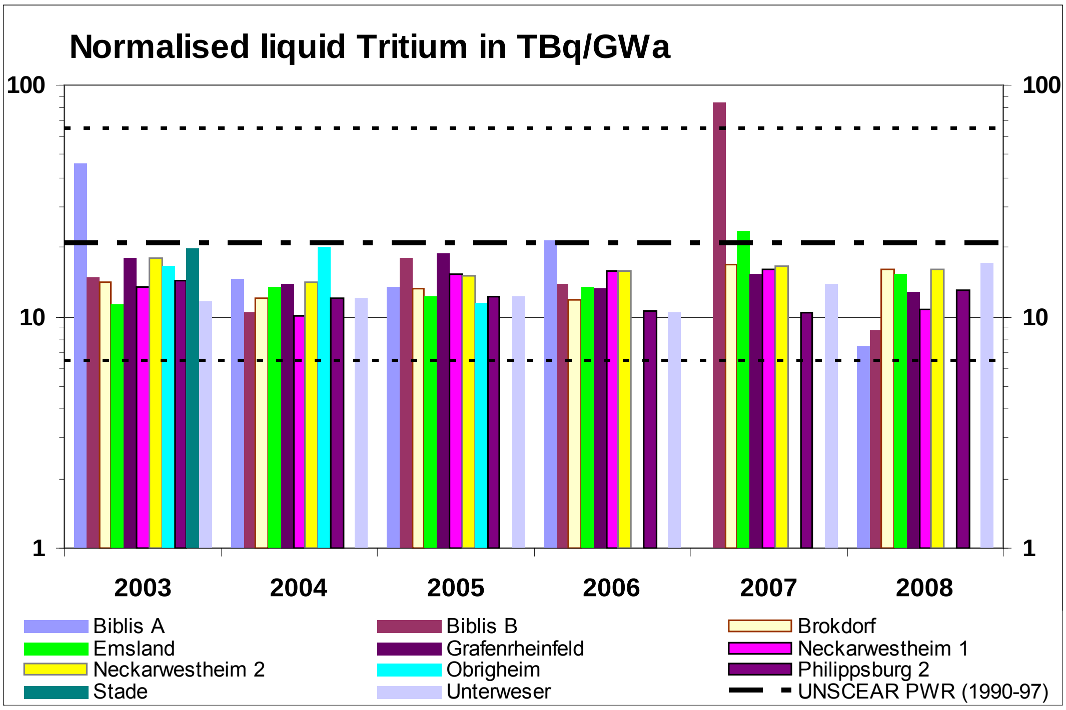

Figure 17 Liquid Tritium data normalised to the net electrical output on an annual basis and comparison to the UNSCEAR values for PWR listed in **table 3**.

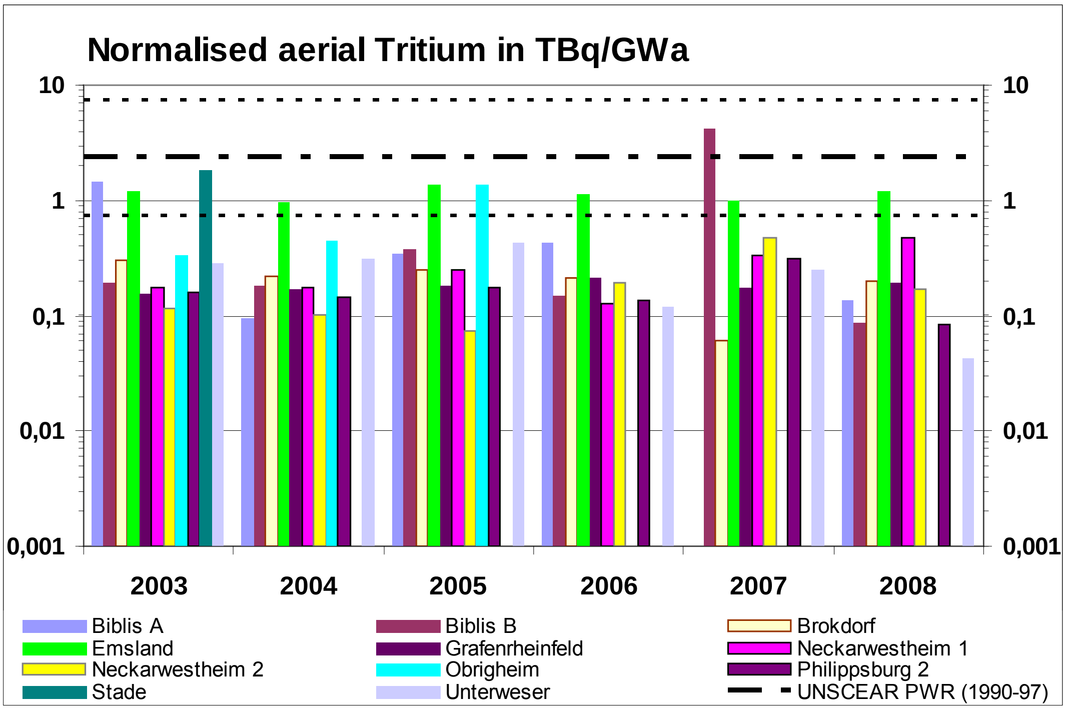

Figure 18 Aerial Tritium data normalised to the net electrical output on an annual basis and comparison to the UNSCEAR values for PWR listed in **table 3**.

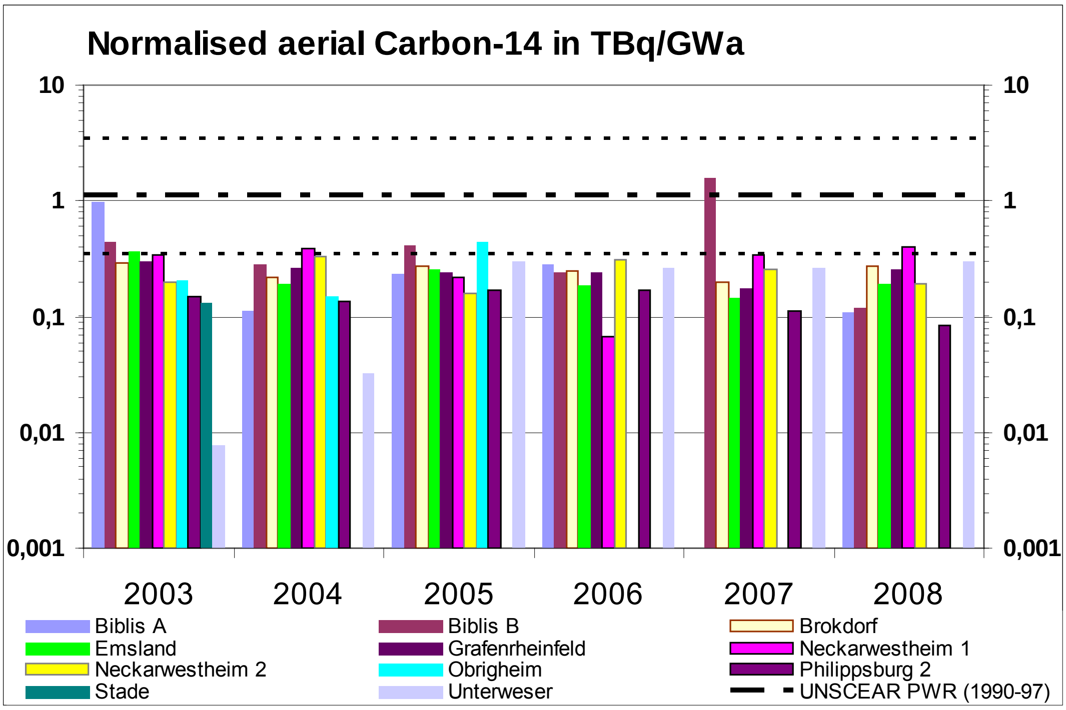

Figure 19 Aerial Carbon-14 data normalised to the net electrical output on an annual basis and comparison to the UNSCEAR values for PWR listed in **table 3**.

The comparision of the normalised discharges and emissions from German nuclear power plants to the normalised releases given by UNSCEAR (**table 3)** shows that:

- Normalised Non-Tritium discharges from BWR and PWR are **far below** the ranges of UNSCEAR.
- Normalised Tritium discharges from BWR and PWR are within the UNSCEAR ranges and in general **below the mean value of UNSCEAR**.
- Normalised Tritium emissions from BWR and PWR are in general **below the ranges of UNSCEAR.**
- Normalised Carbon-14 emisssions from PWR are in general **below the ranges of UNSCEAR**.
- Normalised Carbon-14 emisssions from BWR are slightly higher than the **mean value of UNSCEAR**.

Remark: The slightly higher normalised values of Biblis A in the year 2003, of Biblis B in the year 2007 and of Brunsbüttel in the year 2007 are due to the low ratio of actual output to capacity of 0.27, 0.08 and 0.37. These three power plants had been in a longer period of revision with additional sources of discharges and emissions.

The **dose criterion** is the most important evaluation tool, and applicable to all nuclear installations. Calculations made under conservative assumptions as descriped in **Chapter 2** show that the maximum effective annual dose rates to the population in the vicinity of all nuclear installations are well below the national limit of 0.3 mSv/a (see **figures 20** and **21**).

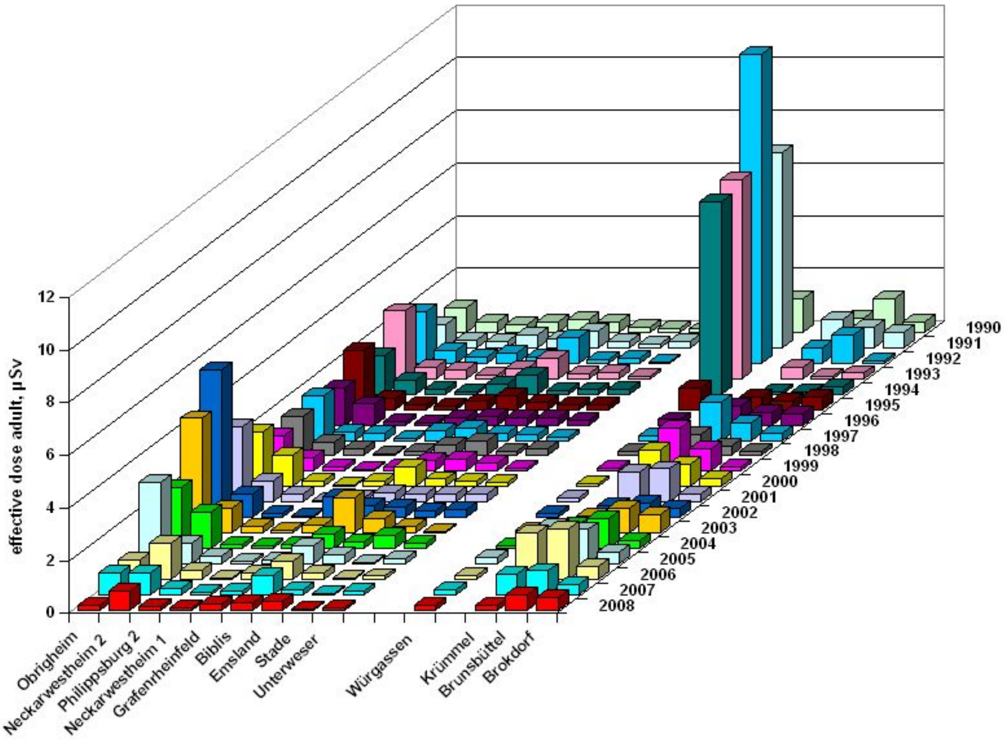

Figure 20 Calculated annual effective dose rates for adults due to the emissions of radionuclides from nuclear power plants (pathway air)

