OSPAR COMMISSION

Protecting and conserving the North-East Atlantic and its resources

Seventh German Implementation Report of PARCOM Recommendation 91/4 on radioactive discharges

Radioactive Substances Series

2019

Seventh Implementation Report (2018)

Report in accordance with PARCOM Recommendation 91/4 on radioactive discharges

presented by Germany

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

Contents

Executive Summary

PARCOM Recommendation 91/4 concerns the use of Best Available Technologies (BAT) to minimise and, as appropriate, eliminate any pollution caused by radioactive discharges from all nuclear industries, including research reactors and reprocessing plants, into the marine environment. The guidelines for the implementation of this Recommendation request that Contracting Parties to the OSPAR Convention report on a four-year basis on their progress in the implementation of BAT in such facilities. This is the report of the Federal Republic of Germany for the seventh round of implementation reporting (2016 - 2019). The information is submitted according to the OSPAR "Guidelines for the submission of information about, and assessment of, the application of BAT in nuclear facilities" (OSPAR Agreement 2004-03).

The information presented in this report indicates that BAT/BEP has been applied to all nuclear installations in Germany: Nuclear power plants in operation as well as in decommissioning, research reactors and nuclear fuel fabrication facilities. Reported low levels of radioactive discharges from all nuclear facilities in conjunction with low levels of radioactive exposure indicate that best technologies available are applied in Germany.

Récapitulatif

La Recommandation PARCOM 91/4 concerne le recours à la meilleure technologie disponible, ou BAT, afin de minimiser et, s'il y a lieu, d'éliminer toute pollution causée par les rejets radioactifs, dans le milieu marin, de l'ensemble des industries nucléaires y compris les réacteurs de recherche et les usines de retraitement. Les lignes directrices pour la mise en œuvre de cette Recommandation demandent que les Parties contractantes à la Convention OSPAR rendent compte tous les quatre ans de la progression de la mise en œuvre de la BAT dans ces installations. Le présent rapport de la République fédérale d'Allemagne porte sur la septième série de notification de mise en œuvre (2016-2019). Ces informations sont présentées selon les « Lignes directrices OSPAR relatives à la communication des informations sur, et à l'appréciation de l'application de la BAT dans les installations nucléaires » (Accord OSPAR 2004-03).

Ces informations indiquent que la BAT/BEP a été appliquée à toutes les installations nucléaires d'Allemagne: les centrales nucléaires en exploitation ainsi que celles en cours de démantèlement, les réacteurs de recherche et les installations de fabrication de combustible nucléaire. On a relevé des niveaux bas de rejets radioactifs provenant de toutes les installations nucléaires ainsi que des niveaux bas d'exposition à la radioactivité ce qui indique que l'Allemagne applique des BAT.

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 2011 to 2016.

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 are given in absolute values and also normalised to the annual electrical power generation compared to the UNSCEAR ranges. Detailed information of emissions is not given in this report. Furthermore the annual effective doses for the water pathway and additionally for 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.

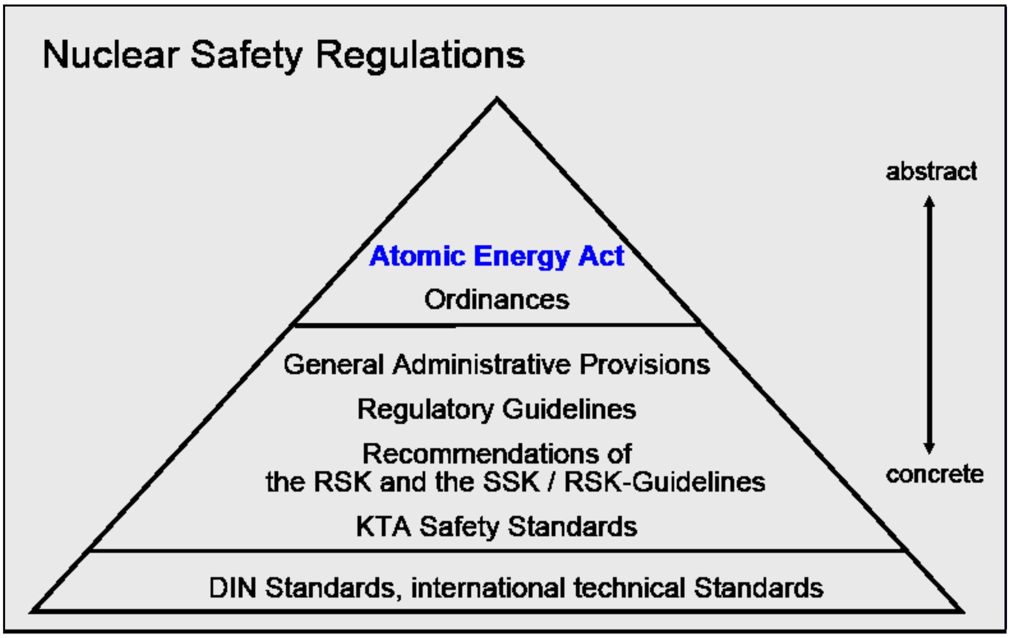

Figure 1 Nuclear safety regulations in Germany

<u>**Laws**</u>

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 2011 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**.

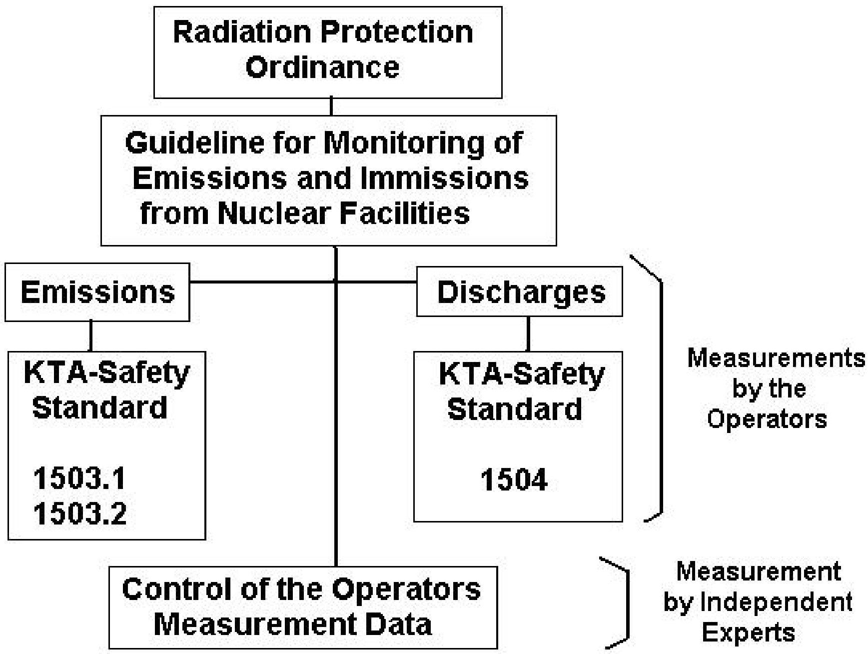

Figure 2 Regulations for the monitoring of radioactive discharges and emissions

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 to KTA 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
□-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-□-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	$5 \cdot 10^{2}$ $Bq \cdot m^{-3}$ (Xe-133) $1 \cdot 10^{4}$ $Bq \cdot m^{-3}$ (Kr-85)	24 hours	quaterly
radioactive iodine	$2 \cdot 10^{-2}$ $Bq \cdot m^{-3}$ (I-131)	week	quaterly
radioactive particulates	$3 \cdot 10^{-2}$ $Bq \cdot m^{-3}$ (Cs-137)	week	quaterly
□-radionuclides	$5 \cdot 10^{-3}$ $Bq \cdot m^{-3}$ (Am-241)	3 months	quaterly
Sr-89/Sr-90	$1 \cdot 10^{-3}$ $Bq \cdot m^{-3}$	3 months	quaterly
H-3	$1 \cdot 10^{2}$ $Bq \cdot m^{-3}$	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 of the OSPAR catchment are shown in **figure 3**. There are thirteen nuclear power plants which were in operation during the time period of the last six years. Ten of them use pressurised water reactors and three boiling water reactors. As a result of the amendment to the German Energy Act in 2011 seven nuclear power plants changed in a permanent non power operation phase. A further nuclear power plant stopped its power operation in 2015. The consumption of electrical energy supplied of Gemany's nuclear power stations decreased from 18 % in 2011 to 13 % in 2016. 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

Nuclear power plant, in operation
Nuclear power plant, in decommissioning
Reprocessing plant / Fuel fabrication plant
Research centre
Research reactor, in operation
Research reactor, in decommissioning

The discharge 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,
- 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 water is described in detail in the documents KTA 1504.

