EUROPEAN COMMISSION
DIRECTORATE-GENERAL FOR ENERGY AND TRANSPORT

DIRECTORATE D – Nuclear Energy
D.4 Radiation Protection

TECHNICAL REPORT

VERIFICATIONS UNDER THE TERMS OF ARTICLE 35 OF THE EURATOM TREATY

BORSSELE NUCLEAR POWER STATION

THE NETHERLANDS

03 March to 07 March 2008

Reference: NL-08/01

VERIFICATIONS UNDER THE TERMS OF ARTICLE 35
OF THE EURATOM TREATY

FACILITIES:	Installations for monitoring and controlling radioactive discharges and for surveillance of the environment during normal operations of the Borssele nuclear power station; facilities of the Dutch national networks for the surveillance of environmental radioactivity.
SITE:	Borssele, The Netherlands
DATE:	03 March to 07 March 2008
REFERENCE:	NL-08/01
INSPECTORS:	C. Gitzinger (Head of team) E. Henrich A. Godeanu-Metz J-L. Frichet (national expert on secondment – France)
DATE OF REPORT:	21 January 2009
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ABBREVIATIONS AND ACRONYMS

AC	Alternating Current
ALARA	As Low As Reasonably Achievable
BNC	Bayonet Neill Concellman (electronic connector)
BZK	*Ministerie van Binnenlandse Zaken en Koninkrijksrelaties* (Minister of the Interior and Kingdom relations)
CBSS	Council of the Baltic Sea States
COVRA	*Centrale Organisatie Voor Radioactief Afval* (Central Organisation for Radioactive Waste)
DG ENER	Directorate-General for Energy (European Commission)
DG TREN	(former) Directorate-General for Energy and Transport (European Commission)
DSL	Digital Subscriber Line (telecommunication)
EC	European Commission
ECCS	Emergency Core Cooling System
EPZ	*Energie Productiemaatschappij Zuid-Nederland*
ETN	(Dutch) Emergency Telephone Network
EURDEP	EUropean Data Exchange Platform
FWHM	Full Width Half Maximum
GM	Geiger-Müller (radiation detector)
GPS	Global Positioning System
HPGe	High Purity Germanium (radiation detector)
IP	Internet Protocol (communication systems)
ISO	International Organization for Standardization
I&C	Instrumentation and Controls
IT	Information Technology
KCB	*Kernenergie Centrale Borssele* (Borssele NPP)
KEMA	*Keuring Electrotechnisch Materieel Arnhem* (predecessor of NRG-Arnhem)
KFD	*KernFysische Dienst* (department of Nuclear Safety, Security & Safeguards)
KTA	*KernTechnischer* Ausschuss (Nuclear Safety Standards Commission)
LAN	Local Area Network
LLD	Lower Limit of Detection
LIMS	Laboratory Information Management System
LMRV	*Landelijk Meetnet Radioactiviteit in Voedsel* (national monitoring network radioactivity in food)
LNV	*Minister van Landbouw, Natuur en Voedselkwaliteit* (Minister of Agriculture, Nature and Food Quality)
LSC	Liquid Scintillation Counting (radiation measurement)
LSO	*Laboratorium voor StralingsOnderzoek* (Laboratory for Radiation Research), at RIVM
MDA	Minimum Detectable Activity
MONET	MOnitoring NEtwork Terrains
MOX	Mixed Oxide (nuclear reactor fuel)
NaI(Tl)	Sodium iodide, thallium activated (radiation detector)
NDKK	*Niederländisch-Deutsche Kommission für grenznahe Kerntechnische Einrichtungen*

	(Dutch-German commission for nuclear facilities in the border region)
NMR	National Monitoring network for Radioactivity
NRG	Nuclear Research Group
NPP	Nuclear Power Plant
PPS	Process Presentation System
REM	Radiological Environmental Monitoring (European Commission database at JRC Ispra)
RIKILT	*Instituut voor Voedselveiligheid* (Institute of Food Safety)
RIVM	*Rijksinstituut voor Volksgezondheid en Milieu* (National Institute for Public Health and the Environment)
RWS WD	*Rijkswaterstaat Waterdienst* (RWS; Water Management)
RWS	*RijksWaterStaat* (Directorate-General for Public Works and Water Management)
QA/QC/QM	Quality Assurance / Quality Control / Quality Management
SAS	directorate of Chemicals, Waste & Radiation Protection (VROM, Directorate General for Environmental Protection)
TLD	Thermoluminescence Dosimetry/Dosimeter
TTL	Transistor-Transistor Logic (integrated circuits)
USB	Universal Serial Bus
UPS	Uninterruptible Power Supply
VPN	Virtual Private Network (communication systems)
VROM	*Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer* (Ministry of Housing, Spatial Planning and the Environment)
VWA	*Voedsel en Waren Autoriteit* (Food and Consumer Product Safety Authority)
VWS	*minister van Volksgezondheid, Welzijn en Sport* (Minister of Health, Welfare and Sport)
V&W	*Ministerie van Verkeer en Waterstraat* (Ministry of Transport, Public Works and Water Management)

1 INTRODUCTION

Article 35 of the Euratom Treaty requires that each Member State shall establish 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.

Article 35 also gives the European Commission (EC) the right of access to such facilities in order that it may verify their operation and efficiency. Such a verification has been performed in September 1993 (Reference NI93/1 KCB).

For the EC, the Directorate-General for Energy (DG ENER; formerly Directorate-General for Energy and Transport - DG TREN) and in particular its Radiation Protection Unit (at the time of the visit: TREN.H.4) is responsible for undertaking these verifications.

For the purpose of such a review, a verification team from DG TREN visited Borssele NPP from 03 March to 07 March 2008. The visit to Borssele NPP included also meetings with the Dutch competent authority, the Ministry of Housing, Spatial Planning and the Environment (*Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer;* VROM), with NRG-Arnhem – *Radioanalytisch Laboratorium*, which, under contract with Borssele NPP provides technical support to perform the sampling within the operator's programme and analysis these samples, with the *Rijksinstituut voor Volksgezondheid en Milieu* (RIVM; National Institute for Public Health and the Environment) at Bilthoven, which runs the national radiological environmental monitoring programme for the regulator, and with the *Rijkswaterstaat Waterdienst* (RWS WD; Centre for Water Management) which runs the environmental monitoring program in water and sediment.

Details of the programme of the verification are given under Section 2.3 below.

The present report contains the results of the verification team's review of relevant aspects of the environmental surveillance at and around the Borssele site. The purpose of the review was to provide independent verification of the adequacy of monitoring facilities for:

- Discharges of radioactivity into the environment.
- Levels of environmental radioactivity at the site perimeter and in the terrestrial and aquatic environment around the site, for all relevant exposure pathways.

With due consideration of the scope of the verification and taking into account the relatively short time available for the execution of the programme, it was agreed that emphasis would be put on:

- The operator's monitoring and control facilities for gaseous and liquid discharges of radioactivity into the environment.
- The implementation of the statutory environmental radioactivity monitoring programme as performed by NRG-Arnhem for the operator and by RIVM-Bilthoven for the regulator.
- The operator's effluent laboratories including aspects of quality assurance and control as well as document control.
- The national environmental monitoring programme as established by the competent authority (VROM) in the region of Borsele and on the territory of The Netherlands. The sampling for this programme and the corresponding measurements are contracted by VROM to RIVM-Bilthoven.

The present report is also based on information collected from documents referred to in Chapter 2.2 and from discussions with various persons met during the visit, listed in Chapter 2.4 below.

2 PREPARATION AND CONDUCT OF THE VERIFICATION

2.1 INTRODUCTION

The Commission's decision to request the conduct of an Article 35 verification was notified to the Dutch authorities on 20 July 2007 (letter referenced TREN.H4/CG/cd D (2007)307719, addressed to the Permanent Representation of The Netherlands to the European Union). Subsequently, practical arrangements for the implementation of the verification were made with the persons designated by the Dutch authority.

2.2 DOCUMENTATION

In order to facilitate the work of the verification team, a package of information was supplied in advance by VROM. Additional documentation was provided during and after the visit. All documentation received is listed in Appendix 1 to this report. The information thus provided has been extensively used for drawing up the descriptive sections of this report.

2.3 PROGRAMME OF THE VISIT

The EC and the Dutch authority (VROM) discussed and agreed upon a programme of verification activities, with due respect to the Communication of the Commission[1] setting out the framework and modalities within which Article 35 verifications are to be conducted.

During the opening meeting introductory presentations were given on the following topics:

- Borssele Nuclear Power Plant (Borssele NPP);
- Environmental Radiological Monitoring Programmes (site related and national);
- Role of NRG-Petten and NRG-Arnhem;
- Role of the National Institute for Public Health and the Environment (RIVM);
- Role of the Ministry of Housing, Spatial Planning and the Environment (VROM);
- Role of the *Rijkswaterstaat* Centre for Water Management (RWS WD).

The verification team notes the quality and comprehensiveness of all the presentations made and the documentation provided.

A summary overview of the programme of verification activities is provided in Appendix 2. The verifications were carried out in accordance with the programme.

2.4 REPRESENTATIVES OF THE COMPETENT AUTHORITIES, THE NPP OPERATOR AND OTHER ORGANISATIONS INVOLVED IN ENVIRONMENTAL RADIOACTIVITY MONITORING

During the visit the following representatives of the national authorities, the operator and other parties involved were met:

Ministry of Housing, Spatial Planning and the Environment {*Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer* (VROM)}

B. van der Werf	Radiation Protection Inspector	Radiation Protection
G. M. Breas	Radiation Protection Expert	Radiation Protection and environment
T.J.M. Klomberg	Expert, policymaker	Nuclear safety policy and licenses

[1] 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", Official Journal (2006/C 155/02), 4 July 2006

Borssele NPP		
M.W.J. Crajé	Manager monitoring,	Monitoring, Radiation Protection, chemistry, rad waste and reactor physics
C. Lous	Head of chemistry department	Chemistry
F. Kamping	Head of Radiation Protection department	Radiation Protection
F. Verplanke	Head rad waste treatment	Rad waste treatment
NRG-Arnhem Environmental Radioactivity Laboratory		
J. Donk	Team member	Environmental sampling
W. van Loon	Team member	Laboratory
F. Moet	Team manager measurement of radioactivity	
C. Timmermans	Project leader environmental measurements	General radiation protection
***Rijkswaterstaat* Centre for Water Management (RWS WD) at Lelystad**		
Onno Epema	Head of section inorganic analyses	Inorganic analyses including radiochemical
Jaap van Steenwijk	Senior advisor	Measuring stations, emergency group
Carlo Engeler	Senior expert radiochemistry	Radiochemical analyses, online monitoring
National Institute for Public Health and the Environment RIVM – Bilthoven; Laboratory for Radiation Research (LSO)		
RCGM Smetsers	Head of Laboratory (LSO)	
HAJM Reinen	Head of department Monitoring and Measuring methods (LSO/MMM)	
PJM Kwakman	Senior scientist	Radiochemical analyses
RMW Overwater	Senior scientist	Radiophysical analyses, gammaspectrometry
PC Görts	Senior scientist	MONET network
RB Tax	Scientist	National Monitoring Network (NMR)
K. Tukker	Scientist	Mobile laboratories
W. Maas	Quality manager	Quality management

3 COMPETENT AUTHORITIES & LEGAL BACKGROUND

3.1 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 an 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 NRG-Petten and NRG-Arnhem on behalf of the operator. In addition, NRG is contracted by the regulator to do scientific work for policymaking. Nation wide environmental radiological monitoring networks are managed by RIVM-Bilthoven, RWS WD Lelystad and RIKILT, Wageningen.

The operator of the nuclear power plant has to run the 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. Table 1 details the analyses required in The Netherlands for each type of sample in a nuclear power plant:

Table 1: NPP Radiological Environmental Monitoring Programme

Type of Sample	Analysis
Air	Gross alpha, Gross beta, gamma spectrometry
Grass	Gamma spectrometry
Soil	Gamma spectrometry
Water	Residual beta, tritium
Suspended solids	Gross beta
Soil	Gamma spectrometry
Seaweed	Gamma spectrometry
Sediment	Gamma spectrometry

The on-site independent environmental monitoring programme of RIVM-Bilthoven is limited to the network for ambient dose rate monitoring at the fence of the NPP (Monitoring Network Terrains - MONET).

With regard to off-site monitoring by the regulator, the MONET ambient dose rate monitoring network at the NPP fence combined with the National Monitoring network for radioactivity (NMR), both providing data at a ten minute interval, are considered to be adequate.

The nation-wide radiological monitoring network established by VROM and managed mainly by RIVM-Bilthoven is independent from the network associated with nuclear facilities. It includes automatic station networks for real-time measurement of ambient gamma dose rate and atmospheric radioactivity and a sampling station network for sampling and analysis programmes for air, soil, river water, coastal water, drinking water, milk and mixed diet. Measurements are performed by different laboratories.

3.2 COMPETENT DUTCH AUTHORITIES/REGULATORY BODY IN THE NETHERLANDS

3.2.1 Introduction

Several ministers are jointly responsible for the licensing, assessment and inspection of nuclear installations. The various organizations within the ministries which are charged with these tasks, and the legal basis on which they operate, are:

- Ministry of Housing, Spatial Planning and the Environment (VROM) (see also figure 1)
    - Directorate-General for the Environment (DGM)
        - Directorate for Chemicals, Waste, Radiation Protection (SAS)
    - Inspectorate-General (VI)
        - Department for Nuclear Safety, Security and Safeguards (KFD)

- Ministry of Social Affairs and Employment (SZW)
        - Directorate Health and Safety at Work

- Ministry of Economic Affairs (EZ)
    - Directorate-General for Energy and Telecommunications
        - Directorate for Energy Production

3.2.2 Ministry of Housing, Spatial Planning and the Environment (VROM)

The Ministry of Housing, Spatial Planning and the Environment has overall responsibility for legislation concerning the Nuclear Energy Act, for licensing and for ensuring that the current legislation is being adequately enforced. It is also responsible for the technical safety considerations on which the decision to grant or reject an application for a licence is based. These considerations are mainly based on assessments and inspections by the KFD, which advises the licensing body (SAS) on licensing conditions and requirements, including those relating to effluent discharge, environmental protection and security and safeguards.

As a result, the various bodies within the Ministry of Housing, Spatial Planning and the Environment, together with the Ministry of Social Affairs and Employment, are responsible for formulating the conditions attached to the licence concerning the safety and the (radiation) protection of the workers and the public and the environment.

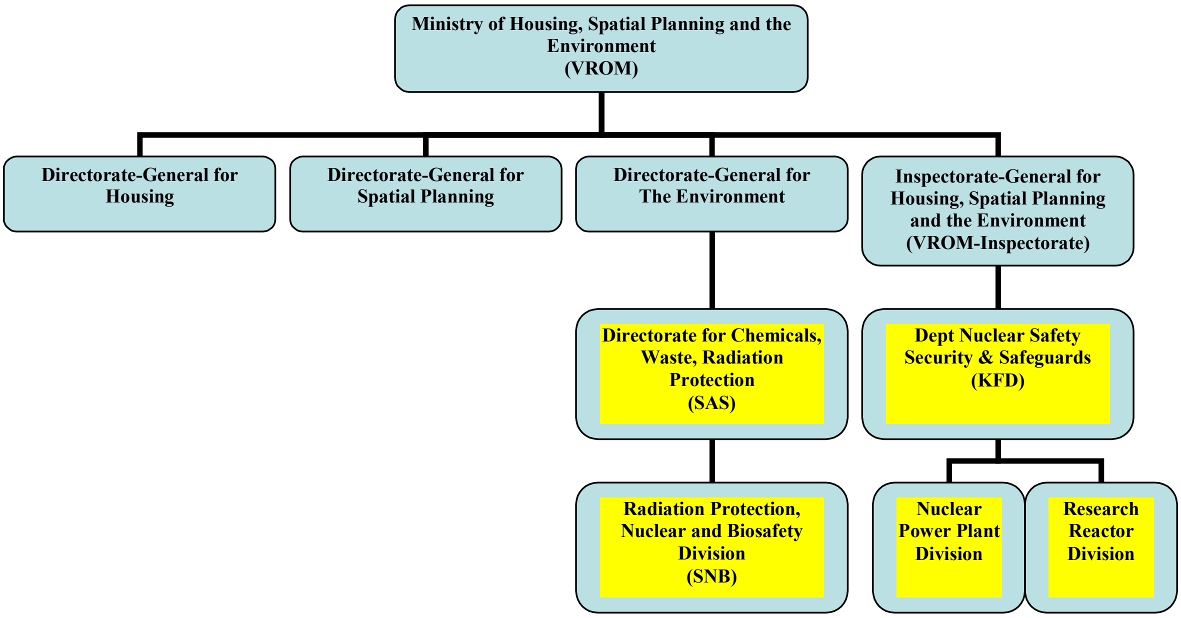


Figure 1: Nuclear safety and radiation protection within the Ministry of the Environment

The nuclear regulatory body in the Netherlands is formed by several entities, of which the most important are SAS and KFD, both from the Ministry of Housing, Spatial Planning and the Environment. An organization chart is presented in figure 1. SAS and KFD together are the regulatory authority for nuclear safety, security and safeguards.

