EUROPEAN COMMISSION
DIRECTORATE-GENERAL FOR ENERGY

DIRECTORATE D – Nuclear energy, safety and ITER
D.3 – Radiation protection and nuclear safety

Verification under the terms of Article 35 of the Euratom Treaty

Technical Report

THE NETHERLANDS

Borssele Nuclear Power Plant

Discharge and environmental monitoring and national environmental radioactivity monitoring network in the vicinity

16 – 19 May 2022

Reference: NL 22-02

VERIFICATIONS UNDER THE TERMS OF ARTICLE 35

OF THE EURATOM TREATY

FACILITIES	- Facilities for monitoring discharges of gaseous and liquid radioactive effluents into the environment at the Borssele nuclear power plant - Facilities for monitoring environmental radioactivity in the vicinity of the Borssele nuclear power plant - Associated analytical laboratories
LOCATIONS	- Borssele NPP and the surrounding area - Bilthoven (National Institute of Public Health and the Environment laboratory)
DATES	16 – 19 May 2022
REFERENCE	NL 22-02
TEAM MEMBERS	Mr Vesa Tanner, DG ENER (team leader) Mr Agris Ozols, DG ENER
REPORT DATE	31 October 2022
SIGNATURES	

V. Tanner A. Ozols

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Annex 1 Verification programme

Legend

Abbreviation	**Explanation**
ANVS	Authority for Nuclear Safety and Radiation Protection
EC	European Commission
EPZ	*Elektriciteits Produktiemaatschappij Zuid-Nederland* (NPP operator)
EU	European Union
EURDEP	EUropean Radiological Data Exchange Platform
GPS	Global Positioning System
HPGe	High Purity Germanium (detector)
IAEA	International Atomic Energy Agency
ICP-MS	Inductively Coupled Mass Spectrometer
IMS	Integrated Management System
KTA	*KernTechnischer Ausschuss* - German Nuclear Safety Standards Commission
LCPS	*Landelijk CrisisPlan Stralingsongevallen*, National Crisis Plan for Radiation Incidents
LIMS	Laboratory Information Management System
LMRV	*Landelijk Meetnet Radioactiviteit in Voedsel*, NL national network for radioactivity in food
LNV	Ministry of Agriculture, Nature and Food Quality
LSC	Liquid Scintillation Counting (detector)
MONET	MOnitoring NEtwork Terrains
NMR	Dutch National Radioactivity Monitoring Network
NPP	Nuclear Power Plant
NRG	Nuclear Research and Consultancy Group
NVWA	Netherlands Food and Consumer Product Safety Authority
PIPS	Passivated Implanted Planar Silicon (detector)
PWR	Pressurized Water Reactor
RIVM	*Rijksinstituut voor Volksgezondheid en Milieu*, NL National Institute of Public Health and the Environment
RWS	*RijksWaterStaat* (an institute part of the Ministry of Infrastructure and the Environment)
STP	Standard Temperature and Pressure
TL	Borssele NPP nuclear ventilation system
TLD	ThermoLuminiscent Dosimeter
TR	Borssele NPP radioactive wastewater system
UPS	Uninterrupted Power Supply
VC	Borssele NPP main cooling water system
VF	Borssele NPP emergency cooling system
WFSR	Wageningen Food Safety Research laboratory

TECHNICAL REPORT

1 INTRODUCTION

Under Article 35 of the Euratom Treaty, all Member States must establish the facilities necessary to carry out continuous monitoring of the levels of radioactivity in air, water and soil and to ensure compliance with the basic safety standards[1]. Article 35 also gives the European Commission (EC) the right of access to such facilities to verify their operation and efficiency. The radiation protection and nuclear safety unit of the European Commission's Directorate-General for Energy is responsible for undertaking these verifications. The EC's Joint Research Centre provides technical support during the verification visits and in drawing up the reports.

The main purpose of the verifications under Article 35 of the Euratom Treaty is to provide an independent assessment of the adequacy of monitoring facilities for:

- liquid and airborne discharges of radioactivity from a site into the environment;
- levels of environmental radioactivity at the site perimeter and in the marine, terrestrial and aquatic environment around the site, for all relevant exposure pathways;
- levels of environmental radioactivity on the territory of the Member State.

Taking into account previous bilateral protocols, a Commission Communication[2] describing practical arrangements for Article 35 verification visits in Member States was published in the *Official Journal of the European Union* on 4 July 2006.

2 PREPARATION AND CONDUCT OF THE VERIFICATION

2.1 PREAMBLE

The Commission notified the Netherlands of its decision to conduct an Article 35 verification in a letter addressed to the Permanent Representation of the Netherlands to the European Union. The Dutch Government subsequently designated the Authority for Nuclear Safety and Radiation Protection (ANVS) to lead the preparations for this visit.

The last verification under Article 35 at the Borssele NPP took place in 2008[3].

2.2 DOCUMENTS

To assist the verification team in its work, the Dutch national authorities supplied an information package in advance[4]. Additional documentation was provided during and after the visit. The information provided was used extensively in drawing up the descriptive sections of this report.

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1 Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation; repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom with effect from 6 February 2018 (OJ L 13 of 17.1.2014)

2 Commission Communication *Verification of environmental radioactivity monitoring facilities under the terms of Article 35 of the Euratom Treaty — Practical arrangements for the conduct of verification visits in Member States* (OJ C 155, 4.7.2006, pp. 2-5)

3 Euratom Art. 35 Verification Borssele NPP 3-7 March 2008, Technical Report NL 08-01

4 Replies to the preliminary information questionnaire addressed to the national competent authority, received on 25 April 2022

2.3 PROGRAMME OF THE VISIT

The EC and ANVS agreed on a programme of verification activities in line with the Commission Communication of 4 July 2006 (Annex 1).

The opening meeting held at the Borssele NPP included presentations on the following:

- Commission Article 35 verification programme
- Borssele NPP introduction
- Environmental radioactivity monitoring in the Netherlands
- Borssele NPP on- and off-site monitoring programmes

The verification team pointed to the quality and comprehensiveness of all the presentations and documentation. The team carried out the verifications in accordance with the programme in Annex 1. It met the following representatives of the national authorities and other parties involved:

Elektriciteits Produktiemaatschappij Zuid-Nederland (EPZ) (Borssele NPP operator)

Ms Renate van der Wekken – de Bruijne, engineer Monitoring Department
Mr Mark Versluijs, Radiation Protection Department
Mr Kees Lous, Radiation protection expert
Mr Hans Meijer, Manager Monitoring
Mr Gido Goulooze, Head of Radiation Protection Department
Mr Steven van Renterghem, Head of Chemistry Department
Ms Danielle de Schipper, engineer Monitoring Department

Authority for Nuclear Safety and Radiation Protection (ANVS)

Ms Barbara Godthelp, Senior advisor
Mr Patrick Arends, Coordinating specialist inspector
Mr Paul van Fessem, Plant inspector for EPZ
Mr Jan Pieter Mook, Department Head

Nuclear Research and Consultancy Group (NRG)

Mr Marcel Raspe, Manager of NRG radionuclide lab
Mr Govert de With, Radiation protection consultant
Mr Laurens Pijl, Radiation protection expert

National Institute of Public Health and the Environment (RIVM)

Mr Herman Schreurs, Manager of RIVM radionuclide laboratory and nuclear incident team
Mr Pieter Kwakman, Co-ordinator radiochemical analyses
Mr Rick Tax, Co-ordinator National Monitoring Network
Ms Cristina Tanzi, Gamma measurements and air dispersion monitoring
Mr Maarten Hakvoort, Co-ordinator MONET equipment service and data processing

3 LEGAL FRAMEWORK FOR RADIOACTIVITY MONITORING

3.1 NATIONAL LEGISLATION IN THE NETHERLANDS

3.1.1 Legislative acts establishing the responsibilities of the various actors

The following legal texts establish the responsibilities in the Netherlands:

- Nuclear Energy Act (Kernenergiewet)[5], law from 21-02-1963, last update 16-02-2022;
- Environmental Protection Act (Wet Milieubeheer)[6], law from 13-06-1979, last update 01-05-2022;
- General Administrative Act (Algemene Wet Bestuursrecht)[7], law from 04-06-1992, last update 01-05-2022.

3.1.2 Legislative acts regulating environmental radioactivity monitoring

The following legal texts regulate the environmental radioactivity monitoring in the Netherlands:

- Nuclear Energy Act (Kernenergiewet), law from 21-02-1963, last update 16-02-2022;
- Decree on Basic Safety Standards for Radiation Protection (Besluit basisveiligheidsnormen stralingsbescherming)[8], decree from 23-10-2017, last update 01-07-2021;
- Nuclear Facilities, Fissionable Materials and Ores Decree (Besluit kerninstallaties, splijtstoffen en ertsen)[9], decree from 04-09-1969, last update 12-11-2021;
- Regulation on Safety of Nuclear Facilities (Regeling Nucleaire Veiligheid Kerninstallaties)[10], regulation from 06-06-2017, last update 06-02-2018;
- ANVS-Regulation on Basic Safety Standards for Radiation Protection (ANVS-verordening basisveiligheidsnormen stralingsbescherming)[11], ANVS-regulation from 09-01-2018, last update 01-10-2021.

3.1.3 Legislative acts regulating discharge radioactivity monitoring

The following legal texts and instructions regulate the monitoring of radioactive discharges in the Netherlands:

- Decree on Basic Safety Standards for Radiation Protection (Besluit basisveiligheidsnormen stralingsbescherming), decree from 23-10-2017, last update 01-07-2021;
- Nuclear Facilities, Fissionable Materials and Ores Decree (Besluit kerninstallaties, splijtstoffen en ertsen), decree from 04-09-1969, last update 12-11-2021;
- Regulation on Safety of Nuclear Facilities (Regeling Nucleaire Veiligheid Kerninstallaties), regulation from 06-06-2017, last update 06-02-2018;
- ANVS-Regulation on Basic Safety Standards for Radiation Protection (ANVS-verordening basisveiligheidsnormen stralingsbescherming), ANVS-regulation from 09-01-2018, last update 01-10-2021.

The legal hierarchy is as follows: Acts are the highest level; Decrees are the second highest, followed by Regulations (from the latter, the ministerial are considered above the ANVS regulations).

[5] https://wetten.overheid.nl/BWBR0002402
[6] https://wetten.overheid.nl/BWBR0003245
[7] https://wetten.overheid.nl/BWBR0005537
[8] https://wetten.overheid.nl/BWBR0040179
[9] https://wetten.overheid.nl/BWBR0002667
[10] https://wetten.overheid.nl/BWBR0039625
[11] https://wetten.overheid.nl/BWBR0040581

3.2 INTERNATIONAL LEGISLATION AND GUIDANCE DOCUMENTS

The list below includes the main international legislative and guidance documents issued by the European Union (EU) and the International Atomic Energy Agency (IAEA), that form the basis for environmental radioactivity monitoring, radiological surveillance of foodstuffs and surveillance of radioactive discharges.

Euratom and European Union legislation

- The Euratom Treaty
- Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom
- Council Directive 2013/51/Euratom of 22 October 2013 laying down requirements for the protection of the health of the general public with regard to radioactive substances in water intended for human consumption
- Council Decision 87/600/Euratom of 14 December 1987 on Community arrangements for the early exchange of information in the event of a radiological emergency
- Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety
- Council Regulation (Euratom) 2016/52 of 15 January 2016 laying down maximum permitted levels of radioactive contamination of food and feed following a nuclear accident or any other case of radiological emergency, and repealing Regulation (Euratom) No 3954/87 and Commission Regulations (Euratom) No 944/89 and (Euratom) No 770/90
- Council Regulation (EEC) No 2219/89 of 18 July 1989 on the special conditions for exporting foodstuffs and feedingstuffs following a nuclear accident or any other case of radiological emergency
- Council Regulation (EC) No 733/2008 of 15 July 2008 on the conditions governing imports of agricultural products originating in third countries following the accident at the Chernobyl nuclear power station
- Council Regulation (EC) No 1048/2009 of 23 October 2009 amending Regulation (EC) No 733/2008 on the conditions governing imports of agricultural products originating in third countries following the accident at the Chernobyl nuclear power station
- Commission Regulation (EC) No 1609/2000 of 24 July 2000 establishing a list of products excluded from the application of Council Regulation (EEC) No 737/90 on the conditions governing imports of agricultural products originating in third countries following the accident at the Chernobyl nuclear power station
- Commission Regulation (EC) No 1635/2006 of 6 November 2006 laying down detailed rules for the application of Council Regulation (EEC) No 737/90 on the conditions governing imports of agricultural products originating in third countries following the accident at the Chernobyl nuclear power station
- Commission Implementing Regulation (EU) 2016/6 of 5 January 2016 imposing special conditions governing the import of feed and food originating in or consigned from Japan following the accident at the Fukushima nuclear power station and repealing Implementing Regulation (EU) No 322/2014
- Commission Recommendation 2000/473/Euratom of 8 June 2000 on the application of Article 36 of the Euratom Treaty concerning the monitoring of the levels of radioactivity in the environment for the purpose of assessing the exposure of the population as a whole
- Recommendation 2004/2/Euratom of 18 December 2003 on standardised information on radioactive airborne and liquid discharges into the environment from nuclear power reactors and reprocessing plants in normal operation

