EUROPEAN COMMISSION
DIRECTORATE-GENERAL FOR ENERGY

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

Verification under the terms of Article 35 of the Euratom Treaty

Technical Report

SPAIN

Almaraz Nuclear Power Plant

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

17 - 19 July 2018

Reference: ES 18-03

VERIFICATIONS UNDER THE TERMS OF ARTICLE 35

OF THE EURATOM TREATY

FACILITIES	- Facilities for monitoring discharges of gaseous and liquid radioactive effluents into the environment at the Almaraz nuclear power plant - Facilities for monitoring environmental radioactivity in the vicinity of the Almaraz nuclear power plant - Associated analytical laboratories
LOCATIONS	- Almaraz NPP and the surrounding area - Cáceres, LARUEX Laboratory
DATES	17 – 19 July 2018
REFERENCE	ES 18-03
TEAM MEMBERS	Mr Vesa Tanner, DG ENER (team leader) Mr Simon Murphy, DG ENER
REPORT DATE	29.1.2019
SIGNATURES	

V. Tanner S. Murphy

TABLE OF CONTENTS

Annexes

Annex 1 Verification programme

Annex 2 Almaraz NPP liquid radioactive effluents sampling and analysis programme

Annex 3 Almaraz NPP gaseous radioactive effluents sampling and analysis programme

Legend

ATI	Almacén Temporal Individualizado (Individualised temporary storage facility)
CC	Operator's Analytical Quality Control Programme
CEDEX	Centro de Estudios y Experimentación de Obras Públicas (Centre for Research and Experimentation of Public Works)
CIEMAT	Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (Centre for Energy, Environmental and Technological Research)
COPUMA	Radiological Environmental Monitoring Programme in the vicinity of Almaraz NPP of the Autonomous Government of Extremadura
CSN	Consejo de Seguridad Nuclear (Nuclear Safety Council)
ENAC	National Entity for Accreditation
ETF	Operation Technical Specifications at NPP
EURDEP	EUropean Radioactivity Data Exchange Platform
LARUEX	Laboratorio de Radiactividad Ambiental de la Universidad de Extremadura en Cáceres / Environmental Radioactivity Laboratory at University of Extremadura at Cáceres.
LRAB	Laboratorio de Radiactividad Ambiental de la Universidad de Extremadura en Badajoz / Environmental Radioactivity Laboratory at University of Badajoz
MASL	Laboratorio de Medidas Ambientales S.L. at Medina de Pomar (Burgos) / Laboratory for Environmental Radiological Monitoring
MINETAD	Ministry for Energy, Tourism and Digital Agenda
MTE	Ministry for the Ecological Transition (previous MINETAD)
ODCM/MCDE	Offsite Doses Calculation Manual of Almaraz nuclear power plant
PENCA	Offsite Nuclear Emergency Plan for Cáceres
PVRA	Radiological Environmental Monitoring Programme
PVRAIN	Independent Radiological Environmental Monitoring Programme (CSN)
RAE	Operator's Offsite Alert Network
RAI	Operator's Onsite Alert Network
RAR	Radioactivity Alert Network of Directorate-General of Civil Protection
RARE	Network of automatic stations of the Autonomous Government of Extremadura
REA	Network of automatic stations (CSN)
REM	Network of sampling stations (CSN)
REVIRA	National Environmental Radiological Monitoring Network (CSN)
SALEM	Emergency Room of CSN
URAyVR	Unit of Environmental Radiology and Radiation Monitoring (CIEMAT)

TECHNICAL REPORT

1 INTRODUCTION

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

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

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

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

2 PREPARATION AND CONDUCT OF THE VERIFICATION

2.1 PREAMBLE

The Commission notified Spain of its decision to conduct an Article 35 verification in a letter addressed to the Permanent Representation of Spain to the European Union. The Spanish Government subsequently designated the Nuclear Safety Council (CSN) to lead the preparations for this visit. There has been no previous verification under Article 35 at the Almaraz NPP.

2.2 DOCUMENTS

To assist the verification team in its work, the Spanish national authorities supplied an information package in advance[3]. Additional documentation was provided during and after the visit. The information provided was used extensively in drawing up the descriptive sections of this report.

2.3 PROGRAMME OF THE VISIT

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

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

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

3 Replies to the preliminary information questionnaire addressed to the national competent authority, received on 19 June 2018

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

- Commission Article 35 verification programme
- Almaraz NPP introduction
- Environmental radioactivity monitoring in Spain
- LARUEX laboratory introduction
- Almaraz NPP on- and off-site monitoring programmes

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

Almaraz NPP

Alberto Foronda	Licensing manager of Almaraz and Trillo Nuclear Power Plants
Nicolás Guillén	Head of Radiation Protection and Environment
Alejandro Moysi	Deputy of the Radiological Protection Service
Enrique Monzo	Head of Environment Area
Carlos Diaz	Environment Technician

Nuclear Safety Council (CSN)

María Jesús Muñoz	Deputy Director for Environmental Radiation Protection
José Ignacio Serrano	Head of the Radiological Impact Assessment Department
Carmen Rey	Head of the Unit of Radioactivity Environmental Monitoring
Sofia Luque	Deputy Direction for Environmental Radiological Protection
Maria Teresa Sanchez	Deputy Direction for Environmental Radiological Protection
Jose Ignacio Martin	Resident Inspector
Rafael Mendilibar	Resident Inspector

Autonomous Government of Extremadura

José Manuel Gil	Head of the Section of Environmental Radioactivity at the Office for environment, agricultural policy and territory of the Autonomous Government of Extremadura in Mérida (Badajoz)

LARUEX

Antonio Baeza	Technical Director of LARUEX and Professor of the Department of Applied Physics of the Veterinary Faculty of the University of Extremadura
Javier Guillén	Deputy Technical Director of LARUEX
María Ángeles Ontalba	Quality of the warning networks
Juan Baeza	Computer networking

3 LEGAL FRAMEWORK FOR RADIOACTIVITY MONITORING

3.1 NATIONAL LEGISLATION IN SPAIN

3.1.1 Legislative acts regulating environmental radioactivity monitoring

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

- Law 25/1964, of 29 April, on nuclear energy. Published in the Boletín Oficial del Estado [Official Gazette] (BOE) nº 107 of 4 May 1964
- Royal Decree 783/2001, of 6 July, adopting the regulations on health protection against ionising radiations. Published in BOE nº 178 of 26 July 2001.
- Royal Decree 1836/1999, of 3 December, adopting the regulations on nuclear and radiological installations. Published in BOE nº 313 of 31 December 1999.
- Law 15/1980, of 22 April, on the creation of CSN. Published in BOE nº 100 of 25 April 1980.
- Law 16/2015, of 23 de April, on the environmental protection of the Autonomous Government of Extremadura. «DOE» no. 81, of April 29, 2015 «BOE» no. 119, of May 19, 2015 (Regional).

3.1.2 Legislative acts regulating discharge radioactivity monitoring

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

National Legislation

- Law 25/1964, of 29 April, on nuclear energy. Published in BOE nº 107 of 4 May 1964.
- Law 14/1999, of 4 May, on rates and public charges for services provided by the Nuclear Safety Council. Published in BOE nº 107 of 5 May 1999.
- Royal Decree 783/2001, of 6 July, adopting the regulations on health protection against ionising radiations. Published in BOE nº 178 of 26 July 2001.
- Royal Decree 1836/1999, of 3 December, adopting the regulations on nuclear and radiological installations. Published in BOE nº 313 of 31 December 1999.
- Law 15/1980, of 22 April, on the creation of CSN. Published in BOE nº 100 of 25 April 1980.

CSN Technical Instructions

CSN has the competence to prepare and approve technical standards on nuclear safety and radiological protection issues, which are binding for the parties affected by their scope of application.

- CSN-IT-DSN-08-25: Technical instruction on standardized information on radioactive airborne and liquid discharges into the environment from nuclear power reactors in normal operation

CSN Safety Guides

CSN has the competence to prepare and approve guides that are technical documents of recommendatory nature, which provide guidance to the affected parties in relation to the regulations currently in force for nuclear safety and radiological protection issues.