The main tasks of the Directorate for Chemicals, Waste, Radiation Protection of VROM (SAS), are licensing, legislation, policy development and implementation in the field of radiation protection, waste management, nuclear safety, security and safeguards in relation to the public and the environment. The subjects of security and safeguards have been included quite recently.

The main activities of KFD, a department of the VROM-Inspectorate, are assessment, inspection, enforcement and technical advising and support of SAS (SNB) in the framework of licensing and the establishment of regulations. KFD has a formal nuclear inspection strategy, which is based on two pillars: prevention of degradation and continuous improvement of safety. The Inspector General has adopted this strategy.

According to the Nuclear Energy Act, the Ministry of Social Affairs and Employment and the Ministry of Economic Affairs are also part of the regulatory body.

3.2.3 The Ministry of Social Affairs and Employment

The Directorate Health and Safety at Work within the Ministry of Social Affairs is responsible for the legal aspects of radiation protection of workers.

3.2.4 The Ministry of Economic Affairs

The Directorate-General for Energy and Telecommunications of the Ministry of Economic Affairs is responsible for aspects concerning the energy demand and energy supply.

3.3 DESCRIPTION OF THE LEGISLATIVE AND REGULATORY FRAMEWORK IN THE NETHERLANDS

3.3.1 Overview of the legal framework

The following are the main laws to which nuclear installations in the Netherlands are subject:

- The Nuclear Energy Act *(Kernenergiewet)*;
- The Environmental Protection Act;
- The General Administrative Act *(Algemene wet bestuursrecht)*.

The basic legislation governing nuclear activities is contained in the **Nuclear Energy Act**.

The Nuclear Energy Act was designed to do two things at once: to regulate the use of nuclear energy and radioactive techniques, and to lay down rules for the protection of the public and workers against the associated risks. In practice, however, the law has developed almost entirely to do the latter. It sets out the basic rules on nuclear energy, makes provision for radiation protection, designates the various competent authorities and outlines their responsibilities.

Licences for nuclear power plants are granted jointly by the Minister of Housing, Spatial Planning and the Environment, the Minister of Economic Affairs, and the Minister of Social Affairs and Employment (plus, where relevant, some other ministers whose departments may be involved). Together, these ministers constitute the competent authorities as defined by the Nuclear Energy Act and are jointly responsible for assessing licence applications and granting licences. The Minister of Housing, Spatial Planning and the Environment (VROM) acts as the coordinator in this respect.

A number of Decrees have also been issued containing additional regulations and these continue to be updated in the light of ongoing developments. The most important of these in relation to the safety aspects of nuclear installations are:

- the Nuclear Installations, Fissionable Materials and Ores Decree;
- the Radiation Protection Decree;
- the Transport of Fissionable Materials, Ores and Radioactive Substances Decree.

The Nuclear Installations, Fissionable Materials and Ores Decree regulates all activities involving fissionable materials and nuclear installations (including licensing).

The Radiation Protection Decree regulates the protection of the public and workers against the hazards of all ionising radiation. It also establishes a licensing system for the use of radioactive materials and radiation-emitting devices, and prescribes general rules for their use.

The Transport of Fissionable Materials, Ores and Radioactive Substances Decree deals with the import, export and inland transport of fissionable materials, ores and radioactive substances by means of a reporting and licensing system.

The **Nuclear Energy Act** and the aforementioned Decrees are fully in compliance with the relevant EURATOM Directive laying down the basic safety standards for the protection of workers and the general public against the health risks associated with ionising radiation. This Directive (96/29/Euratom) is incorporated into the relevant Dutch regulations.

The **Environmental Protection Act**, in conjunction with the **Environmental Impact Assessment Decree,** stipulates that any licence application for a nuclear installation must be accompanied by an environmental impact assessment. This complies with EU Council Directive 97/11/EC.

In the case of non-nuclear installations, this Act regulates all environmental issues (e.g. chemical substances, stench and noise); in the case of nuclear installations, the Nuclear Energy Act takes precedence and regulates both conventional and non-conventional environmental issues.

The **General Administrative Act** sets out the procedure for obtaining a licence and describes the role played by the general public in this procedure (i.e. objections and appeals).

3.3.2 Licensing procedure

The Nuclear Energy Act stipulates (in Article 15, sub b) that a licence must be obtained to construct, commission, operate, modify or decommission a nuclear power plant. Similarly, the Act states (in Article 15, sub a) that a licence is required to import, export, possess or dispose of fissionable material.

Under Article 29 of the same Act, a licence is required in a number of cases (identified in the Radiation Protection Decree) for the preparation, transport, possession, import or disposal of radioactive material.

Article 15a of the Act lists the ministers responsible for licensing. Responsibility for nuclear activities is not centralised, but is divided principally between three ministers, who consult each other in accordance with their areas of competence.

The division of responsibilities is as follows:

- the Minister of Housing, Spatial Planning and the Environment (VROM) is responsible, together with the Minister of Economic Affairs (EZ) and the Minister of Social Affairs and Employment (SZW), for licensing nuclear installations and activities;
- the Minister of Housing, Spatial Planning and the Environment is responsible, together with the Minister of Social Affairs and Employment, for licensing the use of radioactive materials and radiation-emitting devices;
- With regard to nuclear installations the Minister of Housing, Spatial Planning and the Environment is responsible for all public health and safety aspects, including radiation protection for workers and members of the public; the Minister of Economic Affairs is responsible for energy supply policy; and the Minister of Social Affairs and Employment is responsible for regulations concerning the protection of workers.

Other ministers may be consulted on nuclear activities which fall within their particular spheres of competence; for instance, discharges of radioactive material in air and water involve (see table 2 for details) the Minister of Agriculture, Nature and Food Quality (LNV) and the Minister of Transport, Public Works and Water Management (V&W), while the subject of emergency response involves these two Ministers plus the Minister of the Interior and Kingdom relations (BZK) and the Minister of Health, Welfare and Sport (VWS).

Table 2: Detailed distribution of competences of Ministers with regard to nuclear activities

	LNV	V&W	BZK	VWS
Discharges in air	X			
Discharges in water	X	X		
Transport		X		
Emergency provisions	X	X	X	X
Medical applications				X

A move is now being made to reduce the number of authorities involved in order to streamline the licensing procedures and reduce the administrative burden. To this purpose a proposal to change the Nuclear Energy Act has been drafted which is currently under review by the Parliament.

In addition to the Nuclear Energy Act and Environmental Protection Act, the **Steam Act** also includes some provisions relevant to nuclear safety: it prescribes a licence per individual pressure-retaining component.

3.3.3 Regulatory assessment and inspections

Article 58 of the Nuclear Energy Act states that the Ministers responsible for licensing procedures should entrust designated officials with the task of performing assessment, inspection and enforcement. The **Nuclear Regulatory body** in the Netherlands is formed by several entities. The most important two are the **directorate of Chemicals, Waste & Radiation Protection (SAS**), and the **department of Nuclear Safety, Security & Safeguards (**the ***KernFysische Dienst,*** **KFD).**

KFD is the main department regarding assessment and inspection of nuclear facilities. The KFD also is responsible for supervision of nuclear security and safeguards. At the same ministry, the Chemicals, Waste and Radiation Protection Directorate **(SAS)** is responsible for assessing whether the radiological safety objectives have been met in the licensing procedures. Thus, this directorate is responsible for policymaking and licensing; it does not perform inspections.

The function of regulatory inspections is:

- to check that the licensee is acting in compliance with the regulations and conditions set out in the law, the licence, the safety analysis report, the Technical Specifications and any self-imposed requirements;
- to report (to the director of KFD) any violation of the licence conditions and if necessary to initiate enforcement action;
- to check that the licensee is conducting its activities in accordance with its Quality Assurance system;
- to check that the licensee is conducting its activities in accordance with the best technical means and/or accepted industry standards.

All inspections with regard to nuclear safety, radiological protection of personnel and of the environment around nuclear sites, security and safeguards, including transportation of fresh and spent nuclear fuel and related radioactive waste to and from nuclear installations are carried out by KFD.

The licensee has to act in compliance with the Nuclear Energy Act, the licence and the associated safety analysis report. The compliance is verified with a system of inspections, audits, assessment of operational monthly reports, and evaluation of operational occurrences and incidents. Inspection activities are supplemented by international missions and a special arrangement with the Belgian inspection authority, which participates frequently in Dutch inspections.

4 BORSSELE -NPP SITE

4.1 INTRODUCTION

The 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.

Borssele-NPP is located at a straight line distance of 55km from the city of Antwerpen (B), 120km 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 high industrial activity).

The building authorisation for Borssele NPP is dated 1969. The plant was connected to the electric grid in July 1973 and commercial operation started on 26 October 1973. The plant is currently operated by *Energie Productiemaatschappij Zuid-Nederland* (EPZ).

4.2 BASIC TECHNICAL INFORMATION

The Borssele Nuclear Power Plant is a 2-loop pressurised water reactor, built under a turn-key contract between the operator (formerly *PZEM*) and *KWU/Siemens*. It is licensed for a thermal power of 1365 MW_{th}. This thermal power has never been uprated, and the present owner-operator EPZ has no plans for nuclear capacity increases. However, the turbines have been retrofitted in 2006 for better thermal efficiency. The turbine project has added 35 MW_{el}. Presently, the gross capacity is 515 MW_{el} and the net capacity is 485 MW_{el}.

The reactor is fuelled with 121 fuel assemblies 15x15 grid, containing 38.8 tons of uranium as UO_2. The enrichment level of the fuel has over the years been increased from 3.3% U-235 to 4.4%. The present reactor contains a mix of various enrichment levels. No MOX is being used. Since a number of years, EPZ is re-enriching its reprocessed uranium and this uranium is subsequently reloaded as fresh fuel. The reactor is run in a 12-month cycle with the annual refuelling outage in September. Since 2007, this annual refuelling outage is shifted to April. *Framatome ANP* (formerly *KWU/Siemens*) is the exclusive vendor of fuel and is contractor for specialized maintenance and inspection jobs.

The steam-water circuit has one high-pressure turbine and three low pressure turbines, on a single shaft. The condensers are titanium-tubed and cooled with salt water from the Schelde; the condensate is collected and de-aerated in a large feed-water accumulator. This feed-water accumulator is a prominent feature on the turbine floor.

The main control room has been retrofitted during the modification project of 1997 and is based on ergonomically optimization of plant operation procedures, including emergency procedures. A redundant bunkered control room is provided for controlled shutdown and cool down of the reactor in out of design conditions.

There are two grids for emergency AC power system, for different levels of plant accident conditions. The main grid 1 has 300% capacity (3 diesel generators) and the bunkered grid 2 has 2 extra, smaller diesels in separate rooms. Likewise, other essential safety systems have been backed up in the bunkers. The 4-pump Emergency Core Cooling System is backed up by a 2-train bunkered system, and the 3-pump Auxiliary Feed water System is backed up by the 2-train *RS* system.

The 'reactor protection system' has been replaced in 1997 and is based on the principle that all design basis accidents can be handled without operator action during the first 30 minutes into the event. Operating manuals for incidents and accidents are based on the symptom-based Westinghouse Emergency Operating Procedures and Accident Management Guidelines.

History of the Borssele Nuclear Power Plant

1969: *Kraftwerk Union* (*KWU*) is contracted to build a nuclear power plant near the small village of Borsele, in order to supply the near-by aluminium smelter *Péchiney* and other local industry with electrical power. The regional utility *PZEM* will be owner-operator of the nuclear plant. A fossil-fired plant is build next to the nuclear unit for production redundancy. The Borssele site is in green field condition when construction work begins.

1973: Begin of commercial operations. *PZEM* receives an operating license for the nuclear plant which is unlimited in time.

1985: A bunkered auxiliary feed-water system and add-on primary injection system are backfitted.

1997: Extensive safety backfits, called Modification Project (MOD), during a 5-month outage.

2003: The Dutch Government decides that Borssele NPP should be closed in 2013.

2005: The Dutch Government decides that, under circumstances, Borssele NPP is allowed to be in operation up to 2034.

2006: The turbine has been upgraded, the water separators are replaced and the associated I&C systems are renewed. With this project the gross and net unit power increased with 35 MW_{el}.

At the same time the generator stator is replaced.

As a result of the second 10-yearly Safety Review several improvements have been implemented. The most prominent of these improvements are:

- Improved seals for the low-pressure ECCS pumps;
- Larger diesel fuel stocks for emergency AC diesels;
- Countermeasures for water loss during mid-loop operations;
- Protection against accidental drop of irradiated fuel transport container;
- Igniters for external flammable clouds.

The discharge limits per calendar year and the basic principles (such as ALARA) are specified in the license and the Technical Specifications. The rationale upon which the regular discharge limits are based is the general risk policy of the Dutch Government.

Also based on the license and the Technical Specifications the German standard *KTA 1503* and *150*4 are adapted for the instrumentation, the online measurements and the discharge measurements. The *KTA 1503* and *1504* standards are integrated in the NPP's QA-system.

Crosschecks on the results of the discharges are performed by the authorities.

5 BORSSELE NPP RADIOACTIVE DISCHARGES – DESCRIPTION AND VERIFICATION

5.1 INTRODUCTION, DISCHARGE AUTHORISATION, DISCHARGE LIMITS

The regulatory basis for controls on radioactive waste discharges is the Nuclear Power Act *(Kernenergiewet)*. Authorisations, including limits on discharges, are issued by four government ministries: the Ministry of Housing, Spatial Planning and the Environment (VROM); the Ministry of Economic Affairs (EZ); and the Ministry of Social Affairs and Employment (SZW). Of these ministries the Ministry of VROM is responsible for checking compliance with the discharge limits and any enforcement action. VROM is empowered to take enforcement measures, up to and including suspension of operation or instigation of legal proceedings.

In order to demonstrate compliance with their site authorisations, operators are required to undertake sampling, measurements and/or assessments of the discharges and their effects on the environment. These requirements depend on the operations on the site and are detailed in the authorisations. The authorisations also detail the operator's required timetable for the reporting of discharge and environmental measurements to the Ministry of VROM.

Discharge monitoring is primarily the responsibility of the operator. Check monitoring of discharges on behalf of the regulator is carried out by providing part of each sample to RIVM who select at random 8 samples from airborne discharges and 8 samples from liquid discharges per year for analysis. Where differences in analytical results are obtained, these are discussed between the operator, RIVM and VROM. The Ministry of VROM staff includes inspectors who liaise with the site and make regular visits to check on site operations and compliance with the terms of authorisation.

Based on the license and the technical specifications the German standards *KTA1503* (for aerial discharges) and *KTA1504* (for liquid discharges) are adapted for the instrumentation, the on-line measurements and the discharge measurements. They are integrated in the QA system.

Table 3 lists the discharge authorisations currently applicable for Borssele NPP. The maximum annual dose rate in the vicinity of the NPP for members of the public is limited to 40 μSv.

Table 3: Authorisation for annual airborne and liquid discharges by the NPP Borssele, licence number EPZ E/EE/KK/9904681, Ministry of Economic Affairs, 1999

Radionuclide / group	Airborne	Liquid
Noble gases	500 TBq/year	
Halogens including iodine-131	50 GBq/year	
Iodine-131	5 GBq/year	
Aerosols	0.5 GBq/year	
Beta/gamma excluding tritium		0.2 TBq/year
Tritium	2 TBq/year	30 TBq/year
Carbon-14	0.3 TBq/year	
Alpha emitters		200 MBq/year

5.2 Discharges - General Verification Aspects

The verification included control of the discharge monitoring facilities and the associated laboratories of Borssele NPP in order to verify their adequacy and effectiveness. In addition a spot check on archived data was made in order to verify procedures for data management and archiving.