- Commission Recommendation 2003/274/Euratom of 14 April 2003 on the protection and information of the public with regard to exposure resulting from the continued radioactive caesium contamination of certain wild food products as a consequence of the accident at the Chernobyl nuclear power station

International guidance documents, issued mainly by the International Atomic Energy Agency (IAEA)

- *Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards*, IAEA Safety Standards Series No. GSR Part 3, IAEA, Vienna, 2014
- *Clearance of materials resulting from the use of radionuclides in medicine, industry and research*, IAEA-TECDOC-1000, IAEA, Vienna, 1998
- *Generic models for use in assessing the impact of discharges of radioactive substances to the environment*, Safety Reports Series No 19, IAEA, Vienna, 2001
- *Handbook of parameter values for the prediction of radionuclide transfer in temperate environments*, Technical Reports Series No 364, IAEA, Vienna, 1994
- *Management of radioactive waste from the use of radionuclides in medicine*, IAEA-TECDOC-1183, IAEA, Vienna, 2000
- *Regulatory control of radioactive discharges to the environment: Safety Guide*, Safety Standards Series No. WS-G-2.3, IAEA, Vienna, 2000
- *Sources and effects of ionizing radiation*, United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 2000, Report to the General Assembly, Vol. I, United Nations, New York, 2000
- *Guidelines for drinking-water quality*, 4th ed. 2011, World Health Organisation (WHO)

4 BODIES HAVING COMPETENCE IN THE FIELD OF ENVIRONMENTAL AND DISCHARGE RADIOACTIVITY MONITORING

4.1 INTRODUCTION

In the Netherlands, the facilities liable to generate radioactive waste must have effluent storage, treatment and removal systems. Radiological monitoring programmes must be based on site and discharge characteristics. For the Borssele NPP the environmental radiological monitoring programme is composed of the network implemented by the operator at the site and in the zones of influence, as well as by a site-specific programme implemented by the NRG on behalf of the operator.

There are several organisations, which participate in monitoring radioactivity in the environment, foodstuffs or in industrial discharges. Table I below presents a general overview of the environment and food radioactivity monitoring in the Netherlands. Monitoring tasks are divided between RIVM, RWS, WFSR and NRG.

Table I. Monitoring programme overview

Programme	Executive organisation	Client
Discharge monitoring of NPP: waste water and ventilation air	EPZ RIVM	ANVS ANVS
Environmental monitoring in the vicinity of NPP Borssele	Nuclear Research Group (NRG) RIVM	Elektriciteits Productiemaatschappij Zuid Nederland (EPZ) ANVS
Ambient dose rate	EPZ, RIVM	ANVS
Surface water	RWS	Ministry of Infrastructure and the Water Management
Grass and feed	Wageningen Food Safety Research (WFSR)	Ministry of Agriculture, Nature and Food Quality

4.2 MINISTRIES

The Ministry for Infrastructure and Water Management elaborates the environmental monitoring program in the Netherlands. The Ministry of Agriculture, Nature and Food Quality has the overall coordinating role in monitoring grass and foodstuffs.

4.3 RIJKSWATERSTAAT

The Rijkswaterstaat (RWS), an institute part of the Ministry of Infrastructure and Water Management, is responsible for the design, construction, management and maintenance of the main infrastructure facilities in the Netherlands. This includes the main road network, the main waterway network and the water management systems. RWS analyses the quality of surface water, drinking water and seawater, including sediments, biota and suspended matter.

4.4 AUTHORITY FOR NUCLEAR SAFETY AND RADIATION PROTECTION

The competent authority for nuclear safety and radiation protection in the Netherlands is the Authority for Nuclear Safety and Radiation Protection (ANVS). It is an independent body, while the Minister of Infrastructure and Water Management is politically responsible.

ANVS is responsible for the environmental radioactivity monitoring in the Netherlands and for the organisation of radiological crisis response.

4.5 National Institute of Public Health and the Environment

The National Institute of Public Health and the Environment (RIVM), part of the Ministry of Health, Welfare and Sports, co-ordinates the annual report on environmental radioactivity in the Netherlands for the ANVS. RIVM carries out a contra expertise on discharge samples of waste water and air. It also measures air particulates, atmospheric deposition, ambient dose rate and some aspects of drinking water. Additionally, RIVM reports to the European Commission RADD database.

RIVM receives monitoring results from the nuclear organisations and from its own laboratories and compiles a yearly report on the environmental radioactivity monitoring programme, published as "Environmental radioactivity in the Netherlands". These reports can be downloaded from the RIVM website[12].

Measurements during emergencies are co-ordinated by the RIVM. During crises, partners of the RIVM are the fire departments, the Ministry of Defence, RWS, WFSR, drinking water companies, and a network of universities and industrial facilities.

4.6 Wageningen Food Safety Research

The Wageningen Food Safety Research (WFSR), part of the University of Wageningen, monitors the quality of food and feed. WFSR reports to the Netherlands Food and Consumer Product Safety Authority (NVWA), which is a part of the Ministry of Agriculture, Nature and Food Quality.

4.7 Elektriciteits Produktiemaatschappij Zuid-Nederland

Elektriciteits Produktiemaatschappij Zuid-Nederland (EPZ) is the owner of the nuclear power plant in Borssele. EPZ is responsible for taking and analysing environmental samples around the plant and for carrying out the regular analyses on discharges of waste water and air. Sampling and analysis of environmental samples is done for the EPZ by the Nuclear Research and Consultancy Group (NRG), based in Petten. Also these results are included in the "Environmental radioactivity in the Netherlands" publication.

The EPZ applies German Nuclear Safety Standards Commission (Kerntechnischer Ausschuss, KTA) technical standards KTA 1503 and 1504 for monitoring of gaseous and liquid discharges[13].

12 www.rivm.nl

13 http://www.kta-gs.de/common/regel_prog1.htm

5 BORSSELE NPP ENVIRONMENTAL RADIATION MONITORING PROGRAMMES

5.1 INTRODUCTION

Borssele Nuclear Power Plant is located on the right bank of the Schelde estuary, within the municipal boundary of the village of Borsele, some 10 km east of the town of Vlissingen, in the province of Zeeland, in the south-western part of the Netherlands. It is located at a straight line distance of 55 km from the city of Antwerpen (Belgium), 120 km from Utrecht and 130 km from Amsterdam. The region within a perimeter of 200 km is a highly populated region of high electricity consumption and an area of agricultural and industrial activity.

The building authorisation for the Borssele NPP is dated 1969. The plant (Figure 1) is a 485 MWe PWR in operation since 1973, currently licensed to operate until 2033. It is a single unit Pressurized Water Reactor (PWR), operated by the EPZ. The station's thermal capacity is 1365.6 MW.

The plant is currently the only operational NPP in the Netherlands. The current timeline foresees dismantling after shut-down and decommissioning up to the "green field" endpoint envisaged in 2045.

Borssele NPP discharges its liquid radioactive effluents, via the cooling water channel, into the Westerschelde river, which flows to the North Sea. Gaseous effluents are discharged through a ventilation stack. The surveillance programmes relevant to Euratom Treaty Article 35 include gamma dose rate, gaseous and liquid discharge monitoring and environmental sampling.

Figure 1. Borssele nuclear power plant

The main sources of possible contamination of the environment that may result from normal Borssele NPP operations are the discharges of airborne and liquid radioactive effluents. Consequently, the Borssele NPP Environmental Monitoring Programme (procedure PU-N17-13, reviewed in 2019: document 24564/19.159906) determines measurements based on the type of discharge, covering both discharges to atmosphere (with subsequent terrestrial deposition) and those into the marine environment.

The Environmental Monitoring Programme defines the types of samples that are to be taken, and associated laboratory analyses to be accomplished. The baseline level of activity and dose rate measured provide the background against which the significance of any (unanticipated) release of radioactive effluents is assessed. The dose rate on the site's border is used to assess the direct radiation burden on the environment. The Environmental Monitoring Programme does not foresee performing dose calculations based on these results.

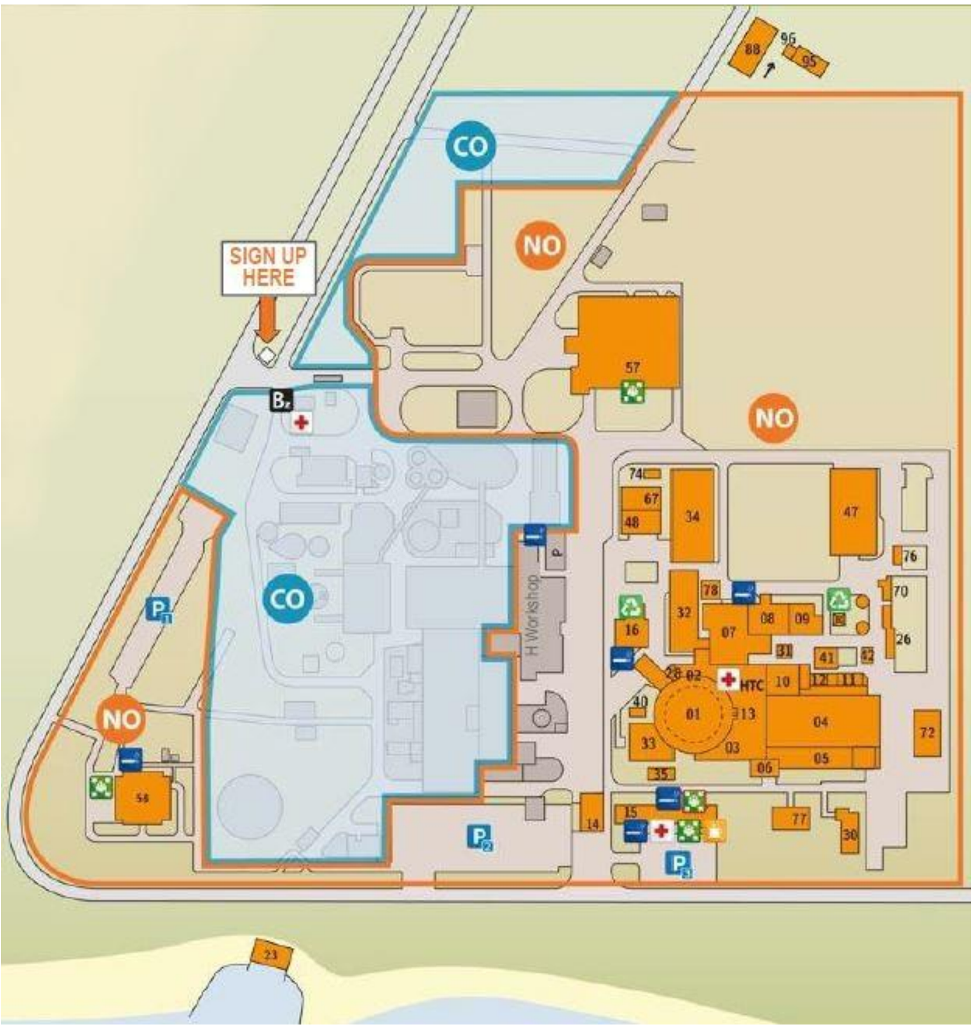


Figure 2. Borssele nuclear power plant area layout (areas marked with NO)

5.2 OPERATORS ON-SITE ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMME

5.2.1 Ambient radiation dose rate

The Borssele NPP operator EPZ has two automatic on-site radiation dose rate monitoring systems:

- Network of GammaTracers installed on the site fence (Figure 4, left). Measurement range of the device is 20 nSv/h - 10 mSv/h (2 GM-tubes). Quarterly data readout.
- Network of 1 spectroscopic monitor and 7 gamma monitors, which have recently been installed (Figure 4, right). Measurement range of the device is 10 nSv/h - 10 Sv/h (2 GM-tubes). Real-time readout.

On both networks, an annual function check is carried out using a known activity source. Within a 5 year interval, the calibration factor and the intrinsic effect are determined and the dead time correction is verified. Two alarm levels based on dose rate are incorporated to keep the target dose rate below 10 microSv/year above the background level.