- CSN Safety Guide 1.4: Control and radiological surveillance of radioactive liquid and gaseous effluents released by nuclear power plants, partially modified by Technical Instruction CSN-IT-DSN-08-25
- CSN Safety Guide 1.7: Information to be sent to the CSN by the licensees on the operation of nuclear power plants, partially modified by Technical Instruction CSN-IT-DSN-08-25

- CSN Safety Guide 4.1.: Design and development of the Environmental Radiation Monitoring Programme for Nuclear Power Plants, CSN, 1993
- CSN Safety Guide 7.9: Offsite dose calculation manual of nuclear installations

3.2 INTERNATIONAL LEGISLATION AND GUIDANCE DOCUMENTS

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

The European Union

- The Euratom Treaty (1957)
- Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation; repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom with effect from 6 February 2018 (OJ L 13 of 17.1.2014)
- Council Directive 2013/51/Euratom of 22 October 2013 laying down requirements for the protection of the health of the general public with regard to radioactive substances in water intended for human consumption (OJ L 296 of 7.11.2013)
- Commission Recommendation 2000/473/Euratom of 8 June 2000 on the application of Article 36 of the Euratom Treaty concerning the monitoring of the levels of radioactivity in the environment for the purpose of assessing the exposure of the population as a whole (OJ L191 of 27.7.2000)
- 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 (OJ L36 of 6.1.2004)

The International Atomic Energy Agency (IAEA)

- *Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards*, IAEA Safety Standards Series No. GSR Part 3, IAEA, Vienna, 2014
- *Clearance of materials resulting from the use of radionuclides in medicine, industry and research*, IAEA-TECDOC-1000, IAEA, Vienna, 1998
- *Generic models for use in assessing the impact of discharges of radioactive substances to the environment*, Safety Reports Series No 19, IAEA, Vienna, 2001
- *Handbook of parameter values for the prediction of radionuclide transfer in temperate environments*, Technical Reports Series No 364, IAEA, Vienna, 1994
- *Management of radioactive waste from the use of radionuclides in medicine*, IAEA-TECDOC-1183, IAEA, Vienna, 2000
- *Regulatory control of radioactive discharges to the environment: Safety Guide*, Safety Standards Series No. WS-G-2.3, IAEA, Vienna, 2000

International Conventions

- The Convention on Nuclear Safety
- The Convention on Early Notification of a Nuclear Accident
- The Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency

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

4.1 NATIONAL BODIES

4.1.1 Ministry for the Ecological Transition

The Ministry for the Ecological Transition (MET) is responsible for the granting of the necessary permits for the different stages of the lifecycle of the Spanish nuclear power plants and facilities using radioactive substances, following a mandatory and binding report of the CSN. This system of authorizations includes also approval of the environmental radioactivity monitoring programmes and the discharge radioactivity monitoring programmes of the facilities.

4.1.2 Nuclear Safety Council

The Nuclear Safety Council (CSN), established in 1980, is the Spanish competent authority for nuclear safety and radiological protection. It is independent from the Government and reports directly to the Spanish Parliament. CSN is a collegiate body consisting of five members (a president/chairman and four commissioners) proposed by the Government and endorsed by the Congress of Deputies. Under the overall responsibility of the Secretary-General, the CSN is organised in two technical directorates: Nuclear Safety and Radiation Protection. The latter includes three sub-directorates: Emergencies and Physical Protection, Operational Protection and Environmental Radiological Protection.

CSN issues mandatory and binding reports prior to the authorisation for nuclear facilities by the MTE and proposes regulations on nuclear safety and radiation protection.

CSN conducts inspections to control the different phases of the life of the installations (project, construction, operation and decommissioning) and any other activity that may have a radiological risk. CSN also provides mandatory and binding reports for modifications of the authorizations of such installations and facilities. On average, the CSN carries out around 200 control inspections per year in nuclear power plants operating in Spain. It is also responsible for proposing regulations to the MTE concerning radiological protection of workers and members of the public.

With respect to the environment, the CSN has the following regulatory functions:

- To assess the radiological impact of nuclear facilities and installations using radioactive substances on the environment, especially concerning radioactive discharges (aerial/liquid) into the environment, their accumulation in the vicinity of such installations and the evaluation of the resulting radiological impact.
- To run its own programmes of environmental radiological monitoring (both in the vicinity of nuclear installations and at national level) and to supervise all environmental radiological protection activities conducted by nuclear installations and by facilities using radioactive substances.

The CSN also has regulatory functions concerning emergencies. It is responsible for the immediate response to any nuclear or radiological incident. Its 24h emergency room SALEM is fitted with redundant communication systems, collecting information in real time and thus facilitating CSN's advisory role in the event of an emergency. The emergency room has permanent automatic communications with all Spanish nuclear power plants.

4.1.3 Centre for Research and Experimentation of Public Works

The Centre for Research and Experimentation of Public Works (CEDEX) is a public research institution, functionally assigned to the Ministry of Public Works. It is responsible for the determination of the radiological quality of the Spanish continental and coastal waters.

4.1.4 Centre for Energy, Environmental and Technological Research

The Centre for Energy, Environmental and Technological Research (CIEMAT) is a public research body assigned to the Ministry of Economy and Enterprise, focusing on energy and environment and the technologies related to them. It has offices in several different regions of Spain. Its activity is structured around projects that form a bridge between R&D&I and social interest goals.

4.1.5 Directorate-General for Civil Protection and Emergencies

The Directorate-General for Civil Protection and Emergencies under the Ministry of Internal Affairs is responsible for the management, operation and maintenance of the Radioactivity Alert Network (RAR). This nationwide network of some 900 stations measures dose rate with the aim of detecting, in real time, abnormal levels of radiation that may pose a radiological risk.

4.2 REGIONAL BODIES

4.2.1 Junta de Extremadura, Autonomous Government of Extremadura

The Junta de Extremadura (hereinafter called Autonomous Government of Extremadura) is responsible for the control and surveillance of its territory regarding the conservation of nature and environment, and of the functions delegated by the central government regarding nuclear and radiological emergencies. Therefore, it is responsible for the management and maintenance of the Environmental Radiological Surveillance Network (RARE).

4.2.2 Government Delegation in Cáceres

The Government Delegation in Cáceres performs tasks for nuclear emergencies through the rules established in the Almaraz nuclear power plant off-site nuclear emergency plan (PENCA), and carries out the delegated functions of the Ministry of Internal Affairs in Cáceres (Extremadura).

5 ALMARAZ NPP ENVIRONMENTAL RADIATION MONITORING PROGRAMMES

5.1 INTRODUCTION

The Almaraz nuclear power plant (Fig. 1) has two pressurized water reactors with electrical power of 1001 and 1006 MW. The plant is located on the bank of the Arrocampo reservoir in the municipality of Almaraz (Cáceres), 16.4 km west-southwest of Navalmoral de la Mata, 68.8 km east-northeast of the provincial capital Cáceres, and 180 km west-southwest of Madrid. The plant is located at an elevation of 258 metres above sea level.

There are two Westinghouse-design three-loop pressurised water reactors (PWR) with rated thermal powers of 2,956.6 MWt (Unit 1) and 2,955.8 MWt (Unit 2). Unit 1 reached initial criticality on April 5th 1981 and Unit 2 on September 19th 1983. The current operating licences extend to 2020.

On the Almaraz NPP site, there is also a new facility for storing spent nuclear fuel (Almacén Temporal Individualizado (ATI)), which was not yet operational during the verification.

Plant cooling water comes from the Arrocampo reservoir, which in turn is supplied from the River Tajo (Tagus) via a pumping station. The coolant discharge is returned to the reservoir, where it is directed to circulate the reservoir and then discharged back to the river via a cooling plant (discharge water temperature must be below 30˚C before reaching the river.). The River Tajo flows to Portugal and reaches the Atlantic Ocean in Lisbon.

Figure 1. Almaraz nuclear power plant and the Arrocampo reservoir

The site-related on-line monitoring capabilities around the Almaraz NPP include the operator's on-site and off-site alert networks (RAI and RAE, respectively) and the CSN's automatic stations network (REA). The Directorate-General for Civil Protection and Emergencies of the Ministry of Internal Affairs also have automatic stations of their Radioactivity Alert Network (RAR) near Almaraz NPP.