Laboratories of NRG at Petten and of *AREVA* at Erlangen, Germany, that perform measurements for Borssele NPP on contract basis were not within the scope of the verification.

In the reactor control room the verification team was shown displays and paper plotters for various on-line measuring devices (e.g. for the stack monitor) and the time graph for the filling levels of the TR41 and TR42 discharge tanks. It saw the screens with the on-line presentation of the discharge flow and discharge activity (displayed as impulse per second)

With regard to stack monitors, graphs are presented as percentage of a value, the time scale can be changed as needed.

Additional direct reading of measurement results (without using a computer as interface) is on dedicated displays and on paper plots. The team was informed that such paper plots are kept in archives for five years. The team could verify that such papers are well labelled to allow easy identification.

All data are also kept in a central data base, access being by a data process computer (PPS: Process Presentation System); data are kept there for two weeks and then archived on disk. These data are used only for the operational on-line monitoring. Under normal circumstances government inspectors do not have access to the PPS system; only total discharge data for a quarter year are reported to the inspectors.

Overview tables on the discharge monitor screens show all discharges for the last hour, for 24 hours, and a forecast estimate. Meteorological data are presented as well. A 'trending system' allows overviews up to one year.

The equipment in the control room had been partly replaced in 1997. The team was informed by the shift supervisor that staff works in eight hour shifts.

Verification does not give rise to recommendations.

5.3 Gaseous Discharges

The main sources of releases to the atmosphere are the ventilation streams from the reactor containment, the reactor building ('building 1'), and buildings 2 (surrounding building 1) and 3 (separate construction) with auxiliary functions. All these paths are monitored separately (noble gases, radio-iodine, particulates) before being piped to the stack, which is 60 m tall (20 m of which over roof), has a diameter of some 750 cm, and is attached to the reactor building. In case of an increased activity level filters are taken and analysed by gamma spectrometry. If the activity surpasses certain limits the ventilation of Building 1 can be reduced or turned off. All gaseous radioactive discharges (including from containment venting) go through this stack.

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. Sampling in the stack is isokinetic; 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).

Within the isokinetic system, for aerosol and iodine sampling (code numbers TL080R15 and TL080R018) *Herfurth* samplers with charcoal filters are used. For H-3 (code number TL080R19) and C-14 determination (code number TL080R20) zeolites are used as filter medium. A first step allows analysis of H-3 in HTO and C-14 in CO_2; a second step in the device oxidizes HT to HTO and methane to CO_2, again allowing analysis of H-3 and C-14. Measurement is performed at the NPP site ('warm' laboratory) and on contract basis at *AREVA*, at Erlangen in Germany.

The system (including alarm levels) is based on *KTA 1503*. The signals of all automatic devices are available at the monitoring site and are transferred to the control room.

Normal stack ventilation rate is 33.3 m^3/s, the emergency ventilation rate is 7.5 m^3/s.

An overview over the detectors used in the monitoring equipment is given in table 4.

Table 4: Aerial discharge monitoring in the stack

Medium	Code	Detector type	Product	Measuring range
Noble gases	TL080R011 TL080R012	Plastic scintillator	*Herfurth H13320*	8.3E3 - 8.3E9 Bq/m^3
Iodine	TL080R016 (plus calculation)	NaI(Tl)	*Herfurth H1399-100*	1E-1 – 1E5 resp. 1E4 – 1E10 Bq/m^3 *)
Aerosols	TL080R014 (plus calculation)	Plastic scintillator Step filter band	*Herfurth H13200*	1E0 – 1E6 resp. 1E5 – 1E11 Bq/m^3 *)

*) calculation based on measurement and additional information

With regard to the aerial discharge monitoring devices the verification team was informed that calibration is performed by the Radiation Protection department every three to six months. Initiation of calibration is by a list: the 'ISO' planning system generates automatic working permits for a week (available on screen). When the task is done an acknowledgment is entered and the work reminder disappears. Some devices (e.g. R014) have a calibration source close to the measuring device, others have separate sources and procedures. 'Calibration' is understood as checking the signal caused by the source; if the signal is within acceptable limits, an ok is reported. If the difference is too large the reason has to be looked for (with help by the Maintenance Department).

Sampling is done by the Chemistry department (formerly by the Radiation Protection department); first measurements are performed using the HPGe detector of the Radiation Protection department (calibrated by Chemistry department staff).

Samples from one redundant system are reserved for RIVM. RIVM staff selects eight such samples per year for analysis at RIVM.

In a room near the control room the verification team was shown the venting measurement device. This device is not included in the isokinetic sampling channel. Calibration of the system is performed with a Cs-137 source with remote controlled in and out movement from the changing room cabinet

XQ03428H07. At verification the display showed a value of '1.88E-6 Gy/hr' = 1.88 µGy/hr. The team was shown the according procedure.

The aerosol on-line measurement device TL080R014 is located in a key locked room near the changing room: the mobile device (*Herfurth*) uses a step filter-band (one step per day; glass fibre). A Mylar foil band is used to protect the plastic scintillator detector. The verification team observed that the description of function tests is taped to the equipment. The team noted a label *'Volgende Controle Januari 2008'* for the pump. Such controls have to be done by the Maintenance department. Obviously the control was still in planning. The team was told that an alarm would be generated if the device was not working. The team was given a presentation of the operation of the device by manually starting it. First a check step for the filter and the Mylar band is performed then underpressure is resumed and a new 1440 minute step is started. The team was informed that a filterband usually keeps for nine months (in normal conditions; less if manual steps are done due to higher activity). Calibrations are performed every three months using an internal Sr-90 source. The team noted a sticker on the device showing that the next calibration is foreseen for 31.05.2008.

In the same room the team was shown the aerosol and iodine sampling device TL080R018 (*Herfurth*; all relevant information was shown on a display, the current flow rate being 4.22 m^3/h). The device uses glass fibre material from *Whatman*, a charcoal cartridge, and zeolite for sampling. The team noted a label that the next check was foreseen for January 2008.

Also in the same room the noble gas monitor TL080R012 is located. It is a *Herfurth* device with NIM electronics from *Canberra* and *Dr. Schröter*, Munich, Germany, and a *RADOS* shield with detector and Sr-90 source. The team observed that according to a label calibration (with an internal Sr-90 source) is foreseen for 30.4.2008. It was informed that a key switch allows to turn off the device during calibration to avoid the triggering of an alarm.

At level 18.70 metres the verification team saw the sampling devices TL080R019 and TL080R020 (for H-3 and C-14), following *KTA 1503*. The NPP operates two parallel devices (the *KTA* rule only asks for one). Sampling is based on continuous flushing with air from the ventilation stack (remark: sampling for Tl080R019 and TL080R020 is not isokinetic) using a zeolite adsorber. The first step samples HTO and CO_2. An oxidizer converts HT (to HTO) and CH_4 (to CO_2) as a second step. Pre-filters are from *Hartmann & Braune*. Every three months the samples from one device are analysed by the operator and from the other one by *AREVA* at Erlangen. There are no control samples for the regulator. The team was told that for the *AREVA* samples the stainless steel cylinders are sent as a whole and then are sent back filled with new zeolite. The cylinders are well labelled. For all devices status information (with possibility for alarms) is sent to the control room. The team was told that all tools to be used for the devices stay in the sampler cabinet. It was told that device 019 was the first one and started with nightly samples. After three months problems occurred and device 020 was started. The team was told that thus the first device could be made available to the authority.

In a room on the other side of the wall the team was shown part of the isokinetic sampling pipe as distributor to the various devices in the nearby rooms. In the same room the second device for aerosol and iodine sampling (TR080R015) is installed. It is similar to the device TR080R018 described above. The room also contains the noble gas monitor TL080R011 which is similar to TL080R012 described above. The team was told that background measurements are performed in the corner of the room with no air flow from the stack. The device has three alarm levels. Since the internal radioactive source is not strong enough for testing the two highest levels a frequency generator is used for this test (using the TTL-BNC input at the *Herfurth N286-111* logarithmic ratemeter). The team observed some of the action functions (e.g. number 3 leading to shutting off ventilation in Building 3).

In the same room the team noted device TL080R016 (radio iodine monitor). The device uses glass fibre as pre-filter and zeolite. For measurement a NaI(Tl) detector is built in with the measuring window set for iodine-131 (two channels are used). Calibration is done with an external Ba-133 source (usually kept in a vault) put around the crystal. A special device guarantees that the source is always in the same position for calibration.

The room also contains a dose rate monitor for room surveillance.

The verification team was informed that these on-line check measurements are not used for balancing radioactive discharges.

At level 13.20 metres the verification team was shown the high rate noble gas monitor TL080R013, which is not part of the isokinetic air stream system. It is used for monitoring of venting and is based on an ion chamber (*MGP instruments*; next calibration marked for 30.4.2008). An external holder contains the Cs-137 calibration source. The team noted that the calibration procedure and the results document are on site. For simulation purposes a laptop can be connected at the RS232 serial port. Sampling of the venting system (3.8 litres, 10 bar; pre-filter) is possible; analysis of the samples is done by gamma spectrometry.

> *The verification team recommends exploring the possibility to supply the authority with zeolite samples to allow for independent checking of aerial releases of H-3 and C-14. It also recommends performing any planned equipment controls within the time frame foreseen.*

5.4 LIQUID DISCHARGES

Liquids to be discharged come from three areas:

a) The radioactive waste treatment system – three closed excess water tanks (180 m^3 each; with ventilation system with carbon filters that are changed annually);

b) The nuclear laundry and showers system – two detergent tanks (7.5 m^3 each);

c) Leakage and spill-over water.

Liquids are piped to four tanks. Laundry and shower waters go to tanks TR011 and TR012. In general, the water from the nuclear laundry is released untreated. After stirring for several hours a sample is taken; if the limit of 200 kBq/m^3 gross gamma activity is not surpassed, the liquid is passed on to one of the discharge tanks (41 or 42). Liquids with higher activity potential go to tanks TR013 and TR014 and from there to the waste treatment system. The resulting sludge is treated as radioactive waste; the condensate is piped to the discharge tanks 41 or 42.

Before release from the discharge tank in use to the Westerschelde each discharge batch is controlled. After stirring, 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 (code TR45R001) with a 2"x2" NaI(Tl) detector for gross gamma measurement is performed allowing stopping of the discharge if needed. As a check, two automatic measuring devices are set up in sea waters (VC07R001 and VC08R001); however there is no possibility to stop a discharge based on the results (during rainstorms, these devices show elevated activity levels due to radon).

The several processes are operated and continuously monitored by the Operations department.

There are some 50 to 100 batch discharges per year.

The on-line instrumentation is continuously monitored on a panel in the control room. It is periodically controlled and calibrated by the Electrical maintenance department and the Radiation Protection department. Discharge samples (per batch) are analysed by the Chemistry department for total beta and gamma activity and for tritium before any release. For activity accounting reasons each batch is also analysed nuclide specifically. The on-line instrumentation (including alarm levels) is based on *KTA 1504*.

Discharge decision measurements as well as activity accounting are performed by the Chemistry Department. Analysis of Fe-55 and Ni-63 in discharge waters for reasons of calculating annual release balances is contracted to *AREVA* at Erlangen, Germany.

A process computer system is used to check the tank levels and – based on this – the amount to be discharged. The team saw the computer display that at the time of the visit showed an increase in the level of tank TR042; it received an explanation about the details of the procedure and was shown a graph with the time trend of the development in tank level.

Based on advice from chemistry the control room decides if it is necessary to empty a tank; within eight hours such a discharge including pumping is complete.

Before discharge samples are taken, a 500 ml bottle goes to chemical analysis (pH, boron), a 2 litre sample is taken for radiological analysis. The team verified that basic information is written on the label, such as tank number and date. New, unused bottles are taken and according to *KTA 1504* rule carrier material is deposited in the bottle (the new version includes a carrier for nickel). The bottle is filled at the sampling point at level 2.20, without rinsing. Afterwards acidic and antimony carrier is added and the sample is mixed by hand. Then part of the sample volume is transferred into a Marinelli beaker and gross gamma analysis with a NaI(Tl) detector is performed. The rest of the sample is kept for up to one year.

The correct discharge volume is determined on the basis of tank level information before and after the discharge. For 'real' discharge activity information the results of the nuclide specific measurement are used; the gross gamma measurement is seen as overestimate of the discharge and is not used for comparison with authorised levels, only for the yes/no decision about the discharge.

Before sampling and discharge circulation pumps in the tank run for several hours (started by a control room operator one floor up). The team was told that after receiving a signed paper on the analysis result staff from the Operations Department opens the discharge valve remotely from the control room. The shift supervisor signs off.

The verification team inspected the device TR45R001 where during releases final discharge checks of gross gamma activity are performed on-line. For that purpose, in a key locked room a NaI(Tl) detector, calibrated with Cs-137 (in agreement with *KTA 1504*), is installed. The team noted a label showing that the next calibration check is foreseen for 30 April 2008. Calibration checks are performed externally with a small source that for that purpose is always placed in the same position.

Real calibrations (e.g. when a new detector is installed) are done using water containing Cs-137 in a simulator having the same measuring geometry as the measurement chamber. The geometry of the device – well type hole for the detector crystal within a lead shield – allows easy removal of the detector.

System checks are done every three months during real discharges, to verify if the discharge pump would stop at high activity reading; these tests are performed with discharges having sufficient activity levels in order to make the test as realistic as possible. The team was told that for measurement the discharge pump has to be on a stable temperature; the whole controlled area is temperature controlled (+- 5°C).

Verification does not give rise to recommendations.

5.5 REGULATORY CONTROL PROGRAMME

The regulator (nuclear inspectorate at VROM) defines the basis of the regulatory control programme also with regard to discharges from Borssele NPP. Samples for this programme ('counter expertise') are taken by NPP staff, pre-prepared if needed and are stored and reserved for RIVM. RIVM staff generally selects on random basis samples for analysis at RIVM (eight per year). For Ni-63 and Fe-55 determinations in discharge water no 'counter-expertise' is performed.

At RIVM the verification team discussed the situation of independent control of the operators work with regard to discharge monitoring: formerly such applications by the nuclear inspectorate were organised year after year, now every ½ year. Currently there are plans to re-organize the nuclear inspectorate; it may be removed from the ministry (VROM) and become an agency (with possible disadvantages due to the 'distance' to the ministry). The nuclear inspectorate currently is financed by the way of general taxation (not directly by nuclear power production related ones)

The verification team strongly recommends guaranteeing the necessary independence of all regulatory bodies, in particular with regard to controlling the operator's discharge monitoring system, and supplying ample staffing and budget. The team also suggests exploring the possibility to provide 'counter-expertise' (i.e. checks by RIVM on behalf of the regulator) for Ni-63 and Fe-55 analyses in discharge water samples from the NPP.

6 NPP RELATED MONITORING OF ENVIRONMENTAL RADIOACTIVITY – DESCRIPTION AND VERIFICATION

6.1 INTRODUCTION

One of the conditions of the authorisation to discharge radioactive effluents and wastes is that an environmental monitoring programme is carried out to determine the effects of these discharges on the environment.

The verification team visited sampling sites of the operator's monitoring programme at the Borssele NPP site and of the Dutch authorities' monitoring programme. The team verified the Environmental Radioactivity Laboratory of NRG-Arnhem*,* which under contract performs the sampling and sample measurements for Borssele NPP. (It verified also both laboratories contracted by the regulator to perform the sampling and measurements of all samples stemming from the national environmental radioactivity monitoring programme, the RWS WD-Environmental Radioactivity Laboratory for surface water samples and the RIVM-Bilthoven for air and soil monitoring.) In addition, spot checks on archived data were made in all three laboratories in order to verify the procedures for data management and archiving.

6.2 THE OPERATOR'S ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMME

6.2.1 Introduction

The number and location of sampling points, the type of samples to be collected and the required analyses have been defined in the pre-operational phase of the NPP, and they have been updated through the years of plant operation. The main pathways of human exposure to radiation are monitored, as well as those ecosystem elements that are good indicators of the behaviour of radionuclides in the environment. From 1972 onwards, measurements of radioactivity in surface water, milk, grass, air, mussels and algae were included into the operator's environmental monitoring programme. An evaluation of this monitoring programme led to the decision to limit the operator's "off-site" monitoring programme.