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 (http://www.bfs.de/en/bfs/publikationen/berichte/umweltradioaktivitaet).

3.5 Trends in discharges in the period from 2011 to 2016 and evaluation

<u>Discharges</u>

Most of the nuclear power plants have been operating continuously throughout this period, hence the releases of radionuclides excluding H-3 have been nearly constant. Tritium releases have a small trend downward (see **figure 4**).

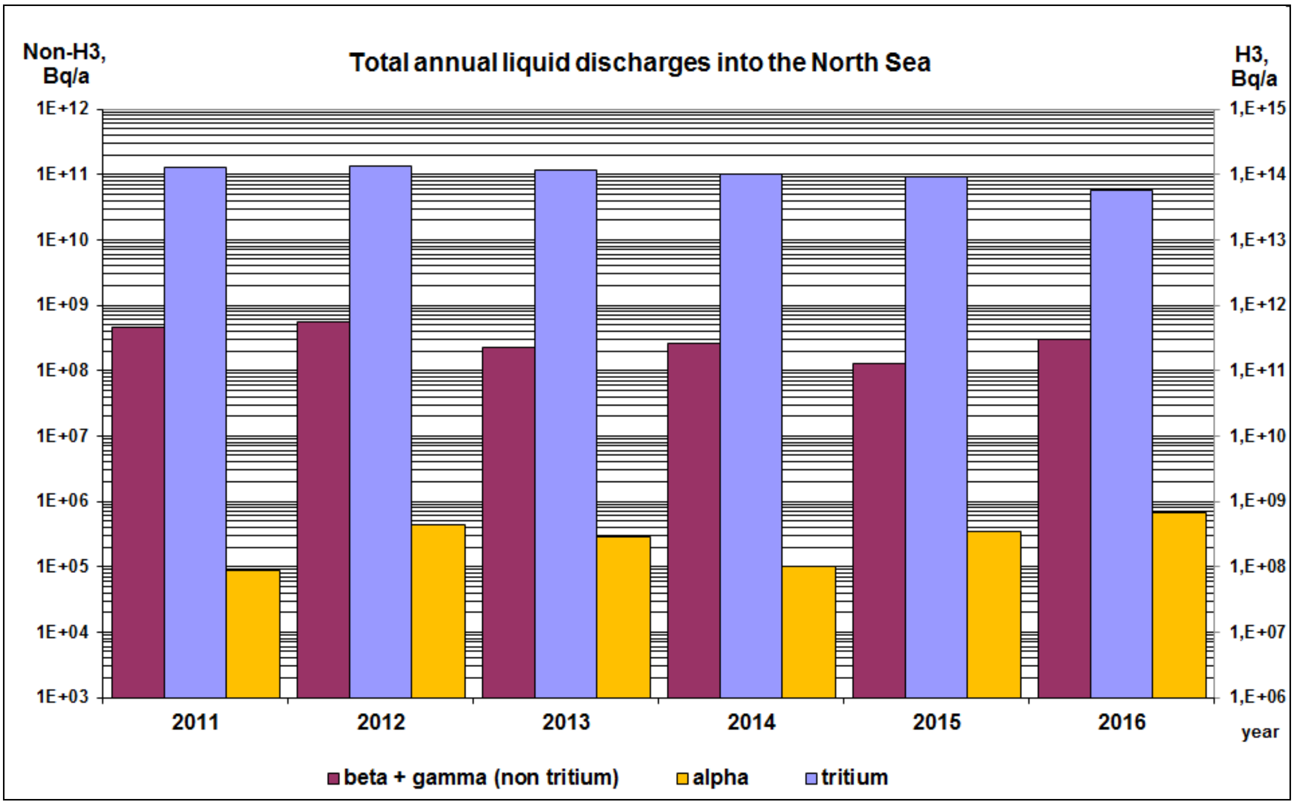

Figure 4 Total annual liquid discharges into the North Sea

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 to the population in the vicinity of all nuclear installations are well below the national limit of 0.3 mSv both for the water pathway and for the air pathway.

The low levels of radioactivity discharges 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 0.006 MBq (0.3 % of the authorised annual limit for Gronau) in 2016. An impact on the environment can not be detected. The calculated annual effective dose for a "reference person" in the vicinity of the enrichment plant due to discharges and emissions is less than 0.1 µSv.

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 for a "reference person" in the vicinity of the enrichment plant due to discharges and emissions is less than 0.1 µSv.

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,
- the dose to members of the public and
- the waste management (provided by the operators).

4.1 Sources of liquid effluent

The sources ofliquid 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 in the period from 2011 to 2016 and evaluation

The alpha discharge level of Gronau from 2011 to 2016 is very low and constant. The alpha activity in discharges 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 of 5 µSv for the pathway water was calculated for a “reference person” in the vicinity of Jülich. The calculated annual effective dose rate in the vicinity of Berlin and Geesthacht is less than 0.1 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,
- 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 annualy by the German Ministry of Environment, Nature Conservation and Nuclear Safety.

5.4 Trends in discharges in the period from 2011 to 2016 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 sum of the discharges from the pressurized nuclear power plants in Germany. Furthermore, there is no trend in discharges from the research and development facilities in Germany in the time period from 2011 to 2016.

6. Conclusion

- Low levels of radioactive discharges 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
	Since March 2011 “non-power operation phase” as result of the amendment to the German Energy Act
Location	Germany
Receiving water	Rhine

	2011	2012	2013	2014	2015	2016
Installed electrical generation capacity, MW(e)	1225					
actual output, MWa	255	-	-	-	-	-

2. Discharge data

Annual liquid discharges, Bq/a

	2011	2012	2013	2014	2015	2016
Cr-51						
Mn-54						
Co-57						
Co-58	3.7E+04					
Co-60	4.3E+06	1.0E+06	9.3E+06	4.2E+07	2.1E+06	4.8E+07
Fe-55	1.2E+06				1.2E+06	7.2E+06
Fe-59						
Ni-63		2.0E+05		7.6E+06	1.0E+06	2.1E+07
Zn-65						
Sr-89						
Sr-90						
Zr-95						
Nb-95						
Ru-103						
Ru-106						
Ag-110m	8.4E+04					
Te-123m	4.2E+06	3.8E+06	3.2E+05	3.7E+05	2.3E+04	
Sb-124	3.2E+06	6.6E+05				
Sb-125	2.2E+06	3.8E+06	5.8E+06	5.0E+07	4.0E+05	1.5E+06
I-131	5.3E+05					
Cs-134	4.4E+04	1.6E+05		1.2E+06		
Cs-137	6.0E+05	2.1E+06	4.0E+05	2.9E+07	8.3E+05	2.8E+05
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides						
Total activity excluding H-3	1.6E+07	1.2E+07	1.6E+07	1.3E+08	5.6E+06	7.8E+07

	2011	2012	2013	2014	2015	2016
Total activity excluding H-3	1.6E+07	1.2E+07	1.6E+07	1.3E+08	5.6E+06	7.8E+07
Authorised annual limit, Bq/a	1.1E+11					
% of annual limit	0.01	0.01	0.01	0.1	0.01	0.07
Normalised to actual output, GBq/Gwa	0.06	-	-	-	-	-
H-3	7.1E+12	8.6E+11	2.2E+12	1.1E+12	2.3E+11	4.3E+11
Authorised annual limit, Bq/a	3.0E+13					
% of annual limit	24	3	7	4	0.8	1
Normalised to actual output, TBq/GWa	28	-	-	-	-	-
Total Alpha-activity	n.d.	1.4E+05	n.d.	n.d.	n.d.	n.d.