The sampling and measuring programmes around the Almaraz NPP include the operator's environmental radioactivity monitoring programme (PVRA), the operator's quality control programme (CC) and the CSN independent environmental radioactivity monitoring programme (PVRAIN). The Autonomous Government of Extremadura also carries out the COPUMA programme.

5.2 OPERATORS ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMME

5.2.1 On-site dose rate monitoring

The operator on-site alert network (RAI) has four dose rate monitoring locations. These provide continuous information about the dose rate within the site. The locations of the monitoring stations are called Edificio H, Caballerizas, Cerro Matraca and Torre Meteorológica (Fig. 2). The communications between the stations and the system central computer are wireless. Each station of the RAI network has a gamma radiation sensor (IGS421) for the environmental gamma dose rate measurement and a control box. There are three Geiger-Müller detectors and an integrated microprocessor for the calculation, storage and transmission of the measurement and system data. The probe has two low dose rate high volume detectors that allow detection of small changes with short counting time. The two detectors also ensure redundancy. The third detector is for higher dose rate monitoring.

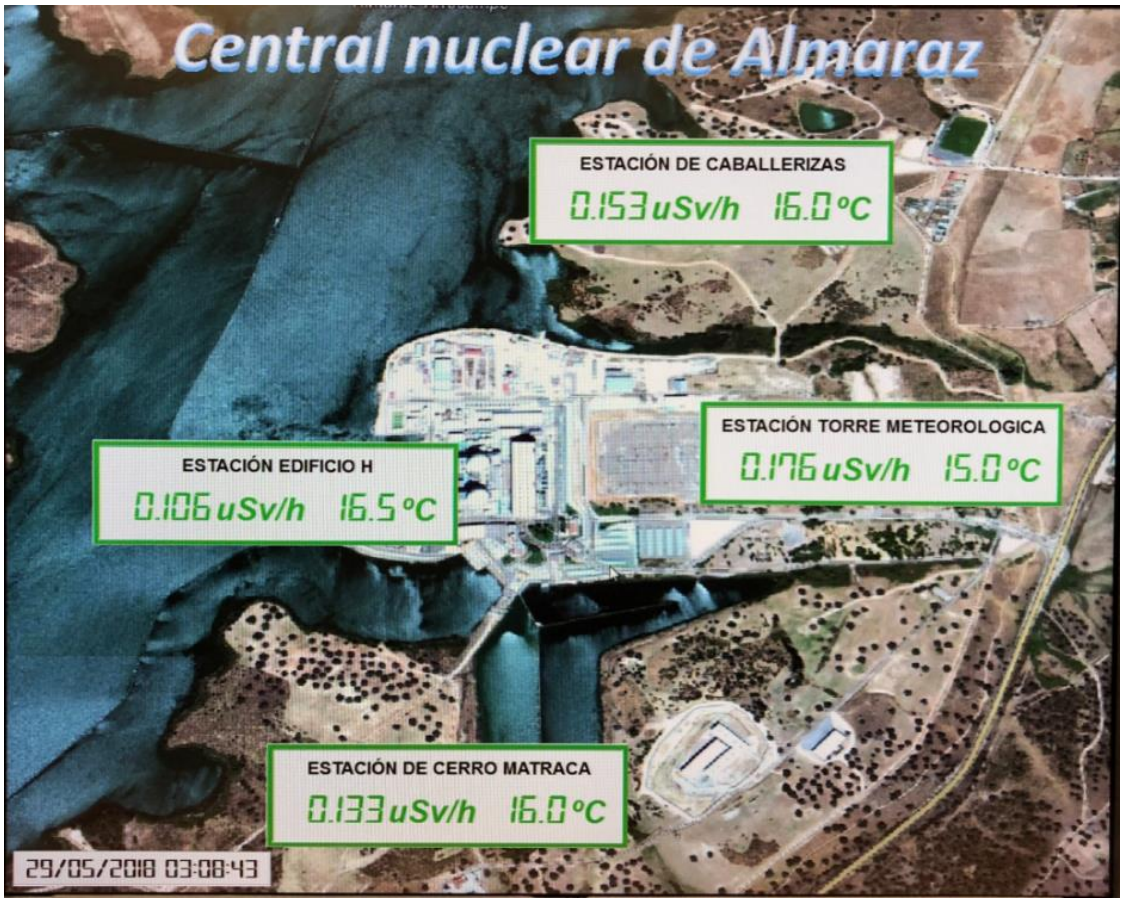

Figure 2. On-site dose rate monitoring network (RAI)

5.2.2 Off-site dose rate monitoring

The operator's off-site alert network (RAE) has four dose rate monitoring locations. The network provides continuous information for the dose rate in CGC Almaraz (E5), Arrocampo Dam (E6), CGC Casatejada (E7) and Navalmoral Operations Base (B.O.N.) (Fig. 3). Each station of the RAE network has a gamma radiation monitor (FHZ-621 G-L4) for the environmental radiation dose rate measurement and a display unit (FHT-6020). A centralized computer is located in the meteorological station of the NPP. The communications between the stations and this centralized PC are wireless, except for the E8 station that only has a local indication.

The monitors have the following features:

- Detector type: gas proportional counter
- Counter gas: Argon/CO_2 82/18 (1000 hPa)
- Measured quantity:
  - Photon dose equivalent rate or H^*_x (DIN 6814)
  - Ambient dose equivalent rate or $H^*(10)$ (ICRP47)
- Accuracy: ± 5% (Cs-137) typical
- Gamma response: 9.5 ± 0,5 s-1/µSv/h
- Energy range: 30 Kev - 1.3 MeV
- Angular acceptance: ± 45º reference direction (perpendicular to the cylinder axis of the counter tube)

This device allows a local indication of the dose rate measurement and an alarm signal (audible and visible).

Figure 3. Off-site alert network (RAE)

5.2.3 Environmental sampling

The operator of the nuclear power plant has to manage the sampling, analysis and measurement programmes of radiation levels and radionuclides in the environment within a 30 km radius (PVRA) and the quality control monitoring programme to verify the analytical quality of the measurements (CC). 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. Tables I and II below detail the analyses required in Spain for each type of sample in a nuclear power plant (where applicable). Additionally, the Almaraz NPP is currently performing a preoperational surveillance program in the surroundings of the future

Individualized Temporary Spent Fuel Storage Facility (ATI)[4].

Table I. Almaraz NPP radiological environmental monitoring programmes

TYPE OF SAMPLE	ANALYSIS
Air	Gross beta, Sr-90, Gamma spectrometry, I-131, gama dose rate (TLD)
Potable water	Gross beta, Residual beta, Sr-90, Tritium, Gamma spectrometry
Rain water	Sr-90, Gamma spectrometry
Ground and surface water	Gross beta, Residual beta, Tritium, Gamma spectrometry
Soils, sediments and biota	Sr-90, Gamma spectrometry
Milk and crops	Sr-90, Gamma spectrometry, I-131
Meat, eggs, fish, seafood and honey	Gamma spectrometry

Table II. Sampling and measuring programmes (PVRA and CC)