Figure 3 below shows the detector positions on the site fence. In addition, on the site perimeter there are dose rate monitoring stations operated by the RIVM (MONET network, see section 5.4.1)

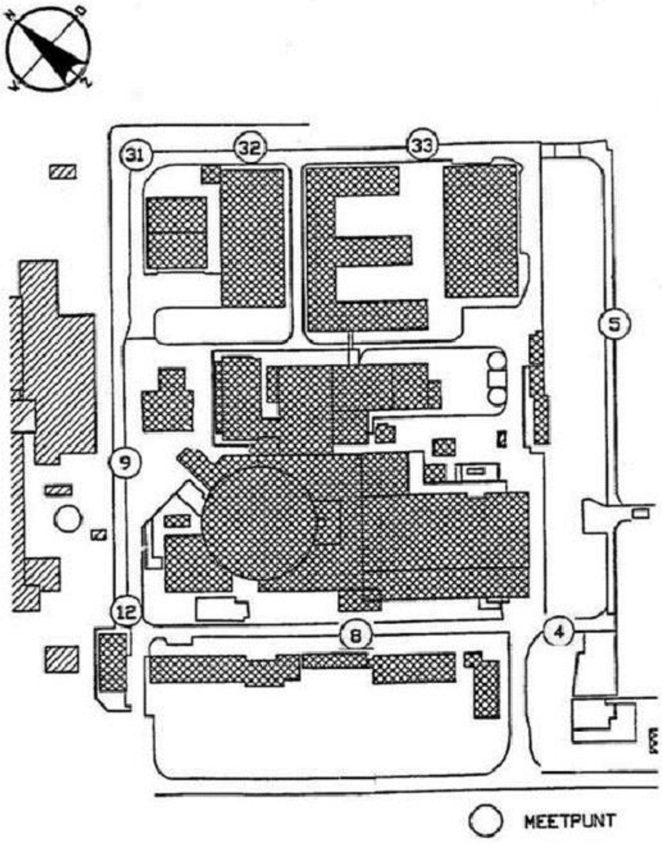


Figure 3. Radiation dose rate monitors' positioning on the site fence

Figure 4. On-site radiation monitoring network stations (left – gamma tracer, right – on-line gamma dose rate measurement station with spectroscopic capability)

5.2.2 Radioactivity in groundwater

On-site groundwater is periodically checked on total gamma and tritium activity. There are several on-site boreholes for taking a ground water sample for laboratory analysis (Figure 5).

Figure 5. Sampling point for ground water

5.3 OPERATORS OFF-SITE ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMME

5.3.1 Introduction

The operator of the nuclear power plant has to run sampling, analysis and measurement programmes of radiation levels and radionuclides present in the environment within a 10 km radius. The main pathways of human exposure to radiation have to be monitored, as well as those ecosystem elements, which are good indicators of the behaviour of radionuclides in the environment.

EPZ runs an off-site environmental monitoring programme in the vicinity of the Borssele NPP. The NRG performs sampling and operates the monitoring equipment. Locations of the sampling points are presented on Figure 6. The Borssele NPP is located right in the centre of this map, where the lines showing the division into north/south *resp*. west/east side of the map cross. Table II presents an overview of samples, analysis methods and locations.

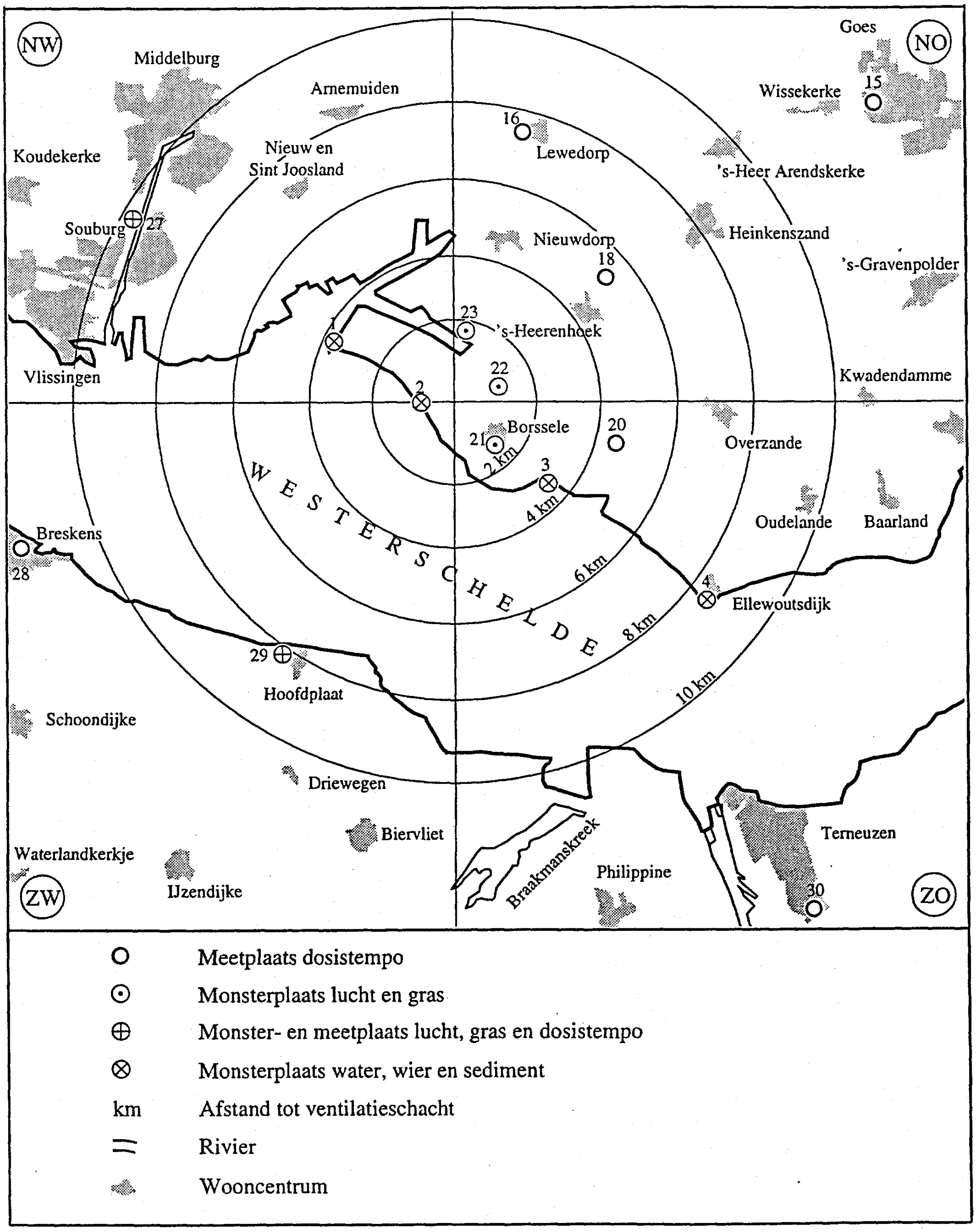


Figure 6: Overview of measuring and environmental sampling points around the Borssele NPP (on the centre of the map)[14]. Numbers on the map correspond to sampling locations explained in the Table II below.

14 'Meetplaats' = measuring point; 'Monsterplaats' = sampling point; 'dosistempo' = dose rate; 'lucht' = air; 'gras' = grass; 'wier' = seaweed; 'Afstand tot ventilatieschacht' = distance to ventilation shaft; 'Rivier' = river; 'Wooncentrum' = habitation centre

Table II. Overview of samples, analysis methods and locations

Sampling compartment (matrix)	Sampling locations	What is monitored	Number of analyses	Comments
Air (dust collection)	5 (21, 22, 23, 27 and 29)	Gross alpha activity [Bq]	5	Monthly exchange of filters
Air (dust collection)	5 (21, 22, 23, 27 and 29)	Gross beta activity [Bq]	5	Monthly exchange of filters
Air (dust collection)	5 (21, 22, 23, 27 and 29)	Gamma activity [Bq]	1	Isotopes analysed: ^{60}Co, ^{131}I, and ^{137}Cs. Analysis performed on a combined sample of monthly samples taken from all 5 locations
Water	4 (1, 2, 3 and 4)	Gross beta activity [Bq]	4	Monthly sample
Water	4 (1, 2, 3 and 4)	Tritium activity [Bq]	4	Monthly sample Liquid scintillation counting
Water (suspended solids)	4 (1, 2, 3 and 4)	Gross beta activity [Bq]	4	Monthly sample Sample is dried before analysis
Water (sediment)	4 (1, 2, 3 and 4)	Gamma activity [Bq]	1	Monthly sample. Sample is dried before analysis. Isotopes analysed: ^{60}Co, ^{131}I, and ^{137}Cs. Analysis performed on a combined sample of monthly samples taken from all 4 locations
Seaweed	4 (1, 2, 3 and 4)	Gamma activity [Bq]	1	
Grass	5 (21, 22, 23, 27 and 29)	Gamma activity [Bq]	1	Sampling area 0.25 m^2; sample is dried before analysis. Isotopes analysed: ^{60}Co, ^{131}I, and ^{137}Cs. Analysis is performed on a combined sample of monthly samples taken from all 5 locations
Soil	4 (O1, O2, O3 and O4: near outlet locations (not seen on Figure 6)	Gamma activity [Bq]	4	Sampling area 0.25 m^2; 4 to 6 kg sample. Isotopes analysed: ^{54}Mn, ^{60}Co, ^{134}Cs, and ^{137}Cs
Radiation background	8 (21, 22, 23, 24, 25, 26, 27, 28, *cf.* Figure 6)	Gamma dose rate [nSv/h]	8	Geiger-Müller tube

5.3.2 Ambient radiation dose and dose rate

Ambient radiation dose measurements are conducted in open access locations, at a height of about 1 m above ground (Figure 6) using GammaTracer detectors. Monitoring by use of TLDs has been discontinued; GammaTracers are in operation since 1997.

Typical battery lifetime for a GammaTracer is 5 years; the frequency for re-calibration of this equipment is also 5 years. The detectors are sent to their manufacturer (Genitron Instruments) for maintenance and re-calibration.

Figure 6. Off-site radiation dose rate monitoring by a gamma tracer located on the borderline of a private property. Right side: close-up on the gamma tracer.

5.3.3 Radioactivity in air

Radioactivity in air is sampled by pumping air through a filter cartridge consisting of fiberglass or paper filter, black carbon filter and activated carbon capsule; the filter radioactivity content is then measured in a laboratory. This system traps radioactive particles in aerosols as well as iodine; gaseous radioactivity which is not trapped by the filters gets adsorbed by the activated carbon.

Continuous sampling of airdust on filters on 5 different locations on a monthly basis is performed. The samples are analysed for total alpha and total beta activity. The artificial nuclides ^{60}Co, ^{137}Cs and ^{131}I (elementary and organic form) are analysed in a mixed sample by gamma spectrometry.

The air filter is located at a height of about 2 m above the ground, on top of a pole (Figure 7, left). The pole is locked in a vertical position on the side of the cabinet housing the pump; it can be unlocked and lowered to enable the filter capsule exchange. Sampling stations are typically located close to the local power supply substations ensuring the power supply for the pumps. No backup power is provided.

The housing cabinets of the pumps and airflow counters (Figure 7, right) are locked; the locked sheds (Figure 7, left) provide additional protection. These installations have been operating for about 30 years. There is no metering of the flow rate (estimated to be around 3 to 4 l/min). Occasional short-term power cuts due to *e.g*. maintenance of the local power supply substations cannot be excluded and there is no established information channel to that end.

Figure 7. Off-site air sampling station: left – filter capsule on top of a pole, right – power supply unit, airflow counter and the low flow-rate pump inside a ventilated cupboard

5.3.4 Environmental sampling

EPZ has an environmental sampling programme in the vicinity of the Borssele NPP, which includes water, soil, sediments and biota. Most environmental samples are collected monthly. Soil sample collection is annual. The programme includes the following components:

- Sampling of water (Westerschelde river) and suspended solids is performed once a month on 4 different locations. Sampling is performed during high tide. Total beta in water and solids is measured; tritium is analyzed using liquid scintillation counting (LSC).
- Sampling of grass is performed once a month on 5 different locations. Sampling is conducted in open access locations (Figure 8). Cutting area is 0.25 m^2; cutting takes place at a height of about 2 cm above ground.
- Soil is sampled on one location (4 samples on a close distance) once a year. Samples are analyzed for artificial nuclides (^{54}Mn, ^{60}Co, ^{134}Cs and ^{137}Cs) with gamma spectrometry.
- Sediment and seaweed are sampled on 4 different locations during low tide. Samples are measured for artificial nuclides (^{60}Co, ^{131}I and ^{137}Cs) with gamma spectrometry.

Figure 8. Off-site grass sampling location

5.4 AUTHORITIES' INDEPENDENT ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMMES

5.4.1 Ambient radiation dose rate

In the Netherlands, the authorities operate automatic radiation dose rate monitoring networks covering the whole country. The dose rate monitoring stations are calibrated annually using a test source. The following automatic dose rate monitoring networks are present in the vicinity of the Borssele NPP:

- The RIVM implements the ANVS monitoring programme by carrying out automatic gamma dose rate measurements on 8 locations at the fence of the NPP (MOnitoring NEtwork Terrains, MONET), (Figure 9). The gamma dose rate monitors of the MONET network are type Bitt RS03/485 and 485L (proportional counters). For each monitor gamma dose rate is recorded with 10-minute time interval. At RIVM in Bilthoven these 10-minute data are recorded and automatically evaluated. The alarm level is set at 200 nSv/h; normal background values range from 75 to 85 nSv/h.
- The Dutch National Radioactivity Network (NMR) employs a large number of gamma monitors in this part of the province of Zeeland (Figure 10). RIVM runs 165 Saphymo dose rate monitoring stations of the nationwide NMR network (Figure 11); in the vicinity of the NPP this network has a higher density. A Saphymo station consists of two GM tubes (low and high dose rate ranges) and is equipped with a rain intensity sensor. Communication within this network is based on fixed telephone lines.