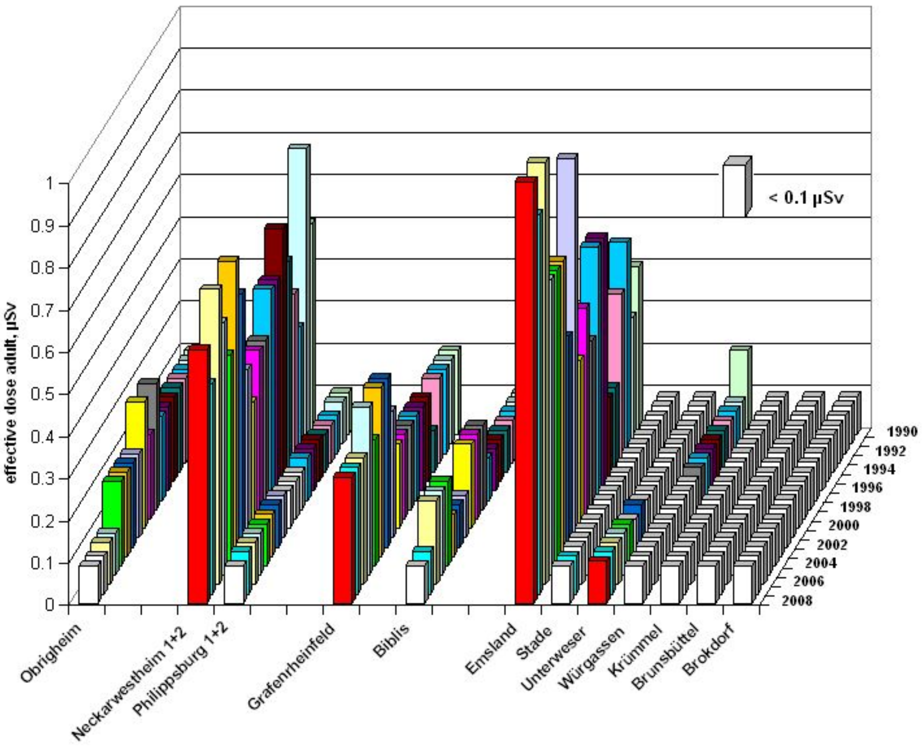

Figure 21 Calculated annual effective dose rates for adults due to the discharges of radio-nuclides from nuclear power plants (pathway water)

The low levels of radioactivity discharges and emissions from all nuclear power stations and low levels of radiation exposure in general show the high standards of technology in Germany.

4. Nuclear fuel fabrication and enrichment plants

Uranium enrichment is carried out at **URENCO's Gronau site** (see **figure 3**). For the enrichment the technology of gas centrifuges is used. The total alpha-activity yearly discharged by waste water is very low with the highest value of 0.015 MBq (2 % of the authorised annual limit for Gronau) in 2003. An impact on the environment can not be detected. The calculated annual effective dose rate for a "reference person" in the vicinity of the enrichment plant due to discharges and emissions is less than 0.1 µSv/a.

The **Advanced Nuclear Fuels GmbH** operates the facility in **Lingen** (see **figure 3**), 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 production processes. Radioactive discharges into environment are below the individual detection limits. The calculated annual effective dose rate for a "reference person" in the vicinity of the enrichment plant due to discharges and emissions is less than 0.1 µSv.

The nuclear fuel fabrications plants in **Hanau** (see **figure 3**) have been shut down in 1996. In the last years buildings and production areas were decontaminated. All facilities in Hanau were decomissioned until 2006 and released from the Atomic Energy Act. The calculated annual effective dose rate for a "reference person" in the vicinity of the enrichment plant from 2003 to 2005 due to discharges and emissions is less than 0.1 µSv/a.

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

- the name of the site,
- the type of facility,
- the location,
- the quantity of processed uranium in nuclear fuel fabrication plants,
- the year of commissioning,
- the year of shut down (if applicable),
- the year of decommissioning (if applicable),
- the discharges and emissions,
- the dose to members of the public, and
- the waste management (provided by the operators).

4.1 Sources of liquid effluent

The sources of liquid effluent are given in **Annex 2.**

4.2 Liquid effluent treatment

The liquid effluent treatment is given in **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 alpha- and beta-activity concentrations referring to radioactive discharges from nuclear fuel fabrication plants. The environmental annual measurement data are documented in "Environmental

Radioactivity and Radiation Exposure" published annualy by the German Ministry of Environment, Nature Conservation and Nuclear Safety.

4.4 Trends in discharges and emissions in the period from 2003 to 2008 and evaluation

For Hanau und Gronau there is a clear downward trend in the alpha discharges in liquid effluent since 2003. The alpha discharge level of Gronau from 2004 to 2008 is very low and constant. The alpha activity in discharges and emissions from Lingen are below the detection limit for the whole implementation period.

5. Research and Development Facilities

There are five sites of research and development facilities in Germany (see **figure 3**) described as former nuclear research centres. The facilities at these sites carry out scientific and commercial program in the nuclear field. In Berlin, Geesthacht and Jülich are reactors with thermal capacity of 5 MW, 10 MW and 23 MW, respectively. The reactors in Karlsruhe and Rossendorf have been shut down and are currently undergoing decommissioning. All five facilities are located at an inland site.

The highest annual effective dose rate of 23 µSv in the year 2004 for the pathway water was calculated for a “reference person” in the vicinity of Rossendorf. The calculated annual effective dose rate in the vicinity of all other research centres are less than 1 µSv. Activity concentrations in non human biota caused by radioactive discharges from the facilities are below the individual detection limits.

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

- the name of the site,
- the type of facility,
- the location,
- the thermal power of reactors in research facilities,
- the year of commissioning,
- the year of shut down (if applicable),
- the year of decommissioning (if applicable),
- the discharges and emissions,
- the dose to members of the public and
- the waste management (provided by the operators).

5.1 Sources of liquid effluent

The sources of liquid effluent are given in **Annex 3**.

5.2 Liquid effluent treatment

The liquid effluent treatment is given in **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, Berlin and Rossendorf show that there are no detectable alpha- and beta-activity concentrations referring to radioactive discharges from these facilities. The environmental annual measurement data are documented in "Environmental Radioactivity and Radiation Exposure" published annually by the German Ministry of Environment, Nature Conservation and Nuclear Safety.

5.4 Trends in discharges and emissions in the period from 2003 to 2008 and evaluation

The sum of total beta excluding tritium and of tritium discharged from the five research and development facilities in Germany are clearly lower (only a few percent) than the discharges from the pressurized nuclear power plants in Germany. Furthermore, there is no trend in discharges and emissions from the research and development facilities in Germany in the time period from 2003 to 2008.

6. Conclusion

- Low levels of radioactive discharges and emissions from all nuclear facilities in Germany
- Low levels of radioactive exposure

⇒ Best available technologies are applied in Germany

Annex 1

Nuclear Power Plants

1. Site Characteristics

Name of facility	**Biblis A**
Type of facility	PWR
Year of commissioning	1974
Location	Germany
Receiving water	Rhine

	2003	2004	2005	2006	2007	2008
Installed electrical generation capacity, MW(e)	1225					
actual output, MWa	326	1166	890	848	0	1023

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
Cr-51						
Mn-54						
Co-57						
Co-58	5.5E+05	3.7E+05	4.6E+06	3.2E+06	7.5E+04	
Co-60	4.8E+07	2.2E+07	4.3E+07	4.9E+07	1.9E+07	7.2E+06
Fe-55	6.1E+06			1.1E+07		
Fe-59						
Ni-63						
Zn-65						
Sr-89						
Sr-90						
Zr-95						
Nb-95						
Ru-103						
Ru-106						
Ag-110m		3.7E+05	8.9E+05	1.7E+07	2.3E+06	7.5E+05
Te-123m	2.5E+07	1.0E+07	3.4E+07	5.6E+07	2.5E+07	2.4E+06
Sb-124	2.4E+07	8.9E+06	5.0E+07	2.0E+07	7.8E+06	
Sb-125	1.2E+07	5.9E+06	1.6E+07	1.5E+07	9.5E+06	7.3E+06
I-131	1.7E+05	4.2E+05	3.5E+06	1.5E+07		1.9E+05
Cs-134	9.8E+05			4.3E+06	7.1E+05	2.9E+04
Cs-137	1.4E+07	2.7E+06	2.5E+06	7.7E+06	3.3E+06	1.8E+06
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides	2.4E+06		6.7E+07	4.5E+07		
Total activity excluding H-3	1.3E+08	5.1E+07	2.2E+08	2.4E+08	6.7E+07	2.0E+07

	2003	2004	2005	2006	2007	2008
Total activity excluding H-3	1.3E+08	5.1E+07	2.2E+08	2.4E+08	6.7E+07	2.0E+07
Authorised annual limit, Bq/a	1.1E+11					
% of annual limit	0.10	0.05	0.20	0.20	0.10	0.02
Normalised to actual output, GBq/Gwa	0.40	0.04	0.25	0.28		0.02
H-3	1.5E+13	1.7E+13	1.2E+13	1.8E+13	5.5E+12	7.6E+12
Authorised annual limit, Bq/a	3.0E+13					
% of annual limit	50	57	41	59	18	25
Normalised to actual output, TBq/GWa	46.0	14.6	13.5	21.2		7.4
Total Alpha-activity	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
H-3	4.8E+11	1.1E+11	3.1E+11	3.7E+11	7.2E+11	1.4E+11
Normalised to actual output, GBq/GWa	1472	94	348	436		136
C-14	3.2E+11	1.3E+11	2.1E+11	2.4E+11	8.5E+10	1.1E+11
Normalised to actual output, GBq/GWa	982	111	236	283		108

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	0.0002	0.0002	0.0002	0.0001	< 0.0001	0.0001
% of dose limit (0.3 mSv/a)	0.05	0.06	0.06	0.04	< 0.03	0.03
Air-pathway						
Annual effective dose, mSv [1]	0.0010	0.0005	0.0007	0.0007	0.0007	0.0003
% of dose limit (0.3 mSv/a)	0.3	0.2	0.2	0.2	0.2	0.1

[1] including Biblis B

n. d. not detected

4. Origin of waste arising

primary coolant cycle

5. Waste treatment

- filtration;
- ion-exchange procedures.

6. Waste management

a) ***applied procedures 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.

7. Evaluation

a) Non-Tritium discharges are below the range published by UNSCEAR;

Tritium discharges are below the mean value published by UNSCEAR by operation of the power plant at nearly full capacity;

Alpha discharges are below the detection limit.

b) No significant trends identifiable.

c) No particularly high or low values.