SAMPLE	SAMPLING	LOCATIONS (SITE CODE)	ANALYSIS	ANALYSIS
Long-time TLD dose measurement (DT)	Change of Dosimeters every three months	01 – Torre meteorológica 02 – Cerro Matraca 03 – Almaraz de Tajo 04 – Casatejada 05 – Serrejón 06 – Valdecañas de Tajo 07 – Navalmoral de la Mata 09 – Presa Arrocampo 11 – Saucedilla 12 – Belvis de Monroy 18 – Romangordo 22 – Casas de Miravete 23 – La Higuera de Albalat 24 – Casas de la Canala 29 – Campillo de Deleitosa 31 – Caballerizas 36 – Majadas de Tiétar 42 – Ayuntamiento Almaraz 43 – Laguna Peraleda 44 – Caserío Oliva 50 – Castañar de Ibor (c)	Gamma integrated exposure	Three months
Air particles (PP)	Weekly Continuous sampling with weekly change of filters	01 – Torre Meteorológica 02 – Cerro Matraca 04 – Casatejada 07 – Navalmoral de la Mata 31 – Caballerizas 50 – Castañar de Ibor (c)	Gross Beta activity Gamma spectrometry Sr-90	Weekly Three months composite Three months composite
I-131 in air (I)	Weekly Continuous sampling with weekly change of filters	01 – Torre Meteorológica 02 – Cerro Matraca 04 – Casatejada 07 – Navalmoral de la Mata 31 – Caballerizas 50 – Castañar de Ibor (c)	I-131	Weekly
Rain water (LL/DES)	Monthly Continuous collection with monthly sampling	01 – Torre Meteorológica 02 – Cerro Matraca 04 – Casatejada 07 – Navalmoral de la Mata 31 – Caballerizas 50 – Castañar de Ibor (c)	Gamma spectrometry Sr-90	Monthly Monthly
Soil (S)	Yearly	01 – Torre Meteorológica 02 – Cerro Matraca	Gamma spectrometry	Yearly

[4] Subsequent to the verification visit, in its letter of 1 August 2019 to the CSN, the operator set out a schedule for monitoring of rainwater from the ATI site (itself within the overall site perimeter), via a rainwater collection shaft, to cover the hypothetical failure of the containers.

SAMPLE	SAMPLING	LOCATIONS (SITE CODE)	ANALYSIS	ANALYSIS
		03 – Almaraz de Tajo 04 – Casatejada 07 – Navalmoral de la Mata 31 – Caballerizas 50 – Castañar de Ibor (c)	Sr-90	Yearly
Drinking water (PO)	Once each two weeks	03 – Almaraz de Tajo 06 – Valdecañas de Tajo (c) 11 – Saucedilla	Gamma spectrometry Gross Beta activity Rest Beta activity H-3 Sr-90	Monthly Composite Monthly Composite Monthly Composite Three months composite Three months composite
Well water (PZ)/ (SB).	Three months	03 – Almaraz de Tajo 06 – Valdecañas de Tajo (c) 11 – Saucedilla	Gamma spectrometry H-3 Gross Beta activity Rest Beta activity	Three months Three months Three months Three months
Surface water (SP)	Monthly	08 – Río Tajo (10 km aguas arriba presa de Arrocampo) 09 – Río Tajo (Presa Arrocampo) 10 – Río Tajo (14 km aguas abajo presa de Arrocampo) 38 – Arroyo Arrocampo Las Casas (c) 39 – Arrocampo Embalse 45 – Embalse Valdecañas (c) 46 – Presa de Arrocampo 55 – Embalse Arrocampo (KK') 56 –Valdecañas Columnata (c)	Gamma spectrometry Gross Beta activity Rest Beta activity H-3	Monthly Monthly Monthly Three months Composite
Surface water (SP)	Once every two weeks (composite and continuous when releases)	46 bis – Aliviadero canal de descarga	H-3	Once every two weeks
Sediments (SDF)	Six months	08 – Río Tajo (5 km aguas arriba de la presa de Arrocampo) 09 – Río Tajo (Presa Arrocampo) 15 – Río Tajo (entrada Monfragüe) 38 – Arroyo Arrocampo Las Casas (c) 39 – Embalse Arrocampo 45 – Embalse Valdecañas (c) 46 – Arrocampo Presa 55 – Embalse Arrocampo (KK')	Gamma spectrometry Sr-90	Six months Six months
Lake and river shore sediments (SDO)	Six months	47 – Embalse Arrocampo (Ensenada cruce Saucedilla). 38 – Arrocampo - Arroyo Las Casas (c)	Gamma spectrometry	Six months
Indicator organisms (OI)	Six months	47 – Embalse Arrocampo (Ensenada cruce Saucedilla) 38 – Arrocampo Arroyo Las Casas (c)	Gamma spectrometry Sr-90	Six months Six months
Cow milk (LV)	Once each two weeks	12 – Belvis de Monroy 54 - Trujillo (c)	I-131 Gamma spectrometry Sr-90	Once each two weeks Monthly Monthly
Goat milk (LC)	Once each two weeks	05 - Serrejón 63 – Valdeobispo 50 – Castañar de Ibor (c)	I-131 Gamma spectrometry Sr-90	Once each two weeks Monthly Monthly

SAMPLE	SAMPLING	LOCATIONS (SITE CODE)	ANALYSIS	ANALYSIS
Sheep milk (LO)	Once each two weeks	49 – Plan de Regadíos de Valdecañas 52 – Peraleda de la Mata (c)	I-131 Gamma spectrometry Sr-90	Once each two weeks Monthly Monthly
Agricultural products, human foodstuffs (CH)	Yearly (while season)	03 – Almaraz 05 – Serrejón 28 – Mesas de Ibor 49 – Plan de Regadíos de Valdecañas 50 – Castañar de Ibor (c) 58 – Almaraz/Las Camadillas 61 – Almaraz / Jincaro III 62 - Finca La Anguila	I-131 (wide leaf) Gamma spectrometry Sr-90	Yearly Yearly Yearly
Agricultural products, animal foodstuffs (CL)	Yearly (while season)	05 - Serrejón 12 - Belvis de Monroy 49 - Plan de regadíos de Valdecañas 50 - Castañar de Ibor (c) 52 - Peraleda de la Mata (c) 54 - Trujillo (c) 63 - Valdeobispo	Gamma spectrometry Sr-90	Yearly
Fish (P)	Six months	15 – Río Tajo (embalse Torrejón) 39 – Embalse Arrocampo 45 – Embalse Valdecañas (c)	Gamma spectrometry	Six months
Meats, Chicken and Eggs	Six months	03 – Almaraz de Tajo 07 – Navalmoral de la Mata 49 – Plan de regadíos de Valdecañas 50 – Castañar de Ibor (c)	Gamma spectrometry	Six months
Hunting meat (CZ)	Yearly	17 – Coto de caza CNA	Gamma spectrometry	Yearly
Honey (ML)	Yearly	18 – Romangordo 50 – Castañar de Ibor (c)	Gamma spectrometry	Yearly

(c) Quality control sampling

The different locations of the **PVRA programme** where the integrated gamma exposure, air particles and I-131 in air are monitored, are provided with the following devices:

- Thermoluminescent Dosimeters: In order to measure the environmental radiation, MASL Laboratory provides TLDs (type TLD-100H) which are placed in the different stations of the Environmental Radiological Surveillance in the Almaraz NPP. Every TLD is composed of a card, which has four thermoluminescent detectors and a holder. The detector material is LiF:Mg, Cu, P. The detectors are calibrated in a Cs-137 irradiation unit (traceable to a national standard body) to calculate their element correction coefficients (ECC).
- Air samplers: Almaraz NPP uses the Model DF28BE environmental air sampling system with a digital flow meter, which is a low volume air sampler consisting of a no-oil carbon vane vacuum pump with a constant air flow. The regulator holds a constant pressure drop across an in-line orifice by varying the flow through a bypass valve into the pump. This system allows the pump to work at a minimum pressure drop at all times, permitting it to run cooler; thus extending its service life. The pump is mounted on a base plate within a weather resistant aluminium environmental enclosure having four rubber feet. The digital flow meter has a large bright LED display. The DF28BE is designed for continuous indoor or outdoor use. The typical operating design flow range is 14 - 122 l/min. The sampling flow in real operating conditions is 30 l/min.

Figure 4 below presents the locations of the PVRA monitoring locations.