3. Radiation Doses to the Public[1]

	2011	2012	2013	2014	2015	2016
Water-pathway						
Annual effective dose, mSv	< 0.0001	< 0.0001	0.002	0.001	0.0002	0.0003
% of dose limit (0.3 mSv/a)	< 0.03	< 0.03	0.5	0.3	0.07	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 in operation phase and very low in non-power operation phase.

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
	Since March 2011 “non-power operation phase” as result of the amendment to the German Energy Act
Location	Germany
Receiving water	Rhine

	2011	2012	2013	2014	2015	2016
Installed electrical generation capacity, MW(e)	1300					
Actual output, MWa	198	-	-	-	-	-

2. Discharge data

Annual liquid discharges, Bq/a

	2011	2012	2013	2014	2015	2016
Cr-51		2.9E+05				
Mn-54						
Co-57						
Co-58	5.2E+05					
Co-60	3.0E+06	9.0E+04	7.8E+05	1.5E+05	2.3E+05	2.3E+05
Fe-55						
Fe-59						
Ni-63					1.5E+05	3.1E+05
Zn-65						
Sr-89						
Sr-90						
Zr-95	2.9E+05					
Nb-95	2.8E+05					
Ru-103						
Ru-106						
Ag-110m	2.6E+06					
Te-123m	3.7E+07	6.0E+05	9.2E+04			
Sb-124	3.6E+07	1.6E+05				
Sb-125	9.8E+06	1.1E+07	2.4E+06	3.1E+04		3.4E+04
I-131	1.6E+05					
Cs-134						
Cs-137	1.3E+06	8.1E+04	4.3E+04	1.1E+04	5.0E+04	1.1E+04
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides						
Total activity excluding H-3	9.1E+07	1.2E+07	3.3E+06	1.9E+05	4.4E+05	5.9E+05

	2011	2012	2013	2014	2015	2016
Total activity excluding H-3	9.1E+07	1.2E+07	3.3E+06	1.9E+05	4.4E+05	5.9E+05
Authorised annual limit, Bq/a	1.1E+11					
% of annual limit	0.08	0.01	0.003	0.0002	0.0004	0.001
Normalised to electrical output, GBq/GWa	0.46	-	-	-	-	-
H-3	1.2E+13	6.0E+12	1.9E+12	2.5E+10	4.1E+11	4.5E+11
Authorised annual limit, Bq/a	3.0E+13					
% of annual limit	39	20	6	0.1	1	2
Normalised to electrical output, TBq/GWa	59	-	-	-	-	-
Total Alpha-activity	n.d.	6.1E+04	n.d.	n.d.	n.d.	n.d.

3. Radiation Doses to the Public

	2011	2012	2013	2014	2015	2016
Water-pathway						
Annual effective dose, mSv	< 0.0001	< 0.0001	0.002	0.001	0.0002	0.0003
% of dose limit (0.3 mSv/a)	< 0.03	< 0.03	0.5	0.3	0.07	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 in operation phase and very low in non-power operation phase.

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

	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Installed electrical generation capacity, MW(e)	1480					
Actual output, MWa	1166	1229	1336	1316	1276	1312

2. Discharge data

Annual liquid discharges, Bq/a

	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Cr-51						
Mn-54						
Co-57						
Co-58						
Co-60						
Fe-55	1.0E+06					
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	1.6E+06		3.1E+05			
Cs-134						
Cs-137	1.8E+04					
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides						
Total activity excluding H-3	2.6E+06	n.d.	3.1E+05	n.d.	n.d.	n.d.

	2011	2012	2013	2014	2015	2016
Total activity excluding H-3	2.6E+06	n.d.	3.1E+05	n.d.	n.d.	n.d.
Authorised annual limit, Bq/a	5.5E+10					
% of annual limit	0.005	0	0.001	0	0	0
Normalised to electrical output, GBq/GWa	0.002		0.0002			
H-3	1.4E+13	2.3E+13	2.3E+13	2.0E+13	2.0E+13	1.2E+13
Authorised annual limit, Bq/a	3.5E+13					
% of annual limit	41	65	65	56	57	33
Normalised to electrical output, TBq/GWa	12	18	17	15	16	9
Total Alpha-activity	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

3. Radiation Doses to the Public

	2011	2012	2013	2014	2015	2016
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

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, 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
	Since March 2011 “non-power operation phase” as result of the amendment to the German Energy Act
Location	Germany
Receiving water	Elbe

	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Installed electrical generation capacity, MW(e)	806					
Actual output, MWa	-	-	-	-	-	-

2. Discharge data

Annual liquid discharges, Bq/a

	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Cr-51						
Mn-54	5.4E+03	1.4E+04				
Co-57						
Co-58						
Co-60	5.2E+06	5.0E+06	6.0E+06	4.0E+06	1.3E+06	2.3E+06
Fe-55	1.5E+06	2.9E+06	3.2E+06			
Fe-59						
Ni-63	4.4E+06	2.3E+06	2.3E+06	5.4E+06		3.9E+06
Zn-65	2.3E+05					
Sr-89						
Sr-90	1.1E+04	4.0E+03	3.2E+04	1.9E+04	1.5E+04	2.6E+04
Zr-95						
Nb-95						
Ru-103						
Ru-106						
Ag-110m						
Te-123m						
Sb-124						
Sb-125						
I-131						
Cs-134						
Cs-137	1.8E+06	2.3E+06	4.5E+06	5.0E+06	2.4E+06	4.1E+06
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides						

Total activity excluding H-3	1.3E+07	1.3E+07	1.6E+07	1.4E+07	3.7E+06	1.0E+07

	2011	2012	2013	2014	2015	2016
Total activity excluding H-3	1.3E+07	1.3E+07	1.6E+07	1.4E+07	3.7E+06	1.0E+07
Authorised annual limit, Bq/a	1.9E+11					
% of annual limit	0.007	0.01	0.01	0.01	0.002	0.01
Normalised to electrical output, GBq/GWa	-	-	-	-	-	-
H-3	3.3E+09	7.3E+09	2.4E+09	1.7E+09	1.6E+09	4.3E+08
Authorised annual limit, Bq/a	3.7E+13					
% of annual limit	0.01	0.02	0.01	0.005	0.004	0.001
Normalised to electrical output, TBq/GWa	-	-	-	-	-	-
Total Alpha-activity	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

3. Radiation Doses to the Public

	2011	2012	2013	2014	2015	2016
Water-pathway						
Annual effective dose, mSv	< 0.0001	< 0.0001	<0.0001	0.0001	0.0002	0.0003
% of dose limit (0.3 mSv/a)	< 0.03	< 0.03	<0.03	0.04	0.06	0.1

n. d. not detected

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

5. Waste treatment ***waste water***

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

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, 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 for Non-Tritium and Tritium discharges.