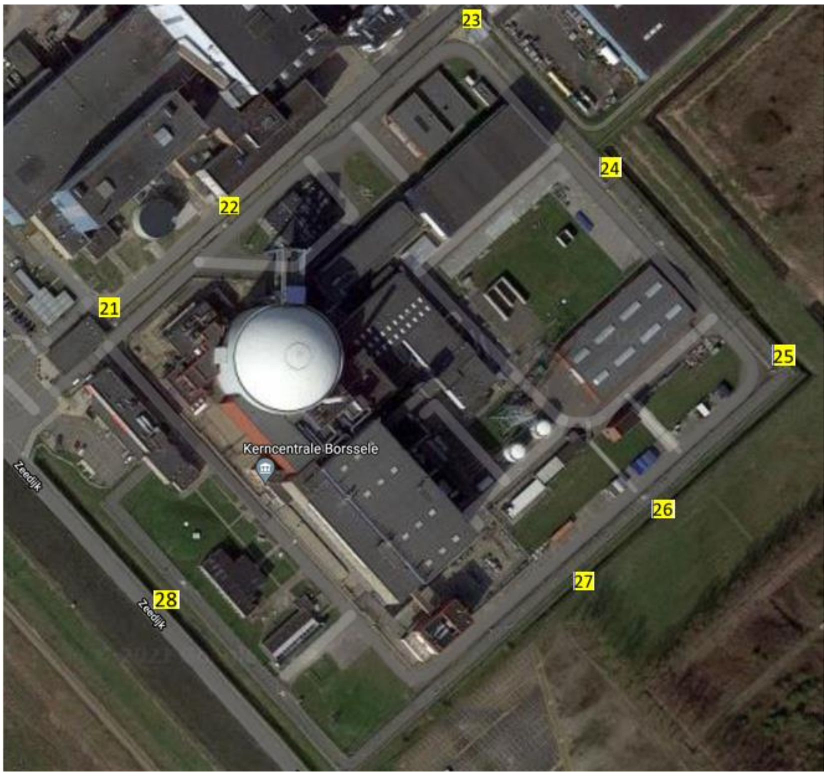


Figure 9. Eight MONET gamma dose rate monitors at the fence of the Borssele NPP

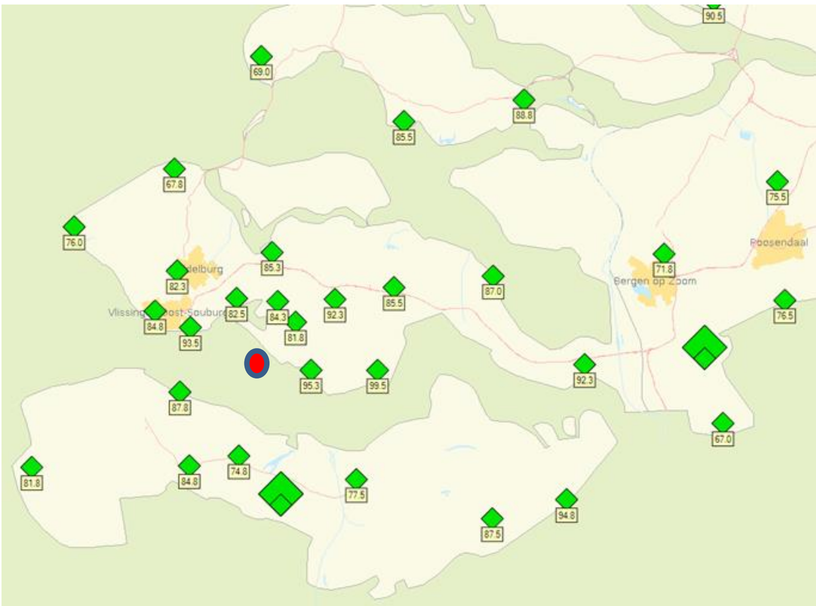


Figure 10. NMR gamma monitors (small symbols) and RIVM air samplers (large symbols) in the province of Zeeland (Borssele NPP indicated by a red dot)

5.4.2 Radioactivity in air

Radioactivity concentration in air is monitored by filtering air and by measuring the radioactivity content of the filter either in a laboratory or by a radiation detector directly on the filter assembly.

Two air sampling devices of the national network are in operation in the vicinity of the Borssele NPP, as indicated by large green squares on the map in Figure 10. Figure 11 presents the locations in the whole Netherlands. These Berthold BAI9128 alpha/beta aerosol monitors also report natural alpha activity concentration. For emergency purposes artificial alpha and beta is reported. The system uses a Passivated Implanted Planar Silicon (PIPS) detector. Integration time of the sample measurement is 10 minutes; values reported are one hour averages.

Figure 11. Locations of the telemetric network for monitoring of radiation dose in the Netherlands (small symbols) and of alpha/beta activity in aerosols (large symbols)

The RIVM operates also a high volume air sampler (Snow White, Senya Ltd) situated at the RIVM premises in Bilthoven. The air flow rate through a large fiberglass filter is approximately 780 m^3/h (normalised to STP conditions). Continuous operation is ensured by an emergency power supply. The flow rate (actually the pressure difference related to the flow rate) is monitored by a software tool every minute and a notification is sent in case a threshold of 760 m^3/h (STP) is passed for more than 5 minutes. In the event of a prolonged reduced flow rate the filter is prematurely exchanged, resulting in two filters for a sampling period of one week. Also, special events reported by other countries may trigger premature exchange of the filter (such as the nuclear accident in Fukushima or the recent report about ^{106}Ru in the air in Europe).

5.4.3 Environmental sampling

Apart from air sampling, the Dutch authorities have no dedicated environmental sampling programme in the vicinity of the Borssele NPP. There are national sampling programmes for drinking water, marine water, surface water, milk and foodstuffs, which cover the whole country, including Zeeland.

The Dutch authorities carry out parallel independent analysis of samples taken by the Borssele NPP operator. Table III below provides data on this activity in 2019 and 2020.

Table III. Overview of contra expertise by RIVM (one monthly sample in 2019 and 2020)[15]

Sample matrix	subsamples	Parameter	Remarks
Air dust	Glass fibre	Gross alpha/beta Gamma spec	Unique samples
	Carbon filter		
	Carbon cartridge		
Grass	3 bags of grass. Third bag for RIVM	Gamma spec	Destroyed after ~1 month
Seaweed	300-400 g seaweed from NRG	Gamma spec	Destroyed after ~1 week
Sediment	Half of sample from NRG	Gamma spec	Kept in freezer until next sample
Sand	Sample of 0,5 kg from NRG	Gamma spec	Yearly sample close to discharge pipe from NPP
Water	2 L of NRG-filtrate for RIVM	Gross alpha/beta, ^{3}H (LSC)	
Suspended solids	Precipitate in filtrate after NH_4OH addition	Gross alpha/beta	4 filters with suspended solids from NRG, also analysed by RIVM

15 Environmental monitoring in the vicinity of the Borssele nuclear power plant**.** Results 2019 and 2020**.** RIVM Letter report 2021-0078, P.J.M. Kwakman

6 MOBILE MONITORING SYSTEMS

6.1 RIVM

The RIVM possesses 25 mobile dose rate monitoring stations, which are technically identical to the fixed stations, but they can be quickly located anywhere in the Netherlands. These stations have wireless communication systems and solar panels for extended autonomous operation. The stations are calibrated annually using a test source.

The main mobile emergency radiation monitoring capability in the Netherlands is provided by two advanced emergency monitoring vehicles operated by the RIVM, and the supporting hand-held monitoring devices. The monitoring vehicles are based on IVECO-trucks. They have been in operation since 2009. The vehicles have been updated in 2021 and 2022 and are equipped for the following:

- Dose rate monitoring with GPS plotting
- Alpha/beta monitoring
- Air sample collection (5 minute particulate and active charcoal filter sample, collection rate 50 litres/minute)
- Pressurised air sample compressor for noble gas measurement (200 bar)
- Hand-held radioactivity monitor (NaI detector)
- On-site swipe test and liquid sample analysis (LSC)
- Gamma spectrometry (one electrically cooled portable and one fixed liquid nitrogen-cooled HPGe detector).

The vehicles are air-conditioned and over-pressurised. In order to provide autonomy they are equipped with electrical generators and UPS systems. Typically operation requires a driver and two measurement staff. Eight members of the RIVM staff have been trained for vehicle operation. The vehicles are on standby in Bilthoven, available for deployment anywhere in the Netherlands.

6.2 Borssele NPP

Routine scanning of paved areas at the Borssele NPP site takes place on annual basis. For this, EPZ uses a LARS-system produced by NUVIA. The system uses two GM-tubes – one designed for energy range from 100 to 2000 keV, the other operating in the 500 to 2000 keV energy range. The detectors are typically 35 mm above the ground level, and the height is adjustable. There is no mapping functionality. After scanning the whole site, EPZ produces a site contamination report.

Borssele NPP has one monitoring vehicle, which can be equipped with portable monitoring and sampling equipment in order to carry out local environmental monitoring in the event of an emergency. Soil, grass, wet deposition, aerosols and Iodine can be sampled. Total alpha and beta activity and artificial nuclides are analysed with gamma spectrometry (HPGe detector). The equipment can be used also during an emergency with discharges from locations other than the Borssele NPP.

7 BORSSELE NPP LIQUID AND GASEOUS RADIOACTIVE DISCHARGE MONITORING PROGRAMMES

7.1 INTRODUCTION

Borssele NPP discharges gaseous radioactive material to the atmosphere via the ventilation stack and liquid radioactive material to the sea via the coolant discharge channel. The plant is equipped for carrying out both continuous and batch-wise monitoring of radioactivity in gaseous and liquid discharges. While the operator is responsible for performing the discharge monitoring programme, the regulator verifies, on a monthly basis, that the sampling programme and the analytical assessment performed fulfil the requirements, as well as that the radioactive effluent monitoring instrumentation has been operable and their alarm and/or trip set points have not been exceeded.

7.2 DISCHARGE REGULATION

Sampling and continuous monitoring of liquid and gaseous discharges of the Borssele NPP are based on the German standards KTA 1503 and 1504.

KTA 1503 describes the monitoring of radioactive gases and airborne radioactive particulates, and consists of three parts:

- KTA 1503.1: Monitoring the discharge of radioactive matter with the stack exhaust air during specified normal operation;
- KTA 1503.2: Monitoring the discharge of radioactive matter with the ventilation stack exhaust air during design-basis accidents;
- KTA 1503.3: Monitoring the non-stack discharge of radioactive matter

KTA 1504 describes the monitoring and assessment of the discharge of radioactive substances with water.

Only mastered discharges through ventilation stack and/or cooling water are authorized. The contributions to the public dose arising from authorized radioactive discharges are kept as low as reasonably achievable, economic and social factors being taken into account. This is achieved by a requirement within the authorization issued to the Borssele NPP to minimize discharges and their impact by using the best available technical means. Tables IV and V specify the numerical limits for liquid and gaseous discharges per calendar year.

Table IV. Annual discharge limits for liquid discharges

Radionuclide or group of radionuclides	Limit [Bq]	Notification level [% of annual limit, weighed per discharge batch of 40 m^3]
Beta and gamma emitters, excluding tritium	2 E+11	5
Tritium, ^{3}H	3 E+13	5
Alpha emitters, total	2 E+8	5

Table V. Annual discharge limits for gaseous discharges

Radionuclide or group of radionuclides	Limit [Bq]	Notification level [% of annual limit, weighed per day]
Noble gases, total	5 E+14	5
Iodine-131, ^{131}I	5 E+9	5
Halogens, total (including ^{131}I above)	5 E+10	5

Radionuclide or group of radionuclides	Limit [Bq]	Notification level [% of annual limit, weighed per day]
Aerosols, total	5 E+8	5
Tritium, ^{3}H	2 E+12	-
Carbon-14, ^{14}C	3 E+11	-

7.3 Monitoring of gaseous discharges

7.3.1 Introduction

Borssele NPP discharges gaseous effluents through one approximately 60 m high ventilation stack; the average flow rate in the stack is 27.5 m^3/s. The nuclear ventilation system (TL) comprises the ventilation systems of the controlled area (buildings 01, 02 and 03). Exhaust gas from primary systems (TS040) is also discharged through the ventilation stack. At a time of weekly filter exchange, the total volume of gaseous effluents is recorded.

Air from the nuclear ventilation system passes through particulate high efficiency filters and iodine adsorption filters. The discharge of exhaust gas is delayed in charcoal filters before it enters the nuclear ventilation system.

The releases of noble gases, halogens (including I-131) and aerosols through the ventilation stack are continuously monitored. There is also a continuous sampling system in place for the determination of aerosols, iodine and total alpha and strontium activity, as well as an on-line sampling device for tritium and carbon-14.