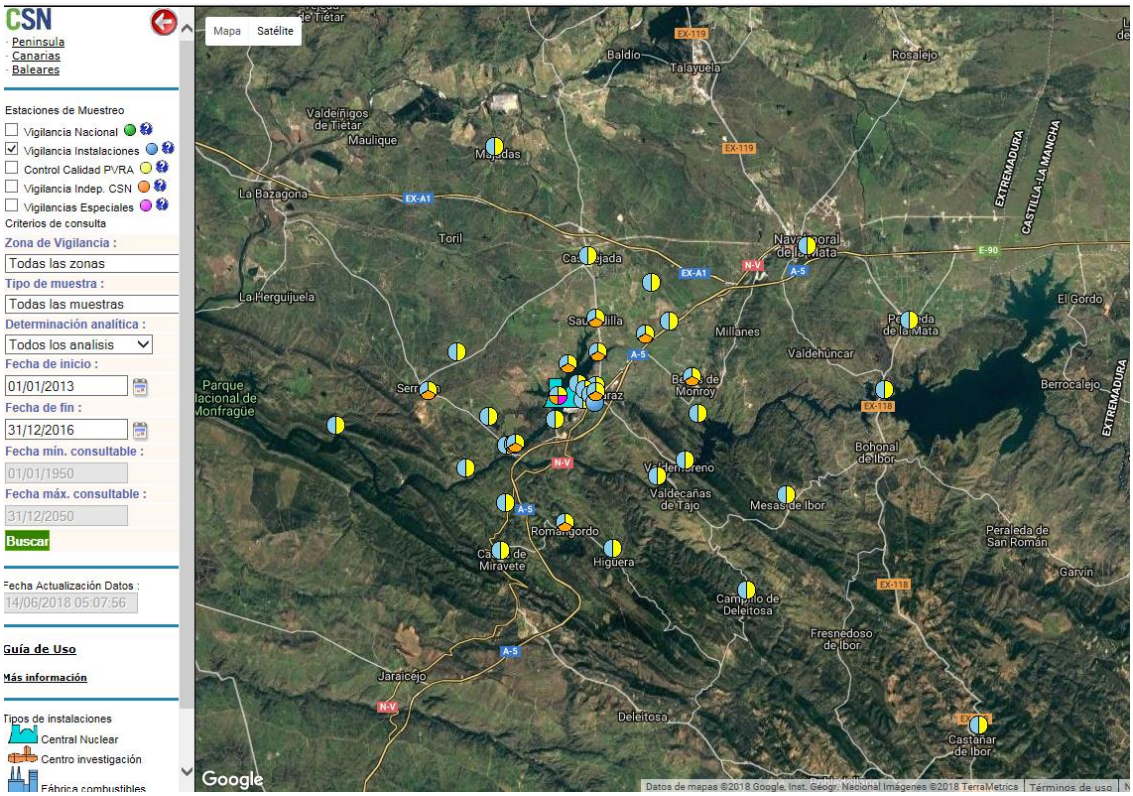

Figure 4. Off-site sampling/monitoring locations (PVRA)

5.3 AUTHORITIES' INDEPENDENT ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMMES

5.3.1 Automatic radiation dose rate monitoring networks

The REA network, operated by the CSN, has 24 monitoring stations nationwide. Two are located in the Autonomous Community of Extremadura. Additionally, in the vicinity of the Almaraz NPP, the Autonomous Government of Extremadura has its own network of online monitoring stations (RARE), managed by the LARUEX, with permanent (7 atmospheric and 2 water) radiation monitors plus one mobile laboratory. The CSN has signed an agreement with the Autonomous Government of Extremadura for the consultation and public use of the data from this network.

The Directorate General for Civil Protection and Emergencies has the Radioactivity Alert Network (RAR) with more than 20 stations for gamma dose rate measurement (more than 900 nationwide) around the Almaraz NPP.

5.3.2 PVRAIN environmental sampling

CSN carries out control of the operator's PVRA results by means of its own independent monitoring programme PVRAIN. The PVRAIN programme is based on a subset of some 5 to 50%, depending on the sample type, of the samples taken by the operator. This site related surveillance programme includes the samples presented in figure 5 and table III below.

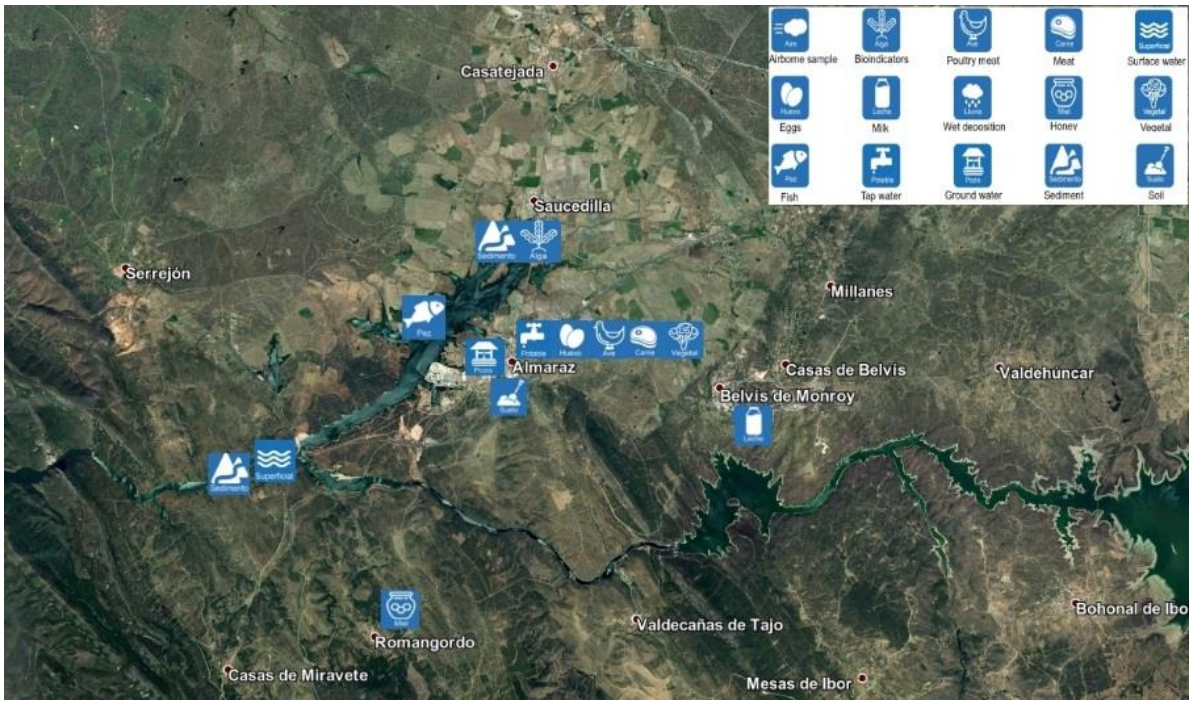

Figure 5. Sampling locations of the PVRAIN programme

Table III. PVRAIN samples

SAMPLE	POSITION	IDENTIFICATION OF SAMPLING POINT
Soil	39º 48' 50'' N 5º 40' 35'' W	Almaraz Town
Tap water	39º 48' 50'' N 5º 40' 35'' W	Almaraz Town
Surface water	39º 46' 57'' N 5º 44' 24'' W	River Tagus –Arrocampo reservoir
Groundwater	39º 48' 50'' N 5º 40' 35'' W	Almaraz Town
Sediment	39º 46' 57'' N 5º 44' 24'' W	River Tagus –Arrocampo reservoir
Shore sediment	39º 49' 56'' N 5º 40' 43'' W	Cove of Arrocampo reservoir
Bio indicators	39º 49' 56'' N 5º 40' 43'' W	Cove of Arrocampo reservoir
Milk	39º 49' 09'' N 5º 36' 36'' W	Belvis de Monroy
Crops	39º 48' 50'' N 5º 40' 35'' W	Almaraz Town
Meat, egg and poultry meat	39º 48' 50'' N 5º 40' 35'' W	Almaraz Town
Fish	39º 47' 15'' N 5º 43' 43'' W	Arrocampo reservoir
Honey	39º 44' 30'' N 5º 42' 02'' W	Romangordo

Sampling is carried out by the LARUEX. Sampling campaigns are scheduled at the beginning of the year in agreement with the operator's surveillance programme (PVRA). In the table IV, the PVRAIN programme for 2017 is presented as an example. Samples that quickly deteriorate (e.g. milk) are stabilised and/or cooled before sending to the analytical laboratory. In the analysis laboratories, sample pre-treatment and preparation for measurement generally follows accepted routines and Spanish standards where available.