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

	2011	2012	2013	2014	2015	2016
Installed electrical generation capacity, MW(e)	1400					
Actual output, MWa	1320	1305	1311	1316	1250	1268

2. Discharge data

Annual liquid discharges, Bq/a

	2011	2012	2013	2014	2015	2016
Cr-51						
Mn-54						
Co-57						
Co-58						
Co-60	6.7E+04					
Fe-55	3.4E+05				6.7E+05	
Fe-59						
Ni-63	3.8E+05					
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						
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides						
Total activity excluding H-3	7.9E+05	n.d.	n.d.	n.d.	6.7E+05	n.d.

	2011	2012	2013	2014	2015	2016
Total activity excluding H-3	7.9E+05	n.d.	n.d.	n.d.	6.7E+05	n.d.
Authorised annual limit, Bq/a	3.7E+10					
% of annual limit	0.002	0	0	0	0.002	0
Normalised to electrical output, GBq/GWa	0.001				0.001	
H-3	1.8E+13	1.6E+13	1.6E+13	1.7E+13	2.0E+13	1.1E+13
Authorised annual limit, Bq/a	3.5E+13					
% of annual limit	52	45	45	47	57	30
Normalised to electrical output, TBq/GWa	14	12	12	13	16	8
Total Alpha-activity	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

3. Radiation Doses to the Public

	2011	2012	2013	2014	2015	2016
Water-pathway						
Annual effective dose, mSv	0.001	0.0009	0.0009	0.0009	0.0009	0.0005
% 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 reactor core with water and steam cycles

5. Waste treatment ***waste water***

- ion-exchange procedures;
- evaporation for waste water .

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, 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
	Since June 2015 “non-power operation phase”
Location	Germany
Receiving water	Main

	2011	2012	2013	2014	2015	2016
Installed electrical generation capacity, MW(e)	1345					
Actual output, MWa	1032	1210	1169	1191	497	-

2. Discharge data

Annual liquid discharges, Bq/a

	2011	2012	2013	2014	2015	2016
Cr-51						
Mn-54	7.3E+04		7.1E+04		1.0E+05	1.7E+05
Co-57						
Co-58	1.4E+06		4.4E+04		3.0E+05	
Co-60	5.4E+07	1.2E+07	1.3E+07	1.4E+07	1.1E+07	1.4E+07
Fe-55	8.0E+06	5.9E+06				5.1E+07
Fe-59						
Ni-63	2.7E+06					2.4E+06
Zn-65						
Sr-89						
Sr-90						
Zr-95		4.7E+05			5.0E+05	
Nb-95		1.1E+06	2.3E+05	7.9E+04	1.6E+06	9.3E+03
Ru-103						
Ru-106						
Ag-110m	1.8E+05				3.5E+05	8.6E+04
Te-123m			1.2E+05		2.0E+05	1.3E+05
Sb-124						
Sb-125						2.0E+05
I-131				1.3E+05		
Cs-134						
Cs-137						
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides					2.3E+04	1.4E+07
Total activity excluding H-3	6.6E+07	2.0E+07	1.3E+07	1.4E+07	1.4E+07	8.2E+07

	2011	2012	2013	2014	2015	2016
Total activity excluding H-3	6.6E+07	2.0E+07	1.3E+07	1.4E+07	1.4E+07	8.2E+07
Authorised annual limit, Bq/a	5.5E+10					
% of annual limit	0.1	0.04	0.02	0.03	0.03	0.1
Normalised to electrical output, GBq/GWa	0.06	0.02	0.01	0.01	0.03	-
H-3	1.5E+13	2.1E+13	1.6E+13	1.4E+13	4.3E+12	1.0E+12
Authorised annual limit, Bq/a	4.1E+13					
% of annual limit	36	51	40	34	11	3
Normalised to electrical output, TBq/GWa	14	17	14	12	9	-
Total Alpha-activity	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

3. Radiation Doses to the Public

	2011	2012	2013	2014	2015	2016
Water-pathway						
Annual effective dose, mSv	0.0003	0.0004	0.0003	0.0003	<0.0001	<0.0001
% of dose limit (0.3 mSv/a)	0.09	0.1	0.09	0.08	<0.03	<0.03

n. d. not detected

4. Origin of waste arising

primary cooling system

5. Waste treatment

- ion-exchange;
- evaporation;

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.
- 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

	2011	2012	2013	2014	2015	2016
Installed electrical generation Capacity, MW(e)	1430					
Actual output, MWa	1161	1335	1258	1146	1192	1014

2. Discharge data

Annual liquid discharges, Bq/a

	2011	2012	2013	2014	2015	2016
Cr-51						
Mn-54						
Co-57						
Co-58						
Co-60	4.3E+06	1.6E+06	1.0E+06		1.8E+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		7.5E+05	7.7E+05			3.3E+05
Sb-124			3.2E+05			
Sb-125						
I-131	9.8E+05					
Cs-134						
Cs-137						
Ba-140		3.4E+05				
La-140						
Ce-141						
Ce-144						
Other nuclides						
Total activity excluding H-3	5.3E+06	2.7E+06	2.1E+06	n.d.	1.8E+05	3.3E+05

	2011	2012	2013	2014	2015	2016
Total activity excluding H-3	5.3E+06	2.7E+06	2.1E+06	n.d.	1.8E+05	3.3E+05
Authorised annual limit, Bq/a	5.5E+10					
% of annual limit	0.01	0.005	0.004	0	0.0003	0.001
Normalised to electrical output, GBq/GWa	0.005	0.002	0.0017	0	0.0001	0.0003
H-3	1.8E+13	1.8E+13	1.9E+13	1.9E+13	9.2E+12	7.0E+12
Authorised annual limit, Bq/a	4.8E+13					
% of annual limit	36	36	40	39	19	15
Normalised to electrical output, TBq/GWa	15	13	15	16	8	7
Total Alpha-activity	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

3. Radiation Doses to the Public

	2011	2012	2013	2014	2015	2016
Water-pathway						
Annual effective dose, mSv	0.0002	0.0002	0.0002	0.0002	0.0001	<0.0001
% of dose limit (0.3 mSv/a)	0.07	0.07	0.07	0.07	0.04	<0.03

n. d. not detected

4.	**Origin of waste arising**		primary coolant cycle
5.	**Waste treatment**		– evaporation.
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
	Since March 2011 “non-power operation phase” as result of the amendment to the German Energy Act
Location	Germany
Receiving water	Elbe

	2011	2012	2013	2014	2015	2016
Installed electrical generation Capacity, MW(e)	1402					
Actual output, MWa	-	-	-	-	-	-

2. Discharge data

Annual liquid discharges, Bq/a

	2011	2012	2013	2014	2015	2016
Cr-51						
Mn-54						
Co-57						
Co-58						
Co-60						3.0E+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						2.3E+05
I-131						
Cs-134						
Cs-137						2.9E+04
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides						
Total activity excluding H-3	n.d.	n.d.	n.d.	n.d.	n.d.	5.6E+05

	2011	2012	2013	2014	2015	2016
Total activity excluding H-3	n.d.	n.d.	n.d.	n.d.	n.d.	5.6E+05
Authorised annual limit, Bq/a	5.0E+10					
% of annual limit	0	0	0	0	0	0.001
Normalised to electrical output, GBq/GWa	-	-	-	-	-	-
H-3	7.3E+09	1.3E+09	3.4E+08	1.9E+08	1.1E+08	1.1E+09
Authorised annual limit, Bq/a	1.9E+13					
% of annual limit	0.04	0.01	0.002	0.001	0.001	0.01
Normalised to electrical output, TBq/GWa	-	-	-	-	-	-
Total Alpha-activity	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

3. Radiation Doses to the Public

	2011	2012	2013	2014	2015	2016
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

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.

6. Waste management

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

- No fuel elements in the spent fuel pool.