The Borssele NPP Operations department uses the on-line instruments and responds in case of deviations. The Radiation protection and the Maintenance departments test the instruments periodically, every three months according to a test plan. According to EPZ calculations, annual dose to the environment resulting from the gaseous discharges is approximately 25 nSv.

7.3.2 Monitoring systems

Gaseous discharges are monitored by sampling and by continuous on-line methods to ensure compliance with the statutory discharge limits. The monitoring system (both its instrumentation and the associated measurements) is based on KTA 1503.1, 1503.2 and 1503.3 standards. The samples are analysed in the operator’s Radiation protection laboratory, except tritium, carbon-14, alpha emitters and strontium.

A pipe from the ventilation shaft (flow rate circa 4.2 m^3/h) passes the effluents through a filter system consisting of activated charcoal, zeolite, and paper filters collecting the halogens and aerosols. Then, the flow passes by the detectors monitoring the noble gases before being directed to the stack. Sampling of gaseous discharges for monitoring (continuous checking against alarm values based on online measurements, with passing the alarms to the control room) and for determination of the discharge (based on the measured activity concentration and the volumetric flow) is performed as illustrated in Table VI. Notification levels listed in Table V serve as alarm values. The explanations below refer to Table VI as well.

Noble gases

Two continuously measuring instruments equipped with plastic scintillation detectors are used for monitoring and determination of the discharges during normal operations (full power and outages). Two continuously measuring instruments using ionisation chambers are used for monitoring and determination of the discharges during accident situations. The nuclide-specific discharges of the noble gases are measured by taking a weekly sample (5-liter stainless steel container filled with air at pressure 1 MN/m^2 or 10 bar). The analytical nuclide library contains

^{41}Ar, ^{85m}Kr, ^{85}Kr, ^{87}Kr, ^{88}Kr, ^{89}Kr, ^{131m}Xe, ^{133}Xe, ^{135m}Xe, ^{135}Xe, ^{137}Xe and ^{138}Xe. Other nuclides are measured if detected.

Halogens (in particular ^{131}I)

Two continuously measuring instruments are used for monitoring; one during normal operations and one designated to accident situations. Both instruments collect iodine on a charcoal filter. The discharge is determined through continuous sampling during a week (sample size is approximately 750 m^3). The halogens are collected on a particulate filter, two zeolite cartridges and two activated charcoal filters. The subsequent analysis allows distinguishing between the possible chemical forms of the halogens: elementary, organic and aerosol-bound. The nuclide-specific analyses allow determining ^{131}I, ^{132}I, ^{133}I, ^{134}I, ^{135}I and ^{82}Br (and other nuclides if detected).

Aerosols

Two continuously measuring instruments are used for monitoring aerosols, one during normal operations and one designated for accident situations. The discharge is determined through continuous sampling during one week (sample size is approximately 750 m^3 collected on an aerosol filter) with subsequent nuclide-specific analysis. The nuclides listed are ^{51}Cr, ^{54}Mn, ^{57}Co, ^{58}Co, ^{59}Fe, ^{60}Co, ^{65}Zn, ^{95}Zr, ^{95}Nb, ^{103}Ru, ^{106}Ru, ^{110m}Ag, ^{124}Sb, ^{125}Sb, ^{131}I, ^{134}Cs, ^{137}Cs, ^{140}Ba, ^{140}La, ^{141}Ce, ^{144}Ce. Other nuclides will be determined if detected.

Tritium

The discharge of tritium is determined after sampling (adsorption of water on a zeolite filter) followed by catalytic oxidation on Pd of the air passing through the zeolite (containing some methane/hydrogen) and adsorption of the water on a second zeolite. After desorption of the water of both the zeolite filters followed by condensing the water, the concentration of tritium is determined. There are two instruments available in Borssele NPP (KTA 1503.1 only prescribes one). A contractor (Framatome, accreditation D-PL-21039-04-00) performs the sample preparation and measurements.

Carbon-14

The discharge of ^{14}C is determined after sampling (adsorption of carbon dioxide on a zeolite filter) followed by catalytic oxidation on Pd of the air passing through the zeolite (containing some methane) and adsorption of the carbon dioxide on a second zeolite). After desorption of the carbon dioxide of both the zeolites followed by absorption in an alkaline solution the activity of ^{14}C is determined using liquid scintillation counting. There are two instruments available in Borssele NPP (KTA 1503.1 only prescribes one). A contractor (Framatome, accreditation D-PL-21039-04-00) performs the sample preparation and measurements.

Alpha emitters

The discharge of alpha-emitting radionuclides is determined after sampling and destruction (ashing) of the filters. Gross alpha activity is determined by a method based on NEN 5622 (NL standard corresponding to ISO 9696 "Water quality — Gross alpha activity — Test method using thick source"), using a proportional counter. If the activity measured is greater than 0.005 Bq/m^3 the nuclide-specific activity is determined. A contractor (NRG Petten, accreditation NEN 5622) performs the sample preparation and measurements.

Strontium

^{89}Sr and ^{90}Sr are determined after sampling and destruction (ashing) of the filters by a method based on NEN 5619 (Standard "Radioactivity measurements - Determination of Strontium-89 and Strontium-90 with liquid scintillation counting"). Detection takes place by liquid scintillation counting. A contractor (NRG Petten, accreditation NEN 5619) performs the sample preparation and measurements.

Total activity

EPZ employs a low sensitivity total activity detector positioned directly in the stack. This detector monitors the activity continuously but is foreseen to provide information in case of an accident.

Table VI. Sampling of gaseous discharges

Radionuclide or group of radionuclides	Sampling frequency	NPP operation mode	Instrument code	Purpose: determination (D), monitoring (M)	Detector type[16]	Detection limit [Bq/m^3]
Noble gases	Continuous	Normal	TL080R011/012	D and M	PS	8.3 E+3
Noble gases	Continuous	Accident	TL080R013/023	D and M	IC	1 E+4 / 1 E+5
Noble gases	Weekly	Normal & Accident	TL080S040	D	HPGe	2.3 E+3 (^{85}Kr) 1.6 E+1 (^{133}Xe)
Halogens	Continuous	Normal	TL080R016	M	NaI	1.0
Halogens	Continuous	Accident	TL080R025	M	NaI	3.0 E+1
Halogens	Weekly	Normal & Accident	TL080R015/018	D	HPGe	1.1 E-3 (^{131}I)
Aerosols	Continuous	Normal	TL080R014	M	PS	2.0
Aerosols	Continuous	Accident	TL080R024	M	NaI	1.0 E+1
Aerosols	Weekly	Normal & Accident	TL080R015/018	D	HPGe	2.2 E-3 (^{60}Co) 4 E-4 (^{137}Cs)
Tritium, ^{3}H	Quarterly	Normal	TL080R019/020	D	LSC	7.3 E-1
Carbon-14	Quarterly	Normal	TL080R019/020	D	LSC	2.2 E-1
Alpha emitters	Quarterly	Normal	TL080R015/018	D	PC	5.0 E-5
Strontium, ^{89}Sr and ^{90}Sr	Quarterly	Normal	TL080R015/018	D	LSC	5.0 E-5

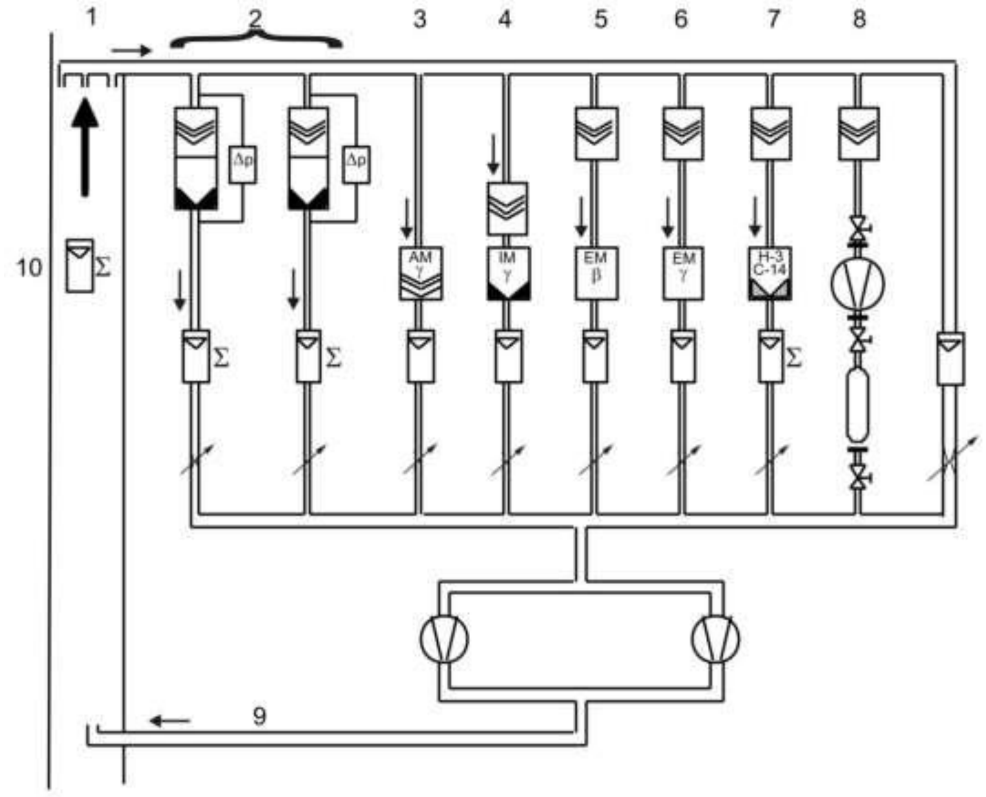
7.3.3 Stack monitoring arrangement

For sampling in the stack the dimensions and curvatures are designed for maximum aerosol transport to the detectors/sampling devices. There are several inlet points at 28 metres (the stack base being at 13 metres) across the stack diameter. The inlet from venting is located after the isokinetic sampling starting point; the related gamma dose rate measurement location is situated above (calibration with source from distance). Monitoring of gaseous discharges from the stack is illustrated in the schematic way in Figure 12.

The flowrate of the ventilation stack is measured with a venturi inside the ventilation stack (Figure 13). Measurement range is 0-55.6 m^3/s. Calibration is performed every four years. At the same time, a functional check of the limit value modules is performed to ensure that the alarms are set correctly. The measuring circuit is checked once every ten years.

[16] Detector types: PS – Plastic Scintillation; IC – Ionisation Chamber; HPGe – High Purity Germanium; NaI – Sodium Iodide; LSC – Liquid Scintillation Counter; PC – Proportional Counter

Measurement of the concentrations of nuclides in the ventilation air takes place in a part of the total flow, which passes the analyzers. For the calculation of the total gaseous discharges a constant flow rate of 33.33 m^3/s is used during normal operation. This leads to an overestimation of the gaseous discharges of about 7.6 %. Only in case of major deviations of the flow rate, for example when maintenance of a ventilation pump takes place, the actual flow rate is used for calculation of the gaseous discharges.



1 Sampling rake
2 Sampling equipment for the detailed assessment of the activity discharge of radioactive substances and iodine compounds bound to aerosols
3 Aerosol monitor
4 Iodine monitor
5 Noble gas monitor (cumulative beta activity measurement)
6 Noble gas monitor and nuclide specific measurement equipment for the detailed assessment of the activity discharge of radioactive noble gases
7 Sampling equipment for the detailed assessment of the activity discharge of H-3 and C-14 compounds
8 Discontinuous sampling
9 Return pipe line
10 Volumetric flow measurement in the stack

Figure 12. Gaseous discharge monitoring by collecting air from the stack (TL080 air sampling system)

Figure 13. Venturi inside view (right) and the measurement pipe instrumentation (left)

7.4 MONITORING OF LIQUID DISCHARGES

7.4.1 Introduction

The radioactive wastewater system (TR) of the Borssele NPP consists of four wastewater collection tanks (each approx. 40 m^3 volume), an evaporator and two final storage tanks (each approx. 40 m^3 volume). Piping, circulation pumps and instrumentation (*e.g.* flowrate and level measuring devices) are also part of the system. The complete system is located in the controlled area. The containment prevents any leakage to the environment.

Active effluent arises in the controlled area of the NPP; it is collected and stored locally and pumped to the wastewater collection tanks (TR011 to TR014) in a closed system. The three main wastewater sources are the active laundry, the decontamination workshop with cleaning water and the purification of primary coolant (removal of tritium). From the total of about 2500 m^3 wastewater released annually, about 19 % come from the active laundry; the decontamination shop contributes around 50 %. The treatment options include evaporation and combination of deionisation, evaporation and degassing for the treatment of primary coolant. Each stream has a default treatment:

- Active laundry: no additional treatment
- Decontamination centre including active workshop: evaporation
- Treatment of primary coolant: deionization, evaporation and degassing

The default treatment may be altered only with qualified advice based on the concentration of radioactivity and/or boric acid. The effluent in the collection tank is processed per batch: sampled, analysed and treated when applicable, then stored in a final storage tank (TR041/042). Prior to discharge (a weekly event during routine operation, more often during outages) the effluent in the storage tank is recirculated, sampled and analysed. Only when the discharge specifications are met the effluent is discharged into the Westerschelde river as described below. The discharge line is protected with a non-return valve to ensure that there is no back flow.