Table IV. Analytical procedures in each of the collected samples in PVRAIN programme

MONTH	SAMPLES	SAMPLING QUANTITIES	ANALYTICAL
February	Cow milk	5 L	I-131
March	Groundwater	20 L	Gamma spect.; H-3; Gross Beta/K-40 contribution
	Cow milk	10 L	I-131, Sr-89/90, Gamma spect.
April	Crop	1 kg fresh	Gamma spect., Sr-89/90; I-131
	Sediments	1 kg wet	Gamma spect., Sr-89/90
	Cow milk	10 L	I-131, Sr-89/90, Gamma spect.
	Surface water	25 L	Gamma spect., Gross Beta/K-40 contribution
May	Meat	1 kg fresh	Gamma spect.
	Poultry meat	1 kg fresh	Gamma spect.
	Eggs	12 eggs	Gamma spect.
	Surface water	25 L	Gamma spect., Beta, T/R
	Cow milk	5 L	I-131
	Fish	1 kg	Gamma spect.

June	Shore sediment	2 kg	Gamma spect.
	Bio indicators	1 kg	Gamma spect., Sr-89/90
	Cow milk	10 L	I-131, Sr-89/90, Gamma spect.
	Surface water	25 L	Gamma spect., Gross Beta/K-40 contribution, H-3
July	Cow milk	5 L	I-131
	Tap water	10 L	Accumulated sample
	Tap water	10 L	Gamma spect., Gross Beta/K-40 contribution , H-3
August	Tap water	10 L	Accumulated sample
	Tap water	10 L	Accumulated sample
	Tap water	10 L	Gamma spect., Gross Beta/K-40 contribution, H-3
September	Cow milk	10 L	I-131, Sr-89/90, Gamma spect.
	Crop	1 kg fresh	I-131, Sr-89/90, Gamma spect.
	Surface water	25 L	Gamma spect., Gross Beta/K-40 contribution
	Surface water	25 L	Sr-89/90 (5); H-3
	Honey	0.5 kg	Gamma spect.
October	Surface water	25 L	Gamma spect., Gross Beta/K-40 contribution
	Cow milk	5 L	I-131
November	Surface water	25 L	Gamma spect., Gross Beta/K-40 contribution
	Soil	2 kg	Gamma spect., Sr-89/90
	Cow milk	10 L	I-131, Sr-89/90, Gamma spect.
December	Cow milk	5 L	I-131
	Surface water	25 L	Gamma spect., Gross Beta/K-40 contribution), H-3 (7)

5.3.3 COPUMA environmental sampling

COPUMA is an independent regional monitoring program around the Almaraz NPP, organised and financed by the Autonomous Government of Extremadura. Figure 6 presents the monitoring locations and tables V and VI the details of the sampling. Sampling is done by LARUEX. Special samples are taken or prepared by local experts. Sampling campaigns are scheduled at the beginning of the year in agreement with the operator's surveillance programme. In the analysis laboratories, sample pre-treatment and sample preparation for measurement follow generally accepted routines and Spanish standards where available.

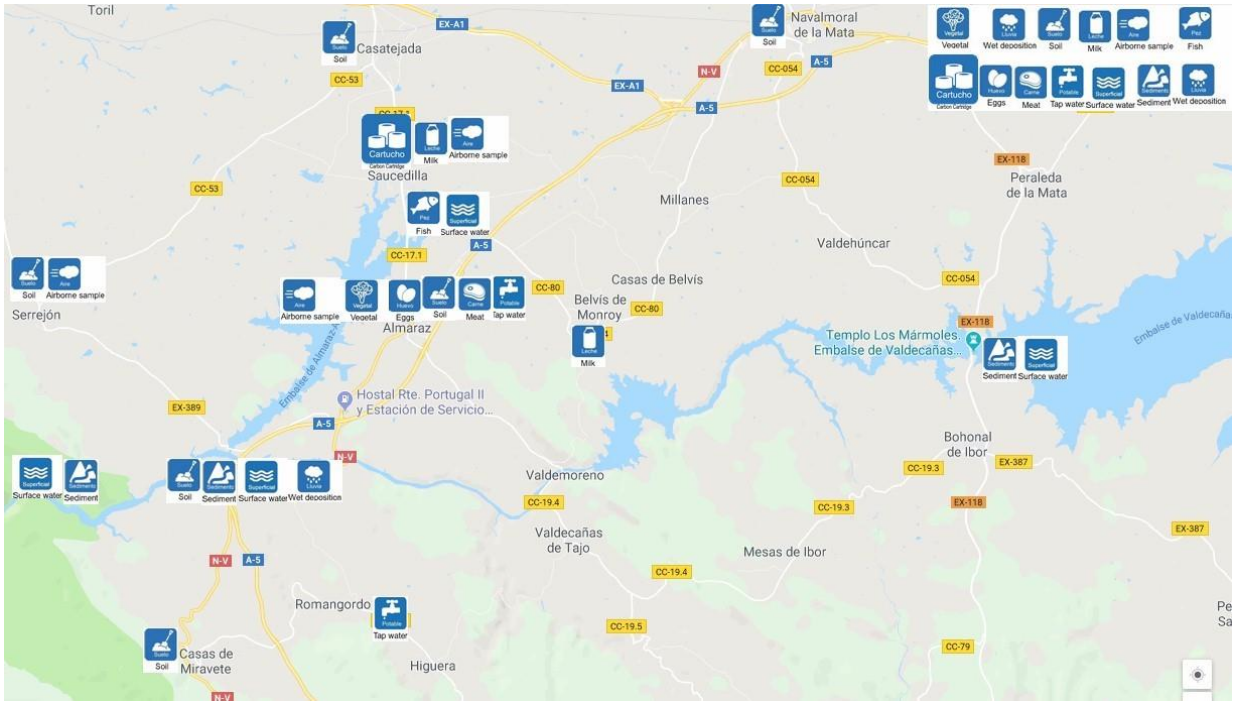

Figure 6. Sampling locations of the COPUMA programme

Table V. Samples of the COPUMA programme

SAMPLE	POSITION	IDENTIFICATION OF SAMPLING POINT
Sediment	39º47´00.41" N 5º44´23.12" W	River Tagus – Arrocampo reservoir
	39º50´18.43" N 5º40´28.45" W	Cove of Arrocampo reservoir
	39º46´41.1" N 5º37´12.47" W	Valdecañas Reservoir
	39º44´44.63" N 6º17´04.30" W	River Tagus (downstream)
	39º47´01.57" N 5º43´42.19" W	River Tagus Arrocampo reservoir
Soil	39º48´42.51" N 5º41´03.13" W	Almaraz town
	39º43´48.35" N 5º45´10.63" W	Casas de Miravete
	39º52´19.33" N 5º34´10.01" W	Navalmoral
	39º49´05.03" N 5º47´51.31" W	Serrejón
	39º52´48.35" N 5º41´45.87" W	Casatejada
Surface water	39º46´38.16" N 5º37´21.95" W	Valdecañas Reservoir
	39º47´02.94" N 5º44´20.41" W	River Tagus – Arrocampo reservoir
	39º50´21.13" N 5º40´27.99" W	Cove of Arrocampo reservoir
	39º44´44.63" N 6º17´04.30" W	River Tagus (downstream)
Tap water	39º49´08.36" N 05º40´18.02" W	Almaraz Town
	39º44'35.50'' N 5º41'57.25'' W	Romangordo
Wet deposition	39º47´00.41" N 5º44´23.12" W	River Tagus – Arrocampo reservoir
Cow milk	39º49´14.02" N 5º36´39.44" W	Belvis de Monroy
Goat milk	39º51´43.31" N 5º38´15.04" W	Saucedilla
Crops or Vegetables	39º48´55.16" N 05º40´29.83" W	Almaraz Town
Fish	39º47´30.06" N 05º41´49.82" W	Arrocampo reservoir
Meat, egg and poultry meat	39º48´55.16" N 05º40´29.83" W	Almaraz Town
Airborne particles and radioiodine charcoal cartridges	39º51´25.05" N 05º40´43.08" W	Saucedilla
Airborne particles	39º 48´51.8´´ N 05º 40´37.1´´ W	Almaraz
	39º49´12.34" N 5º47´53.50" W	Serrejón