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

- permanent monitoring of operations;
- due to adherence to the minimisation obligation, discharges are kept as low as possible.

7. Evaluation

a) Non-Tritium discharges are very low and in operational phase below the range published by UNSCEAR;

Tritium discharges are very low and in operational phase below 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	**Mülheim-Kärlich**
Type of facility	PWR
Year of commissioning	1986
Year of shut down	1988
Year of decommisioning	2004
Location	Germany
Receiving water	Rhine

	2011	2012	2013	2014	2015	2016
Installed electrical generation capacity, MW(e)	1302					
Actual output, MWa	-	-	-	-	-	-

2. Discharge data

Annual liquid discharges, Bq/a

	2011	2012	2013	2014	2015	2016
Cr-51						
Mn-54						
Co-57						
Co-58						
Co-60	4.3E+05	6.4E+05	3.2E+05	1.7E+04	3.2E+04	2.9E+05
Fe-55						
Fe-59						
Ni-63	1.5E+06	2.2E+06	1.0E+06	4.2E+04	8.1E+04	4.8E+05
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						
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides						
Total activity excluding H-3	2.0E+06	2.9E+06	1.3E+06	5.9E+04	1.1E+05	7.6E+05

	2011	2012	2013	2014	2015	2016
Total activity excluding H-3	2.0E+06	2.9E+06	1.3E+06	5.9E+04	1.1E+05	7.6E+05
Authorised annual limit, Bq/a	1.0E+10					
% of annual limit	0.02	0.03	0.01	0.001	0.001	0.01
Normalised to electrical output, GBq/GWa	-	-	-	-	-	-
H-3	3.1E+07	1.6E+07	2.1E+07	9.8E+05	6.1E+05	5.9E+07
Authorised annual limit, Bq/a	5.0E+11					
% of annual limit	0.006	0.003	0.004	0.0002	0.0001	0.01
Normalised to electrical output, TBq/GWa	-	-	-	-	-	-
Total Alpha-activity	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

3. Radiation Doses to the Public

	2011	2012	2013	2014	2015	2016
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

n. d. not detected

4. Origin of waste arising — primary cooling system

5. Waste treatment — ***waste water***

- installations for evaporating of all nuclear waste water.

6. Waste management — ***applied procedures to minimise the production of waste***

- minimisation of discharges 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 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
	Since March 2011 “non-power operation phase” as result of the amendment to the German Energy Act
Location	Germany
Receiving water	Neckar

	2011	2012	2013	2014	2015	2016
Installed electrical generation capacity, MW(e)	840					
Actual output, MWa	167	-	-	-	-	-

2. Discharge data

Annual liquid discharges, Bq/a

	2011	2012	2013	2014	2015	2016
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						
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.	n. d.	n. d.	n. d.	n. d.	n. d.

	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Total activity excluding H-3	n.d.	n.d.	n. d.	n. d.	n.d.	n.d.
Authorised annual limit, Bq/a	1.9E+10					
% of annual limit	0	0	0	0	0	0
Normalised to electrical output, GBq/GWa	0	-	-	-	-	-
H-3	6.0E+12	2.0E+12	9.6E+10	6.2E+10	1.3E+10	1.3E+10
Authorised annual limit, Bq/a	1.9E+13					
% of annual limit	32	11	0.5	0.3	0.07	0.07
Normalised to electrical output, TBq/GWa	36	-	-	-	-	-
Total Alpha-activity	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

3. Radiation Doses to the Public

	2011	**2012**	**2013**	**2014**	**2015**	**2016**
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)	0.04	< 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 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	**Neckarwestheim 2**
Type of facility	PWR
Year of commissioning	1988
Location	Germany
Receiving water	Neckar

	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Installed electrical generation capacity, MW(e)	1400					
Actual output, MWa	1319	1270	1243	1295	1279	1300

2. Discharge data

Annual liquid discharges, Bq/a

	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Cr-51						
Mn-54						
Co-57						

Co-58						
Co-60						
Fe-55		3.2E+06				
Fe-59						
Ni-63						
Zn-65						
Sr-89						
Sr-90						
Zr-95						
Nb-95						
Ru-103						
Ru-106						
Ag-110m	5.6E+04					
Te-123m						
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	5.6E+04	3.2E+06	n.d.	n.d.	n.d.	n.d.

	2011	2012	2013	2014	2015	2016
Total activity excluding H-3	5.6E+04	3.2E+06	n.d.	n.d.	n.d.	n.d.
Authorised annual limit, Bq/a	6.0E+10					
% of annual limit	0.0001	0.005	0	0	0	0
Normalised to electrical output, GBq/GWa	0.00004	0.003	0	0	0	0
H-3	2.3E+13	2.0E+13	2.1E+13	1.8E+13	2.0E+13	1.5E+13
Authorised annual limit, Bq/a	7.0E+13					
% of annual limit	33	29	41	35	40	28
Normalised to electrical output, TBq/GWa	17	16	17	14	16	11
Total Alpha-activity	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

3. Radiation Doses to the Public

	2011	2012	2013	2014	2015	2016
Water-pathway						
Annual effective dose, mSv	0.0005	0.0004	0.0003	0.0004	0.0005	0.0003
% of dose limit (0.3 mSv/a)	0.2	0.1	0.1	0.1	0.2	0.1

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 decommisioning	2008
Location	Germany
Receiving water	Neckar

	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Installed electrical generation Capacity, MW(e)	357					
Actual output, MWa	-	-	-	-	-	-

2. Discharge data

Annual liquid discharges, Bq/a

	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Cr-51						
Mn-54						

Co-57						
Co-58						
Co-60	1.7E+07	3.5E+07	1.1E+07	1.1E+07	3.1E+07	6.1E+06
Fe-55	2.0E+07	3.2E+07	5.2E+06	4.4E+06	7.2E+06	
Fe-59						
Ni-63	7.3E+07	2.0E+08	6.1E+07	3.7E+07	4.0E+07	8.3E+07
Zn-65						
Sr-89						
Sr-90		2.3E+04				
Zr-95						
Nb-95						
Ru-103						
Ru-106						
Ag-110m						
Te-123m						
Sb-124						
Sb-125	5.7E+05					
I-131						
Cs-134						
Cs-137	2.0E+06	4.5E+06	2.1E+06	6.2E+05	1.4E+06	8.6E+04
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides	8.2E+04	1.9E+05	5.2E+04			
Total activity excluding H-3	1.1E+08	2.7E+08	8.0E+07	5.3E+07	8.0E+07	8.9E+07

	2011	2012	2013	2014	2015	2016
Total activity excluding H-3	1.1E+08	2.7E+08	8.0E+07	5.3E+07	8.0E+07	8.9E+07
Authorised annual limit, Bq/a	3.0E+10					
% of annual limit	0.4	0.9	0.3	0.2	0.3	0.3
Normalised to electrical output, GBq/GWa	-	-	-	-	-	-
H-3	3.5E+09	6.4E+08	3.9E+08	1.4E+09	3.4E+08	1.2E+09
Authorised annual limit, Bq/a	1.8E+13					
% of annual limit	0.02	0.004	0.002	0.01	0.002	0.01
Normalised to electrical output, TBq/GWa	-	-	-	-	-	-
Total Alpha-activity	1.3E+04	7.2E+04	1.6E+05	1.5E+04	1.4E+05	1.4E+05

3. Radiation Doses to the Public

	2011	2012	2013	2014	2015	2016
Water-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	0.08	0.04	0.07	<0.03

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*** – waste processing.
7.	**Evaluation**	**a)**	Non-Tritium and Tritium discharges are low; 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
	Since March 2011 “non-power operation phase” as result of the amendment to the German Energy Act
Location	Germany
Receiving water	Rhine