The discharge stream (TR045) is connected to the emergency cooling system (VF004 and VF005). The outlet of the emergency cooling system is connected to the main cooling water system (VC007). Via the main cooling water outlet culvert (VC007) the water is discharged out into the Westerschelde river. The flow rate of the discharge (0.01 m^3/s) is compared to that of the main cooling water (11.7 m^3/s when two pumps operate) to ensure maximal mixing and suitable dilution.

There are some 50 to 100 batch discharges per year. Before release from the discharge tank in use to the Westerschelde each discharge batch is controlled. After pumping circulation, a sample is taken and analysed for gross gamma activity. The results are transmitted to the control room who gives authorisation for the discharge if the limits are not surpassed. During discharge, an on-line measurement with a 2x2" NaI(Tl) detector for gross gamma measurement is performed allowing stopping of the discharge if needed.

In order to facilitate continuous surveillance and control, instantaneous limits are established that provide a sufficient margin to guarantee that the annual dose limit will not be compromised, while at the same time providing operational flexibility for the facility.

7.4.2 Monitoring points

The quantitative analysis of the radioactivity content of the liquid discharges is based on sampling the NPP wastewater tanks before discharges. The on-line monitoring of the liquid discharges consists of monitoring the wastewater discharge in order to detect any abnormal activity in the discharge flow – this do not contribute to the calculation of the total discharge.

The discharges are monitored both by sampling and by continuous on-line methods to ensure compliance with the statutory discharge limits. There are two measurement sessions, one to determine the treatment of the wastewater, and another to verify that the criteria in the license and the optimization principle are met.

The monitoring points for liquid discharges are:

- Flow rate and activity concentration on-line monitoring both locally and in the main control room (TR045R001)
- Radioactivity concentration on-line monitoring in the cooling water outlet (VC007R001)

7.4.3 Liquid waste discharge monitoring

To establish the treatment, each wastewater collection tank is sampled and analysed. The key parameters are total beta/gamma activity concentration and the boron and chloride concentration. Extra chemical analyses are performed to optimize the evaporation process. Table VII displays an overview of measurements performed at this stage.

Table VII. Overview of initial set of measurements for liquid discharges

Measured parameters	Analysis method	Purpose
Total beta/gamma activity concentration	NaI detector	Establishing treatment
Boron concentration	Titration	Establishing treatment, optimising the evaporation
pH	pH-meter	Establishing treatment
Chloride concentration	Titration	Optimising the evaporation
NaOH concentration (pH → 10.5)	Titration	Optimising the evaporation

Each discharge sample consists of two 1 litre containers, one of which is stabilized for longer storage and the other is used for the measurements. The stabilization is needed for the subsequent preparation of a mixed quarterly and annual samples, and as a backup for verification. Table VIII illustrates the measurements performed. The explanations below refer to Table VIII as well.

Gross beta and gamma activity (excluding tritium)

A 1-litre sample in a Marinelli beaker is measured using a sodium iodide detector (NaI). The activity concentration is used as a criterion for allowing a discharge.

Gamma spectrometry

A 250 ml sample is prepared and gelled to prevent the precipitation of particles prior to measuring using an HPGe detector to determine the gamma nuclide-specific concentrations. Isotopes such as ^{51}Cr, ^{54}Mn, ^{57}Co, ^{58}Co, ^{59}Fe, ^{60}Co, ^{65}Zn, ^{95}Zr, ^{95}Nb, ^{103}Ru, ^{106}Ru, ^{110m}Ag, ^{123m}Te, ^{124}Sb,

^{125}Sb, ^{131}I, ^{134}Cs, ^{137}Cs, ^{140}Ba, ^{140}La, ^{141}Ce and ^{144}Ce are routinely measured and reported. Other nuclides need only to be reported if confirmed by measurements. The activity concentrations and the volume to discharge are used to calculate the total discharge per nuclide (in Bq).

Tritium

Tritium concentration is measured after distillation of a sample to separate the tritium from the other nuclides. The measurement is performed in a liquid scintillation counter. The activity concentration and the volume to discharge are used to calculate the total release of tritium, in Bq.

Strontium (^{89}Sr and ^{90}Sr)

NRG measures strontium activity in a mixed sample prepared quarterly, and reports the results (activity concentration) back to Borssele NPP. The activity concentration combined with the discharged volume in the quarter are used to calculate the total discharge of strontium during the quarter.

Gross alpha activity

NRG measures gross alpha activity in a mixed sample prepared quarterly, and reports the results (activity concentration) back to Borssele NPP. The activity concentration combined with the discharged volume in the quarter are used to calculate the total discharge of alpha emitters during the quarter.

^{55}Fe and ^{63}Ni

Framatome measures ^{55}Fe and ^{63}Ni activity in a yearly prepared mixed sample, and reports the results (activity concentrations) back to Borssele NPP. The activity concentrations combined with the discharged volume in the year are used to calculate the total discharge of ^{55}Fe and ^{63}Ni during the year.

Table VIII. Overview of set of measurements to verify that the criteria in the license and the optimization principle are met

Measured parameters or isotopes	Analysis method	Tank(s) concerned	Detection limit [Bq/l]
Total beta/gamma activity concentration	NaI detector	Storage & Discharge	20
Gamma spectrometry	HPGe detector	Discharge	1 (for ^{60}Co)
Tritium, ^{3}H	LSC	Discharge	40
Strontium, ^{89}Sr and ^{90}Sr	LSC	Discharge	0.5
Total alpha activity concentration	ZnS-counter	Discharge	0.2
^{55}Fe and ^{63}Ni	LSC	Discharge	2
Boron concentration	Titration	Storage & Discharge	N/A
pH	pH-meter	Storage & Discharge	N/A

The amount of beta/gamma activity and the amount of tritium combined with the boron concentration and the pH value are reported to the Operations department. This information is used for obtaining a permission for discharge.

Alarm values are set; the discharge pump stops and valves close in case of an alarm. In addition, the discharge pump stops automatically in case of inflow of water in the final storage tank during a discharge.

8 LABORATORIES PARTICIPATING IN THE BORSSELE NPP DISCHARGE AND ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMMES

8.1 OPERATOR'S LABORATORIES FOR DISCHARGE SAMPLES

8.1.1 Borssele NPP laboratories

Borssele NPP has a well-equipped radiological laboratory for analysing the radioactivity content of gaseous and liquid samples for discharge monitoring and operational purposes. It is situated inside the controlled area boundary on 18.7 m level of the auxiliary building (two parts: Radiochemistry and Radiation protection laboratory). The third part - Chemical laboratory - is outside the controlled area, on the third floor of Building 8.

The laboratory is available on 24/7 basis with a staff of 10. Samples are taken and/or received by the laboratory, examined and identified for control and subsequent analysis. Once the samples have been received at the laboratory, every sample is examined, identified by a standardised reference code and recorded in a sample file of the computer application specifically designed for radiological analysis. The reference code is recorded in the sample file and on all the sample containers. Sample preparation differs depending on the sample matrix, the analysis to be performed and the measurement technique.

All measurements are conducted as per relevant procedures and work instructions. Table IX lists main measurement instruments available, as well as the associated procedures.

Table IX. Instruments and procedures for analysing discharge samples

Instrument / measurement chain	Backup available?	Location	Procedure ID
HPGe / gamma spectrometry	Yes (duplicate)	Radiation protection laboratory	N17-26-042
HPGe / gamma spectrometry Be3830P with CP5-Plus-SL-ULB	Yes (duplicate)	Radiochemistry laboratory	N04-26-176
HPGe / gamma spectrometry Be5030P with CP5-Plus-F-RDC-6-UL3	Yes (duplicate)	Chemistry laboratory	N04-26-176
NaI / gamma spectrometry	Yes (duplicate)	Radiochemistry laboratory	N04-26-176
TRIcarb 4910 / Liquid Scintillation Counting	No	Radiochemistry laboratory	N04-26-002
TRIcarb 4910 / Liquid Scintillation Counting	No	Radiochemistry laboratory	N04-26-033

Calculations of specific activities and characteristic limits are performed by applying the ISO 11929 standard using the Genie2K application for gamma spectrometry and spreadsheets validated for this purpose for the other determinations. The validated spreadsheets link to an Excel database used for data storage, discharge calculations, analysis of results, and generation of required reports.

The laboratory is not accredited; it employs an integrated management system and periodically reviews the set of written procedures used for the different tasks related to the discharges and the environmental programme (sampling, sample preparation, measurements, calculations, equipment calibrations and reporting). This concerns not only instruments installed in the laboratory but also those used for on-line monitoring, and foresees repairs and adjustments to be made as necessary.

Borssele NPP participates regularly in two proficiency test exercises organized by the German Bundesamt für Strahlenschutz (BfS). In the BfS proficiency test 'Abwasser' two water samples are provided: one with a standardized amount of several gamma-emitting radionuclides, tritium, alpha-emitters, strontium, iron-55 and nickel-63; and the other with an unknown amount of several radionuclides. In another BfS proficiency test on gaseous discharges, filters are provided with a standardized amount of several gamma-emitting radionuclides. BfS prepares and delivers the samples, receives and analyses the results and reports back to the participants. Borssele NPP uses these results to improve procedures on sampling, sample preparation and measurement.

8.1.2 Borssele NPP contracted laboratories

There are two contractors – NRG and Framatome – analysing the discharge samples for the Borssele NPP. These contracted laboratories also participate in Proficiency test exercises organized by the BfS.

8.2 OPERATOR'S LABORATORIES FOR ENVIRONMENTAL SAMPLES

8.2.1 Laboratory of the Nuclear Research and Consultancy Group

The environmental sampling programme, which is carried out by the Nuclear Research and Consultancy Group (NRG), Petten, has been described in the RIVM publication "Environmental monitoring in the vicinity of the Borssele nuclear power plant. Results 2018" (Letter Report 2018-0145)[17].

The laboratory of the NRG processes the environmental samples from the Borssele NPP vicinity. The contractor collects and measures the samples, and reports on the results obtained. In addition, dose rate measurements are carried out using Genitron GammaTracers. NRG provides monthly averages from 16 gamma dose rate monitors, situated on various distances around the NPP.

The NRG performs also the operational measurements on samples received from EPZ in accordance with the contract between two entities; this includes e.g. wipe samples taken on reactor pressure vessel. The ISO 17025 accreditation covers H-3 measurements as well as determining Fe and Ni. Future enlargement of accreditation scope will include gamma spectrometry in the energy range from 30 to 3000 keV.

The NRG has implemented the environmental sampling programme routinely on a monthly frequency for a large number of years. Samples are taken in order to monitor radionuclides in air, grass, sand, water, suspended solids, seaweed and sediments. The sampling locations are presented in Figure 6, and the relevant data listed in Table II.

NRG reports to the Borssele NPP twice a year: a 6-month report and a yearly report. Borssele NPP enters the highlights annually in a company report on environmental topics (PO-N08-31). These results are reported to all stakeholders: ANVS, province of Zeeland, community of Borssele, Ministry of Infrastructure and Water Management, Department of Waterways and Public Works, National Rijkswaterstaat and the Regional Water Authority. The report contains data on the liquid and gaseous discharges, and a summary of the results of the environmental radioactivity monitoring program.

8.3 REGULATORS' LABORATORIES FOR SITE-RELATED ENVIRONMENTAL AND DISCHARGE SAMPLES

8.3.1 RIVM laboratory

The RIVM has a well-equipped radiological laboratory in Bilthoven. The laboratory analyses environmental samples from the Dutch territory and the control samples received from nuclear installations environment and discharge monitoring programmes. The laboratory is accredited according to ISO 17025 proficiency standard.

The RIVM radiochemical laboratory verifies the operator's measurements by annual analysis of eight samples of Borssele NPP liquid and gaseous discharges. Comparison is made between the results of gamma spectrometry analysis, tritium, alpha and strontium activity in liquid samples, and gamma spectrometry analysis, tritium and carbon-14 activity in gaseous samples. Discussions that follow the

[17] https://www.rivm.nl/publicaties/environmental-monitoring-in-vicinity-of-borssele-nuclear-power-plant-results-2018

analyses and reports may lead to adjustment of the Borssele NPP procedures on sampling, sample preparation and/or measurements.

8.3.2 Rijkswaterstaat laboratory

The laboratory of the Rijkswaterstaat (RWS)[18] in Lelystad is equipped to carry out analytical work on water and marine environmental samples, including concentrations of radionuclides. The laboratory holds ISO 17025 accreditation.

RWS carries out a sampling programme for collecting samples of surface water, sediments, biota and suspended matter (the North Sea, lakes and rivers). Altogether there are about 20 sampling locations on Dutch inland waterways and coastal waters, including three water sampling points in the Westerschelde river estuary (Figure 14).