1. Site Characteristics

Name of facility	**Biblis B**
Type of facility	PWR
Year of commissioning	1976
Location	Germany
Receiving water	Rhine

	2003	2004	2005	2006	2007	2008
Installed electrical generation capacity, MW(e)	1300					
Actual output, MWa	945	1060	835	1005	107	1253

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
Cr-51						
Mn-54	6.2E+05					
Co-57						
Co-58	6.4E+06	5.4E+06	8.4E+06	2.7E+04	1.6E+05	
Co-60	7.8E+07	1.7E+07	1.5E+07	4.0E+06	4.1E+06	1.6E+06
Fe-55	6.8E+06					
Fe-59						
Ni-63	5.7E+06					
Zn-65						
Sr-89						
Sr-90						
Zr-95						
Nb-95						
Ru-103						
Ru-106	3.4E+06					
Ag-110m	7.4E+05	2.2E+06	1.4E+05	5.4E+04	9.0E+05	
Te-123m	3.7E+07	1.0E+07	3.1E+07	2.2E+07	2.3E+07	2.2E+06
Sb-124	5.6E+07	2.2E+07	3.2E+07	7.4E+06	2.1E+07	
Sb-125	7.4E+07	1.2E+07	3.1E+07	8.8E+06	1.5E+07	6.4E+06
I-131	4.9E+06	2.8E+06		5.4E+04		
Cs-134	8.9E+06		2.4E+05			
Cs-137	7.2E+07	2.3E+06	7.1E+06	6.6E+05	2.8E+06	3.9E+05
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides		1.0E+07	9.6E+05			
Total activity excluding H-3	3.5E+08	8.5E+07	1.3E+08	4.3E+07	6.8E+07	1.1E+07

	2003	2004	2005	2006	2007	2008
Total activity excluding H-3	3.5E+08	8.5E+07	1.3E+08	4.3E+07	6.8E+07	1.1E+07
Authorised annual limit, Bq/a	1.1E+11					
% of annual limit	0.3	0.1	0.1	0.04	0.1	0.01
Normalised to electrical output, GBq/GWa	0.37	0.08	0.16	0.04	0.64	0.01
H-3	1.4E+13	1.1E+13	1.5E+13	1.4E+13	9.0E+12	1.1E+13
Authorised annual limit, Bq/a	3.0E+13					
% of annual limit	46	35	50	47	30	36
Normalised to electrical output, TBq/GWa	14.8	10.4	18.0	13.9	84.1	8.8
Total Alpha-activity	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
H-3	1.8E+11	1.9E+11	3.2E+11	1.5E+11	4.5E+11	1.1E+11
Normalised to electrical output, GBq/GWa	190	179	383	149	4205	88
C-14	4.1E+11	3.0E+11	3.5E+11	2.4E+11	1.7E+11	1.5E+11
Normalised to electrical output, GBq/GWa	434	283	419	238	1589	120

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	0.0002	0.0002	0.0002	0.0001	< 0.0001	0.0001
% of dose limit (0.3 mSv/a)	0.05	0.06	0.06	0.04	< 0.03	0.03
Air-pathway						
Annual effective dose, mSv [1]	0.0010	0.0005	0.0007	0.0007	0.0007	0.0003
% of dose limit (0.3 mSv/a)	0.3	0.2	0.2	0.2	0.2	0.1

[1] including Biblis A

n. d. not detected

4. Origin of waste arising

primary coolant cycle

5. Waste treatment

- filtration;
- ion-exchange procedures.

6. Waste management

a) ***applied procedures 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.

7. Evaluation

a) Non-Tritium discharges are below the range published by UNSCEAR;

Tritium discharges are below the mean value published by UNSCEAR by operation of the power plant at nearly full capacity;

Alpha discharges are below the detection limit.

b) No significant trends identifiable.

c) No particularly high or low values.

1. Site Characteristics

Name of facility	**Brokdorf**
Type of facility	PWR
Year of commissioning	1986
Location	Germany
Receiving water	Elbe

	2003	2004	2005	2006	2007	2008
Installed electrical generation capacity, MW(e)			1440			1480
Actual output, MWa	1269	1326	1368	1345	1371	1375

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
Cr-51						
Mn-54						
Co-57						
Co-58					2.5E+04	
Co-60	1.3E+05	1.4E+05				
Fe-55						
Fe-59						
Ni-63						
Zn-65						
Sr-89						
Sr-90						
Zr-95						
Nb-95						
Ru-103						
Ru-106						
Ag-110m						
Te-123m						
Sb-124						
Sb-125						
I-131	3.8E+04					
Cs-134	8.2E+04					
Cs-137	9.3E+05	6.3E+04	7.6E+04	1.8E+05	1.1E+06	
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides						
Total activity excluding H-3	1.2E+06	2.0E+05	7.6E+04	1.8E+05	1.1E+06	n. d.

	2003	2004	2005	2006	2007	2008
Total activity excluding H-3	1.2E+06	2.0E+05	7.6E+04	1.8E+05	1.1E+06	n. d.
Authorised annual limit, Bq/a	5.5E+10					
% of annual limit	0.002	0.0004	0.0001	0.0003	0.002	
Normalised to electrical output, GBq/GWa	0.0009	0.0002	0.0001	0.0001	0.0008	
H-3	1.8E+13	1.6E+13	1.8E+13	1.6E+13	2.3E+13	2.2E+13
Authorised annual limit, Bq/a	3.5E+13					
% of annual limit	53	44	50	46	67	61
Normalised to electrical output, TBq/GWa	14.2	12.1	13.1	11.9	16.8	16.0
Total Alpha-activity	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
H-3	3.9E+11	2.9E+11	3.4E+11	2.9E+11	8.4E+10	2.7E+11
Normalised to electrical output, GBq/GWa	307	219	249	216	61	196
C-14	3.7E+11	2.9E+11	3.7E+11	3.3E+11	2.7E+11	3.8E+11
Normalised to electrical output, GBq/GWa	292	219	270	245	197	276

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
% of dose limit (0.3 mSv/a)	0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Air-pathway						
Annual effective dose, mSv	0.0007	0.0003	0.0004	0.0005	0.0004	0.0005
% of dose limit (0.3 mSv/a)	0.2	0.1	0.1	0.2	0.1	0.2

n. d. not detected

4. Origin of waste arising

primary coolant cycle and attached system

5. Waste treatment

- filtration;
- ion-exchange procedures;
- evaporation;
- combustion;
- collection.

6. Waste management

a) ***applied procedures 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.

7. Evaluation

a) Non-Tritium discharges are far below the range published by UNSCEAR;

Tritium discharges are below the mean value published by UNSCEAR;

Alpha discharges are below the detection limit.

b) No significant trends identifiable.

c) No particularly high or low values.

1. Site Characteristics

Name of facility	**Brunsbüttel**
Type of facility	BWR
Year of commissioning	1976
Location	Germany
Receiving water	Elbe

	2003	2004	2005	2006	2007	2008
Installed electrical generation capacity, MW(e)	806					
Actual output, MWa	582	579	716	711	297	0

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
Cr-51	1.3E+05	4.3E+05	1.9E+05	4.2E+06	3.7E+07	
Mn-54	7.3E+06	1.2E+07	2.2E+07	2.6E+07	6.1E+07	7.1E+06
Co-57						
Co-58	3.0E+05	1.8E+06	6.4E+05	4.3E+06	1.2E+07	4.1E+05
Co-60	4.1E+07	4.2E+07	1.2E+08	6.8E+07	8.0E+07	2.5E+07
Fe-55	7.0E+07	1.1E+08	1.7E+08	1.5E+07	4.6E+07	8.8E+06
Fe-59		3.8E+05	1.0E+05	2.2E+05	1.1E+07	
Ni-63	1.0E+07	1.0E+07	1.2E+07	5.5E+06	1.0E+07	2.4E+06
Zn-65	3.6E+06	1.9E+07	5.6E+07	4.9E+07	1.0E+08	6.3E+07
Sr-89	1.2E+04	5.4E+04		7.4E+04	9.7E+04	
Sr-90	1.3E+05	1.2E+05	1.9E+05	1.3E+05	1.2E+05	4.2E+05
Zr-95				2.3E+04	7.1E+05	
Nb-95			8.7E+04	8.5E+05	2.1E+06	3.3E+03
Ru-103						
Ru-106						
Ag-110m				3.3E+04	1.5E+05	1.1E+05
Te-123m						
Sb-124		4.7E+04			1.3E+06	
Sb-125	2.3E+05		1.1E+05		2.3E+06	
I-131		2.8E+04			2.5E+05	
Cs-134	4.8E+04	3.0E+04	7.0E+04		7.9E+04	
Cs-137	1.3E+07	1.2E+07	2.5E+07	1.6E+07	2.1E+07	3.6E+06
Ba-140						
La-140						
Ce-141		3.6E+04	5.1E+04			
Ce-144						1.2E+05
Other nuclides						
Total activity excluding H-3	1.5E+08	2.1E+08	4.0E+08	1.9E+08	3.9E+08	1.1E+08

	2003	2004	2005	2006	2007	2008
Total activity excluding H-3	1.5E+08	2.1E+08	4.0E+08	1.9E+08	3.9E+08	1.1E+08
Authorised annual limit, Bq/a	1.9E+11					
% of annual limit	0.08	0.1	0.2	0.1	0.2	0.06
Normalised to electrical output, GBq/GWa	0.26	0.36	0.56	0.27	1.31	
H-3	2.1E+11	4.4E+11	2.6E+11	2.9E+11	3.8E+11	4.6E+10
Authorised annual limit, Bq/a	3.7E+13					
% of annual limit	1	1	1	1	1	0.1
Normalised to electrical output, TBq/GWa	0.4	0.8	0.4	0.4	1.3	
Total Alpha-activity	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
H-3	3.5E+10	5.7E+10	1.3E+11	1.6E+11	5.7E+10	3.6E+10
Normalised to electrical output, GBq/GWa	60	98	181	225	192	
C-14	2.3E+11	2.6E+11	3.1E+11	2.8E+11	2.2E+11	1.2E+11
Normalised to electrical output, GBq/GWa	395	449	433	393	741	

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
% of dose limit (0.3 mSv/a)	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Air-pathway						
Annual effective dose, mSv	0.001	0.001	0.001	0.002	0.001	0.0005
% of dose limit (0.3 mSv/a)	0.3	0.3	0.3	0.7	0.3	0.2

n. d. not detected

4. Origin of waste arising

reactor core with water and steam cycles

5. Waste treatment

a) ***waste water***

- centrifugation;
- ion-exchange procedures;
- evaporation;
- cross-flow filtration only for wash water.

b) ***exhaust air***

- HEPA filtration;
- delay lines with retention of short-lived radioactive noble gases;
- filtration and hold-up loop.

6. Waste management

a) ***applied procedures 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.

7. Evaluation

a) Non-Tritium discharges are below the range published by UNSCEAR;

Tritium discharges are below the mean value published by UNSCEAR by operation of the power plant at nearly full capacity;

Alpha discharges are below the detection limit.

b) No significant trends identifiable.

c) No particularly high or low values.

1. Site Characteristics

Name of facility	**Emsland**
Type of facility	PWR
Year of commissioning	1988
Location	Germany
Receiving water	Ems

	2003	**2004**	**2005**	**2006**	**2007**	**2008**
Installed electrical generation capacity, MW(e)	1400					
Actual output, MWa	1337	1343	1311	1343	1324	1312

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
Cr-51						
Mn-54						
Co-57						
Co-58						
Co-60						
Fe-55						
Fe-59						
Ni-63						
Zn-65						
Sr-89						
Sr-90						
Zr-95						
Nb-95						
Ru-103						
Ru-106						
Ag-110m						
Te-123m		6.0E+03				
Sb-124						
Sb-125						
I-131						
Cs-134						
Cs-137						
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides						
Total activity excluding H-3	n. d.	6.0E+03	n. d.	n. d.	n. d.	n. d.

	2003	2004	2005	2006	2007	2008
Total activity excluding H-3	n. d.	6.0E+03	n. d.	n. d.	n. d.	n. d.
Authorised annual limit, Bq/a	3.7E+10					
% of annual limit		0.00002				
Normalised to electrical output, GBq/GWa		0.000004				
H-3	1.5E+13	1.8E+13	1.6E+13	1.8E+13	3.1E+13	2.0E+13
Authorised annual limit, Bq/a	3.5E+13					
% of annual limit	43	51	46	51	89	56
Normalised to electrical output, TBq/GWa	11.2	13.4	12.2	13.4	23.4	15.2
Total Alpha-activity	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
H-3	1.6E+12	1.3E+12	1.8E+12	1.5E+12	1.3E+12	1.6E+12
Normalised to electrical output, GBq/GWa	1197	968	1373	1116	982	1219
C-14	4.8E+11	2.6E+11	3.4E+11	2.5E+11	1.9E+11	2.5E+11
Normalised to electrical output, GBq/GWa	359	194	259	186	143	191

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	0.001	0.002	0.0007	0.001	0.001	0.0009
% of dose limit (0.3 mSv/a)	0.4	0.5	0.3	0.3	0.3	0.3
Air-pathway						
Annual effective dose, mSv	0.0005	0.0002	0.0003	0.0002	0.0002	0.0003
% of dose limit (0.3 mSv/a)	0.2	0.1	0.1	0.1	0.1	0.1

n. d. not detected

4.	**Origin of waste arising**	reactor core with water and steam cycles
5.	**Waste treatment**	**a)** ***waste water*** – ion-exchange procedures; – evaporation for waste water . **b)** ***exhaust air*** – HEPA filtration; – hold-up loop for exhaust air.
6.	**Waste management**	**a)** ***applied procedures 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.
7.	**Evaluation**	**a)** Non-Tritium discharges are far below the range published by UNSCEAR; Tritium discharges are in general in the lower part of the range published by UNSCEAR; Alpha discharges are below the detection limit. **b)** No significant trends identifiable. **c)** No particularly high or low values.