	2011	2012	2013	2014	2015	2016
Installed electrical generation capacity, MW(e)	926					
Actual output, MWa	169	-	-	-	-	-

2. Discharge data

Annual liquid discharges, Bq/a

	2011	2012	2013	2014	2015	2016
Cr-51						
Mn-54	5.7E+06	6.4E+05	4.0E+05	2.4E+05	6.5E+04	7.5E+04
Co-57						
Co-58	6.9E+06	3.3E+05	3.6E+05	3.3E+05		2.7E+05
Co-60	1.7E+07	9.4E+06	1.1E+07	5.4E+06	3.5E+06	4.8E+06
Fe-55	8.7E+06	8.3E+06	5.5E+06			
Fe-59						
Ni-63	3.0E+06	1.7E+06	4.1E+06			
Zn-65	1.1E+07	7.8E+06	5.2E+06	4.2E+05	1.9E+04	
Sr-89	1.4E+06					
Sr-90		1.1E+05				3.8E+04
Zr-95		9.6E+04				1.3E+05
Nb-95		2.1E+05				1.1E+05
Ru-103						
Ru-106						
Ag-110m		1.6E+06	7.9E+05	1.9E+05	1.8E+05	
Te-123m						
Sb-124		7.3E+04				4.5E+04
Sb-125				1.1E+06	3.7E+05	
I-131	9.1E+05					
Cs-134	9.2E+05	4.0E+05	1.1E+06	8.8E+04		
Cs-137	1.0E+07	2.3E+06	5.2E+06	1.9E+06	5.2E+06	2.1E+06
Ba-140	1.1E+06					
La-140	9.2E+05					
Ce-141						
Ce-144						
Other nuclides						
Total activity excluding H-3	6.8E+07	3.3E+07	3.3E+07	9.7E+06	9.4E+06	7.6E+06

	2011	2012	2013	2014	2015	2016
Total activity excluding H-3	6.8E+07	3.3E+07	3.3E+07	9.7E+06	9.4E+06	7.6E+06
Authorised annual limit, Bq/a	1.5E+11					
% of annual limit	0.05	0.02	0.02	0.01	0.01	0.01
Normalised to electrical output, GBq/GWa	0.4	-	-	-	-	-
H-3	3.6E+11	8.6E+10	7.2E+09	4.0E+10	2.0E+11	6.1E+10
Authorised annual limit, Bq/a	1.8E+13					
% of annual limit	2	0.5	0.04	0.2	1	0.3
Normalised to electrical output, TBq/GWa	2	-	-	-	-	-
Total Alpha-activity	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

3. Radiation Doses to the Public

	2011	2012	2013	2014	2015	2016
Water-pathway						
Annual effective dose, mSv	< 0.0001	< 0.0001	0.0001	0.0002	0.0003	0.0002
% of dose limit (0.3 mSv/a)	< 0.03	< 0.03	0.05	0.06	0.1	0.07

n. d. not detected

[1] including Philippsburg 2

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

5. Waste treatment ***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.

6. Waste management **a)** ***applied procedures to minimise the production of waste***

- No fuel elements in the spent fuel pool since 2016.

7. Evaluation **a)** Non-Tritium discharges are below the range published by UNSCEAR;

Tritium discharges are below 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	**Philippsburg 2**
Type of facility	PWR
Year of commissioning	1984
Location	Germany
Receiving water	Rhine

	2011	2012	2013	2014	2015	2016
Installed electrical generation Capacity, MW(e)	1468					
Actual output, MWa	1292	1230	1052	1168	1290	1177

2. Discharge data

Annual liquid discharges, Bq/a

	2011	2012	2013	2014	2015	2016
Cr-51						2.7E+05
Mn-54	7.3E+04	2.5E+05	2.7E+05	2.9E+05	3.2E+05	1.7E+06
Co-57	6.6E+04					
Co-58	7.6E+05	1.1E+06	2.2E+06	8.5E+05	4.7E+05	2.7E+06
Co-60	2.4E+06	6.9E+06	6.8E+06	7.8E+06	6.6E+06	1.1E+07
Fe-55	1.8E+06	6.2E+06				
Fe-59						
Ni-63	4.4E+06	7.2E+06	6.3E+06			
Zn-65		2.5E+05				
Sr-89						
Sr-90						
Zr-95						
Nb-95		5.7E+05	5.9E+04		2.0E+05	5.6E+05
Ru-103	5.0E+04					
Ru-106						
Ag-110m		2.1E+05	6.0E+05			1.0E+05
Te-123m		3.0E+05		2.0E+05		4.3E+04
Sb-124	1.4E+06	3.2E+06	1.8E+06	7.8E+05	1.1E+06	9.4E+05
Sb-125						
I-131	1.3E+05					
Cs-134	7.4E+06	4.4E+06	1.1E+06	1.3E+05		
Cs-137	1.0E+07	9.7E+06	4.9E+06	3.1E+06	1.3E+06	1.0E+07
Ba-140						
La-140						
Ce-141						6.4E+04
Ce-144						
Other nuclides						
Total activity excluding H-3	2.9E+07	4.0E+07	2.4E+07	1.3E+07	1.0E+07	2.7E+07

	2011	2012	2013	2014	2015	2016
Total activity excluding H-3	2.9E+07	4.0E+07	2.4E+07	1.3E+07	1.0E+07	2.7E+07
Authorised annual limit, Bq/a	5.5E+10					
% of annual limit	0.05	0.07	0.04	0.02	0.02	0.05
Normalised to electrical output, GBq/GWa	0.02	0.03	0.02	0.01	0.01	0.02
H-3	1.5E+13	1.1E+13	1.2E+13	1.2E+13	1.5E+13	1.1E+13
Authorised annual limit, Bq/a	4.8E+13					
% of annual limit	31	23	24	25	31	23
Normalised to electrical output, TBq/GWa	12	9	11	10	12	9
Total Alpha-activity	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

3. Radiation Doses to the Public

	2011	2012	2013	2014	2015	2016
Water-pathway						
Annual effective dose, mSv	< 0.0001	< 0.0001	0.0001	0.0002	0.0003	0.0002
% of dose limit (0.3 mSv/a)	< 0.03	< 0.03	0.05	0.06	0.1	0.07

n. d. not detected

[1] including Philippsburg 1

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***;
- a hollow-fiber microfiltration 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. 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.

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

	2011	2012	2013	2014	2015	2016
Installed electrical generation Capacity, MW(e)	672					
Actual output, MWa	-	-	-	-	-	-

2. Discharge data

Annual liquid discharges, Bq/a

	2011	2012	2013	2014	2015	2016
Cr-51						
Mn-54						
Co-57						
Co-58						
Co-60	1.8E+06	1.2E+06	9.6E+04	1.3E+05	2.6E+02	2.5E+02
Fe-55	4.2E+05	9.2E+04	2.2E+04			
Fe-59						
Ni-63	1.4E+07	7.6E+06	2.2E+06	1.9E+05	2.3E+03	7.5E+04
Zn-65						
Sr-89						
Sr-90		3.4E+03	1.3E+03	1.4E+03		
Zr-95						
Nb-95						
Ru-103						
Ru-106						
Ag-110m						
Te-123m						
Sb-124						
Sb-125			1.7E+03	1.2E+03		
I-131						
Cs-134						
Cs-137	2.1E+06	1.7E+06	2.7E+05	6.9E+04	3.7E+03	3.3E+03
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides						
Total activity excluding H-3	1.8E+07	1.1E+07	2.6E+06	3.9E+05	6.3E+03	7.9E+04

	2011	2012	2013	2014	2015	2016
Total activity excluding H-3	1.8E+07	1.1E+07	2.6E+06	3.9E+05	6.3E+03	7.9E+04
Authorised annual limit, Bq/a	1.9E+09					
% of annual limit	1	0.6	0.1	0.02	0.0003	0.004
Normalised to electrical output, GBq/GWa	-	-	-	-	-	-
H-3	2.2E+09	1.2E+09	2.4E+08	1.7E+08	7.7E+06	1.1E+07
Authorised annual limit, Bq/a	3.5E+12					
% of annual limit	0.06	0.03	0.01	0.01	0.005	0.0002
Normalised to electrical output, TBq/GWa	-	-	-	-	-	-
Total Alpha-activity	4.5E+03	1.6E+04	2.2E+03	2.5E+03	1.1E+02	6.7E+02

3. Radiation Doses to the Public

	2011	2012	2013	2014	2015	2016
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

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, discharges are kept as low as possible.