Figure 14. Three RWS sampling points in the area near NPP Borssele: Vlissingen Boei (near Breskens), Terneuzen and Doel

8.3.3 Wageningen Food Safety Research laboratory

The WFSR monitors milk, mixed diet and foodstuffs, including wild foodstuffs[19].

Whereas mixed diet is considered out of scope for the NPP Borssele region, food and feed monitoring is covered by the national network for radioactivity in food (Landelijk Meetnet Radioactiviteit in Voedsel, LMRV), which comprises about 50 measuring stations equipped with low resolution gamma spectrometers (NaI detectors) placed throughout the Netherlands. 23 of these stations are positioned at dairy factories. The monitoring stations consist of a stainless steel housing (weight about 700 kg) in which a computer, a NaI detector, a monitor and a printer are placed. Samples collected in a 1 litre Marinelli beaker can be placed into the lead castle above the NaI detector. Standard geometry measurements are performed varying from 10 minutes to 1 hour in duration, depending on the expected activity in the samples.

In Wageningen, a central communication infrastructure including a central database is operated. This system collects data from all measuring stations every day. Results of the weekly samples of cow and goat milk from all dairy locations are combined into a monthly average for the whole country.

WFSR analyses radioactivity in food products as part of the national monitoring programme. Samples are taken throughout the year and measurements carried out according to standard procedures. Of

[18] The RWS laboratory in Lelystad was verified by the EC in 2017 (verification NL 17-01).

[19] The WFSR laboratory in Wageningen was verified by the EC in 2017 (verification NL 17-01).

these food samples, about 10 % are additionally analysed for ^{90}Sr content. In addition, monitoring of food imported from countries affected by the Chernobyl fallout is carried out (^{137}Cs in mushrooms, berries, *etc*.).

The following samples are regularly taken as a representative cross-section of the human food package:

- Vegetables and fruits
- Meat and meat products
- Game and poultry
- Eggs
- Fish and fishing products
- Ready meals

Complementary to the LMRV samples, raw milk samples collected across the Netherlands are analysed for a range of gamma emitters on a high resolution gamma spectrometer at the WFSR laboratory in Wageningen. The samples are analysed also to detect the beta emitter ^{90}Sr using low level liquid scintillation counting (LSC). WFSR also monitors raw milk, food and feed specifically for export certification. For this, samples are analysed for ^{137}Cs and ^{90}Sr.

In the event of a nuclear or radiological emergency, as described in the National Crisis Plan for Radiation Incidents (Landelijk Crisisplan Stralingsongevallen, LCPS), the WFSR monitoring network makes an important contribution to the data supplied to decision makers.

9 VERIFICATIONS

9.1 INTRODUCTION

Verifications were carried out in accordance with the agreed programme (Annex 1). This chapter summarises the verifications carried out the by the verification team. The team has assessed the monitoring arrangements based on their own expertise and comparison with similar arrangements in other Member States.

The outcome of the verification is expressed as follows:

- A '*Recommendation*' is made when there is a clear need for improvement in implementing Art. 35. These are included in the main conclusions of the verification. The Commission requests a report on the implementation of the recommendations – lacking implementation of a recommendation can lead to a reverification.
- A '*Suggestion*' is made when the verification team identifies an action, which would further improve the quality of the monitoring.

In addition, the team may '*commend'* particularly good arrangements, which could serve as a best practice indicator for the other EU Member States.

9.2 OPERATOR ON-SITE ENVIRONMENTAL RADIOACTIVITY MONITORING

9.2.1 Ambient radiation dose rate

The verification team visited the measurement point 31 (Figure 3 and Figure 4). This monitoring point features both a sealed gamma tracer (s/n 381236, part of the long-standing monitoring system requiring data readout, *cf.* chapter 5.2.1) and a new LaBr detector with spectroscopic capability. The new detector provides data via cable to a small server building about 30 m away. It has a battery backup power supply and a solar panel that charges the aforementioned battery. This measurement point supports also a weather station providing measurement of temperature, wind (acoustic method) and rain (yes/no data).

No remarks.

9.2.2 Surface contamination

The verification team verified the NUVIA LARS-system (Figure 15), which is used to monitor on-site paved areas to identify possible surface contamination. The results displayed include the background data as well as counts per second above the background. The LARS features an alarm that activates if it is moved too fast, and whenever pre-set level of ambient dose rate (7.5 sigma above the background) is exceeded.

No remarks.

Figure 15. On-site pavement surface contamination monitor LARS

9.2.3 Ground water radioactivity

There are several boreholes for ground water sampling on the plant area. The verification team verified point 2, which is located outdoors next to the turbine building (Figure 5).

No remarks.

9.3 OPERATOR OFF-SITE ENVIRONMENTAL RADIOACTIVITY MONITORING

9.3.1 Ambient radiation dose

The verification team visited the sampling point 20 and observed the gamma tracer (s/n GF0256) under a seal there (Figure 6). The device is on public area next to a bush fence at about 1 m height. It is quite old (20-30 years), but functional. Calibration and battery replacement is carried out every 5 years.

The verification team suggests replacement of the aging gamma tracer equipment in the near future.

The verification team suggests installing the probes at one meter height above soil or above a large flat surface without any obstacles in the surroundings.

9.3.2 Radioactivity in air

The verification team visited the air sampling point 21 located in the town of Borssele. The sampler is located behind a bus stop over which the filter of the capsule protrudes (Figure 7). The verification team took note of the impressive age (over 30 years) of the sampling station (Figure 16) and reflected on the very low airflow (approximately 3-4 l/min) that can barely be felt at the airflow exit.

The system is equipped with a total flow counter, but has no flowmeter. The system has no electrical back-up.

The verification team recommends renewal of the off-site air sampling systems in the vicinity of the Borssele NPP.

Figure 16. Close view of the air sampling system at the Borssele village

9.3.3 Radioactivity in vegetation

The verification team visited sampling point 21, which is a split-location point since the area in the town where the air sampler is located does not provide for sufficient grass sample throughout the year. Consequently, grass is sampled outside of the town, next to a small road which is closer (less than 1 km) to the NPP (Figure 8) than the air sampling station (Figure 7).

No remarks.

9.4 OPERATORS MOBILE MONITORING EQUIPMENT

9.4.1 Radioactivity in air and atmospheric deposition

The verification team verified the mobile air sampling system and the deposition collection system, which are stored on-site in a monitoring trailer (Figure 17) fitted with a 20 m electrical cable to ensure the power supply. The air sampling system (F&J) is one of eight such systems in the Netherlands. They can be activated in the event of an emergency and used in a synchronised manner to monitor particulate and gaseous (iodine) radioactivity in air. Standard collection time is two hours.

The deposition sampler has a large funnel for collecting a dry/wet sample in a plastic container. Standard collection time is 12 hours.

The monitoring trailer is also equipped with tools for eventual grass and soil sampling.

No remarks.

Figure 17. Mobile air monitor and dry/wet deposition collector

9.5 MONITORING OF GASEOUS RADIOACTIVE DISCHARGES

9.5.1 NPP stack

Gaseous radioactive discharges are released to the environment through ventilation shafts collecting all effluents in a single stack. The stack is equipped with routine and emergency monitoring systems. (Equipment installed on the routine monitoring system, including that used for monitoring the discharges through the stack, bears a pre-fix TL.) A sample flow from the outflow gas is taken at 2/3 height of the stack. The verification team verified the following systems:

$^{14}C/^{3}H$ samplers

The sampler (Figure 18) pumps air taken from the stack through two molecular sieves (zeolite collection tubes) capturing carbon and tritium that are bound to organic compounds or not, respectively (see chapter 7.3.2 for details). The system is equipped with a flow meter to measure the total volume of pumped air. The tubes are changed every three months and analysed in the following manner: two cylinders are sent to Framatome, two are kept in the EPZ laboratory. There are two such systems in parallel operation.

Figure 18. $^{14}C/^{3}H$ sampler

Ventilation air monitors

The effluent air monitoring system consist of a filter assembly (zeolite, activated charcoal and paper filters collecting halogens and aerosols, Figure 19) and a noble gas monitor (Figure 20) using a plastic scintillation counter. The noble gas monitor (TL080R011) is equipped with an alarm function serving the control room and activating the emergency monitor described below. The system allows filling a sample container (observed: container TL080B003) pressurized to 10 bar for subsequent gamma spectrometry by placing the container directly on the HPGe detector (Figure 21). There are two such systems in operation at the Borssele NPP. Filters are analysed in the plant laboratory.

Figure 19. Ventilation air sampler

On-line iodine monitors

The on-line iodine monitors – semiconductor detectors – are installed on the iodine adsorption zeolite filters part of the nuclear ventilation system (7.7 m level, equipment TL080R016). It filters the air flow passing through the pipe before returning the flow to the stack via the noble gas monitor. The filters are exchanged weekly and measured in the following sequence: paper filter, 1st charcoal filter, then 1st zeolite filter. The analysis is considered complete if no significant activity is found by these measurements.

Figure 20. Ventilation air noble gas monitor

On-line aerosol monitor

The on-line aerosol monitor (TL080R014) is a new system; it filters the air flow passing through the pipe before returning the flow to the stack via the noble gas monitor. The filters are exchanged weekly and measured in the following sequence: paper filter, 1st charcoal filter, then 1st zeolite filter. The analysis is considered complete if no significant activity is found by these measurements.

Emergency monitors

The emergency monitors (TL080R024 and TL080R025) have paper and zeolite filters on a detector unit. It is put on cyclic operation mode when a high-activity signal is received from the noble gas monitor. This results in repeating 5 min. sample collection, 5 min. measurement and 5 min flush. These filters are exchanged every two weeks but not measured under normal operating conditions.

For emergency monitoring two noble gas measurement chambers – high range ionisation chambers TL080R013 and R023, are installed. Additionally TL080R015 and R018 are equipped with paper filter and two activated charcoal cartridges to collect the halogens, including iodine, and aerosols.

The verification team commends the sophisticated systems for measuring gaseous radioactive discharges at the Borssele NPP.

9.5.2 Turbine building

The verification team verified the following gaseous and liquid monitoring points in the turbine building:

Secondary steam generator gases monitor

This on-line system (13.7 m level, measuring 0.7 cps at the time of verification) is used to detect activity in the secondary steam-generator gases (non-condensable gases). This detector is not used for quantitative discharge monitoring.

Steam generator blow-down monitor

This on-line system (6.7 m level, measuring below 0.2 microSv/h at the time of verification) is used to detect activity in the steam-generator blow-down water; it has a high-activity alarm function to the control room. The Geiger-Müller detector is placed outside the blow-down tank and calibrated regularly with a Cs-137 source. It is not used for quantitative discharge monitoring.

Steam generator blow-down sampling

The system facilitates taking a 10 bar air sample from the blow-down water. Sample activity is measured in the laboratory using gamma spectrometry (Figure 21). It is not used for quantitative discharge monitoring.

No remarks.

Figure 21. Gaseous discharge 10 bar sampling container and its counting position on a HPGe detector

9.6 Monitoring of liquid radioactive discharges

The verification team observed the equipment used for monitoring radioactive discharges as well as some equipment destined to monitor radioactivity in liquids at measurement points situated inside the controlled area and turbine building.

9.6.1 Liquid waste discharge

The liquid waste discharge facility comprises a shielded monitoring system, which provides an alarm to the control room if the outgoing waste water discharge activity limit is exceeded. The system controls also an automatic shut-off valve (TR045S009), which closes on detection of high activity on the discharge line (Figure 22).

No remarks.

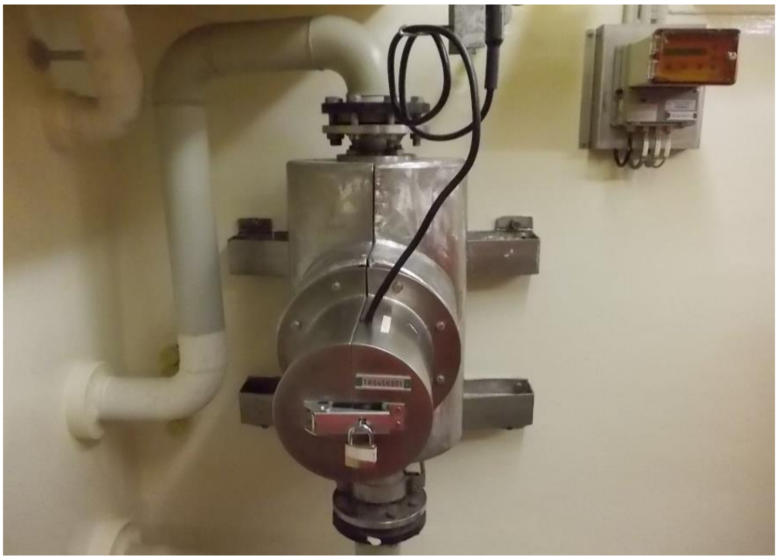


Figure 22. Waste water discharge monitor

9.6.2 Waste treatment building tanks

Radioactive discharges from the NPP liquid waste treatment facility is collected in two tanks, which are discharged to the Westerschelde river after analysis of the radioactivity content. Sample homogeneity is ensured by recirculating the tank content before sampling. Sampling takes place in a sampling cabinet (Figure 23). Samples are analysed in the plant laboratory before a discharge permission is given to the plant operations staff.