Table VI. Analytical procedures of the collected samples in COPUMA programme

SAMPLES	FREQUENCY	SAMPLING QUANTITIES	ANALYTICAL
Sediments	monthly	2 kg	Sr-90, Gamma spect.
Soils	monthly	2 kg	Sr-90, Gamma spect.
Surface waters	monthly	25 L	Sr-90, Gamma spect. and H-3
Tap waters	monthly	25 L	Sr-90, Gamma spect. and H-3
Wet deposition	monthly	Related to the weather	H-3
Cow milk	monthly	10 L	Sr-90, Gamma spect.
Goat milk	monthly	5 L	I-131, Sr-90, Gamma spect.
Airborne particles	Every 15 days	~ 400 m^3	Sr-90 (accumulated samples) Gross alpha/beta
Airborne particles	Every 15 days	~ 8 m^3	H-3
Radioiodine charcoal cartridges	Every 15 days	~ 400 m^3	Gamma spect.
Meat	Every two months	1 kg fresh	Sr-90, Gamma spect.
Fish	monthly	1 kg fresh	Sr-90, Gamma spect.
Eggs	Every two months	12 eggs	Sr-90, Gamma spect.
Crops or Vegetables	monthly	1 kg fresh	Sr-90, Gamma spect.

5.4 MOBILE MONITORING SYSTEMS

5.4.1 Nuclear Safety Council

The Nuclear Safety Council (CSN) has signed collaboration agreements with the following specialized public entities, whose mobile radiological characterization units are available in case of emergency:

- Mobile unit for radiological characterization of the Centre for Energy, Environmental and Technological Research (CIEMAT), equipped with the following:
    - Measurement of external radiation (GAMMATRACER Geiger-Muller tube, Reuter Stokes RSS112 ionization chamber)
    - Air activity concentration measurement (high flow suction pump and solid scintillation detector (NaI(Tl))
    - Surface contamination measurement (two NaI(Tl) scintillation detectors)
- Mobile radiological characterization laboratory of the Autonomous Government of Extremadura operated by the Environmental Radioactivity Laboratory of the University of Extremadura (LARUEX) (see section 5.4.2).
- NRBQ VELIRE reconnaissance light vehicle of the Technological and Environmental Emergency Intervention Group (GIETMA) of the Military Emergency Unit (UME), with the ability to detect, identify and take environmental samples in radiological surveys by:
    - Integrated LAM 35 radiological detector, with two scintillation probes and two GM probes
    - Integrated RSX-1 radioisotope detector/identifier
    - Two SASS 3100 radiological sampling detectors

In the CSN Emergency Room (SALEM) the data recorded by the three radiological mobile units described above are received in real time. These data are shown on the map of the area that is being characterized. Operation of these mobile monitoring systems and the transmission of radiological and positioning variables is periodically exercised as part of the CSN's emergency planning.

5.4.2 Autonomous Government of Extremadura

The mobile laboratory shown in the figure 7 was designed and built by the Environmental Radioactivity Laboratory at the University of Extremadura (LARUEX) as an integral part of the Radiation Alert Network of Extremadura (RARE) for near real-time radiological surveillance. This is a commercial van of 5.5 m length and 28 m^3 capacity with the following equipment:

- A dose rate monitor calibrated for measurement of ambient dose rate. This is installed above the vehicle's front wheel. The monitor comprises a 54.2 cm^3 pressurized proportional counter, designed to measure dose rates in the range 0.005 µSv/h to 1 mSv/h.
- For the detection of local anomalies, it is necessary to work with very short measurement time intervals between 1 and 10 seconds. For this purpose, a $LaBr_3$(Ce) 1,5''x1,5'' detector is also installed above the vehicle's front wheel. It is designed to identify gamma-emitting radionuclides using a 1024-channel multichannel analyser calibrated in the energy range of 50 keV to 3 MeV.
- In order to locate orphan sources two NaI(Tl) 3x3'' detectors are situated on each side under the vehicle's chassis. These detectors are associated with their corresponding multichannel analysers.
- The mobile laboratory is also equipped with a high-resolution gamma spectrometry system. It consists of a portable coaxial p-type HPGe detector. When this detector is mounted on its tripod, it allows in-situ radioactivity measurement and characterization of soils. Housed within a low background iron shielding available inside the mobile

laboratory, it also facilitates radioactive characterization of different types and geometries of samples, such as the aerosols collected by the filters in the suction pump.

- An aerosol collecting system is installed in the vehicle. This system has an inflow rate of 334 l/min, using a 4.7 cm diameter glass fibre filter.
- The information on the radionuclide activity levels measured from the aerosol filters is supplemented with data provided by the mobile laboratory's meteorological station. This is installed on a telescopic mast that can be raised to a height of 1.7 m above the vehicle's roof.

The mobile laboratory's main power supply is a 4 kVA gasoline generator with an autonomy between 8 and 10 h. The secondary supply is a 12 V, 72 Ah battery, with an autonomy between 3 and 4 hours. A conventional GPS device is installed to register the mobile laboratory's geographical position, altitude above sea level and speed.

The primary communication system between the mobile laboratory and the headquarters is GSM, using a conventional mobile telephone. The mobile unit has a secondary backup communication system to take over automatically when there is no GSM coverage or the quality of that service is insufficient. This secondary system is based on satellite communication.

Figure 7. Mobile laboratory of the Autonomous Government of Extremadura operated by LARUEX.

6 ALMARAZ NPP LIQUID AND GASEOUS RADIOACTIVE DISCHARGE MONITORING PROGRAMMES

6.1 INTRODUCTION

Almaraz NPP discharges liquid radioactivity in the River Tajo via the Arrocampo reservoir and gaseous radioactivity to the atmosphere. Discharge of radioactive effluents is controlled by the document DAL-02.01 "Almaraz Nuclear Power Plant Offsite Doses Calculation Manual (ODCM)". This document is based on national and international regulations and guidelines, including:

- RD 783/2001 Regulation on the Protection of Health against Ionizing Radiations
- NUREG-1301 "Offsite dose calculation manual guidance: Standard radiological effluents controls for PWR"
- NUREG-0472 “Standard Radiological Effluent Technical Specifications for Pressurized Water Reactors”

The maximum dose limit for members of the public in the plant vicinity is specified in RD 783/2001, and is set at 1 mSv/year. The CSN establishes an operational restriction of 100 µSv per twelve consecutive months per reactor unit for the dose attributed to radioactive effluents (20 µSv liquid and 80 µSv gaseous).

6.2 MONITORING OF GASEOUS DISCHARGES

6.2.1 On-line monitoring

Gaseous radioactive effluents instrumentation is provided to monitor emissions of radioactive materials in gaseous effluents. Trigger points established for these instruments are calculated and adjusted to ensure that the trigger occurs before the dose rate limits specified in the ODCM are exceeded at points situated at the site boundary. The instruments are detailed in the Table VII below.

Table VII. Gaseous effluent monitoring instrumentation

INSTRUMENTATION		MINIMUM OPERATING CHANNELS
1.	**Discharge from the condenser air evacuation system**	
	a. Noble gases activity monitor that provides an alarm (RE-6790)	1
	b. Radioiodine sampler (TMA-6790A)	1
	c. Particle sampler (TMA-6790A)	1
	d. Flow meter (FT-2040 A/B)	1
	e. Sample flow meter (FI-6790)	N.A.
2.	**Auxiliary and safeguards buildings flue**	
	a. Noble gases activity monitor that provides an alarm and automatic activation (RE-6797)	1
	b. Radioiodine sampler (RE-6798)	1
	b. Particles sampler (RE-6799)	1
	d. Flow meter (FT-5714)	1
	e. Sample flow meter (FI-97-8-9)	N.A.
3.	**Containment enclosure and fuel building flue**	
	a. Noble gases activity monitor that provides an alarm and automatic activation (RE-6794)	1
	b. Radioiodine sampler (RE-6795)	1
	b. Particles sampler (RE-6796)	1
	d. Flow meter (FT-6327)	1
	e. Sample flow meter (FI-94-5-6)	N.A.