7. Evaluation

a) Non-Tritium and Tritium discharges are low;

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
Date commissioned	1978
	Since March 2011 “non-power operation phase” as result of the amendment to the German Energy Act
Location	Germany
Receiving water	Weser

	2011	2012	2013	2014	2015	2016
Installed electrical generation capacity, MW(e)	1410					
Actual output, MWa	-	-	-	-	-	-

2. Discharge data

Annual liquid discharges, Bq/a

	2011	2012	2013	2014	2015	2016
Cr-51						
Mn-54	5.1E+04					
Co-57						
Co-58	3.7E+05					
Co-60	2.5E+07	9.7E+07	1.4E+07	2.7E+06	3.4E+06	2.0E+06
Fe-55	2.1E+06	1.7E+07				
Fe-59						
Ni-63	2.3E+06	2.4E+06				
Zn-65						
Sr-89						
Sr-90						
Zr-95						
Nb-95	2.0E+05					
Ru-103						
Ru-106						
Ag-110m		8.3E+06				
Te-123m	7.4E+05	9.3E+05	5.3E+06	2.1E+06		
Sb-124						
Sb-125		9.4E+05	1.4E+07	1.5E+07		
I-131						
Cs-134		1.2E+06				
Cs-137	1.2E+06	6.8E+06	5.7E+05	2.0E+05		8.5E+05
Ba-140						
La-140						
Ce-141						
Ce-144						

Total activity excluding H-3	3.2E+07	1.4E+08	3.4E+07	2.0E+07	3.4E+06	2.9E+06

	2011	2012	2013	2014	2015	2016
Total activity excluding H-3	3.2E+07	1.4E+08	3.4E+07	2.0E+07	3.4E+06	2.9E+06
Authorised annual limit, Bq/a	3.7E+10					
% of annual limit	0.08	0.4	0.09	0.05	0.01	0.01
Normalised to electrical output, GBq/GWa	0.1	-	-	-	-	-
H-3	1.3E+12	1.9E+13	3.5E+12	1.6E+12	4.7E+10	1.4E+12
Authorised annual limit, Bq/a	3.5E+13					
% of annual limit	4	54	10	5	0.1	4
Normalised to electrical output, TBq/GWa	4	-	-	-	-	-
Total Alpha-activity	n.d.	n.d.	n. d.	n. d.	n. d.	n. d.

3. Radiation Doses to the Public

	2011	2012	2013	2014	2015	2016
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

n. d. not detected

4. Origin of waste arising

primary coolant cycle and attached systems

5. Waste treatment

waste water

primary coolant cycle

- filtration;
- ion-exchange procedures;
- degassing;
- evaporation with decontamination factors up to 10^6.

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, 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 decommisioning	1997, no liquid discharges since 2014
Location	Germany
Receiving water	Weser

	2011	2012	2013	2014	2015	2016
Installed electrical generation Capacity, MW(e)	670					
Actual output, MWa	-	-	-	-	-	-

2. Discharge data

Annual liquid discharges, Bq/a

	2011	2012	2013	2014	2015	2016
Cr-51						
Mn-54						
Co-57						
Co-58						
Co-60	6.3E+05	2.9E+05	2.0E+04			
Fe-55						
Fe-59						
Ni-63	2.2E+05	1.5E+05				
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	1.1E+05	1.0E+05				
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides						

Total activity excluding H-3	9.6E+05	5.4E+05	2.0E+04	-	-	-

	2011	2012	2013	2014	2015	2016
Total activity excluding H-3	9.6E+05	5.4E+05	2.0E+04	-	-	-
Authorised annual limit, Bq/a	2.0E+08			-		
% of annual limit	0.5	0.3	0.01	-	-	-
Normalised to electrical output, GBq/GWa	-	-	-	-	-	-
H-3	1.3E+08	9.4E+07	4.1E+07	-	-	-
Authorised annual limit. Bq/a	2.0E+10			-		
% of annual limit	0.7	0.5	0.2	-	-	-
Normalised to electrical output, TBq/GWa	-	-	-	-	-	-
Total Alpha-activity	n.d.	n.d.	n. d.	-	-	-

3. Radiation Doses to the Public

	2011	2012	2013	2014	2015	2016
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

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, discharges are kept as low as possible.

7. Evaluation

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

Alpha discharges are very low or below the detection limit.

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	4500 t/a
Year of commissioning	1985
Location	Gronau
Receiving water	Vechte, Ijsselmeer

2. Discharge data

Annual liquid discharges, Bq/a

	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Total Alpha-activity	4.6E+03	3.1E+03	3.8E+03	-	3.9E+03	5.9E+03
Authorised annual limit, Bq/a	2.0E+06	2.0E+06	2.0E+06	2.0E+06	2.0E+06	2.0E+06
% of annual limit	0.2	0.1	0.2	0	0.2	0.3

3. Radiation Doses to the Public

	2011	**2012**	**2013**	**2014**	**2015**	**2016**
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

4.	**Origin of waste arising**		– vacuum pump oil from UF_3-pumps – 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 have been constantly low.

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 data

Annual liquid discharges, Bq/a

	2011	2012	2013	2014	2015	2016
Total Alpha-activity	n. d.					
Authorised annual limit, Bq/a	220 g uranium					
% of annual limit						

Annual aerial emissions, Bq/a

3. Radiation Doses to the Public

	2011	2012	2013	2014	2015	2016
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.
5.	**Waste treatment**		
6.	**Waste management**		***applied procedures to minimise the production of waste***
			– 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	**Helmholtz-Zentrum Geesthacht, Centre for Materials and Costal Research**
Type of facility	Different research and development facilities including two reactors
Reactor capacity	5 MW / 15 MW
Year of commissioning	1958
Year of shut down	1963
Year of decommisioning	1991
Location	Geesthacht
Receiving water	Elbe

2. Discharge data

Annual liquid discharges, Bq/a

	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Cr-51						
Mn-54						
Co-58						
Co-60	2.0E+06	7.2E+05	1.9E+06	1.5E+06	1.0E+06	3.0E+07
Fe-55					3.2E+04	6.9E+05
Fe-59				6.1E+04		
Ni-63					3.2E+04	6.3E+05
Zn-65	2.2E+05	9.1E+03	2.6E+05			3.6E+05
Sr-89			9.8E+03	4.1E+04	3.6E+04	
Sr-90			1.3E+05	3.2E+05	2.3E+05	
Zr-95						
Nb-95						
Ru-103						
Ru-106						
Ag-110m						
Te-123m						
Sb-124						
Sb-125	7.5E+04					
I-131						
Cs-134	4.8E+04			2.7E+04	2.2E+04	3.1E+04
Cs-137	5.3E+06	2.7E+05	1.2E+06	8.1E+06	6.1E+06	1.8E+07
Ba-140						
La-140						
Ce-141						
Ce-144						
Other nuclides						
Total activity excluding H-3	8.1E+06	3.7E+06	3.5E+06	1.0E+07	7.4E+06	4.9E+07