1. Site Characteristics

Name of facility	**Grafenrheinfeld**
Type of facility	PWR
Year of commissioning	1981
Location	Germany
Receiving water	Main

	2003	2004	2005	2006	2007	2008
Installed electrical generation capacity, MW(e)	1345					
Actual output, MWa	1236	1218	1218	1137	1244	1179

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
Cr-51						
Mn-54		3.2E+04				
Co-57						
Co-58	3.0E+06	6.1E+06	4.4E+05	4.7E+05	4.9E+05	3.5E+05
Co-60	2.0E+07	2.9E+07	1.9E+07	1.5E+07	1.3E+07	2.1E+07
Fe-55	5.7E+06	6.0E+06			4.8E+07	4.4E+06
Fe-59						
Ni-63						
Zn-65						
Sr-89						
Sr-90						
Zr-95	1.1E+06	8.7E+05	7.9E+04			
Nb-95	2.5E+06	2.6E+06	1.1E+05		4.1E+05	1.7E+05
Ru-103						
Ru-106						
Ag-110m		6.6E+05				5.9E+04
Te-123m	6.1E+05	1.1E+06	4.2E+05	3.3E+05	6.9E+05	1.9E+04
Sb-124	3.4E+05	5.7E+05				
Sb-125						
I-131						
Cs-134		2.8E+05				
Cs-137	1.0E+06	1.5E+06	1.8E+06			
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides		1.2E+05			3.7E+07	
Total activity excluding H-3	3.4E+07	4.9E+07	2.2E+07	1.6E+07	9.9E+07	2.6E+07

	2003	2004	2005	2006	2007	2008
Total activity excluding H-3	3.4E+07	4.9E+07	2.2E+07	1.6E+07	9.9E+07	2.6E+07
Authorised annual limit, Bq/a	5.5E+10					
% of annual limit	0.06	0.09	0.04	0.03	0.2	0.05
Normalised to electrical output, GBq/GWa	0.03	0.04	0.02	0.01	0.08	0.02
H-3	2.2E+13	1.7E+13	2.3E+13	1.5E+13	1.9E+13	1.5E+13
Authorised annual limit, Bq/a	4.1E+13					
% of annual limit	54	42	55	37	47	38
Normalised to electrical output, TBq/GWa	17.8	13.9	18.8	13.2	15.3	12.7
Total Alpha-activity	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
H-3	1.9E+11	2.1E+11	2.2E+11	2.4E+11	2.2E+11	2.3E+11
Normalised to electrical output, GBq/GWa	154	172	181	211	177	195
C-14	3.7E+11	3.2E+11	2.9E+11	2.7E+11	2.2E+11	3.0E+11
Normalised to electrical output, GBq/GWa	299	263	238	237	177	254

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	0.0007	0.0005	0.0004	0.0003	0.0003	0.0003
% of dose limit (0.3 mSv/a)	0.23	0.18	0.13	0.09	0.11	0.09
Air-pathway						
Annual effective dose, mSv	0.0003	0.0001	0.0001	0.0002	0.0001	0.0002
% of dose limit (0.3 mSv/a)	0.10	0.03	0.03	0.07	0.03	0.07

n. d. not detected

4. Origin of waste arising

primary cooling system

5. Waste treatment

- ion-exchange;
- evaporation;
- aerosol filters;
- activated carbon filters.

6. Waste management

a) ***applied procedures 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 river.
- Exhaust air from the controlled area passes through 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 %.
- 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.
- Due to internal operating guidelines, the training of the staff and differentiated preparatory work, radioactive discharges are kept as low as possible.

7. Evaluation

a) Non-Tritium discharges are below the range published by UNSCEAR;

Tritium discharges are below the mean value published by UNSCEAR;

Alpha discharges are below the detection limit.

b) No significant trends identifiable.

c) No particularly high or low values.

1. Site Characteristics

Name of facility	**Grohnde**
Type of facility	PWR
Year of commissioning	1984
Location	Germany
Receiving water	Weser

	2003	2004	2005	2006	2007	2008
Installed electrical generation Capacity, MW(e)	1430					
Actual output, MWa	1322	1294	1312	1329	1308	1275

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
Cr-51						
Mn-54						1.1E+07
Co-57						
Co-58						9.2E+06
Co-60	1.8E+06	4.4E+06	1.3E+06	2.0E+05	4.6E+06	1.2E+08
Fe-55						9.4E+07
Fe-59						
Ni-63						4.4E+06
Zn-65						
Sr-89						1.3E+06
Sr-90						
Zr-95						
Nb-95	3.4E+04					
Ru-103						
Ru-106						
Ag-110m		2.6E+05				
Te-123m	2.0E+05	9.8E+05	1.2E+05			
Sb-124	1.8E+05					1.5E+06
Sb-125						
I-131	4.7E+05	1.1E+06	4.3E+06			2.5E+06
Cs-134	4.4E+04					2.3E+05
Cs-137	9.2E+04	3.3E+04	5.4E+04			6.1E+04
Ba-140						2.4E+05
La-140						
Ce-141	8.0E+04	5.3E+04	1.0E+05			
Ce-144	1.9E+05		3.7E+05			
Other nuclides						
Total activity excluding H-3	3.0E+06	6.8E+06	6.3E+06	2.0E+05	4.6E+06	2.5E+08

	2003	2004	2005	2006	2007	2008
Total activity excluding H-3	3.0E+06	6.8E+06	6.3E+06	2.0E+05	4.6E+06	2.5E+08
Authorised annual limit, Bq/a	5.5E+10					
% of annual limit	0.006	0.01	0.01	0.0004	0.008	0.5
Normalised to electrical output, GBq/GWa	0.0020	0.0050	0.0050	0.0002	0.0040	0.20
H-3	2.2E+13	2.2E+13	2.3E+13	2.0E+13	2.4E+13	2.1E+13
Authorised annual limit, Bq/a	4.8E+13					
% of annual limit	45	47	48	42	49	43
Normalised to electrical output, TBq/GWa	16.6	17.0	17.5	15.1	18.4	16.5
Total Alpha-activity	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
H-3	6.6E+11	6.9E+11	4.9E+11	3.9E+11	4.3E+11	3.7E+11
Normalised to electrical output, GBq/GWa	499	533	373	293	329	290
C-14	3.8E+11	3.1E+11	3.1E+11	2.9E+11	2.8E+11	3.6E+11
Normalised to electrical output, GBq/GWa	287	240	236	218	214	282

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	0.0004	0.0005	0.0003	0.0002	0.0003	0.0002
% of dose limit (0.3 mSv/a)	0.1	0.2	0.09	0.08	0.09	0.08
Air-pathway						
Annual effective dose, mSv	0.0005	0.0004	0.0004	0.0004	0.0003	0.0006
% of dose limit (0.3 mSv/a)	0.2	0.1	0.1	0.1	0.1	0.2

n. d. not detected

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

applied procedures to minimise the production of waste

- administrative requirements,
- protection of the equipment against leaking;
- preventive maintenance;
- monitoring of leakages;
- Separator / decanter for contaminated laundry drains and sludges.

7. Evaluation

a) Non-Tritium discharges are below the range published by UNSCEAR;

Tritium discharges are below the mean value published by UNSCEAR;

Alpha discharges are below the detection limit.

b) No significant trends identifiable.

c) No particularly high or low values.

1. Site Characteristics

Name of facility	**Krümmel**
Type of facility	BWR
Year of commissioning	1983
Location	Germany
Receiving water	Elbe

	2003	**2004**	**2005**	**2006**	**2007**	**2008**
Installed electrical generation Capacity, MW(e)		1316			1402	
Actual output, MWa	1131	1148	1101	1209	649	0

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	**2004**	**2005**	**2006**	**2007**	**2008**
Cr-51						
Mn-54				2.6E+05	7.2E+04	
Co-57						
Co-58			6.5E+05	2.5E+05		
Co-60	1.8E+06	5.3E+05	1.2E+07	4.7E+06	3.4E+06	
Fe-55						
Fe-59						
Ni-63						
Zn-65			2.1E+06	1.2E+06	3.2E+05	
Sr-89						
Sr-90						
Zr-95						
Nb-95						
Ru-103						
Ru-106						
Ag-110m						
Te-123m						
Sb-124			5.0E+05	3.4E+05		
Sb-125			2.4E+06	6.3E+05		
I-131				3.5E+06	2.6E+06	
Cs-134						
Cs-137				1.1E+05	5.5E+04	
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides						
Total activity excluding H-3	1.8E+06	5.3E+05	1.8E+07	1.1E+07	6.4E+06	n. d.

	2003	2004	2005	2006	2007	2008
Total activity excluding H-3	1.8E+06	5.3E+05	1.8E+07	1.1E+07	6.4E+06	n. d.
Authorised annual limit, Bq/a	5.0E+10					
% of annual limit	0.004	0.001	0.036	0.022	0.013	
Normalised to electrical output, GBq/GWa	0.0016	0.0005	0.0163	0.0091	0.0099	
H-3	4.8E+11	5.6E+11	5.5E+11	5.6E+11	4.8E+11	7.1E+10
Authorised annual limit, Bq/a	1.9E+13					
% of annual limit	3	3	3	3	3	
Normalised to electrical output, TBq/GWa	0.4	0.5	0.5	0.5	0.7	
Total Alpha-activity	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
H-3	3.4E+10	3.7E+10	3.6E+10	3.9E+10	2.8E+11	1.0E+10
Normalised to electrical output, GBq/GWa	30	32	33	32	431	
C-14	1.2E+11	1.7E+11	2.7E+11	3.5E+11	1.9E+11	3.9E+10
Normalised to electrical output, GBq/GWa	106	148	245	289	293	

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
% of dose limit (0.3 mSv/a)	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Air-pathway						
Annual effective dose, mSv	0.0006	0.0009	0.001	0.002	0.0008	0.0002
% of dose limit (0.3 mSv/a)	0.2	0.3	0.3	0.7	0.3	0.07

n. d. not detected

4.	**Origin of waste arising**		reactor core with water and steam cycles
5.	**Waste treatment**	**a)**	***waste water*** – ion-exchange procedures; – evaporation.
		b)	***exhaust air*** – HEPA filtration; – delay lines for short-lived radioactive noble gases; – retaining of iodine available by activated carbon filter.
6.	**Waste management**	**a)**	***applied procedures 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.
7.	**Evaluation**	**a)**	Non-Tritium discharges are below the range published by UNSCEAR; Tritium discharges are below the mean value published by UNSCEAR; Alpha discharges are below the detection limit.
		b)	No significant trends identifiable.
		c)	No particularly high or low values.