6.2.2 On-site environmental monitoring

Borssele NPP does not carry out site related monitoring of grass, milk, leafy vegetables or food stuffs. In the 90's, part of the environmental monitoring consisted of a TLD network.

Instead a network, complementary to the regulator's monitoring network "MONET" has been constructed at the fence around Borssele NPP. This system consists of 8 gamma probes (*Genitron Gamma Tracer*), each containing two GM tubes and having a measuring range of 10 nSv/h to 10 Sv/h at temperatures of -40 to +60°C. Figure 1 shows the measuring points. The detectors are read out quarterly by use of a *Genitron infrared RS-232* data gate. With this network, the operator, has information about the gamma dose rates around the facility. It is assumed that a possible discharge from the NPP to air will always contain a gamma emitter; a discharge of pure alpha or beta emitters is considered highly unlikely. Alarm levels are set at 200 nSv/h in a usual background of about 80 nSv/h.

The verification team verified the installation of several probes and witnessed the data transfer from one of the probes by *Genitron* infrared technology to a data notebook.

Before 2008, data were entered into *Excel* data sheets and the net dose value was calculated. Since January 2008 the data are gathered in a SQL server within the NPP. The system's purpose is to evaluate whether any increase of the average dose values occurs. An evaluation is done four times per year. This is not a prerequisite for the NPP operating licence. Yearly reports of the operator's network values are compared to the MONET network values (RIVM).

The verification team was informed that based on an evaluation of the previous environmental monitoring programme (Report 40318/40575-NUC 94-5935), measurements of environmental radioactivity parameters have been abandoned and a decision to limit the operator's on-site monitoring programme to the continuous measurement of the ambient gamma dose rate with eight GM probes installed at the fence of the NPP was taken by the regulator.

No other routine measurements are performed, except contamination measurement of the plane surfaces (buildings and roofs). This monitoring is done once a year with a scintillator device (*LARS* mobile detection system from *S.E.A Gmbh,* Dülmen, Germany). Two persons are in charge of this task. The team was told that it takes two weeks to achieve the task for the whole area. The calibration of the device, with Cs-137 is made every two years. The verification team acknowledged the device, the instruction manual, the calibration and the scintillator maintenance lists.

Verification does not give rise to recommendations.

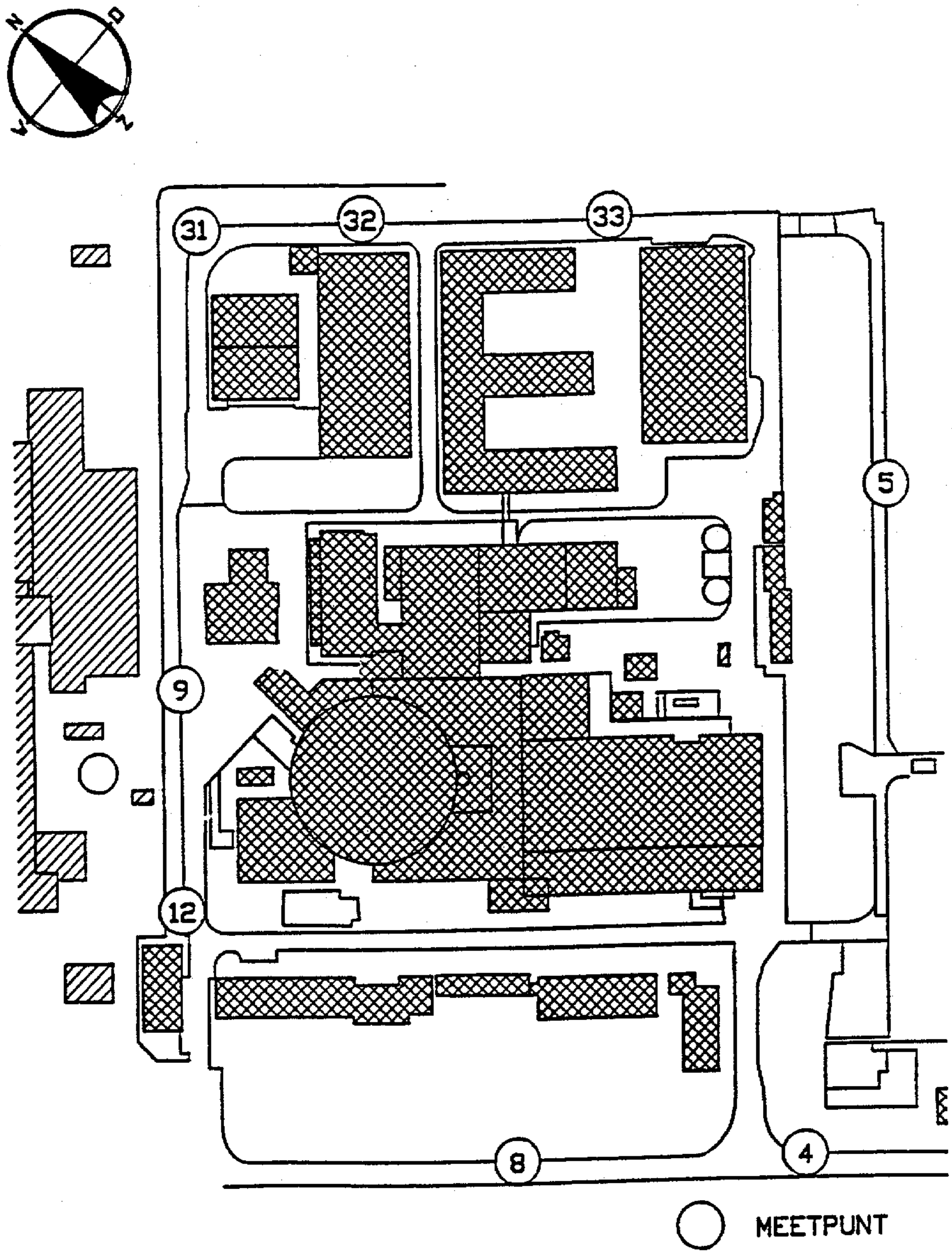


Figure 1: Ambient gamma dose rate measuring points ('MEETPUNT') at the fence of Borssele NPP.

6.2.3 Off-site environmental monitoring

Sampling and analytical assessments of environmental samples off-site the NPP fenced-in area are outsourced. The independent Nuclear Research Group (NRG) executes this task on a contract basis. The results are reported twice a year. The results are integrated in the environmental yearly report and as such reported to the authorities. The Monitoring Department of Borssele NPP is responsible for the continuity of the programme, the analysis of the results and the determination of the net dose on the site boundary. Table 5 and figure 2 give an overview over the sampling programme respectively over the sampling points around Borssele NPP.

The execution of the environmental monitoring programme has to fulfil the requirements laid down in KEMA document 40318/40575NUC5935. These requirements are approved by the Dutch nuclear regulator.

Table 5: NPP Borssele off-site environmental monitoring programme

Compartment	Sub part	Nuclide group	Method	Key nuclide	Sampling points (number)	Frequency (per year)
Air	dust	aerosols	Gamma spectrometry Total alpha Total beta	Co-60, Cs-137 Total alpha Total beta	5	12
	gases	halogens	Gamma spectrometry	I-131	5	12
Soil	grass	aerosols, halogens	Gamma spectrometry	Co-60, I-131, Cs-137	4	12
	ground	Liquid discharge (corrosion and fission products)	Gamma spectrometry	Mn-54, Co-60, Cs-134, Cs-137	4	1
Water	water	Liquid discharge (corrosion and fission products) Tritium	Total beta Flame photometry LSC	Total beta K (K-40) H-3	4	12
	seaweed	Liquid discharge (corrosion and fission products)	Gamma spectrometry	Co-60, I-131, Cs-137	4	12
	sediment	Liquid discharge (corrosion and fission products)	Gamma spectrometry	Co-60, I-131, Cs-137	4	12
Dose rate		external dose rate	Dose rate		16	12

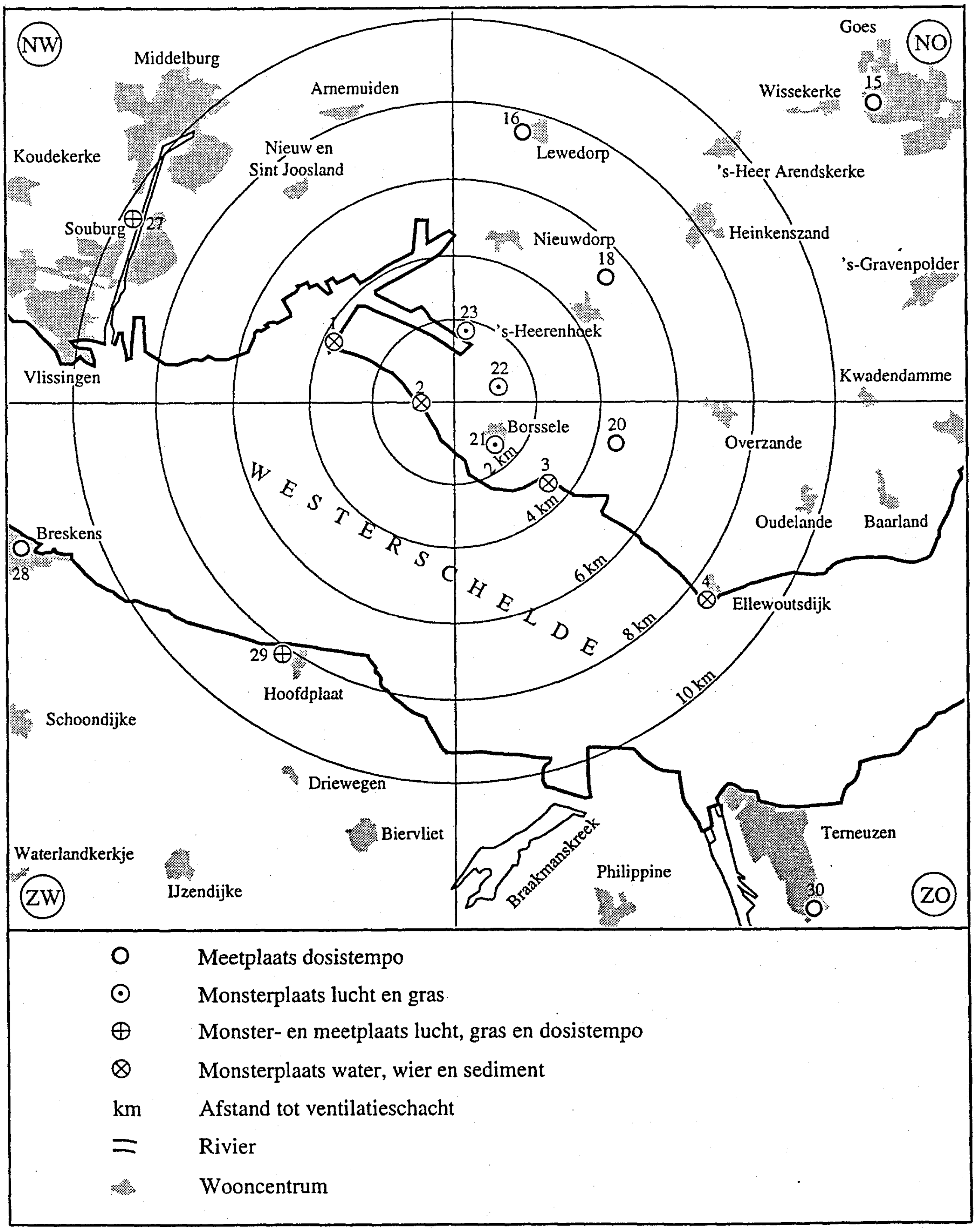


Figure 2: Overview over measuring and environmental sampling points around Borssele NPP ('Meetplaats' = measuring point; 'Monsterplaats' = sampling point; 'dosistempo' = dose rate; 'lucht' = air; 'gras' = grass; 'wier' = seaweed; 'Afstand tot ventilatieschacht' = distance to ventilation shaft; 'Rivier' = river; 'Wooncentrum' = habitation centre)

6.2.3.1 Ambient gamma dose rate monitoring

The ambient gamma dose rate measurement system consists of eight *Genitron Gamma Tracer* probes, each containing two GM tubes and having a measuring range of 10 nSv/h to 10 Sv/h at temperatures of -40 to +60°C. The detectors are read out by use of a *Genitron infrared RS-232* data gate.

The team verified the off-site ambient gamma dose rate monitoring system of the operator at measuring sites n° 27, 28, 29 and 30. It witnessed the presence of the gamma probes at all four stations and the data transfer by *Genitron* infrared technology to a data notebook.

At sampling site n° 27, the station was not fenced. The team checked, after transfer of the data from the gamma-dosimeter to a computer, an average of 80 nSv/h for a one month period.

At site n° 29 the device is located at one meter aside of a building of 3 to 4 meters of height.

At sampling site n° 30, the team noticed that the gamma probe was situated amid of bushes.

After transfer of the data, it was shown that they were within a range of 80 to 100 nSv/h over the last months at all verified sites.

> *The verification team suggests discussing the installation of the ambient dose rate probes (i.e.: the possibility to install the probes at one meter above soil or above a large flat surface without any obstacles in the surroundings).*

6.2.3.2 Air monitoring (particles and iodine)

In order to monitor the environmental compartment air, monitoring devices are located in nine different locations (see figure 2). Every device (self-construction; pump: *Robbins & Myers Inc.*, Dayton, Ohio, USA) consists of a continuous extraction system used to pass air over a cartridge holder provided with an absolute filter (particle filter), an impregnated carbon filter and a carbon cartridge. In this way aerosols and elementary and organically bound iodine are collected. Gamma spectrometry, total α measurements and total β measurements are performed on the samples thus obtained.

6.2.3.2.1 Air sampling sites n° 23, 27 and 29

The team verified the low volume air samplers of the operator at measuring sites n° 23, 27 and 29 (see also figure 2). It witnessed the presence of "low volume" air samplers (~4 m^3 per hour). The team also witnessed at all three stations the change of the cartridge holder by NRG-Arnhem staff. Each cartridge is provided with an absolute filter, an impregnated carbon filter and a carbon cartridge. The team was explained that due to the permanent strong winds in the Netherlands always the total cartridge holder is changed and only in the laboratory, the different filters and the carbon cartridge itself are removed and replaced. Filter change is once per month.

> *Verification does not give rise to recommendations.*

6.2.3.3 Sediments, surface water and algae

At four locations samples of River Schelde surface water, sediment and algae are taken. On account of the tendency of radionuclides to bind with the floating sludge fraction (often consisting of clay minerals), which subsequently settles to the sediment, the sediment is regarded as the accumulation point for discharged radionuclides. Algae are sampled, since these organisms can concentrate radionuclides from the aqueous environment. The environmental impact from the discharge of tritium is monitored in the surface water.

6.2.3.3.1 Surface water sampling site n° 1

At sampling site n° 1 (see figure 2) the team witnessed the sampling of the monthly sample of 5 litres of sea water with a bucket, then stored in a can labelled with all relevant sampling data . There are four identical sampling sites on the sea shore.

> *Verification does not give rise to recommendations.*

6.2.3.3.2 Algae sampling site n° 1

The team witnessed the sampling of the monthly sample of algae from the stony beach at low tide at sampling site n° 1 (see figure 2); a quantity of 500 g to 1 kg is stored in a plastic bag labelled with all relevant sampling data. There are four identical sampling sites on the sea shore.

> *Verification does not give rise to recommendations.*

6.2.3.4 Grass

On grass activity is caused by dry and wet deposition and by interception of radioactive contaminants. Therefore analysis of grass samples is seen as an integrating method.

6.2.3.4.1 Grass sampling sites n° 23; 27 and 29

The team witnessed grass sampling at the three sites n° 23, 27 and 29 (see figure 2). Twice, surfaces of 50 cm^2 of grass are cut 1 cm above ground (one for reserve in case) and stored in two plastic bags labelled with all relevant sampling data. Sampling is monthly.

Verification does not give rise to recommendations.