No remarks.

Figure 23. Waste water tank sampling cabinet

9.6.3 Turbine building waste water monitor

The verification team verified the detectors placed in the turbine building waste water collection sump, which are used to detect possible activity in the waste water. There is one detector in the sump at -2m height and another one in the collection box, from which the water can be recirculated if radioactivity is detected.

No remarks.

9.7 OPERATOR LABORATORIES

9.7.1 Controlled area

The verification team visited the operator's laboratory on 18.7 m level inside the controlled area. The laboratory performs quantitative analyses of water samples, gas samples, aerosol filters, zeolite filters and paper filters. The main laboratory equipment is the following:

- Four electrically cooled HPGe-based gamma spectroscopy systems (Canberra characterised detectors, 8192 channels, energy range up to 2 MeV, LABSOCS)
- Tennelec Series 5 alpha/beta counters (2x) for swipe samples
- Liquid scintillation counter (Tri-Carb 4910 TR) for primary circuit water ^{3}H-analysis
- Inductively Coupled Mass Spectrometer (ICP-MS) (not used for discharge samples)
- Sodium-Iodine Scintillation Counter for total activity of wastewater

The laboratory employs a StarLIMS for automatically storing and subsequent processing of measurement results in addition to a data storing system based on MS Excel. It also monitors environmental conditions such as temperature and humidity in the measurements area, and controls the personnel exiting by means of a hand/foot monitor.

Water samples are kept for one year. The verification team noted that the laboratory routinely uses a gelling agent to prevent sedimentation of water samples during analysis and storage (Figure 24).

The laboratory is very clean and well organised. No staff shortage was reported to the verification team.

The verification team commends the fixing a solution as a gel for maintaining water sample homogeneity.

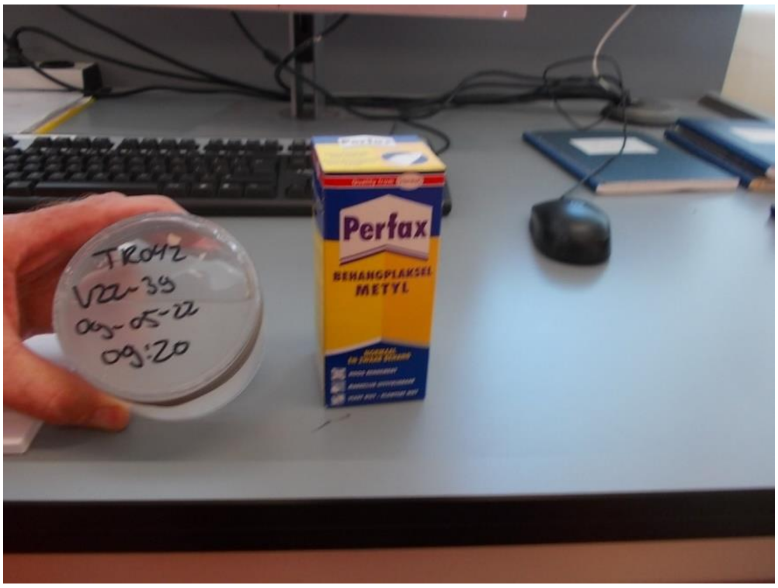


Figure 24. Water sample turned into a gel to maintain its homogeneity

9.7.2 Non-controlled area

The verification team visited the operator laboratory outside the controlled area, which analyses the liquid discharge samples. The main laboratory equipment is the following:

- Two electrically cooled HPGe-based gamma spectroscopy systems (Canberra) (Figure 25)
- NaI counting system (not used for discharge monitoring)
- Liquid scintillation counter (Tri-Carb 4910 TR) for ground water and steam generator blow-down ^{3}H-analysis

The lower radiation background in this laboratory allows achieving the detection limits such as e.g. 1 Bq/l for ^{60}Co. This laboratory participates in practices organised by RIVM and exercises organised by BfS in Germany. In case of an emergency requiring conducting large number of analyses, this laboratory may turn into a controlled area. The laboratory is very clean and well organised. No staff shortage was reported to the verification team.

No remarks.

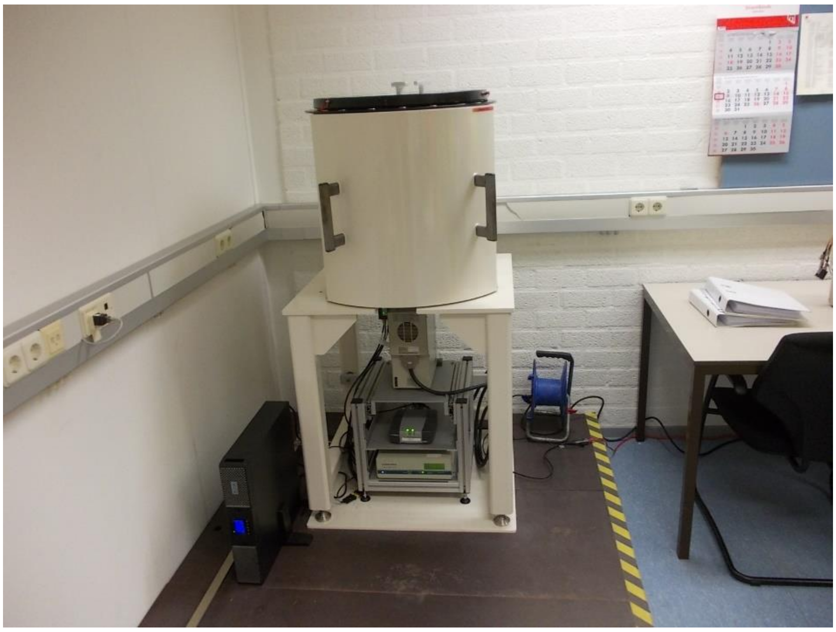


Figure 25. Electrically cooled HPGe detector at the laboratory outside controlled area

9.8 RIVM Bilthoven

9.8.1 Monitoring laboratory

The verification team visited the RIVM radionuclide laboratory, which is very well equipped for monitoring environmental radioactivity.

Samples are collected by the RIVM staff and nuclear facility staff (discharge samples). When entering the laboratory, each sample is recorded in the RIVM LIMS.

The main analytical equipment are the following:

- Gamma spectrometers (6 Mirion HPGe detectors, one with automatic sample changer). Calibration is based either on physical activity standards or mathematical modelling (Canberra ISOCS)
- Alpha-spectrometers (Canberra AlphaAnalyst, 4 chambers) for ^{210}Po, Pu, Am and U-analysis
- Gross alpha/beta counter (Canberra, 4+4 planchet positions)
- Liquid scintillation counters (Tri-Carb 5110 TR and Tri-Carb 2910 TR)
- Gas flow counter (Tennelec LB410)

The laboratory is ISO 17025 accredited. It has sufficient T/H-controlled space for equipment and sample storage. 26 staff members work in the department of the laboratory; no staff shortage was reported.

The verification team was informed that an emergency operation guideline for the laboratory is being prepared. This is needed to prepare for a situation where the laboratory receives an increased number of contaminated samples for analysis.

The verification team suggests that the RIVM finalises the laboratory emergency operation guideline as soon as possible.

9.8.2 Mobile laboratory

RIVM operates two mobile laboratories, which are equipped to carry out environmental sampling and analysis. The laboratory space is protected from contamination by air filters and airlock. The air sampling equipment consists of three sampling lines (one for on-line detection and two for filters) and a pressure container for sampled air. The detection equipment consists of two Mirion gamma spectrometers (one electrically cooled and one cooled by liquid nitrogen). In addition there is a portable Hidex liquid scintillation counter.

Altogether 8 RIVM laboratory staff members have been trained to operate the mobile laboratory; one of them is on continuous stand-by.

The verification team commends the sophisticated mobile laboratory equipment of the RIVM.

9.8.3 Monitoring systems

The verification team verified the following radiation monitoring systems at the RIVM in Bilthoven:

- High-volume air sampler SnowWhite, which is located on the roof of the RIVM building. The airflow is about 800 m^3/h. The airflow is controlled and recorded by a computer.
- Automatic aerosol monitor Berthold BAI 2128. This is one of 13 such stations in the Netherlands. The system is located in a temperature controlled container and equipped with a UPS to maintain power during power cuts shorter that 10 minutes.
- Gamma dose rate monitor number 1280 (type Saphymo GT-XL2-3), which belongs to the national monitoring network (164 stations). The detector is equipped with a precipitation detector. Internal alarm is given at 200 nSv/h (local fire brigade alert).

- Dry/wet deposition samplers (Figure 26)
- Mobile gamma dose rate monitor, equipped with a solar panel, rain detector and a GPS-location system (Figure 27)
- High-precision radiation dose rate monitor (Reuter-Stokes) used for equipment calibration (Figure 27)
- Mobile F&J air sampling system, which can be equipped with aerosol and carbon filters (iodine monitoring). This system is identical to the one at the Borssele NPP (Figure 17). Altogether there are 8 such systems available in different locations in the Netherlands.

The verification team was informed that currently there is no public on-line access to the radiation dose rate readings in any website of a national authority in the Netherlands. The RIVM website[20] includes a link to the EURDEP system, but there is no map of the national radiation situation with actual radiation dose rate. The team points out that making radiation information available to the public is a national responsibility - EURDEP can be used to complement a national website, but is should not be used as a sole means for presenting national dose rate results.

The verification team suggests, that the RIVM include a public access map of actual radiation dose rate readings from the national network on its website.

Figure 26. RIVM atmospheric deposition samplers

20 https://www.rivm.nl/nationaal-meetnet-radioactiviteit/resultaten

Figure 27. RIVM high-precision and mobile radiation dose rate monitors

10 CONCLUSIONS

All planned verification activities were completed successfully. The information supplied in advance of the visit, as well as the additional documentation received during and after the verification activities, proved very useful.

The information provided and the verification findings lead to the following observations:

(1) The verification activities that were performed demonstrated that the facilities necessary to carry out monitoring of levels of radioactivity in air, water and soil at the Borssele nuclear power plant and in its vicinity are adequate. The Commission could verify the operation and efficiency of a representative part of these facilities.

(2) The verification activities that were performed demonstrated that the facilities necessary to carry out monitoring of levels of radioactivity in air, water and soil at the Borssele nuclear power plant and in its vicinity in the event of a radiological emergency are adequate. The Commission could verify the availability of a representative part of these facilities.

(3) The verification activities that were performed demonstrated that the facilities necessary to carry out continuous monitoring of levels of radioactivity in the gaseous and liquid discharges at the Borssele nuclear power plant are adequate. The Commission could verify the operation and efficiency of a representative part of these facilities.

(4) One recommendation and a few technical suggestions are formulated. Notwithstanding these remarks, the verified parts of the monitoring system for environmental radioactivity and radioactive discharges in place are in conformity with the provisions laid down under the Article 35 of the Euratom Treaty.

(5) The verification summary is presented in the 'Main Conclusions' document that is addressed to the Dutch competent authority through the Permanent Representative of the Netherlands to the European Union.

(6) The Commission services kindly request the Dutch authorities to submit, before the end of 2024, a progress report on how the team's recommendation has been implemented, and on any significant changes in the set-up of the monitoring arrangements. Based on this report the Commission will consider the need for a follow-up verification.

(7) The verification team acknowledges the excellent co-operation it received from all persons involved in the activities it performed.

ANNEX 1

VERIFICATION PROGRAMME

Day/date	Time	Verification
Monday 16 May	13:00 – 14:30	Entrance to the Borssele NPP site & formalities
	15:00 – 17:00	Borssele NPP - Opening meeting • Introductory presentations by EPZ, ANVS & RIVM • Article 35 programme introduction by the EC • ANVS presentations: - General information on regulatory system - Feedback on Recommendation & Suggestions of previous verification visits • Overview of the Borssele NPP environment monitoring • Overview of the Borssele NPP discharge monitoring • Verification planning
Tuesday 17 May	09:00 – 12:30	Borssele NPP • Gaseous discharge monitoring facilities
	13:30 – 17:00	Borssele NPP • Liquid discharge monitoring facilities • Laboratories on the controlled area
Wednesday 18 May	09:00 – 12:30	Borssele NPP • Laboratories outside the controlled area
	13:30 – 17:00	Borssele NPP on- and off-site monitoring stations • Dose rate monitoring at the site fence • Collective dose monitoring • Air samplers • Deposition samplers • NMR dose rate monitors • Mobile monitoring systems • Other monitoring systems
Thursday 19 May	09:00 – 12:00	RIVM • National monitoring system & laboratories
	13:00 – 15:30	RIVM • Measuring systems and monitoring equipment • Mobile monitoring laboratory
	15:30 – 16:30	RIVM • Review of the Netherlands data on the EC Art. 35 database
	16:30 – 17:00	RIVM - Closing meeting