1. Site Characteristics

Name of facility	**Mülheim-Kärlich**
Type of facility	PWR
Year of commissioning	1986
Year of shut down	1988
Year of decommissioning	2004
Location	Germany
Receiving water	Rhine

	2003	2004	2005	2006	2007	2008
Installed electrical generation capacity, MW(e)	1302					
Actual output, MWa	-	-	-	-	-	-

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
Cr-51						
Mn-54						
Co-57						
Co-58						
Co-60	5.5E+07	1.1E+07	1.9E+06	2.0E+06	2.0E+06	4.9E+06
Fe-55						
Fe-59						
Ni-63	1.9E+07	7.9E+06	1.3E+06	3.0E+06	4.0E+06	8.3E+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	7.4E+07	1.9E+07	3.2E+06	5.0E+06	6.0E+06	1.3E+07

	2003	2004	2005	2006	2007	2008
Total activity excluding H-3	7.4E+07	1.9E+07	3.2E+06	5.0E+06	6.0E+06	1.3E+07
Authorised annual limit, Bq/a	6.0E+10					
% of annual limit	0.1	0.03	0.005	0.008	0.01	0.02
Normalised to electrical output, GBq/GWa						
H-3	9.3E+10	7.3E+09	2.1E+09	8.9E+07	2.9E+08	2.5E+08
Authorised annual limit, Bq/a	5.0E+13					
% of annual limit	0.2	0.01	0.004	0.0002	0.001	0.0005
Normalised to electrical output, TBq/GWa						
Total Alpha-activity	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
H-3	2.5E+10	8.8E+09	n. d.	n. d.	1.8E+11	n. d.
Normalised to electrical output, GBq/GWa						
C-14	9.7E+09	7.3E+08	9.1E+08	4.8E+09	2.3E+09	7.0E+08
Normalised to electrical output, GBq/GWa						

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
% of dose limit (0.3 mSv/a)	< 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 (0.3 mSv/a)	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03

n. d. not detected

4. Origin of waste arising — primary cooling system

5. Waste treatment

a) ***waste water***

- The systems of ion-exchange, silting filtration, floc precipitation were shut down as a result of decommissioning.
- They are replaced by two new smaller installations for evaporating of all nuclear waste water.

b) ***exhaust air***

- Filters for aerosols and iodine and hold-up line for retention of noble gases were shut down too as a result of decommissioning.

6. Waste management

applied procedures to minimise the production of waste

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

7. Evaluation

a) Non-Tritium and Tritium discharges are very low;

Alpha discharges are below the detection limit.

b) Decreasing trend of the Tritium discharges.

c) No particularly high or low values.

1. Site Characteristics

Name of facility	**Neckarwestheim 1**
Type of facility	PWR
Year of commissioning	1976
Location	Germany
Receiving water	Neckar

	2003	2004	2005	2006	2007	2008
Installed electrical generation capacity, MW(e)	840					
Actual output, MWa	743	731	725	762	592	478

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
Cr-51						
Mn-54						
Co-57						
Co-58						
Co-60						2.9E+05
Fe-55						
Fe-59						
Ni-63						
Zn-65						
Sr-89						
Sr-90						
Zr-95						
Nb-95						
Ru-103						
Ru-106						
Ag-110m						
Te-123m	2.3E+05				5.1E+04	9.3E+05
Sb-124					5.6E+04	
Sb-125						
I-131						
Cs-134						
Cs-137						
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides						
Total activity excluding H-3	2.3E+05	n. d.	n. d.	n. d.	1.1E+05	1.2E+06

	2003	2004	2005	2006	2007	2008
Total activity excluding H-3	2.3E+05	n. d.	n. d.	n. d.	1.1E+05	1.2E+06
Authorised annual limit, Bq/a	1.9E+10					
% of annual limit	0.001				0.001	0.006
Normalised to electrical output, GBq/GWa	0.0003				0.0002	0.0025
H-3	1.0E+13	7.4E+12	1.1E+13	1.2E+13	9.5E+12	5.1E+12
Authorised annual limit, Bq/a	1.9E+13					
% of annual limit	54	39	58	64	50	27
Normalised to electrical output, TBq/GWa	13.5	10.1	15.2	15.8	16.0	10.7
Total Alpha-activity	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
H-3	1.3E+11	1.3E+11	1.8E+11	9.7E+10	2.0E+11	2.3E+11
Normalised to electrical output, GBq/GWa	175	178	248	127	338	481

C-14	2.5E+11	2.8E+11	1.6E+11	5.1E+10	2.0E+11	1.9E+11
Normalised to electrical output, GBq/GWa	336	383	221	67	338	397

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	0.0004	0.0002	0.0002	0.0002	0.0002	0.0001
% of dose limit (0.3 mSv/a)	0.12	0.08	0.07	0.08	0.06	0.03
Air-pathway						
Annual effective dose, mSv	0.0001	0.0001	0.0001	< 0.0001	0.0001	< 0.0001
% of dose limit (0.3 mSv/a)	0.03	0.03	0.03	< 0.03	0.03	< 0.03

n. d. not detected

4. Origin of waste arising

primary cooling system

5. Waste treatment

- evaporation;
- ion-exchange.

6. Waste management

a) ***applied procedures 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.

7. Evaluation

a) Non-Tritium discharges are below the range published by UNSCEAR;

Tritium discharges are below the mean value published by UNSCEAR;

Alpha discharges are below the detection limit.

b) No significant trends identifiable.

c) No particularly high or low values.

1. Site Characteristics

Name of facility	**Neckarwestheim 2**
Type of facility	PWR
Year of commissioning	1988
Location	Germany
Receiving water	Neckar

	2003	2004	2005	2006	2007	2008
Installed electrical generation capacity, MW(e)		1365		1395	1400	
Actual output, MWa	1290	1279	1322	1327	1269	1305

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
Cr-51						
Mn-54						
Co-57						
Co-58						2.3E+05
Co-60	1.6E+06	8.2E+04			6.1E+05	1.4E+05
Fe-55						
Fe-59						
Ni-63						
Zn-65						
Sr-89						
Sr-90						
Zr-95						
Nb-95	1.3E+05					
Ru-103						
Ru-106						
Ag-110m						
Te-123m	9.7E+06					
Sb-124	1.5E+06					
Sb-125	5.3E+06					
I-131	1.9E+05					
Cs-134						
Cs-137	3.0E+05					
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides	1.40E+08					
Total activity excluding H-3	1.6E+08	8.2E+04	n. d.	n. d.	6.1E+05	3.7E+05

	2003	2004	2005	2006	2007	2008
Total activity excluding H-3	1.6E+08	8.2E+04	n. d.	n. d.	6.1E+05	3.7E+05
Authorised annual limit, Bq/a	6.0E+10					
% of annual limit	0.264	0.0001			0.001	0.001
Normalised to electrical output, GBq/GWa	0.1240	0.0001			0.0005	0.0003
H-3	2.3E+13	1.8E+13	2.0E+13	2.1E+13	2.1E+13	2.1E+13
Authorised annual limit, Bq/a	7.0E+13					
% of annual limit	33	25	29	30	30	30
Normalised to electrical output, TBq/GWa	17.8	14.1	15.1	15.8	16.6	16.1
Total Alpha-activity	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
H-3	1.5E+11	1.3E+11	9.7E+10	2.6E+11	6.0E+11	2.2E+11
Normalised to electrical output, GBq/GWa	116	102	73	196	472	169

C-14	2.6E+11	4.2E+11	2.1E+11	4.1E+11	3.2E+11	2.5E+11
Normalised to electrical output, GBq/GWa	201	328	158	309	252	192

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	0.0008	0.0007	0.0004	0.0004	0.0004	0.0004
% of dose limit (0.3 mSv/a)	0.3	0.2	0.1	0.1	0.1	0.1
Air-pathway						
Annual effective dose, mSv	0.0009	0.001	0.0008	0.001	0.0008	0.0007
% of dose limit (0.3 mSv/a)	0.3	0.3	0.3	0.3	0.3	0.2

n. d. not detected

4. Origin of waste arising — primary cooling system

5. Waste treatment

- evaporation;
- ion-exchange.

6. Waste management

a) ***applied procedures 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.

7. Evaluation

a) Non-Tritium discharges are below the range published by UNSCEAR;

Tritium discharges are below the mean value published by UNSCEAR;

Alpha discharges are below the detection limit.

b) No significant trends identifiable.

c) No particularly high or low values.

1. Site Characteristics

Name of facility	**Obrigheim**
Type of facility	PWR
Year of commissioning	1968
Year of shut down	2005
Year of decommissioning	2008
Location	Germany
Receiving water	Neckar

	2003	2004	2005	2006	2007	2008
Installed electrical generation Capacity, MW(e)	357					
Actual output, MWa	296	313	104	-	-	-

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
Cr-51		2.8E+06				
Mn-54	7.4E+05	5.6E+05		2.7E+05	4.4E+05	
Co-57				3.1E+05		
Co-58	7.1E+06	4.5E+07	5.1E+06	2.4E+06	4.1E+04	
Co-60	1.2E+07	1.0E+07	4.5E+06	3.5E+07	6.9E+07	2.3E+07
Fe-55	1.8E+07	6.9E+06	3.6E+06	3.4E+07	9.8E+07	4.4E+07
Fe-59						
Ni-63	8.6E+06	1.2E+07	1.5E+07	8.5E+07	1.2E+08	2.7E+07
Zn-65		1.9E+05				
Sr-89						
Sr-90				9.5E+03		2.4E+04
Zr-95						
Nb-95						
Ru-103						
Ru-106						
Ag-110m	7.5E+06	5.7E+06	4.5E+06	3.3E+06	4.5E+05	3.6E+05
Te-123m	1.9E+05		2.0E+06	2.4E+05		
Sb-124	2.2E+06	5.4E+06	1.6E+06			
Sb-125			4.6E+05	8.9E+05		
I-131						
Cs-134	1.6E+05	4.8E+05	3.3E+04			
Cs-137	3.0E+06	2.8E+06	4.0E+06	7.1E+06	4.9E+06	9.8E+05
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides						
Total activity excluding H-3	6.0E+07	9.2E+07	4.1E+07	1.7E+08	2.9E+08	9.6E+07

	2003	2004	2005	2006	2007	2008
Total activity excluding H-3	6.0E+07	9.2E+07	4.1E+07	1.7E+08	2.9E+08	9.6E+07
Authorised annual limit, Bq/a	3.0E+10					
% of annual limit	0.2	0.3	0.1	0.6	1	0.3
Normalised to electrical output, GBq/GWa	0.20	0.29	0.39			
H-3	4.9E+12	6.3E+12	1.2E+12	8.2E+10	3.2E+11	9.5E+10
Authorised annual limit, Bq/a	1.8E+13					
% of annual limit	27	35	7	0	2	1
Normalised to electrical output, TBq/GWa	16.5	20.1	11.5			
Total Alpha-activity	2.9E+04	n. d.	n. d.	n. d.	1.8E+05	6.5E+04

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
H-3	9.8E+10	1.4E+11	1.4E+11	7.7E+10	7.0E+10	4.6E+10
Normalised to electrical output, GBq/GWa	331	447	1346			
C-14	6.0E+10	4.7E+10	4.6E+10	5.5E+09	8.6E+09	1.8E+09
Normalised to electrical output, GBq/GWa	202	150	442			

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	0.0002	0.0003	0.0001	0.0001	< 0.0001	< 0.0001
% of dose limit (0.3 mSv/a)	0.07	0.09	0.03	0.03	< 0.03	< 0.03
Air-pathway						
Annual effective dose, mSv	0.004	0.002	0.003	0.0007	0.0008	0.0002
% of dose limit (0.3 mSv/a)	1	0.7	1	0.2	0.3	0.1

n. d. not detected

4. Origin of waste arising

primary coolant cycle

5. Waste treatment

- filtration;
- ion-exchange procedures;
- evaporation.

6. Waste management

applied procedures to minimise the production of waste

- leak tightness of fuel elements until 2005;
- specialised operation modes for fuel elements until 2005
- cleaning of the primary cooling cycle until 2005, full system decontamination in 2007;
- ozone laundry system for contaminated clothing until 2008;
- waste processing.