6.2.3.5 Borssele soil sampling site n° 1

Once per year soil samples are collected (50 x 50 cm and 5 cm depth) by personnel from NRG-Arnhem. The verification team witnessed the sampling of a soil (sand) sample, at sampling site n° 1, on the beach at a distance of 1 m from the waterfront (low tide). For this, an area (surface 1/4 m^2, 5 cm depth) was marked and the soil (sand) was collected into a labelled plastic bag. There are four such similar sampling sites on the sea-shore.

Verification does not give rise to recommendations.

6.3 THE COMPETENT AUTHORITY'S ON-SITE INDEPENDENT CONTROL PROGRAMME

6.3.1 Introduction

From 1972 onwards, measurements of radioactivity in surface water, milk, grass, air, mussels and algae were included into the operator's environmental monitoring programme. An evaluation of this monitoring programme[2] led to the decision to limit the operator's on-site monitoring programme to the continuous measurement of the ambient gamma dose rate with eight GM probes installed at the fence of the NPP. At the same time and based on the same evaluation, the regulator's on-site monitoring programme was limited to the MONET network described below. Thus, RIVM does not carry out on-site monitoring of grass, milk, leafy vegetables or food stuffs.

An early warning alarm network (MONET = Monitoring Network Terrains) was constructed around the former NPP Dodewaard, the NPP Borssele and the waste storage facility COVRA. With this MONET network, the regulator has on-line access to the gamma dose rate data around the facilities. It is assumed that a possible discharge of a nuclear site to air will always contain a gamma emitter; a discharge of pure alpha or beta emitters is considered highly unlikely. Alarm levels are set at 200 nSv/h in a usual background of about 80 nSv/h. The information which is supplied by the MONET network is thought to be much faster and more accurate than a food stuff analysis.

6.3.2 MONET: An independent site related control programme for Borssele NPP

RIVM's Laboratory for Radiation Research (*Laboratorium voor Stralingsonderzoek*, LSO) continually measures gamma radiation levels around the perimeter of *N.V. Elekriciteits-Productiemaatschappij Zuid Nederland's* nuclear power plant in Borssele (EPZ/KCB) using the MONET monitoring network. This is done at the request of the VROM inspectorate in order to monitor radiation levels in accordance with the licence granted to the plant under the Nuclear Energy Act.

This licence stipulates the following:

"NV EPZ must ensure that the effective dose received by members of the public outside the plant as a result of its activities, the fissile and radioactive materials used, disposed of or stored for transport purposes, and the use, in the plant, of equipment that emits ionising radiation is as low as reasonably possible and, in any case, lower than 40 microsieverts per year. For these purposes, effective dose is defined as the dose corresponding to the most restrictive use of the land around the plant. The

[2] Borssele NPP internal document 40318/40575 – NUC 94 – 5935

multifunctional and actual individual doses should be calculated in accordance with the rules set out in the Annex to the Ministerial Regulation on analysis of the impact of ionising radiation (MR-AGIS) (Government Gazette 2002, 22 and 73, as amended in Government Gazette 2003, 81).

There are eight radiation monitors positioned along the fence surrounding the Borssele nuclear power plant (see figure 1). These ambient dose rate monitors (gamma-monitors**)** contain a *Bitt RS03/X* proportional counter tube for the detection of external radiation and are identical with the national radioactivity monitoring network devices. The counter tube is placed at 1 m above the ground in an area free from obstacles (in practice a free radius of three times the height of the nearby obstacle is aimed for) to reduce environmental influences on the measurements. The readings are expressed as ambient dose-equivalent rate (ambient dose rate), H*(10), in nSv/h. Measurements are averaged over a 10 minute interval and stored in a relational database at RIVM. Monitors 21 to 24 make up the first network subdivision, while monitors 25 to 28 make up the second.

The verification team verified sites n°9; 12 and 31 of the MONET network situated at the surrounding fence of Borssele NPP.

The team witnessed that the detectors are mounted in a plastic housing at a height of about 1 meter above the soil. At the moment of the verification, the team could not see the inside the key-locked box since the keys were not available. However, later, when the team was in the possession of pictures of the inside and after visualising at Elst (national system) the interior of a device of the same type as the ones used in the MONET system, one could see that inside the plastic cover there are also placed the voltage converters and the circuits. The detectors are connected to the local PC where the data are collected. The collected data consist of two values: the one minute average and the 10 minute average dose rate. The local PC is connected to the RIVM/LSO server using DSL line and the information is processed at RIVM in a 10 minutes interval.

The system is not equipped with an alarm. Every working day the data are inspected by RIVM and the NPP is informed about any anomalies. NPP personnel has no access to MONET monitoring devices.

A yearly report is written in which the doses are reported.

Verification does not give rise to recommendations.

7 DUTCH NATIONAL ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMMES – DESCRIPTION AND VERIFICATION

7.1 INTRODUCTION

The Netherlands installed several monitoring programmes with regard to environmental radioactivity, both, networks based on automatically working stations with on-line data transmission to a data centre, and networks based on sampling of various environmental media and sample analysis in a laboratory.

In the context of the verification the team visited sampling sites of the Dutch national monitoring programme near Borssele NPP. The laboratories contracted by the national authority to perform the sampling and measurements of samples stemming from the national environmental radioactivity monitoring programme, the RWS WD-Environmental Radioactivity Laboratory for surface water samples and the RIVM-Bilthoven radiological laboratory for air and soil monitoring, were visited. Spot checks on archived data were made in the laboratories in order to verify the procedures for data management and archiving.

The Dutch National Radioactivity Monitoring Network (NMR) measures

- airborne alpha and beta activity concentrations and ambient dose rates under routine and emergency conditions (done under contract and control by RIVM).

  This task is realised by a **dense network** consisting of 153 ambient dose rate monitors and a **sparse network** consisting mainly of 14 alpha/beta air monitors. For description and verification see Chapter 7.2.

- waters and sediments.

This task is done by the *Rijkswaterstaat Waterdienst* (RWS WD; *Rijkswaterstaat* Centre for Water Management). For description and verification see Chapter 7.5.

- various foodstuffs.

  The Institute of Food Safety monitors radioactivity e.g. in milk on a weekly basis via the National Monitoring Network for Radioactivity in Food and Feed (*Landelijk Meetnet Radioactiviteit in Voedsel*, LMRV). For description and verification see Chapter 7.6.

The primary task of NMR is to provide early warnings against nuclear accidents. An increase of radiation levels above certain thresholds will issue a warning to the national and local authorities, which after careful validation may activate the national emergency plan for nuclear accidents. The overall objectives of the network are summarised by:

- The provision of early warnings against (major) nuclear accidents.
- The assessment of the magnitude and geographical extent of a radioactive contamination in the air and on the ground during and after a nuclear accident.
- The assessment of actual radiation doses to the population and its development in time.

Under regular (non emergency) conditions the network provides information on the natural background radiation levels in the Netherlands and it provides a reference value for other radiation measurement networks, e.g. the fence monitoring systems (MONET) of the nuclear power plant in Borssele and the radioactive waste storage facility (COVRA) in Vlissingen. During nuclear emergencies NMR data form the basis for the calculation and validation of actual radiation doses via the direct pathways external radiation and inhalation.

7.2 AIR AND DOSE RATE MONITORING

The objectives of air and dose rate monitoring are realised by a **dense network** of 153 ambient dose rate monitors and a **sparse network** of 14 alpha/beta air monitors.

The map in figure 3 indicates the monitoring locations of the Dutch National Monitoring Network.

RIVM, Bilthoven, is the organisation in charge of operating this part of the national network.

7.2.1 Dense network for dose rate monitoring

The **ambient dose rate monitors (gamma-monitors)** contain a *Bitt RS03/X* proportional counter tube for the detection of external radiation. The counter is placed at 1 m above the ground in an area free from obstacles (in practice a free radius of three times the height of the nearby obstacle is aimed for) to reduce environmental influences on the measurements. The readings are expressed as ambient dose-equivalent rate (ambient dose rate), H*(10), in nSv/h. Measurements are averaged over a 10 minute interval and stored in a relational database at RIVM.

The team verified the gamma dose rate probe at Elst which is installed on the premises of the local fire brigade (as are most of the 153 devices installed in the Netherlands). A man from the fire brigade opened the surrounding box and showed the team the *Bitt RS03/X* proportional counter tube for the detection of external irradiation. The counter was placed at 1 m above the ground in an area free from obstacles. He explained the team also that the measurements are averaged over a 10 minute interval and transmitted to the database at RIVM. The team was shown the measurement values of the day of the verification. The team witnessed such a device also at RIVM Bilthoven. The team was informed that calibration and control checks are performed at each site by NRG Petten.

Verification does not give rise to recommendations.

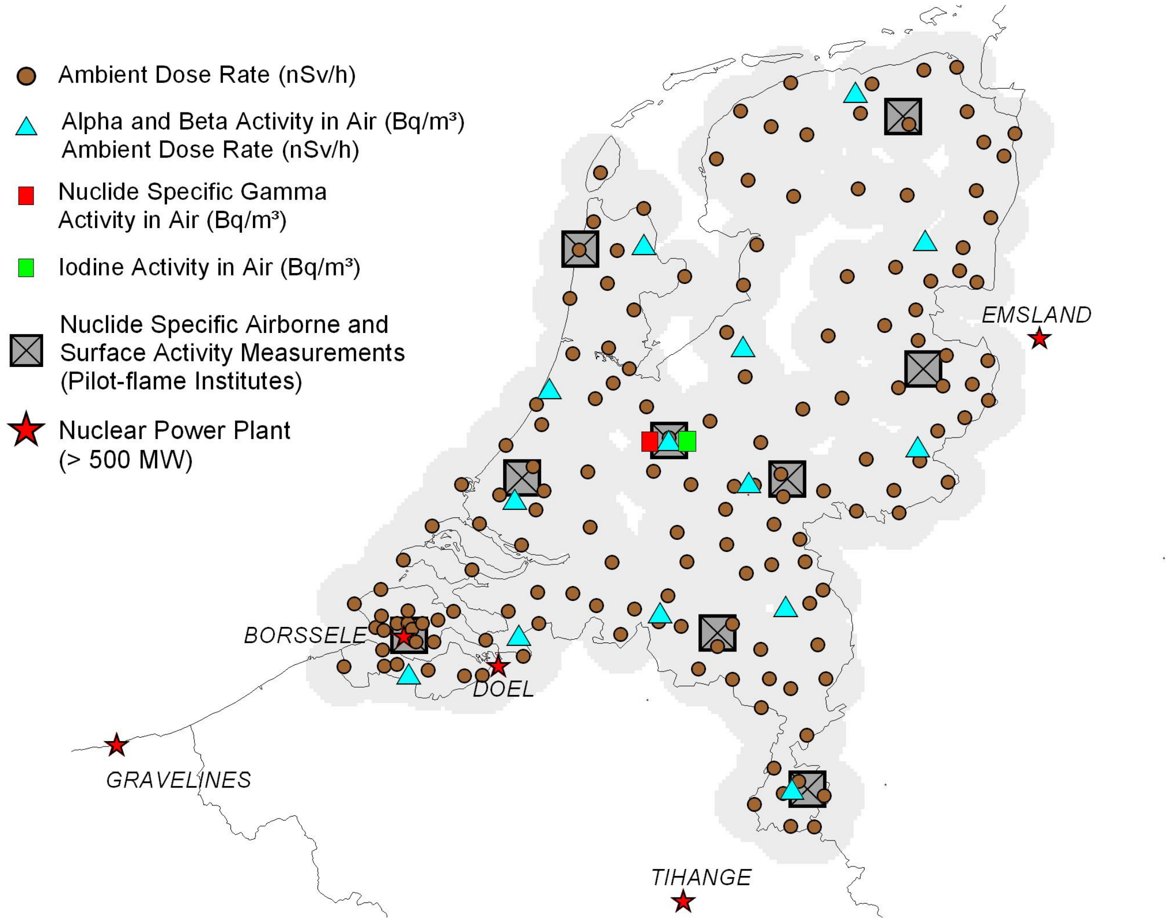


Figure 3: Locations of the ambient dose rate and the air monitors. A 15 km proximity area to the nearest gamma monitor is indicated in grey. The dark grey squares represent the locations of the 'pilot-flame' institutes where additional nuclide specific measurements in air and deposition can be performed.

7.2.2 Sparse network for air, dose rate and precipitation monitoring

Within the **sparse network** at 14 locations *Berthold BAI 9128* **airborne radioactivity monitors** measure aerosol bound gross alpha and gross beta activity in air. The monitors determine an artificial beta concentration from the measured gross alpha and beta activity, collected on a moving filter (air flow 3-4 m^3/h). The use of this filter complicates the response of the monitor for fast varying radioactive air concentrations since a complicated reconstruction is generally required to extract momentary air concentrations from deposited activity on the moving filter.

The use of a compensation method for natural activity in the determination of artificial beta concentrations results in a superior sensitivity when compared to the gamma monitors. The resulting low warning threshold makes the device well suited for generating early warnings.

At all 14 monitoring locations the alpha/beta measurements are complemented by ambient gamma dose rate measurements with a *Bitt RS02/RM10* probe. The design and mounting position (ca. 3 m above ground on top of the container) of these dose rate detectors differ slightly from the ones for the 153 *Bitt RS03/X* devices: they originate from the 1st generation radioactivity network and will be replaced in the near future.

Additionally, at RIVM Bilthoven two continuously operating specific monitors were installed within the **sparse network**:

- an iodine monitor (*Herfurth H1399*), which measures gaseous radioactive iodine concentration in air[3], and

[3] Later information from RIVM: the *Herfurth* monitor is no longer operational

- a *Canberra FHT 59 CP* monitor that measures nuclide specific gamma activity of airborne particles.

The information from these monitors is used to improve dose calculations.

At RIVM Bilthoven a high volume air sampler is installed as well, the samples being analysed at RIVM/LSO.

7.2.2.1 KEMA site at Arnhem

The team visited one of the 14 sparse network stations at KEMA on the same campus as NRG-Arnhem. Concerning dose rate, it witnessed that a *Bitt RS02/RM10*-proportional counter was mounted on the flat roof of the housing of the automatic sampler at a height of 1 metre above the roof and about 3.5 metres above the soil surface. The gamma probe is connected to the data logger with an alarm level set at 200 nSv/h; and data collection is every 10 minutes. Another level of alarm at 2000 nSv//h is taken into account for the Regional Fire Brigade.

Concerning the automatic air sampling part of the station the team witnessed the *Berthold BAI 9128* airborne radioactivity monitor that measures gross alpha and beta activity in aerosols. The team noticed that the air inlet was located at a high of about 3.5 meters above ground on the roof of the housing (one meter above the roof) close to the ambient gamma dose rate probe. The team was informed that calibration is performed with a source of chlorine-36 for beta and americium-241 for alpha measurement. Both sources were purchased from Amersham. The team was told that a service contract signed with NRG-Petten includes filters changes every 3 months and, at the same time an efficiency calibration and the cleaning of the detector. The team was also informed that data are logged in a *Berthold BAI 9111* data logger and are sent every 10 minutes to RIVM-Bilthoven and that the alarm level for beta activity is set at 3 Bq per m^3, with a call on beeper in case of higher values.

> *The verification team suggests discussing the installation of the ambient dose rate probes (i.e.: the possibility to install the probes at one meter above soil or above a large flat surface without any obstacles). The rest of the verification did not raise any recommendations.*

7.2.2.2 RIVM-Bilthoven

The team verified the automatic station of the sparse network at RIVM-Bilthoven, located on the campus.

<u>Dose rate</u>

The team visited the station and concerning dose rate, witnessed that – as in the case of the Kema site – a *Bitt RS02/RM10* proportional counter was mounted on the flat roof of the housing of the automatic sampler at a height of 1 metre above the roof and about 3.5 metre above the soil surface (alarm level of 200 nSv/h).

> *The verification team suggests discussing the installation of the ambient dose rate probes (i.e.: the possibility to install the probes at one meter above soil or above a large flat surface without any obstacles).*

<u>Air monitor</u>

Concerning the automatic air sampling part of the station the team witnessed the presence of a *Berthold BAI 9128* airborne radioactivity monitor, which functions exactly as the one described under the KEMA site.

> *Verification does not give rise to recommendations.*

<u>Iodine and gamma emitter monitors</u>

The team verified the presence of the additional specific air monitors, the iodine monitor *Herfurth H1399* (see footnote [3] , page 30) and the high resolution gamma spectrometric monitor *Canberra FHT 59 CP*.