	2011	2012	2013	2014	2015	2016
Total activity excluding H-3	8.1E+06	3.7E+06	3.5E+06	1.0E+07	7.4E+06	4.9E+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	0.04	0.02	0.02	0.05	0.04	0.3
H-3	4.5E+08	1.5E+08	1.3E+08	4.5E+08	4.2E+08	1.2E+09
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	0.8	0.3	0.2	0.8	0.8	2
Total Alpha-activity	2.4E+04	4.5E+03	6.4E+03	1.9E+04	7.1E+02	2.2E+04

3. Radiation Doses to the Public

	2011	2012	2013	2014	2015	2016
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

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 data

Annual liquid discharges, Bq/a

	2011	2012	2013	2014	2015	2016
Total activity excluding H-3	1.7E+05	4.6E+04	1.3E+05	5.1E+04	4.1E+04	3.5E+04
Authorised annual limit, Bq/a	**-1-**	**-1-**	**-1-**	**-1-**	**-1-**	**-1-**
% of annual limit						
H-3	2.2E+08	6.9E+08	6.3E+08	7.5E+08	2.5E+08	2.5E+08
Authorised annual limit, Bq/a	**-1-**	**-1-**	**-1-**	**-1-**	**-1-**	**-1-**
% of annual limit						
Total Alpha-activity	1.5E+04	1.5E+04	1.1E+04	2.0E+04	n.d.	n.d.
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).

3. Radiation Doses to the Public

	2011	2012	2013	2014	2015	2016
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

4. Origin of waste arising

5. Waste treatment

All the contaminated waste water that is generated in the Helmholtz-Zentrum Berlin 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. Discharges can arise from the treatment and storage of these wastes.

6. Waste management

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.

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	1885 / 1988 / 2006
Location	Jülich
Receiving water	Rur

2. Discharge data

Annual liquid discharges, Bq/a

	2011	2012	2013	2014	2015	2016
Co-60						
Sr-89						
Sr-90	2.0E+07	4.1E+06	1.3E+07	2.5E+07	4.9E+07	3.4E+07
I-131	6.0E+06	6.4E+06	4.9E+06	6.2E+06	6.4E+06	1.8E+06
Cs-137	2.0E+06	3.0E+06	3.5E+06	1.1E+07	5.1E06	1.9E+07
Other nuclides	1.0E+08	8.6E+07	1.4E+08	1.0E+08	1.40E+08	6.52E+07
Total activity excluding H-3	1.3E+08	9.9E+07	1.4E+08	1.5E+08	2.0E+08	1.2E+08

	2011	2012	2013	2014	2015	2016
Total activity excluding H-3	1.3E+08	9.9E+07	1.4E+08	1.5E+08	2.0E+08	1.2E+08
Authorised annual limit, Bq/a	7.6E+09	7.6E+09	7.6E+09	7.6E+09	7.6E+09	7.6E+09
% of annual limit	1	1	2	2	3	2
H-3	1.0E+12	3.0E+11	1.9E+12	8.5E+11	1.2E+11	5.2E+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	10	3				
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	0	0	0	0	0	0

3. Radiation Doses to the Public

	2011	2012	2013	2014	2015	2016
Water-pathway						
Annual effective dose, mSv	0.005	0.001	0.005	0.003	0.001	0.002
% of dose limit (0.3 mSv/a)	2	0.5	2	1	0.4	0.6

n. d. not detected

4.	**Origin of waste arising**		***waste water***
			Radioactive waste water is collected in 25 drain tanks, the contents of which are then centrally collected.
5.	**Waste treatment**	**a)**	***waste water***
			– higher storage times for short-lived nuclides;
			– evaporation in the case of higher concentrations.
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	**Karlsruhe Institute Of Technolofy Campus North and further facilities**
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 data

Annual liquid discharges, Bq/a

	2011	**2012**	**2013**	**2014**	**2015**	**2016**
C-14						
Co-60	1.9E+05					
Sr-89						
Sr-90	7.9E+06	1.1E+06	2.4E+05	1.9E+05	4.6E+05	5.4E+04
Cs-137	1.9E+08	2.9E+07	1.6E+06	2.0E+06	2.2E+06	2.7E+06
Pu-241						
Other nuclides			2.5E+05	6.2E+05	4.4E+05	6.5E+05
Total activity excluding H-3	1.9E+08	3.0E+07	2.1E06	2.8E+06	3.1E+06	3.4E+06

	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Total activity excluding H-3	1.9E+08	3.0E+07	2.1E06	2.8E+06	3.1E+06	3.4E+06
Authorised annual limit, Bq/a	3.2E+11	3.2E+11	3.2E+11	3.2E+11	3.2E+11	3.2E+11
% of annual limit	0.06	0.01	0.001	0.001	0.001	0.001
H-3	3.9E+11	5.7E+10	6.7E10	8.6E+10	4.0E+11	3.3E+11
Authorised annual limit, Bq/a	8.0E+13	8.0E+13	8.0E+13	8.0E+13	8.0E+13	8.0E+13
% of annual limit	0.5	0.07	0.5	0.07	0.08	0.1
Total Alpha-activity	2.1E+06	3.9E+06	1.8E+06	n.d.	9.9E+05	n. d.
Am-241	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.
Authorised annual limit, Bq/a	4.0E+08	4.0E+08	4.0E+08	4.0E+08	4.0E+08	4.0E+08
% of annual limit						
Am-243	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.
Authorised annual limit, Bq/a	5.0E+08	5.0E+08	5.0E+08	5.0E+08	5.0E+08	5.0E+08
% of annual limit						

n. d. not detected

3. Radiation Doses to the Public

	2011	2012	2013	2014	2015	2016
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

4. Origin of waste arising

At the Facility Site Campus North 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

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 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.

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	**VKTA – Strahlenschutz, Analytik & Entsorgung Rossendorf e. V.; former nuclear research centre**
Type of facility	Former nuclear research centre; reactors are now closed
Reactor capacity	
Year of commissioning	1957
Location	Rossendorf
Receiving water	Elbe

2. Discharge data

Annual liquid discharges, Bq/a

	2011	2012	2013	2014	2015	2016
Co-60	2.3E+05	3.8E+04	8.7E+03			
Cs-137	9,9E+05	2,4E+06	8.7E+05	2.3E+06	1.3E+06	6.2E+05
Sr-90	7.2E+05	1.4E+05	1.2E+05	7.4E+04	6.3E+04	3.4E+04
Total activity excluding H-3	2.0E+06	3.1E+06	2.0E+06	6.1E+06	1.9E+06	2.6E+06

	2011	2012	2013	2014	2015	2016
Total activity excluding H-3	2.0E+06	3.1E+06	2.0E+06	6.1E+06	1.9E+06	2.6E+06
Authorised annual limit, Bq/a	-1-	-1-	-1-	-1-	-1-	-1-
% of annual limit						
H-3	3.1E+08	6.5E+07	2.3E+07	8.2E+07	3.3E+07	6.2E+07
Authorised annual limit, Bq/a	-1-	-1-	-1-	-1-	-1-	-1-
% of annual limit						
Total Alpha-activity	7.3E+04	5.2E+03	3.8E+04	4.6E+04	9.6E+03	1.9E+04
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).

3. Radiation Doses to the Public

	2011	2012	2013	2014	2015	2016
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

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). If decision analysis allow this, water will be released passing the laboratory wastewater purification facility.

Until the year 2010 the release went via sewage purification plant and settling pong at the side to the receiving water, time after waste water is released into the municipal sewerage plant with the limit values of Article 47 (4) of the Radiation Protection Ordinance being observed.

5. Waste treatment

waste water

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

6. Waste management

7. Additional information

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