7. Evaluation

a) Non-Tritium discharges are below the range published by UNSCEAR;

Tritium discharges are below the mean value published by UNSCEAR;

Alpha discharges are very low.

b) Decreasing trend of Tritium discharges.

c) No particularly high or low values.

1. Site Characteristics

Name of facility	**Philippsburg 1**
Type of facility	BWR
Year of commissioning	1979
Location	Germany
Receiving water	Rhine

	2003	2004	2005	2006	2007	2008
Installed electrical generation capacity, MW(e)	926					
Actual output, MWa	766	757	696	823	831	733

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
Cr-51	1.4E+07	4.9E+06	5.8E+07	1.5E+07	6.5E+05	9.5E+06
Mn-54	2.1E+07	6.8E+06	8.9E+06	1.0E+07	4.0E+06	3.8E+06
Co-57			8.7E+04			
Co-58	1.1E+07	6.3E+04	5.9E+06	6.1E+06	5.1E+06	3.7E+06
Co-60	1.1E+08	3.5E+07	4.3E+07	5.2E+07	2.5E+07	2.0E+07
Fe-55	4.0E+07	3.2E+07	1.8E+07	3.7E+07	1.7E+07	
Fe-59						
Ni-63	8.1E+07					
Zn-65	3.8E+07	2.6E+07	6.5E+07	8.2E+07	6.4E+07	4.0E+07
Sr-89		4.3E+06	2.3E+06	1.6E+06		
Sr-90						
Zr-95						
Nb-95			5.7E+04			
Ru-103						
Ru-106						
Ag-110m	8.0E+05	9.5E+05	5.8E+05	2.0E+05	5.2E+05	4.2E+05
Te-123m						
Sb-124					1.5E+05	
Sb-125		1.8E+05				
I-131		2.3E+07	3.1E+07	1.9E+07	3.2E+06	1.1E+06
Cs-134	4.9E+05	7.5E+05	2.4E+06			5.8E+04
Cs-137	1.0E+07	3.1E+06	1.0E+07	2.5E+06	2.0E+06	2.5E+06
Ba-140		2.3E+06	1.0E+07	4.4E+06		7.4E+05
La-140		3.0E+06	1.2E+07	5.7E+06		
Ce-141		1.0E+06	5.8E+05			
Ce-144			6.8E+05			
Other nuclides						
Total activity excluding H-3	3.3E+08	1.4E+08	2.7E+08	2.4E+08	1.2E+08	8.1E+07

	2003	2004	2005	2006	2007	2008
Total activity excluding H-3	3.3E+08	1.4E+08	2.7E+08	2.4E+08	1.2E+08	8.1E+07
Authorised annual limit, Bq/a	1.5E+11					
% of annual limit	0.2	0.1	0.2	0.2	0.08	0.05
Normalised to electrical output, GBq/GWa	0.43	0.18	0.39	0.29	0.14	0.11
H-3	4.7E+11	4.6E+11	5.1E+11	3.8E+11	3.1E+11	3.8E+11
Authorised annual limit, Bq/a	1.8E+13					
% of annual limit	3	3	3	2	2	2
Normalised to electrical output, TBq/GWa	0.61	0.61	0.73	0.46	0.37	0.52
Total Alpha-activity	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
H-3	4.6E+10	4.5E+10	3.2E+10	2.9E+10	3.0E+10	2.7E+10
Normalised to electrical output, GBq/GWa	60	59	46	35	36	37
C-14	4.8E+11	4.1E+11	4.1E+11	5.0E+11	4.9E+11	4.3E+11
Normalised to electrical output, GBq/GWa	626	542	589	607	590	587

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	< 0.0001	< 0.0001	0.0001	0.0001	< 0.0001	0.0001
% of dose limit (0.3 mSv/a)	< 0.03	< 0.03	0.03	0.03	< 0.03	0.03
Air-pathway						
Annual effective dose, mSv	0.004	0.003	0.003	0.004	0.005	0.003
% of dose limit (0.3 mSv/a)	1	1	1	1	2	1

n. d. not detected

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***;
- cross-flow filtration is used for wash water.

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

a) ***applied procedures to minimise the production of waste***

- 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 limiters 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.

– Pilot installation of hollow-fiber micro filtration is at experimental stage. It will replace the used cross-flow filtration installation in future.

7. Evaluation

a) Non-Tritium discharges are below the range published by UNSCEAR;

Tritium discharges are below the mean value published by UNSCEAR;

Alpha discharges are below the detection limit.

b) No significant trends identifiable.

c) No particularly high or low values.

1. Site Characteristics

Name of facility	**Philippsburg 2**
Type of facility	PWR
Year of commissioning	1984
Location	Germany
Receiving water	Rhine

	2003	2004	2005	2006	2007	2008
Installed electrical generation Capacity, MW(e)	1458					
Actual output, MWa	1327	1240	1303	1318	1344	1305

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
Cr-51				3.7E+05		1.0E+06
Mn-54	3.8E+04	2.2E+05	4.9E+05	2.0E+05	6.2E+05	1.9E+06
Co-57	6.7E+04		4.1E+04			
Co-58	1.8E+06	2.8E+05	4.1E+06	2.2E+06	8.5E+06	4.7E+06
Co-60	1.8E+07	7.9E+06	2.0E+07	2.1E+07	2.6E+07	2.1E+07
Fe-55	1.4E+07	6.2E+06	9.9E+06	1.5E+07	1.3E+07	9.0E+06
Fe-59						
Ni-63	1.6E+07	8.0E+06	2.2E+07	1.4E+07	2.0E+07	1.3E+07
Zn-65		2.7E+05	3.1E+05	7.4E+04		2.8E+06
Sr-89						
Sr-90			1.4E+05			
Zr-95				5.7E+05		3.3E+05
Nb-95	2.4E+05	3.9E+04	8.4E+04	3.3E+05	8.0E+05	1.5E+06
Ru-103	3.8E+04	1.3E+05			7.9E+04	6.2E+04
Ru-106						
Ag-110m	1.0E+06	5.4E+05	2.9E+06	8.5E+05	1.2E+06	6.4E+04
Te-123m	1.1E+06		4.3E+04	3.2E+04		1.4E+05
Sb-124	3.7E+06	2.2E+06	1.3E+06	2.7E+06	2.7E+06	1.3E+06
Sb-125	2.5E+06	7.0E+05	5.8E+05	8.6E+04	9.0E+05	
I-131		7.9E+05	1.2E+06	1.1E+06		
Cs-134	8.3E+06	2.6E+06	7.4E+06	5.0E+06	3.1E+06	
Cs-137	2.6E+07	1.9E+07	6.1E+07	3.3E+07	3.9E+07	1.9E+07
Ba-140						
La-140						
Ce-141	8.0E+04	2.9E+05			3.6E+04	
Ce-144	5.9E+05					1.2E+06
Other nuclides						
Total activity excluding H-3	9.3E+07	4.9E+07	1.3E+08	9.6E+07	1.2E+08	7.7E+07

	2003	2004	2005	2006	2007	2008
Total activity excluding H-3	9.3E+07	4.9E+07	1.3E+08	9.6E+07	1.2E+08	7.7E+07
Authorised annual limit, Bq/a	5.5E+10					
% of annual limit	0.2	0.09	0.2	0.2	0.2	0.1
Normalised to electrical output, GBq/GWa	0.07	0.04	0.10	0.07	0.09	0.06
H-3	1.9E+13	1.5E+13	1.6E+13	1.4E+13	1.4E+13	1.7E+13
Authorised annual limit, Bq/a	4.8E+13					
% of annual limit	40	30	34	29	29	36
Normalised to electrical output, TBq/GWa	14.3	12.1	12.3	10.6	10.4	13.3
Total Alpha-activity	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
H-3	2.1E+11	1.8E+11	2.3E+11	1.8E+11	4.2E+11	1.1E+11
Normalised to electrical output, GBq/GWa	158	145	176	137	313	84

C-14	2.0E+11	1.7E+11	2.2E+11	2.2E+11	1.5E+11	1.1E+11
Normalised to electrical output, GBq/GWa	151	137	169	167	112	84

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	0.0002	0.0002	0.0001	<0.0001	<0.0001	0.0001
% of dose limit (0.3 mSv/a)	0.08	0.06	0.03	< 0.03	< 0.03	0.03
Air-pathway						
Annual effective dose, mSv	0.0002	0.0001	0.0003	0.0003	0.0002	0.0001
% of dose limit (0.3 mSv/a)	0.07	0.03	0.1	0.1	0.07	0.03

n. d. not detected

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***;
- cross-flow filtration is used for wash water.

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

a) ***applied procedures to minimise the production of waste***

- 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 limiters 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.

- Pilot installation of hollow-fiber micro filtration is at experimental stage. It will replace the used cross-flow filtration installation in future.

7. Evaluation

a) Non-Tritium discharges are below the range published by UNSCEAR;

Tritium discharges are below the mean value published by UNSCEAR;

Alpha discharges are below the detection limit.

b) No significant trends identifiable.

c) No particularly high or low values.

1. Site Characteristics

Name of facility	**Stade**
Type of facility	PWR
Year of commissioning	1972
Year of shut down	2003
Year of decommissioning	2005
Location	Germany
Receiving water	Elbe

	2003	2004	2005	2006	2007	2008
Installed electrical generation Capacity, MW(e)	672					
Actual output, MWa	555	-	-	-	-	-

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
Cr-51			1.7E+06			
Mn-54		5.2E+05	1.7E+06			
Co-57						
Co-58		5.4E+04	9.0E+04			
Co-60	3.1E+05	2.4E+07	4.8E+08	6.1E+06	4.4E+06	3.6E+06
Fe-55		1.2E+07		5.5E+06	3.1E+06	6.4E+05
Fe-59						
Ni-63		4.3E+06		3.6E+06	3.7E+06	3.8E+06
Zn-65						
Sr-89						
Sr-90			2.1E+04		1.3E+05	
Zr-95						
Nb-95	9.2E+04					
Ru-103						
Ru-106			1.3E+06			
Ag-110m	1.5E+05	4.8E+06	4.4E+06	1.0E+05		
Te-123m	5.2E+05	1.3E+06	8.4E+07			
Sb-124	4.8E+04	4.7E+04	1.8E+06			
Sb-125			1.8E+08	2.6E+05		
I-131						
Cs-134						
Cs-137	2.8E+05	1.2E+06	2.7E+07	3.9E+05	4.4E+05	1.8E+06
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides						
Total activity excluding H-3	1.4E+06	4.8E+07	7.8E+08	1.6E+07	1.2E+07	9.8E+06

	2003	2004	2005	2006	2007	2008
Total activity excluding H-3	1.4E+06	4.8E+07	7.8E+08	1.6E+07	1.2E+07	9.8E+06
Authorised annual limit, Bq/a	1.9E+11					
% of annual limit	0.001	0.03	0.4	0.009	0.006	0.005
Normalised to electrical output, GBq/GWa	0.002					
H-3	1.1E+13	1.4E+13	1.5E+13	1.9E+12	6.8E+12	4.9E+10
Authorised annual limit, Bq/a	4.8E+13					
% of annual limit	23	29	31	4	14	0
Normalised to electrical output, TBq/GWa	19.8					
Total Alpha-activity	n. d.	1.9E+04	2.4E+05	4.1E+04	1.6E+04	1.5E+04

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
H-3	1.0E+12	6.9E+11	7.2E+11	1.0E+12	1.9E+11	9.2E+09
Normalised to electrical output, GBq/GWa	1802					
C-14	7.2E+10	2.0E+11	8.0E+10	2.2E+10	3.0E+10	3.7E+10
Normalised to electrical output, GBq/GWa	130					

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
% of dose limit (0.3 mSv/a)	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Air-pathway						
Annual effective dose, mSv	0.0003	0.0005	< 0.0001	< 0.0001	< 0.0001	< 0.0001
% of dose limit (0.3 mSv/a)	0.10	0.17	< 0.03	< 0.03	< 0.03	< 0.03

n. d. not detected

4.	**Origin of waste arising**	primary coolant cycle and attached systems
5.	**Waste treatment**	– filtration; – ion-exchange procedures; – decantation; – evaporation.
6.	**Waste management**	**a)** ***applied procedures 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.
7.	**Evaluation**	**a)** Non-Tritium discharges are below the range published by UNSCEAR; Tritium discharges are below the mean value published by UNSCEAR; Alpha discharges are very low. **b)** Decreasing trend of Tritium discharges. **c)** No particularly high or low values.