The team received an explanation about the functioning of both devices.

The system operates with a filter band. The gamma spectrum is measured during sampling; the filter makes a step every 2 hours. The limit of detection is 50 mBq/m^3 for Cs-137.

This detector does not generate an automatic alarm, it is checked every working day. Calibration is done every 3 weeks when the filter bands are changed, with *Isotrak*™ reference sources from *nuclitec GmbH*, Braunschweig, Germany.

Verification does not give rise to recommendations.

High volume aerosol sampler

The verification team witnessed the presence of a high volume aerosol sampler. The device uses a *Siemens* 20 kW pump with a *Siemens Simovert* control unit. Each week at flow rates of about 300 m^3/h a total of about 48.000 m^3 air is drawn through four glass fibre filters. Filters are changed weekly. The flow meter is calibrated yearly. In case the filter pores are stuck, the outgoing air temperature rises and an alarm level is triggered. This will make the pump stop. The next morning, filters will be changed and normal sampling will proceed.

The sampler is not coupled to a detector. Only the volume of the outgoing air is measured as a check on clogging of the filters.

The filters are routinely analysed in the laboratory for gamma emitters directly after folding and decay of radon daughters. After a chemical destruction procedure a long term gamma spectrometric analysis is performed; for this, the LLD for Cs-137 is about 1-2 μBq/m^3.

Part of the filter is analyzed for gross-alpha and gross-beta activity.

Verification does not give rise to recommendations.

Precipitation sampling

The verification team witnessed several precipitation collectors at RIVM, Bilthoven with different collection areas. No heating to allow melting of any snow is applied.

Samples for gamma spectrometry are collected weekly. Smaller samples for H-3, gross alpha/beta and Po-210 determination are taken on a 4-weekly basis.

Verification does not give rise to recommendations.

7.3 DATA CENTRE AT RIVM

NMR uses a central system to collect and display the automatic measurement data and to alert the users in case of elevated radiation levels, including the MONET network. The system is made up of two servers in a cluster configuration. A back-up system automatically takes over in case of a malfunction in the operational system.

In the course of 2005 the connection to the 14 alpha / beta monitoring stations has been converted from the public telephone network to a dedicated IP-VPN; for the 153 gamma monitoring stations such a conversion from using the emergency telephone network in the Netherlands (ETN) followed in 2006. The main reason for this conversion was the impending discontinuance of the emergency telephone network in the Netherlands. This method of communication using a direct network connection allows the monitoring stations to be continuously on-line. This means that the central system can communicate directly with the radiation monitors. The use of local processing units is no longer necessary as is the need to send alerts from the monitoring stations, since these can now be generated by the central system. A web server is used to present the data to the users. Users connected to the local area network (LAN) of RIVM have a direct connection to the server. A dedicated IP-VPN is available for users belonging to the regional emergency response team (e.g. the fire brigades). This IP-VPN is based on Internet technology but uses a separate, private physical network. This network is managed and monitored by the provider and the availability and capacity of all connections is guaranteed. Other privileged users can contact the web server through the public telephone network (analogue or ISDN), the ETN or a VPN over Internet. The central server also provides data for external users. By using the "export" facility it is possible to select data based on a time period and/or monitoring stations and export these data in different formats such as *CSV*, *XML* and EURDEP. This last format is used to send data to the European Data Exchange Platform, EURDEP, hosted by the

Joint Research Centre in Ispra, Italy. Other data exchange protocols exist or are being developed; examples are the bilateral agreement between the Netherlands and Germany under the Dutch-German commission for nuclear facilities in the border region (the NDKK), the memorandum of understanding between the Netherlands and Belgium and the upcoming agreement with the CBSS (Council of the Baltic Sea States) member states.

An additional but important feature of the system is the possibility to conduct exercises by supplying the system with simulated data and alerts. Only the users that are selected to participate in the exercise have these simulated data presented. All other users see the real data and alerts; thus the normal operation of the system is unimpaired.

The team was informed that an important task of NMR is to provide early warning against severe radiological accidents. All measurements are therefore compared to warning levels. When a level is exceeded, the officer(s) on duty is(are) alerted immediately by the central system by means of a call to a pager or a spoken message by telephone. When it is clear that the warning message is not a result of a technical deficiency, a senior officer may further decide what actions are to be taken. In case of a severe radiological accident this will activate the national emergency response organisation.

Under normal conditions and a correctly adjusted compensation for the background the air activity monitors allow detection of artificial beta activity down to a fraction of 1 Bq/m^3. For ambient dose rate the long term (natural) average in the Netherlands is between 55 and 115 nSv/h with superimposed enhancements typically up to 80 nSv/h. Only under extreme conditions higher elevations are observed. The verification team was informed that until the end of 2007 the maximum value recorded by the network was 165 nSv/h and that it was caused by heavy rainfall.

The applied warning levels must be balanced between the capability to detect small contaminations and an acceptable number of false alarms. Based on these findings and the experiences from previous operating periods, warning levels were set at thresholds of 200 nSv/h ambient dose rate and 3 Bq/m^3 artificial beta activity concentration. A second warning level is set at 2000 nSv/h ambient dose rate; this warning will trigger not only RIVM, but also directly the regional emergency response centre of the corresponding region.

The national and regional emergency response centres can visualize the data in NMR by means of the web server function of the central system. This web server provides a map based view of all monitoring stations at a selected date and time. It is possible to zoom in on a specific region and to select one or more stations for which additional data are displayed; e.g. a graph of measurements versus time can be generated. In addition it is possible to look at detailed information from a monitoring station. If a user has sufficient authorization it is also possible to start an extra readout of one or more monitoring stations or to generate an "exercise alert".

The verification team was given a presentation of the NMR-3 Client data system, a software developed by a Dutch company. RIVM has a contract that allows software changes in this system. The team was shown the visualization of maps, time trends and tables; a data export facility with a flexible selection mode is available.

Currently fire brigades have access to the system, but not the public.

In addition to data from the automatic networks RIVM also manages data from the laboratory based network, issues the yearly report and transfers data to the European REM database at JRC Ispra.

Verification does not give rise to recommendations.

7.4 EMERGENCY MONITORING PROVISIONS

During emergencies the number of nuclide specific measuring possibilities is increased by the activation of nine so-called **'pilot-flame' institutes**, located all-around the country, and with **two mobile measuring vans**. The emergency measurement programme is co-ordinated by RIVM. It provides for a determination of nuclide specific airborne and nuclide specific surface activity concentrations from deposition.

The verification team witnessed the two vans equipped with hand-held monitors and a high purity germanium gamma spectrometry system. These vans also contain sampling equipment, a power generator, on-line data communication with RIVM and a GPS.

RIVM also has some mobile solar powered dose rate meters to be used where appropriate. The verification team witnessed these devices and the two measuring vans.

Verification does not give rise to recommendations.

7.5 RWS WD-MONITORING PROGRAMMES (WATERS AND SEDIMENTS)

Within NMR waters and sediments are dealt with by the monitoring programmes (waters and sediments) of the *Rijkswaterstaat Waterdienst* (RWS WD; *Rijkswaterstaat* Centre for Water Management).

7.5.1 Ground water and drinking water

In the Netherlands, water pumping stations monitor raw input water. Raw water and tap water samples are taken at pumping stations and analysed by drinking water producing companies. The monitoring frequency per location ranges from once to 27 times per year depending on the volume of water produced.

The sampling devices are not coupled to radiological detectors.

Radionuclides are assessed according to the Drinking Water Directive. H-3, gross-alpha/beta and K-40 are routinely monitored.

7.5.2 Surface water and sediment sampling programme by RWS WD (Lelystad)

The sampling locations of the surface water monitoring programme (including coastal waters) are shown in figure 4. Sediments and suspended solids are also within this programme.

The verification team was informed that in addition an alarm system (Aqualarm) is run by RWS WD. It is used to monitor the water quality of rivers on the basis of measurement data. Aqualarm is fed by data measured by *Waterdienst*, the *Landesumweltamt* (LUA) of Rhineland-Westphalia, Germany and the *EVIDES* water company. Within this system RWS WD continuously checks the gamma-activity of the border crossing rivers Rhine at Lobith, and Meuse at Eijsden. Alarms are communicated to the drinking water producing companies. There are common agreements between the Netherlands, Germany, Belgium and France in which case an exceeded alarm level leads to a data communication. RWS WD uses the same alarm levels that are applied in Germany: In case the gamma level exceeds 25 Bq/l during 2 hours, samples will be taken and analysed. Next, the contamination will be followed in time.

The radioactivity monitor for on-line alarms uses gamma spectrometry based on a NaI(Tl) detector: (Only gamma emitters are detected. Pure alpha emitters and pure beta emitters can not be detected with this monitor.) The spectrum is divided into 8 channels as shown in table 6.

Table 6: Details of gamma measurement setup

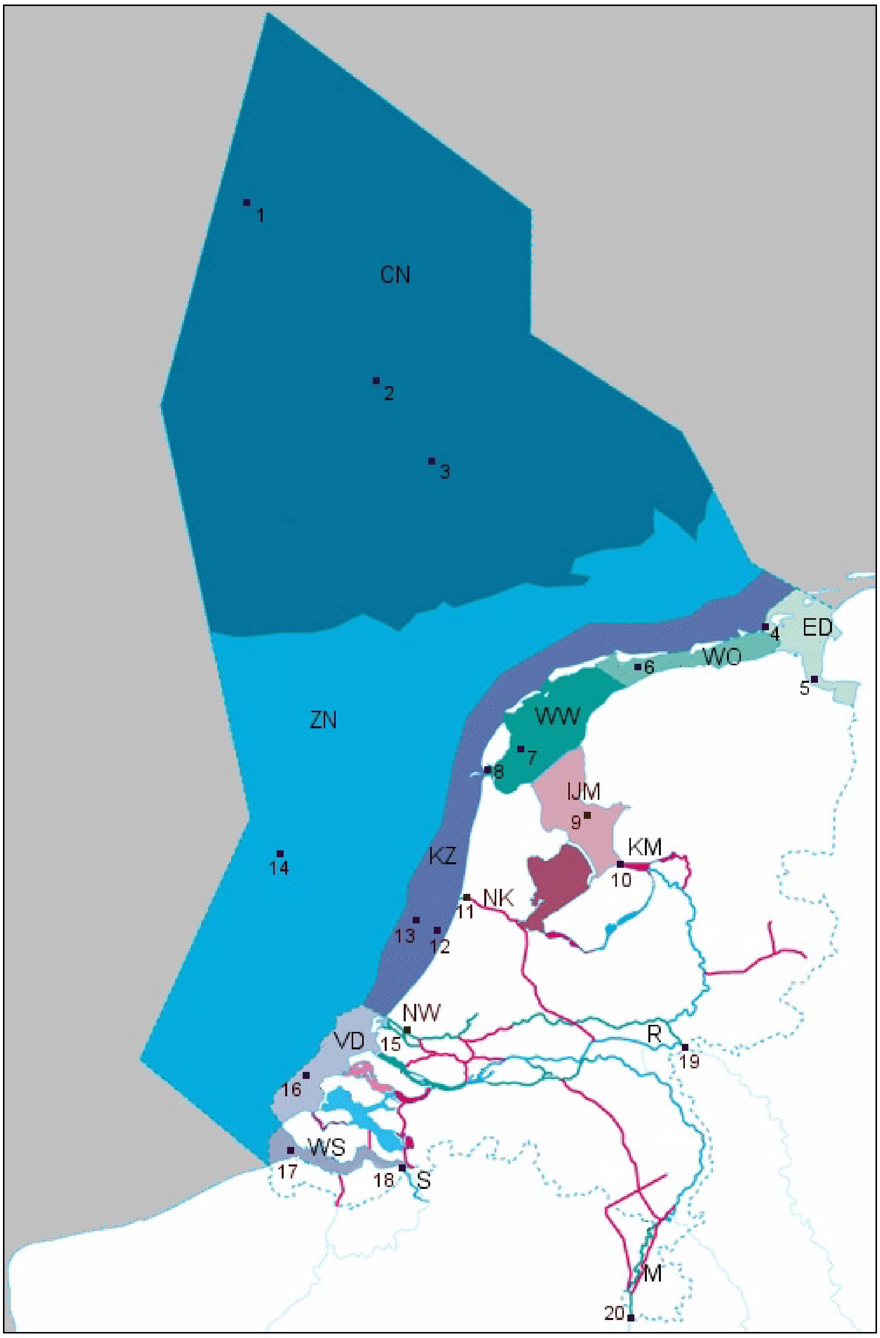
Channel number and energy range in keV	Example of isotope *
Channel 1 295-405	lead-214 **
Channel 2 310-500	iodine-131
Channel 3 500-660	bismuth-214 **
Channel 4 600-750	caesium-137
Channel 5 750-1050	cobalt-58
Channel 6 1050-1250	cobalt-60
Channel 7 1250-1380	cobalt-60
Channel 8 1380-1540	potassium-40 **

* In each channel several isotopes can occur. In the table the most common nuclides are given as an example.

** Channel 8 has a calibration source of K-40. In case an alarm level is exceeded samples will be taken for analysis to the Laboratory of RWS WD (Lelystad).

The verification team received a demonstration of the Aqualarm system.

Verification does not give rise to recommendations.



Sea water areas:
CN =Central North Sea
ED =Eems-Dollard
WO =Wadden Sea East
WW =Wadden Sea West
ZN =Southern North Sea
KZ =Coastal area
VD =Delta Coastal Waters
WS =Westerscheldt

Fresh water areas:
IJM =IJsselmeer
KM =Ketelmeer
NK =Noordzeekanaal
NW =Nieuwe waterweg
R =Rhine
M =Meuse
S =Scheldt

1 =Terschelling 235
2 =Terschelling 135
3 =Terschelling 100
4 =Huibergat Oost
5 =Bocht van Watum
6 =Dantziggat
7 =Doove Balg West
8 =Marsdiep Noord
9 =Vrouwezand
10 =Ketelmeer West
11 =IJmuiden
12 =Noordwijk 2
13 =Noordwijk 10
14 =Noordwijk 70
15 =Maassluis
16 =Schouwen 10
17 =Vlissingen Boei
18 =Schaar van Ouden Doel
19 =Lobith
20 =Eijsden

Noordwijk 2 means Noordwijk 2 km offshore.

Figure 4: Overview of monitoring locations for the monitoring program in surface water and in seawater. Terschelling 135 km offshore and Terschelling 100 km offshore were the old monitoring locations for the Central North Sea during 1989 and 1988-1994 (except 1989), respectively. Terschelling 235 km offshore is the monitoring location for the Central North Sea from 1995 and onwards. Noordwijk 10 km offshore was the old monitoring location for the Coastal area during 1988-1998. Noordwijk 2 km offshore is the monitoring location for the Coastal area from 1999 and onwards]. Doove Balg West was the monitoring location for radionuclides in suspended solids for the Wadden Sea West during 1996-2005.

7.6 FOODSTUFFS SAMPLING PROGRAMME

7.6.1 General

RIKILT (*Instituut voor Voedselveiligheid;* Institute of Food Safety) is a Dutch independent scientific organisation that carries out radiological analyses on grass and milk over the country, however not in the vicinity of Borssele-NPP by setting up an appropriate sampling and measuring network (*Landelijk Meetnet Radioactiviteit in Voedsel, LMRV)*. LMRV is a monitoring network that in principle is set up as an emergency network for monitoring relatively high contamination levels. It consists of 70 '*Voedselmonitors*' (foodstuff monitors with NaI(Tl) detector and Marinelli beaker as measurement geometry) of which 24 are stationed at dairy factories.

The verification team witnessed one such monitor at the premises of RWS WD-Lelystad (see Chapter 9.2).

7.6.2 Milk

The Institute of Food Safety monitors radioactivity in milk on a weekly basis via LMRV. For milk, the weekly samples of all locations are combined into a monthly average for the whole country. The milk samples are analyzed for the presence of K-40, Co-60, I-131, Cs-134, Cs-137, and Sr-90 by RIKILT, Wageningen.