1. Site Characteristics

Name of facility	**Unterweser**
Type of facility	PWR
Year of commissioning	1978
Location	Germany
Receiving water	Weser

	2003	2004	2005	2006	2007	2008
Installed electrical generation capacity, MW(e)	1410					
Actual output, MWa	1113	1167	1065	1248	1088	1116

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
Cr-51						
Mn-54	2.0E+06	3.6E+06	9.6E+04		3.7E+05	6.6E+05
Co-57						
Co-58	1.6E+06	1.4E+07	1.5E+06	2.5E+06	4.4E+06	2.7E+06
Co-60	1.9E+08	1.3E+08	3.6E+07	2.3E+07	9.4E+07	6.1E+07
Fe-55	2.6E+07	2.3E+07			2.4E+07	7.9E+06
Fe-59						
Ni-63	2.2E+07	1.1E+07	7.4E+06		1.3E+07	4.3E+06
Zn-65						
Sr-89						
Sr-90						
Zr-95	5.7E+05					
Nb-95	1.4E+06	4.2E+05		2.5E+04		
Ru-103						
Ru-106						
Ag-110m	8.3E+04					
Te-123m	9.1E+06	7.5E+06	8.0E+06	5.1E+06	1.0E+07	5.2E+06
Sb-124	2.9E+06	3.6E+07	1.4E+07	2.6E+06	1.2E+06	1.2E+06
Sb-125	1.2E+07	1.6E+06		3.0E+05	1.4E+06	
I-131			1.7E+06			
Cs-134	5.2E+05					
Cs-137	8.2E+06	2.1E+06	1.9E+06	6.0E+05	6.6E+05	1.1E+05
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides						
Total activity excluding H-3	2.7E+08	2.3E+08	7.0E+07	3.4E+07	1.5E+08	8.3E+07

	2003	2004	2005	2006	2007	2008
Total activity excluding H-3	2.7E+08	2.3E+08	7.0E+07	3.4E+07	1.5E+08	8.3E+07
Authorised annual limit, Bq/a	7.4E+10					
% of annual limit	0.4	0.3	0.1	0.05	0.2	0.1
Normalised to electrical output, GBq/GWa	0.24	0.20	0.07	0.03	0.14	0.07
H-3	1.3E+13	1.4E+13	1.3E+13	1.3E+13	1.5E+13	1.9E+13
Authorised annual limit, Bq/a	3.5E+13					
% of annual limit	36	41	38	38	42	53
Normalised to electrical output, TBq/GWa	11.7	12.0	12.2	10.4	13.8	17.0
Total Alpha-activity	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
H-3	3.2E+11	3.6E+11	4.6E+11	1.5E+11	2.7E+11	4.7E+10
Normalised to electrical output, GBq/GWa	288	308	432	120	248	42
C-14	8.5E+09	3.8E+10	3.2E+11	3.3E+11	2.9E+11	3.4E+11
Normalised to electrical output, GBq/GWa	8	33	300	264	267	305

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
% of dose limit (0.3 mSv/a)	0.03	0.05	0.03	0.03	0.03	0.03
Air-pathway						
Annual effective dose, mSv	< 0.0001	0.0002	0.0002	0.0001	0.0001	0.0001
% of dose limit (0.3 mSv/a)	< 0.03	0.07	0.07	0.03	0.03	0.03

n. d. not detected

4. Origin of waste arising

primary coolant cycle and attached systems

5. Waste treatment

a) ***waste water***

primary coolant cycle

- filtration;
- ion-exchange procedures;
- degassing;
- evaporation.

controlled area

- collection;
- silting filtration;
- evaporation.

6. Waste management

a) ***applied procedures 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 of 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.

7. Evaluation

a) Non-Tritium discharges are below the range published by UNSCEAR;

Tritium discharges are below the mean value published by UNSCEAR;

Alpha discharges are below the detection limit.

b) No significant trends identifiable.

c) No particularly high or low values.

1. Site Characteristics

Name of facility	**Würgassen**
Type of facility	BWR
Year of commissioning	1971
Year of shut down	1995
Year of decommissioning	1997
Location	Germany
Receiving water	Weser

	2003	2004	2005	2006	2007	2008
Installed electrical generation Capacity, MW(e)	670					
Actual output, MWa	-	-	-	-	-	-

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
Cr-51						
Mn-54						
Co-57						
Co-58						
Co-60	2.7E+07	1.5E+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	1.1E+06	7.8E+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						
I-131						
Cs-134						
Cs-137	1.7E+07	2.0E+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	4.5E+07	3.5E+07	1.3E+07	5.2E+07	1.8E+07	1.5E+07

	2003	2004	2005	2006	2007	2008
Total activity excluding H-3	4.5E+07	3.5E+07	1.3E+07	5.2E+07	1.8E+07	1.5E+07
Authorised annual limit, Bq/a	6.0E+10					
% of annual limit	0.1	0.1	0.02	0.1	0.03	0.02
Normalised to electrical output, GBq/GWa						
H-3	3.4E+10	2.8E+10	2.2E+10	2.0E+11	7.5E+10	3.9E+10
Authorised annual limit. Bq/a	1.0E+13					
% of annual limit	0.3	0.3	0.2	2.0	0.8	0.4
Normalised to electrical output, TBq/GWa						
Total Alpha-activity	7.2E+05	3.3E+05	n. d.	n. d.	1.6E+05	n. d.

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
H-3	5.4E+10	4.9E+10	1.0E+11	3.1E+10	1.6E+10	3.1E+09
Normalised to electrical output, GBq/GWa						
C-14	1.0E+09	7.9E+08	3.3E+09	1.5E+09	2.2E+09	1.4E+09
Normalised to electrical output, GBq/GWa						

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway Annual effective dose, mSv	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
% of dose limit (0.3 mSv/a)	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Air-pathway						
Annual effective dose, mSv	0.0001	0.0001	0.0002	0.0001	0.0002	0.0001
% of dose limit (0.3 mSv/a)	0.03	0.03	0.07	0.03	0.07	0.03

n. d. not detected

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

5. Waste treatment

- filtration;
- ion-exchange procedure (no more in use);
- distillation.

6. Waste management

a) ***applied procedures to minimise the production of waste***

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.

7. Evaluation

a) Non-Tritium and Tritium discharges are very low;

Alpha discharges are very low.

b) No significant trends identifiable.

c) No particularly high or low values.

Annex 2

Nuclear Fuel Fabrication
and
Enrichment Plants

1. Site Characteristics

Name of facility	**Gronau**
Type of facility	Nuclear fuel fabrication (uranium enrichment)
Capacity, Uranium	1800 t/a
Year of commissioning	1985
Location	Gronau
Receiving water	Vechte, Ijsselmeer

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
Total Alpha-activity	1.5E+04	1.4E+03	2.7E+03	2.3E+03	1.0E+03	2.3E+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	2	0.2	0.4	0.3	0.1	0.3

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
Total Alpha-activity	5.4E+04	2.6E+04	2.9E+04	3.2E+04	2.3E+04	2.8E+04

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
% of dose limit (0.3 mSv/a)	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 003
Air-pathway						
Annual effective dose, mSv	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
% of dose limit (0.3 mSv/a)	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03

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) ***applied procedures to minimise the production of waste***

- protection of UF_6-system against leaking;
- utilisation of vacuum systems;
- minimisation of radioactive discharges by recycling residual waste;
- recovery / reuse of cleaned auxiliary substances;
- utilisation of maintenance free gas centrifuges.

b) ***improvements in waste treatment***

- at present there are no further measures planned.

7. Evaluation

Since 1985 the releases into water and air have been constantly low.

1. Site Characteristics

Name of facility	**Hanau**
Type of facility	different facilities for nuclear fuel fabrication (PWR MOX)
Capacity, U	1350 t/a
Year of commissioning	1969
Year of decommissioning	1996
Decommissioned	2006
Location	Hanau
Receiving water	Main

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
Total Alpha-activity	3.7E+07	8.4E+06	7.6E+06	-	-	-
Authorised annual limit, Bq/a	1.5E+10	1.5E+10	1.5E+10	-	-	-
% of annual limit	0.2	0.1	0.1	-	-	-

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
Total Alpha-activity	4.1E+05	2.4E+06	1.2E+06			

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	< 0.0001	< 0.0001	< 0.0001			
% of dose limit (0.3 mSv/a)	< 0.03	< 0.03	< 0.03			
Air-pathway						
Annual effective dose, mSv	0.0002	0.001	0.001			
% of dose limit (0.3 mSv/a)	0.07	0.3	0.2			

4. Origin of waste arising no waste arising anymore

5. Waste treatment

6. Waste management

7. Evaluation

- 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.
- All facilities were decommissioned until 2006 and released from the Atomic Energy Act.

1. Site Characteristics

Name of facility	**Lingen**
Type of facility	Nuclear fuel fabrication (LWR)
Capacity, Uranium	400 t/a
Year of commissioning	1979
Location	Lingen
Receiving water	Ems

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
Total Alpha-activity	n. d.					
Authorised annual limit, Bq/a	220 g uranium					
% of annual limit						

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
Total Alpha-activity	n. d.					

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
% of dose limit (0.3 mSv/a)	< 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 (0.3 mSv/a)	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03

n. d. not detected

4. Origin of waste arising

a) ***waste water***

– There is no discharge of water from the process areas of the fuel fabrication plant to areas outside of the plant In other words: radioactive substances cannot be released in that way.

b) ***exhaust air***

– Exhaust air from the production process and building ventilation system may contain uranium compounds.

5. Waste treatment

a) ***waste water***

b) ***exhaust air***

– production process:
Before exhaust air from production areas is released to the environment via a stack, it is cleaned with the help of dust separators and two filtration steps for aerosols.

– building ventilation system:
Exhaust air from those areas in which open uranium is available is cleaned by means of two filtration steps for aerosols before it is released into the environment via a stack.

6. Waste management

applied procedures to minimise the production of waste

– Air pressure in the working areas and in those areas in which open uranium is processed or handled is lower than that in 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 more clean areas is routed to potentially less cleaner areas.

– The difference in pressure is regularly controlled at each aerosol filter.

– To guarantee the functionalities of the air ventilation and the exhaust air system the major components are part of the inservice inspections and maintenance tasks with the following inspection scope:
  - the absence of uranium in exhaust airducts for exhaust air from processing;
  - factors for retaining at the second step 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.

– Radioactivity in 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 measurements are based on approved and controlled procedures.

7. Evaluation

a) Alpha discharges are below the detection limit.

Annex 3

Research and Development Facilities

1. Site Characteristics

Name of facility	**GKSS Geesthacht**
Type of facility	Different research and development facilities including two reactors
Reactor capacity	5 MW / 15 MW
Year of commissioning	1958 / 1963
Year of decommissioning	- / 1993
Location	Geesthacht
Receiving water	Elbe

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
Cr-51				1.1E+05		
Mn-54	1.9E+04				3.7E+05	2.9E+05
Co-58				1.1E+07		
Co-60	7.3E+06	4.9E+06	2.1E+06		7.2E+06	4.2E+06
Fe-59				2.3E+05		
Zn-65	6.6E+04			1.4E+05	6.1E+06	8.0E+06
Sr-89	5.0E+04	2.5E+04	1.1E+05	5.9E+05	1.6E+05	8.5E+04
Sr-90	5.9E+05	5.4E+05	6.5E+05		5.8E+05	3.4E+05
Zr-95						
Nb-95					5.0E+04	
Ru-103					3.2E+04	
Ru-106						
Ag-110m						
Te-123m						
Sb-124						
Sb-125						
I-131						
Cs-134				9,2E+03		
Cs-137	3.3E+07	1.7E+07	9.9E+06	1,0E+07	1.2E+07	6.3E+06
Ba-140						
La-140						
Ce-141					3.0E+04	
Ce-144					2.5E+05	
Other nuclides					4.0E+05	
Total activity excluding H-3	4.1E+07	2.2E+07	1.3E+07	2.3E+07	2.7E+07	1.9E+07

	2003	2004	2005	2006	2007	2008
Total activity excluding H-3	4.1E+07	2.2E+07	1.3E+07	2.3E+07	2.7E+07	1.9E+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	0.2	0.1	0.6	0.9	0.2	0.1
H-3	2.0E+08	1.6E+08	2.9E+07	3.6E+08	2.1E+09	1.3E+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	0.4	0.3	0.1	0.6	3.7	0.2
Total Alpha-activity	1.7E+04	1.6E+04	2.6E+04	2.6E+04	2.8E+04	1.2E+04

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
H-3	9.8E+10	9.0E+10	9.3E+10	9.6E+10	7.9E+10	9.9E+10
C-14	6.2E+08	8.5E+08	7.1E+08	4.7E+08	4.6E+08	6.9E+08

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
% of dose limit (0.3 mSv/a)	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Air-pathway						
Annual effective dose, mSv	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001
% of dose limit (0.3 mSv/a)	0.07	0.07	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) ***applied procedures 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.
- Future in-process measures:
  concentration of waste water by reverse osmosis and / or evaporation.

7. Additional 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 conditions.

1. Site Characteristics

Name of facility	**Helmholtz-Zentrum Berlin, former Hahn-Meitner-Institut (HMI) Berlin**
Type of facility	Different research and development facilities including one reactor
Reactor capacity	10 MW
Year of commissioning	1973
Location	Berlin
Receiving water	Havel

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
Total activity excluding H-3	1.2E+06	1.2E+06	2.3E+05	1.3E+05	2.8E+05	1.5E+05
Authorised annual limit, Bq/a	-1-	-1-	-1-	-1-	-1-	-1-
% of annual limit						
H-3	1.4E+09	6.6E+08	5.9E+08	5.1E+08	2.0E+09	4.6E+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 requirements for activity concentrations of radionuclides in waste water are the same as in drinking water (see § 47 of the German Radiation Protection Ordinance).

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
H-3	9.0E+10	7.9E+10	9.4E+10	8.6E+10	7.6E+10	6.6E+10
C-14	2.1E+09	2.8E+09	3.7E+09	1.7E+10	1.4E+10	2.6E+09

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
% of dose limit (0.3 mSv/a)	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Air-pathway						
Annual effective dose, mSv	0.0003	0.0004	0.0004	0.011	0.0004	0.0002
% of dose limit (0.3 mSv/a)	0.1	0.1	0.1	4	0.1	0.07

4. Origin of waste arising

5. 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 47 (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 Facility 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 properties 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) ***applied procedures to minimise the production of waste***

- The fuel elements used in BER II are MTR elements with a low U-235 enrichment of 20 % (LEU). Within the fuel plates the fuel is tightly 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 elements 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.

7. Additional 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 conditions.

1. Site Characteristics

Name of facility	**Jülich Research Centre (KfA)**
Type of facility	Different research and development facilities including three reactors
Reactor capacity	10 MW / 15 MW / 23 MW
Year of commissioning	1962 / 1966 / 1962
Year of decommissioning	1985 / 1988 / 2006
Decommissioned	2007 / - / -
Location	Jülich
Receiving water	Rur

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
Co-60	7.5E+05	1.0E+06		1.2E+06	2.9E+05	2.6E+06
Sr-89						
Sr-90	2.9E+07	5.1E+07	2.5E+07	4.9E+07	5.2E+07	2.8E+07
I-131	9.8E+06	2.1E+06	1.2E+07	8.5E+06	2.3E+07	1.9E+07
Cs-137	3.9E+06	3.5E+06	2.9E+06	1.3E+07	4.7E+07	3.6E+07
Other nuclides	7.7E+07	6.2E+07	1.1E+08	1.1E+07	7.1E+06	5.4E+06
Total activity excluding H-3	1.2E+08	1.2E+08	1.5E+08	8.2E+07	1.3E+08	9.1E+07

	2003	2004	2005	2006	2007	2008
Total activity excluding H-3	1.2E+08	1.2E+08	1.5E+08	8.2E+07	1.3E+08	9.1E+07
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	2	2	1	2	1
H-3	8.0E+11	4.2E+11	6.3E+11	6.6E+11	5.6E+11	2.2E+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	7	4	6	6	5	2
Total Alpha-activity	n. d.					
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

	2003	2004	2005	2006	2007	2008
H-3	2.9E+12	3.5E+12	3.3E+12	5.5E+12	2.8E+12	2.3E+12
C-14	4.4E+11	3.2E+11	3.2E+11	1.5E+11	2.3E+11	1.5E+11

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	0.002	0.001	0.002	< 0.002	0.002	0.002
% of dose limit (0.3 mSv/a)	0.8	0.4	0.5	< 0.5	0.5	0.6
Air-pathway						
Annual effective dose, mSv	0.005	0.005	0.005	0.002	0.009	0.001
% of dose limit (0.3 mSv/a)	2	2	2	0.5	3	0.4

n. d. not detected

4. Origin of waste arising

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***

– higher storage times for short-lived nuclides;
– evaporation in the case of higher concentrations.

b) ***exhaust air***

– delayed emissions of short-lived nuclides;
– using aerosol filters of level H12;
– routing exhaust air through activated carbon filters.

6. Waste management

7. Additional 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 conditions.

1. Site Characteristics

Name of facility	**Institut for Technology of Karlsruhe (KIT)**
Type of facility	Different research and development facilities; pilot reprocessing plant
Reactor capacity	44 MW / 58 MW / 20 MW
Year of commissioning	1961 / 1965 / 1971
Year of decommissioning	1981 / 1984 / 1991 / 1990 (pilot reprocessing plant)
Location	Karlsruhe
Receiving water	Rhine

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
C-14						
Co-60	5.7E+05	1.1E+06	7.9E+04		2.1E+05	2.6E+04
Sr-89						
Sr-90	1.3E+07	8.9E+06	2.1E+07	8.3E+06	4.1E+06	9.9E+05
Cs-137	1.0E+07	9.0E+06	1.0E+07	1.2E+07	7.0E+06	5.4E+06
Pu-241						
Other nuclides						2.7E+06
Total activity excluding H-3	2.3E+07	1.9E+07	3.1E+07	2.0E+07	1.1E+07	9.1E+06

	2003	2004	2005	2006	2007	2008
Total activity excluding H-3	2.3E+07	1.9E+07	3.1E+07	2.0E+07	1.1E+07	9.1E+06
Authorised annual limit, Bq/a	3.2E+11	2.3E+11	3.2E+11	3.2E+11	3.2E+11	2.3E+11
% of annual limit	0.01	0.01	0.01	0.01	0.003	0.004
H-3	4.3E+11	9.3E+11	6.8E+12	1.6E+12	1.2E+11	1.5E+12
Authorised annual limit, Bq/a	1.5E+14	8.0E+13	8.0E+13	8.0E+13	8.0E+13	8.0E+13
% of annual limit	0.3	1	8	2	0.2	2
Pu-238	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.
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						
Pu-239 + Pu-240	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.
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						

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
H-3	9.0E+11	9.8E+11	1.0E+12	1.8E+12	2.9E+12	7.7E+12
C-14	2.6E+10	2.3E+10	3.3E+10	9.1E+10	2.8E+10	5.3E+10
I-129	2.7E+06	2.6E+06	1.5E+06	1.1E+06	0.6E+06	1.2E+06

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
% of dose limit (0.3 mSv/a)	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Air-pathway						
Annual effective dose, mSv	0.0008	0.0008	0.0009	0.0024	0.002	0.002
% of dose limit (0.3 mSv/a)	0.3	0.3	0.3	0.8	0.5	0.8

n. d. not detected

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 16 collecting stations next to the place of waste water generation. When the measured activity concentrations are higher than the maximum permissible values, the waste water is transferred into the decontamination plant, where the radioactivity is reduced by ***evaporation with a decontamination factor of*** $\boldsymbol{10^4}$.
- 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.
- For further treatment single batches were transferred to a biological sewage plant.

b) ***exhaust air***

- To the end of 2008 the radioactive emissions to air are released through a total of 27 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 (in the reprocessing plant for vessel off-gas).

6. Waste management

7. Additional 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 conditions.

1. Site Characteristics

Name of facility	**Verein für Kernverfahrenstechnik und Analytik Rossendorf e.V.; former nuclear research centre**
Type of facility	research reactor
Reactor capacity	
Year of commissioning	1957
Year of decommissioning	1991
Location	Rossendorf
Receiving water	Elbe

2. Discharge and Emission data

Annual liquid discharges, Bq/a

	2003	2004	2005	2006	2007	2008
Mn-54						
Co-58						
Co-60	1.1E+06	5.9E+06	1.0E+06	2.9E+05	9.6E+04	1.5E+05
Cs-137	7.7E+05	1.6E+06	5.1E+06	3.0E+06	7.2E+05	7.4E+05
Ce-144						
Eu-152						
Sr-90	1.0E+06	8.3E+05	1.8E+05	1.4E+05	1.3E+05	6.0E+04
Total activity excluding H-3	2.9E+06	8.3E+06	7.1E+06	4.4E+06	8.3E+05	9.5E+05

	2003	2004	2005	2006	2007	2008
Total activity excluding H-3	2.9E+06	8.3E+06	7.1E+06	4.4E+06	8.3E+05	9.5E+05
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	1	4	3	2	0.4	0.4
H-3	2.1E+10	1.5E+11	4.0E+10	1.8E+09	1.3E+08	1.8E+08
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	5	38	10	0.5	0.03	0.05
Total Alpha-activity	5.2E+05	3.8E+05	5.1E+05	1.5E+05	8.1E+04	9.7E+04
Authorised annual limit, Bq/a	3.5E+06	3.5E+06	3.5E+06	3.5E+06	3.5E+06	3.5E+06
% of annual limit	15	11	15	4	2	3

Annual aerial emissions, Bq/a

	2003	2004	2005	2006	2007	2008
H-3	9.5E+09	7.4E+09	2.4E+10	9.2E+09	5.0E+10	1.8E+11
C-14	4.7E+09	3.2E+09	5.6E+08	1.6E+08	5.9E+08	8.1E+08

3. Radiation Doses to the Public

	2003	2004	2005	2006	2007	2008
Water-pathway						
Annual effective dose, mSv	0.006	0.023	0.011	0.005	0.001	0.0008
% of dose limit (0.3 mSv/a)	2	7	4	2	0.5	0.3
Air-pathway						
Annual effective dose, mSv	0.0007	0.0006	0.0006	0.0004	0.0004	0.0007
% of dose limit (0.3 mSv/a)	0.2	0.2	0.2	0.1	0.1	0.2

4. Origin of waste arising

a) ***waste water***

Radioactive waste water is collected in 6 drain tanks up to 10.5 cubic metre and 5 small tanks (30 litre).

b) ***exhaust air***

The radioactive emissions to air are released through a total of 11 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***

- higher storage times for short-lived nuclides;
- ion exchange in the case of higher concentrations;
- plant for cleaning effluents (precipitation, filtration).

b) ***exhaust air***

- delayed emissions of short-lived nuclides;
- using aerosol filters of level H12;
- routing exhaust air through activated carbon filters.

6. Waste management

7. Additional 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 conditions .

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