7.6.3 Mixed diet

Since 2005 the Food and Consumer Product Safety Authority monitors activity concentrations in mixed diet. In 2006 mixed diet was sampled mainly as separate ingredients but also as some complete meals. During two weeks in five different regions a standard sampling was carried out which consisted of 471 samples, which were taken from retail shops, auctions and distribution centres. The separate ingredients were divided in the following product groups: grain, vegetables, fruit, milk and dairy products, meat and meat products, game and poultry, salads and oil and butter.

The verification team was informed that generally the samples are analysed for gamma emitters and Sr-90. However, in 2006 Sr-90 analyses were not performed.

7.6.4 Other foodstuffs

Radioactivity is also measured in food suspected to contain more than the normal activity concentrations.

8 LABORATORIES RUN OR CONTRACTED BY THE NPP OPERATOR – DESCRIPTION AND VERIFICATION

The following analytical laboratories are participating in the surveillance of the NPP site with regard to discharges and environmental media on behalf of the operator:

8.1 THE OPERATOR'S LABORATORIES FOR DISCHARGE SAMPLES

8.1.1 General

The verification team was informed that the chemical laboratories are staffed with six technicians (five technicians are available in the Radiation Protection Department), both, for work in the 'warm' and in the 'cold' laboratory. During outages to be able to manage the higher workload more personnel is hired. Generally, all sample related work (sampling, preparation, measurement) is done by one person. In case the person that took a sample falls ill another staff member goes back for redundant sampling

The team was explained the method for stabilising liquid discharge samples. A 250 ml *Petri* dish is filled with a mix of sample, carrier and starch (*Henkel Perfax Métyl, 'coll à tapisses'*) to avoid sedimentation. The dish is sealed with tape and has the sampling date written on it. The sample then goes to the 'cold' laboratory for gamma spectrometry. A detailed report on the errors including methodological uncertainties of the method is available.

Distillation of liquid discharge samples for tritium analysis is performed under a chemical hood. *Perkin Elmer Ultima Gold™ LLT* scintillation cocktail and 20 ml plastic vials are used for measurement.

The team verified that procedures were available on the intranet; regulatory inspection has access to the procedures, however access to the PPS system for the regulator's inspection staff is only given in alarm situations.

With regard to liquid discharges the discharge permit is based on the activity released per year; for internal operational use the activity concentration measured in the 500 ml samples is taken.

The team noted that good overviews (tables, graphs) over various calibrations are available and are used for checking e.g. LSC quality (vial effects etc.). If necessary, results are corrected ex post (currently work on an according procedure is ongoing): if the result lies within 10% it is deemed ok; in case the difference is larger, thorough checks have to be performed; in case of a difference of more than 15%, the sample batch has to be re-analysed.

Backups of all data are made within the main NPP system.

The verification team saw that result forms are prepared with all necessary information entered at the various analysis task related points. The forms contain all signatures and are forwarded to the control room.

Verification does not give rise to recommendations.

8.1.2 The 'Radiation Protection Counting Room'

The counting room of the Radiation Protection Department is located within the controlled area. It is also used by the Chemistry Department for measuring ventilation stack samples.

The devices in this room include a 20% *Canberra* HPGe detector, a *Canberra* portable HPGe detector and two *Oxford Tennelec XLB* planchette counters for wipe tests and beta measurements.

For gamma spectrometry the laboratory uses on one hand NIM electronics from *Canberra,* on the other a *Canberra Inspector 2000* device. For spectrum analysis *Canberra Genie 2000* and *Canberra Genie ProCount,* and currently for some sample types *Canberra ISOCCS* is used. One shield is made of 10 cm Pb and a 1 mm Cu lining. The other shield consists of some 8 cm Pb and can be disassembled (military type).

The verification team visited the Radiation Protection Counting Room which is located in the controlled area. It is also used by the Department of Chemistry that measures stack samples here.

The team was impressed by the technical expertise of the staff, in particular with regard to gamma spectrometry.

The team saw that the *Canberra* HPGe coming back from repair, was out of function. Staff had found out about the detector problem by routine spectrum checks. The final detector check was done by *Canberra*.

With regard to measurements of carbon cartridges that are prepared by the Chemistry) Department, the team was explained that the device is built of two parts, each containing ca. 100 ml charcoal, with a diameter of 10 cm, separated by a grid. The first part is measured first; in case artificial radionuclides are detected, also the 2nd part is measured. Using this method the absorption efficiency can be estimated and a calculation of the total percentage that passes through the system can be performed.

With regard to gamma spectrometry detector data sheets are kept in the 'normal' office and not in the controlled area, to allow easier access.

The laboratory uses cling film and *Kleenex* for protection of the detector endcap; no centering devices are used as sample holders.

Measurement results are stored on PC in various folders; connection to the NPP IT network exists for data archiving.

The verification team was told that for the future it is foreseen to obtain two *Canberra Inspector* devices. For improved data handling the setting up of a laboratory management system (LIMS) is planned.

Some 20 geometries are calibrated. Calibration is partly done by Radiation Protection, partly by the Chemistry Department. Formerly radioactive standard sources were used (most from *Canberra, Amersham*); currently the team tests the use of *Canberra ISOCCS*.

Before each stack sample measurements are performed to check energy and FWHM (using a mixed radionuclide source containing Am-241, Co-57, Co-60, Cs-137 and Y-88), and background;

> *The verification team encourages all efforts to introduce a laboratory management system.*

8.1.3 The Chemistry Department 'Warm' Laboratory

The verification team was shown the Chemistry Department's 'Warm' Laboratory, where gross gamma measurements on liquid discharge samples (using a NaI(Tl) detector) and low energy beta emitter determinations are performed. (Gamma spectrometry is done in the 'cold' lab).

The verification team was explained and shown in detail how sample preparation for tritium and C-14 determination in air is performed:

For tritium analysis from ventilation stack air samples the zeolite containing cylinder is heated to remove the aqueous sample. For C-14 determination the zeolite is purged with hydrogen followed by further sample preparation. The according device has been developed at the laboratory; only few technicians are firm in using the method thus samples are prepared only once per quarter considering the vacation time of the personnel. *Perkin Elmer Ultima Gold*™ is used as scintillation cocktail. Sampling itself is done on a monthly basis. The data for the reports are based on the results submitted by *AREVA* at Erlangen, Germany, contracted to perform the 'official' analysis.

Since all German NPPs use this zeolite method and most contract *AREVA* for measurement plans are to ask *PTB Braunschweig*, Germany, to produce zeolite reference samples for test purposes.

Liquid scintillation counting

For tritium measurements on liquids and ventilation stack samples as well as for C-14 measurements on ventilation stack samples the laboratory operates a Packard TriCarb 2700TR liquid scintillation counter.

For tritium determinations demineralised water is used as background water; specific low background water is not necessary. Calibration sources are produced in house by buying H-3 and making dilutions. The department checks the calibration factor for H-3 if feasible on a monthly basis with a view to avoid re-calibration.

With regard to the results from LSC measurements the team was told that they are noted in a log book and then manually input into the 'waste water data base'. MS Excel is used for calculations and to check routines; results are kept in the NPP's network (limited access).

The team saw that all liquid samples were well labelled with sample number (reference in data base).

A service contract exists with *Canberra / Perkin Elmer* to guarantee device availability.

Gamma spectrometry

The two *Canberra* HPGe detectors in the laboratory are used for measuring other types of samples, not related to the visit (sample centering devices and a sample distancer for higher activity samples are available). LN_2 supply is centrally organised via the control room; the LN_2 container is located outside.

The verification team encourages co-operation with partners e.g. in Germany with a view to improve quality and reliability of the zeolite method.

8.1.4 The Chemistry Department 'Cold' Laboratory

The verification team was shown the Chemical Department's 'Cold' laboratory and was explained its tasks and procedures.

With regard to discharge samples the laboratory is responsible for gamma spectrometric measurements on samples from the tanks 41 and 42 (discharge tanks).

Before any discharge samples of the tank to be discharged are taken according to *KTA 1504*. Part of the sample goes to the chemistry laboratory for further analysis.

Other samples handled in the laboratory come from other areas (secondary system, intermediate cooling system for leakage control), following *KTA 1504*.

To fix the geometry of the liquid discharge samples starch (*Henkel Perfax Métyl*) is used. This method is the result of a working group on particle measurement in 1995 that had been set up to discuss problems with sedimentation in liquid samples and analysis errors involved.

Mixed quarterly samples are prepared and sent to NRG-Petten for alpha analysis and Sr-89 and Sr-90 determination; yearly mixed samples go to *AREVA* at Erlangen for the determination of Fe-55 and Ni-63. These samples are kept in the original sample bottle and are prepared shortly before transport.

All procedures are available from a database via the NPP's intranet (paper copies are available in the lab); the inspectors from the regulator have access to this.

All technicians are trained to perform gamma spectrometry, however the specialist for gamma spectrometry is in the Radiation Protection laboratory, where also system and data backups are made.

For reasons of custody, all radioactive sources are stored in the 'warm' lab.

Measuring devices

For gamma spectrometry the laboratory operates two HPGe detectors from *Canberra* (one with 29% and one with 21% relative efficiency), using NIM electronics and *Canberra AIM*, locked in a 19" rack (PC controlled). Gamma spectrometry software is *Canberra Genie 2000*, Version 3.1. For samples from tank 41 and 42 one geometry is calibrated, using *Amersham QCY.44* as multiple radionuclide standard; the individual standard sources are made in the department.

For checks of energy (weekly) and efficiency (once per month) the standards are used, not the samples. Energy re-calibration is performed whenever necessary; however this occurs very rarely because the system is very stable. Background measurements are made once per month: results on minimal detectable activities (MDA) of waste water measurements are used as background check data to decide on any decontamination.

The laboratory applies the same procedures as the other labs (cling sheet, *Kleenex* tissue). The procedures are stored in the database and also available as hardcopy in the lab. All actions in the lab are documented in a log book.

The team was informed that the department currently uses *Canberra Genie* gamma spectrometry analysis software; plans are to switch to *Canberra APEX* lab productivity suite.); for new detectors *Canberra ISOCCS* will be bought.

Measurements are done during night (50 000 sec), the measuring room being locked. The next morning the spectra are analysed and the values are entered in the waste water database; thus no change of sample custody is necessary. Values below MDA are entered in the database but are not used in discharge calculations (according to *KTA 1504)*, the procedure being agreed with the authority. The verification team notes that this procedure is in discrepancy with Commission 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 (Official Journal L2/36 of 4.1.2004).

The laboratory is connected to the central LN_2 supply system.

The lab also has a NaI(Tl) detector and a *Packard TriCarb 1000TR* liquid scintillation counter.

Archiving and reporting

The verification team was informed that data archiving and backup is task of the NPP's IT department (spectra, written forms etc.).

Reporting is quarterly, directly to RIVM (that performs a counter expertise that is delivered to the regulatory authority) and to the regulatory authority (VROM inspection). In case of problems discussion among all involved groups tries to clarify the issue.

Monthly a report on total gamma results for liquid discharges, aerial discharges (noble gases, iodine, aerosols) is sent to VROM as overview.

Tracing

For tracing the verification team chose a discharge sample from February 2006. The file information was still on the 'old' system in the archive in the office room, well organised. Using a USB stick for data transfer the spectrum analysis was done in the measuring room. The analysis with the 'new' system uses the appropriate background information from the time of the original measurement. No discrepancies were found.

> *The verification team suggests studying in depth the differences between using KTA 1504 rules and Commission Recommendation 2004/2/Euratom, in particular with regard to reporting discharge data to the EC.*

8.2 LABORATORIES CONTRACTED BY THE OPERATOR

8.2.1 NRG-Petten (discharge samples)

NRG-Petten has been contracted by the NPP operator to perform analysis of alpha emitters, Sr-89 and Sr-90 on liquid discharge samples. The verification did not include a visit of this laboratory.

8.2.2 *AREVA* Erlangen, Germany (discharge samples)

AREVA Erlangen has been contracted by the NPP operator to perform analysis of H-3 and C-14 on aerial discharge samples (zeolite method) as well as Fe-55 and Ni-63 on liquid discharge samples. The verification did not include a visit of this laboratory.

8.2.3 NRG-Arnhem (environmental samples)

8.2.3.1 Introduction

The independent Nuclear Research Group (NRG) executes the obligations described in the environmental radioactivity monitoring programme of Borssele NPP on a contract basis (sampling and measurements).

The Monitoring department of the NPP is responsible for the continuity of the programme, the analysis of the results and the determination of the net dose on the site boundary.

Apart from the Environmental Monitoring Programme several other related programmes are in place, e.g. the control of the rain water draining system.

The Environmental Monitoring Programme is designed to establish the impact on the environment by monitoring dose rate and the concentration of radio nuclides in several compartments: air, soil, seawater.

Food (including) milk and life stock are not part of the programme.

8.2.3.2 Environmental Radioactivity Laboratory

The laboratory is in the process of ISO 17025 accreditation. It is staffed with two persons.

The verification team was informed that the laboratory handles about 100 samples per year stemming from Borssele NPP and about 300 stemming from other industries.

Sample reception and registration, data handling

The verification team witnessed the sample reception and registration at the laboratory. Samples taken by staff from NRG-Arnhem arrive at the laboratory together with a filled-in sampling sheet and labelled with all relevant sampling data. An internal data base is used for storing and retrieving all sample and measurement related data. Calculations are performed using spreadsheets. The team was informed that particle filter samples are kept for one year after measurement.

Laboratory equipment

Alpha/beta laboratory

The laboratory has 10-channel low level planchet counters *LB 770-PC* from *Berthold*, comprising proportional gas flow counter tubes allowing the simultaneous measurement of 10 sample planchets. For each sample there are two separate measuring channels, one for alpha and one for beta activity. The team was informed that background measurements are performed at least once per month and that the calibration is done with Sr-90 and Am-241 sources purchased from Amersham.

Gamma spectroscopy laboratory

The team witnessed the presence of two *Canberra* HPGe detectors, one n-type and one p-type. Counting time is 70 000 seconds. The team was informed that energy calibration checks are performed every month using a combination source from *Amersham* with americium and thallium, that background is measured once per year and that peak width is checked with a Co-60 source once per month.

Liquid Scintillation Counting

The laboratory uses a *Wallac Guardian 1414* LSC device; calibration is performed at each batch measurement.

QC, Intercomparisons

The team learned that the laboratory participates once or twice per year in intercomparisons (organised by the German *Bundesamt für Strahlenschutz – BfS*, and nationally in the Netherlands).

Tracing

The team traced a particle filter from May 2003. The air filter was shown to the team as well as the corresponding gamma spectrum and the calculated results. No discrepancies were found.

Reporting and archiving

The results are reported twice a year to Borssele NPP. The results are integrated in the environmental (annual) report of the NPP and as such reported to the authorities.

Verification does not give rise to recommendations.

9 THE REGULATOR'S LABORATORIES FOR ENVIRONMENTAL SAMPLES STEMMING FROM THE CONTROL OF THE OPERATOR'S MONITORING PROGRAMME AND FROM THE NATIONAL ENVIRONMENTAL MONITORING PROGRAMME

9.1 GENERAL

In the Netherlands several institutions are involved in the analysis of environmental, foodstuff and feeding stuff samples. The one at RIVM-Bilthoven is described in chapter 10.3, the one at RWS WD-Lelystad is described in chapter 9.2 below. Others, such as the National Institute for Coastal and Marine Management and the Food and Consumer Product Safety Authority were not part of the verification.

9.2 ENVIRONMENTAL RADIOACTIVITY LABORATORY OF RWS WD LELYSTAD

The verification team visited this environmental radioactivity measuring laboratory, which is responsible for analysis of environmental samples from seawater, surface water and sediments. Three persons are working in the lab in the frame of the national monitoring programme.

AQUALARM network

The verification team was given a demonstration of the AQUALARM web site and was informed that the alarm level is 25 Bq/l and that from 100 Bq/l, the Drinking Water Company is involved and asked to stop production. Average measurements in Dutch rivers are around 10 Bq/l, sometimes 14 Bq/l are reached.

Sample reception and registration, data handling

The team was informed that the samples are taken according to written procedures; they arrive at the laboratory (by courier service, often transported by night; cooled service) together with a filled-in sampling sheet.

The verification team found the procedures for sample registration and storage well documented and in order. The team witnessed that samples were registered upon arrival receiving special sample codes.

The team was informed that the samples are stored for measurements on a shelf. Those marked with a red point have to be analysed quickly. After measurement sediment samples are (if not destroyed for measurement) archived and stored for at least one year after the running year.

The team was explained that an internal LIMS system is used for storing and retrieving all sample and measurement related data, as well as for data analysis.

Laboratory equipment

The verification team found that the equipment in the laboratory was in good shape. Sample treatment, measurement, calibration and checking procedures were available and at hand. The involved personnel were well aware of the tasks and the procedures to follow and generally had good knowledge of the background to the analysis methods applied.

Electric power in the counting room is guaranteed by the use of a UPS.

Alpha/beta laboratory

Alpha/beta radioactivity in samples is measured with large area proportional counters. The verification team was shown a *Thermo Electron FHT 770 GR* device with automatic sample changer for samples up to 200 mm diameter. For measurement and evaluation a *Thermo Electron FHT 8000* electronics device is used. Data are stored and presented on PC. Four older large area proportional counters of similar design are available as well. For smaller planchets a Tennelec LB4100 is available with 2-inch and 5-inch detectors, and for Alpha Spectroscopy a *Canberra Alpha Analyst* with 8 PIPS detectors.

Gamma spectroscopy laboratory

The team witnessed that gamma spectroscopy is performed in an air conditioned room and that three Canberra devices are available, one of 23% and two of 35% relative efficiency. 600 to 700 samples are analysed each year.

Efficiency calibrations are performed once per year (sources are from *isotrak*, UK); background is measured every two months. Peak width controls are done with Na-22 and Eu-155.

Liquid Scintillation Counting

The verification team witnessed the presence of a *Wallac 1220 Quantulus* ultra low-level LSC device which is used for tritium and Tc-99 determinations. It was informed that calibration is done at each measurement.

Special device for milk measurements

The team was shown a food measuring device ("Voedsel monitor" No. 122 – type FMS-96) as used for milk control in dairies; for that purpose counting time is 4 hours. The device shown was out of order and for repair.

Tracing

The verification team traced a sediment sample from October 2001 (inclusive gamma spectrum, gamma analysis and report) and found everything complete and coherent.

Archiving and Reporting

The verification team witnessed that all sample registration and measurement data are archived, both, on paper as well as on PC; security copies are generated on CD-ROM. Calibration data are stored for any measurement re-analysis if needed.

Sediment measurements are archived since 1970. The samples of sediment are stored since 1989 in a little room very well organised. A sample from October 2001 has been asked by the Verification Team and quickly found (see also tracing of a sample). Water samples are stored until approval of the measurement results.

The results are reported twice a year. The results are integrated in the environmental (annual) report and as such reported to the authorities.

Quality management

The team was informed that the laboratory has an ISO 17025 accreditation since 1991 for H-3,and alpha/beta counting in water and sediment. Other types of measurement are Ra-226, Ra-228, Sr-89, Sr-90, Tc-99, Actinides and gamma emitting nuclides. The accreditation process is ongoing.

The verification team had a close look at various sample treatment methods, all very well documented on paper.

The verification team noted that the procedures for the various working areas are comprehensive and generally stored close to the workplace. Copies are with the personnel performing the work. Certificates of standard sources were available. Standard sources are stored in locked devices.

> *Verification does not give rise to recommendations. The team encourages the ongoing additional accreditations.*

10 RIVM – DESCRIPTION AND VERIFICATION

10.1 GENERAL

The Dutch National Institute for Public Health and the Environment (RIVM) is formed as an agency, under the responsibility of the Ministry of Public Health. Approximately two thirds of its work is commissioned by the Ministry of Public Health, the rest by the Ministry of the Environment (VROM), which includes tasks for the nuclear inspectorate. Environmental monitoring formerly was based on project applications year after year, now a three year programme is directly commissioned by the ministry. Reporting depends on the project type and is based on the respective request; the verification team was informed that currently some 90% of the reporting goes to VROM.

No work is performed based on contracts with the industry; the institute is not allowed to work for non-governmental bodies.

The verification team was told that currently funding is reasonable but there is a staffing issue. Co-operation with universities is possible in some areas but not in the field of radioactivity measurements due to the necessary confidentiality.

All radiological tasks including analyses of radioactivity in various media are performed in the Laboratory of Radiation Research (*Laboratorium voor StralingsOnderzoek*, LSO) of the institute.

Usually LSO staff members have a general education, followed by 'level 3' (1/2 year) radiation protection courses as fundamental training plus training on the job. Some staff members are graduates of the University of Delft, which is the only university in the Netherlands with both teaching and research subjects in the field of radiochemistry and radiophysics.

At the time of the verification visit the law establishing the institute has given wide independence: The government has no right to interfere with how work is done. The verification team was told that a law that has been recently proposed may decrease the number of civil servants (including RIVM personnel) and may reduce the institute's independence in technically fulfilling its tasks in the future.

In case of a nuclear or radiological emergency the radiological unit may have access to other staff from the institute. There is some basic organisational planning within RIVM staff (two 12 hr shifts with 20 persons in each are defined). A possibility exists to engage NRG-Petten. The team was informed that, in addition, there exists a contract (rather a gentlemen's agreement) with eight institutes ('pilot flame') all over the country for maintaining an emergency monitoring programme. Sampling equipment needed is supplied by RIVM, analysis is performed using those institutes' equipment. Emphasis is lying on the analysis of radio-iodine in air and deposition. Inter-comparison exercises are organised once in three years; all participants use the same procedures. This model would allow nuclide specific information of any large scale contamination over the whole country.

> *The verification team strongly recommends guaranteeing the necessary independence of RIVM in fulfilling all its tasks.*

10.2 REGULATORY CONTROL ACTIVITIES WITH REGARD TO NPP DISCHARGES

Verification with regard to RIVM's NPP discharge specific tasks ('counter-expertise') is elaborated in Chapter 5.5.

10.3 RIVM RADIATION RESEARCH LABORATORY

RIVM's Laboratory for Radiation Research (LSO) employs five staff. Funding of staff costs is based on the working hours spent on the specific project (some compensation is possible within the institute).

With regard to the timing of analysis tasks, generally, nuclear inspectorate samples come first. 'Counter-expertise' samples have higher priority in case short lived nuclides are involved, otherwise samples from national monitoring come first. The verification team was informed that the laboratory does not measure hospital discharge samples.

10.3.1.1 Sample reception and preparation

Samples come in a container (if needed a cool box; labelled with code and site information); they are stored in a refrigerator at a temperature between 1 and 5 degrees Celsius. For 'counter-expertise' samples, after measurement, the unused rest is stored in the basement (in cases of doubt this rest is used for re-analysis of the sample); after reporting and after agreeing on the values, i.e. approx. after 1 ½ years, disposal is possible.

Sample registration is done in a LIMS (Belgian system by *COMPEX*; the system will be changed to another LIMS in 2008), then a barcode label is placed on the bottles etc.; printed codes contain number and analysis method. LIMS prints out the complete task form.

With regard to sample preparation two rooms (high activity sample / low activity sample preparation) are available. The verification team was shown the rack with samples 'still to be analysed', e.g. bottles labelled by writing and by barcode.

The team was informed in particular about the details of the procedure for all samples to be done for Borssele NPP liquid and aerial effluents. E.g. with regard to zeolite samples for H-3 and C-14 determination Borssele NPP staff takes the sample from equipment no. I and prepares it by desorption, making one subsample for the NPP and one to be sent to RIVM. The zeolite sample from equipment no. II is sent to *AREVA*, Erlangen, Germany and is the one seen by the NPP operator as the 'official' sample. All involved laboratories use the same analysis method, however 'full' independence of RIVM's sample from the operator or a guarantee to have the 'same' sample is not given); all involved groups are aware of that fact.

Also with regard to 'starch samples' from Borssele NPP (liquid discharge samples using starch as stabilising agent) RIVM is aware that due to the possible inhomogeneity such samples are not necessarily 'the same' as the ones measured by the NPP operator. However, in contrast to the method used before changing the preparation method to starch samples, the results between NPP and 'counter-expertise' compare much better.

> *With regard to aerial discharge 'counter-expertise' sample analysis the verification team encourages finding a solution to receiving samples fully independent from any sample preparation step performed by the NPP operator or receiving an aliquot of the sample officially to be analysed by or on behalf of the operator. In the latter case it is recommended performing sample preparation witnessed by an inspector from the regulatory authority.*

10.3.1.2 Laboratory equipment

Gamma spectroscopy laboratory

The laboratory's gamma spectrometry room is located in the building basement where very stable counting conditions are obtained.

HPGe detectors are from *Ortec* and *Canberra*. Currently spectrum acquisition and analysis tools are *ORTEC ADCAM*, *92x DSPEC*, *Spectrum Master* and *GammaVision*. The lab uses proprietary analysis jobs for *GammaVision*; the spectral files are kept on the internal network; hardcopies of report files are not archived, the files stay on hard disk for one week, the system manager then backups to the network (if possible every day; according 'data keeper' software runs in background after logging off).

The day before the visit PC problems had occurred and a spare device had to be used. The team was told that currently no UPS device is available; however a secured power supply exists for the institute. Installation of a UPS is foreseen after moving.

Altogether 7 HPGe detectors (15-40% relative efficiency; n-type, p-type, well type; 1.87 to 2.5 keV resolution) are available; some in ultra low background shields with Cu and plastic liners. The lab operates one n-type *Ortec* HPGe detector with sample changer (*Andrews Nucleonics*, UK); and a portable *ORTEC* device. The laboratory uses sample holders with centering devices.

As a new step the lab installed *Canberra DSA1000* with *Canberra Genie* software, currently on two PCs; this system is not yet operated in routine. The team was told the reason for moving from *Ortec* to *Canberra* was on one side the better company representation, on the other side the better peak fit algorithm.

One detector is calibrated for a distant geometry (15 cm) to allow reliable measurement of any samples with somewhat 'elevated' activity.

Every day before first measurement checks are performed measuring a control sample (Co-60, Cd-109, Co-57) for 600 sec; for this purpose commercial samples are used (*Amersham*, now *PTB*). The procedure is to check activity, peak position and peak width; data are managed in an *EXCEL* spreadsheet, results are plotted for visual observation; sources are replaced after 2 years.

Log books for samples are conveniently kept on the desk; a 'job-log' paper containing basic information about the ongoing measurement is fixed on the detector (to prevent opening the shield by mistake).

The QC procedure contains an alarm feature: in case a discrepancy is detected an investigation has to follow; otherwise normal measurement cannot start.

According to the schedule (available in writing on the measuring desk) background measurements (lasting 200 000 sec) have to be performed over the weekend; all background spectrum files are kept (also as printout); the background values used for analysis are long year averages. This approach is possible due to the fact that the system is very stable.

LN_2 filling is done as a weekly routine (an according log exists); RIVM has a contract for LN_2 supply.

Alpha/beta laboratory

The lab operates a *Packard TriCarb 3100 TR* LSC system with spectrum facility. Tritium, C-14 measurements and Sr-determinations (method with *Eichrom* Sr-resin; Sr-85 is used for chemical yield checks) are standard routine. For tritium determinations, after distillation, it uses *Ultima Gold* as scintillation cocktail; for C-14 measurement *Carbosorb* and *Instagel* are used. Such analysis series are prepared once per year, the last samples prepared this year already being stored in the basement. The team saw the procedure available; it was told that specific pipettes were used for organic liquids.

Background blank water for H-3 determinations is very old, coming from a deep mine.

> *With regard to measuring equipment the verification does not give rise to general recommendations. The use of UPS devices to increase power security is encouraged.*

10.3.1.3 Reporting

The verification team was told that the preparation of reports to the ministries is done within the *EXCEL* file that contains the results, in a chart in another data sheet; the report is then transferred by copy-paste to a *Word* document (as bitmap, with a view that it cannot be changed anymore). For external reports files are converted to *pdf* format.

Analysis reports are stored within the LIMS.

For Borssele NPP samples, for comparison reasons results are reported to the NPP, to *AREVA* (by the NPP), and to the nuclear inspectorate.

The laboratory produces the annual report on the 'Monitoring of radiation in the environment in the Netherlands'.

> *Verification does not give rise to recommendations.*

10.3.1.4 Quality assurance, Tracing

The laboratory has a certification from the Dutch *Raad voor Accreditaties* (which is similar to ISO 9001) since 1994 and is accredited according to ISO 17025 since 2002 (for gamma spectrometry, H-3, C-14, Sr analysis, and gross alpha measurement based on calibration with Am-241).

The team was told that as many value transfers as possible are done by using appropriate interfaces; typing in by hand is avoided.

The team was given a presentation of the analysis check procedure. After spectrum analysis validation and a complex error calculation (5 types of errors) is performed. For comparison with data from the NPP, NPP supplied result values are filled in by hand and checked using a *Visual Basic* programme. So-called evaluation factors (A1, A2, B or C) are given. In case the result is poor ('C') staff from the NPP, RIVM and the inspectorate meet and discuss the discrepancy with a view to improve analysis methods on both sides.

The verification team traced a discharge sample from 17 February 2006 from Borssele NPP, no. 16384, 'KCB gel'. Data were already stored in the 'old' archive on optical disk. The value for Co-60 in the report and in the spectrum analysis result file matched perfectly.

The verification team encourages all efforts to have accreditation according to ISO 17025 in as many areas as necessary for fulfilling the radiological monitoring tasks.

11 CONCLUSIONS

All verification activities that had been planned were completed successfully. In this regard, the information supplied in advance of the visit, as well as the additional documentation received during and after the verification activities, was useful.

The information provided and the verification findings led to the following conclusions:

(1) The verification activities that were performed demonstrated that the facilities necessary to carry out continuous monitoring of levels of radioactivity in the air, water and soil around the site of Borssele NPP as well as on the territory of the Netherlands are adequate. The Commission could verify the operation and efficacy of a representative part of these facilities.

(2) Independence of all regulatory bodies is an important issue and should be granted, in particular with regard to controlling the operator's discharge monitoring system.

(3) A number of topical recommendations and suggestions are formulated. These aim at improving some aspects of discharge monitoring from, and environmental surveillance around the Borssele NPP site and the national monitoring system. They do not discredit the fact that environmental monitoring around the NPP site as well as the verified parts of the national monitoring system for environmental radioactivity are in conformity with the provisions laid down under Article 35 of the Euratom Treaty.

(4) The verification findings and ensuing recommendations are compiled in the ‘Main Findings’ document that is addressed to the Dutch competent authority through the Dutch Permanent Representative to the European Union.

(5) The Commission services having competence will closely follow up the progress made by the Dutch authorities with respect to points (2) and (3).

(6) The present Technical Report is to be enclosed with the Main Findings.

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

APPENDIX 1

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APPENDIX 2

THE VERIFICATION PROGRAMME – SUMMARY

Monday **3 March 2008**	• Arrival at the Borssele NPP site and site access formalities. • Opening meeting: introductions / presentations / programme of the visit. • Team 1: Verification of the regulatory provisions for monitoring/sampling of radioactive discharges of the Borssele Reactor (aerial and liquid) and visit of the reactor's operations' control room. • Team 2: Verification of a representative selection of the site-related provisions for environmental monitoring/sampling (on-site Borssele NPP) put in place by the operator (statutory obligations) as well as by the regulator (check monitoring).
Tuesday **4 March 2008**	• Team 1: Verification of "aerial and liquid discharges" from the Borssele-NPP • Team 2: Verification of a representative selection of the site-related provisions for environmental monitoring/sampling (off-site Borssele NPP) put in place by the operator (statutory obligations) as well as by the regulator (check monitoring).
Wednesday **5 March 2008**	• Team 1: Verification of the operator's laboratory(ies) for discharge samples. • Team 2: Verification of national monitoring network installations in the region between Zeeland and Arnhem. • Team 2: Verification of the NRG laboratory (operator contract) at Arnhem).
Thursday **6 March 2008**	• Team 1: Verification of the regulator's laboratory at RIVM, Bilthoven. • Team 2: Verification of the RWS WD (then: RIZA) laboratory (national water monitoring) at Lelystad. • Team 2: Verification of installations at RIVM, Bilthoven with regard to the national environmental control programme, e.g. HiVol air sampler, national data centre.
Friday **7 March 2008**	• Closing meeting: presentation of preliminary verification findings (Bilthoven).

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Ms Adriana Godeanu Metz

Team 2 **Mr Constant Gitzinger**
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