4.	**Discharge from the Controlled Zone Access Building (EAZC)**	
	a. EAZC Laundry Particle Sampler (PSX-TMA-04-CA)	1
	b. EAZC Services Particle Sampler (PSX-TMA-12-CA)	1
5.	**Discharge from the Decontamination and Hot Workshops Building (EDTC)**	
	a. EDTC General particle sampler (RE-6745)	1
	b. EDTC Backup particle sampler(RE-6746)	1
	c. EDTC General flow meter (FT-6425)	1
	d. EDTC Backup flow meter(FT6426)	1
6.	**Ventilation discharge from the FREC room**	
	a. Particle sampler (PSX-TMA-6803)	1

6.2.2 Sampling and analysis programme

Surveillance for protection of the public is based on evaluating the cumulative dose in 12 consecutive months that could potentially be received by members of the public as a consequence of the emissions of radioactive material into the environment. In order to facilitate continuous surveillance and control, instantaneous limits are established that provide a sufficient margin to guarantee that the annual dose limit will not be exceeded, while at the same time providing the facility with operational flexibility. The instantaneous dose rate limits ensure at all times that discharge rates of radioactive materials in gaseous effluents will be such that the corresponding doses above the background level, to members of the public at points located at or beyond the site boundary, will not exceed the values specified above.

To ensure these limits are met, the following surveillance requirements are performed:

- It is determined periodically that the dose rate due to noble gases in gaseous effluents is within the stated limits.
- It is determined periodically that the dose rate due to I-131, I-133, tritium, C-14 and all particulate radionuclides, with a half-life of more than 8 days in gaseous effluents, is within the stated limits, and representative samples and analyses are performed according to the sampling and analysis programme detailed in the Annex 3.

6.3 MONITORING OF LIQUID DISCHARGES

6.3.1 On-line monitoring

Liquid radioactive effluents monitoring instrumentation is provided to monitor emissions of radioactive materials in liquid effluents. Trigger points for these instruments are calculated and adjusted to ensure that the concentration limit trip occurs before the concentration limit in the uncontrolled area is exceeded. The instruments detailed in the Table VIII below are used to ensure that the established concentration limits are not exceeded.

Table VIII. Liquid effluent monitoring instrumentation

Instrument		**Minimum operating channels**
1.	**Radioactivity monitors that provide an alarm and automatic termination of emission**	
	a. Discharge from the radioactive liquid waste treatment system (RE-6787)	1
	b. Discharge from the steam generators purge treatment system (RE-6751/RE-6752)	1
	c. Discharge of atypical liquid effluents (RE-6783)(*)	1
	d. Discharge from the turbine sumps (RE-6801-I/II)	1
2.	**Radioactivity monitors that provide an alarm but no automatic termination of emission**	
	a. Discharge from the essential services system (RE-6786)	1

3.	**Flow measuring devices**	
	a. Discharge from the radioactive liquid waste treatment system (FT-4272/FT-4273)	1
	b. Discharge from the steam generators purge treatment system (FT-4960)	1
	c. Discharge of atypical liquid effluents (FT-2475)(*)	1
	d. Discharge from the essential services system FT-3615/FT-3616 and FT-3617/FT-3618	1

(*) If discharge of radioactive liquid effluents via the route is required.

6.3.2 Sampling and analysis programme

Surveillance to protect the public is based on evaluating cumulative doses in 12 consecutive months that can potentially be received by members of the public, as a consequence of the emissions of radioactive material into the environment. In order to facilitate continuous surveillance and control, instantaneous limits are established that provide a sufficient margin to guarantee that the annual dose limit will not be exceeded, while at the same time providing operational flexibility for the facility.

Samples of radioactive liquid waste are taken and analysed following the sampling and analysis programme in the table in Annex 2. The results of the radioactivity analyses are used to ensure that concentrations at the point of discharge remain within the established limits.

7 LABORATORIES PARTICIPATING IN THE ALMARAZ NPP DISCHARGE AND ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMMES

7.1 OPERATORS LABORATORY FOR DISCHARGE SAMPLES

The Almaraz NPP has a well-equipped radiological laboratory for analysing the radioactivity content of gaseous and liquid samples for discharge monitoring and operational purposes. The laboratory is available on 24/7 basis with a staff of 21. Samples are taken and/or received by the laboratory, examined and identified for their control and subsequent analysis. Sample preparation differs depending on the sample matrix, the analysis to be performed and the measurement technique.

Radiochemical measurements are recorded in measurement control books (gamma spectrometry, total gamma counting, liquid scintillation, total alpha counting). Measurement times are established to meet the detection limits specified in Commission Recommendation 2004/2/Euratom and in the Offsite Dose Control Manual (ODCM).

Calculations of specific activities and characteristic limits are performed by applying the ISO-11929 standard using the Genie2K application for gamma spectrometry and spreadsheets validated for this purpose for the other determinations. Table IX below presents the laboratory equipment.

Table IX. Almaraz NPP laboratory equipment

MEASUREMENT	EQUIPMENT NUMBER	MANUFACTURER	TYPE	CALIBRATION PROCEDURE	CALIBRATION SOURCE	RESULTS CALCULATION
Gamma	5	CANBERRA	HpGe semiconductor	QRX-CA-01.10E Efficiency and energy calibration Efficiency check Background measurements	Certified nuclide mixture E&Z	Genie2k
H-3	2	BECKMAN	Liquid scintillation counter	QRX-CA-01.11 and 11B Efficiency and energy calibration Efficiency check Background measurements	Certified H-3 standard	Spreadsheet
Sr-89/90	2	BECKMAN	Liquid scintillation counter	QRX-CA-01.11 and 11B Efficiency and energy calibration Efficiency check. Background measurements	Sr-89 and -90 certified standards	Spreadsheet
C-14	2	BECKMAN	Liquid scintillation counter	QRX-CA-01.11 and 11B Efficiency and energy calibration Efficiency check. Background measurements	Certified C-14 standard	Spreadsheet

MEASUREMENT	EQUIPMENT NUMBER	MANUFACTURER	TYPE	CALIBRATION PROCEDURE	CALIBRATION SOURCE	RESULTS CALCULATION
Total alpha	3	PERKIN-ELMER	Total alpha counter	QRX-CA-01.08E. Efficiency and energy calibration. Efficiency check Background measurements	Certified Am-241 standard	Spreadsheet
Total gamma	3	PERKIN-ELMER	Total gamma counter	QRX-CA-01.09.10E Efficiency calibration Efficiency check. Background measurements	Certified Cs-137 standard	Spreadsheet

Spreadsheets are used to calculate beta emitters and total alpha measurements. Specific activity values are calculated and recorded in the database with 2σ deviations. The results of the specific activity regarding an undetected physical signal are reported at half the level of the measurement decision threshold, as a conservative measure, as described in the Commission Recommendation 2004/2/Euratom. All results are calculated in accordance with Almaraz NPP ODCM. The Chemistry and Radiochemistry (QR) Section reports all the results obtained to the Environment and Radiation Protection Department (PS) Section, issuing the corresponding reports and computer files necessary to be uploaded to the CSN's computer applications. The results are printed and saved in the NPP archive as well as on the QR Section computer. The samples, once analysed, are stored until PS approval is obtained.

Every week, QR and PS meet to check that all reported results are in accordance with the requirements of the CSN and the Commission Recommendation 2004/2/Euratom.

Radiochemical measurement equipment is calibrated using Ecker & Ziegler radiochemical standards or similar for the different radionuclides of interest, and checked periodically, as well as being subject to a statistical control process with trend reports on the main quality variables. The entire quality control process is described in the QRX-ES-10 procedure. This procedure describes quality assurance methods for measurements using the different equipment using different statistical tools. These tools are used when a deviation is suspected in the measurements made by executing check measurements of background and standards.

In the case of gaseous sampling using gas samplers (TMG), samplers are checked periodically by the Instrumentation and Control staff, and for each sample taken by QR staff by applying the QRX-RQ-06.01 procedure.

The laboratory quality assurance system is certified in accordance with ISO 9001 standards. Results traceability is evaluated by means of a technical competency test by an accredited body using ISO 17025, CIEMAT (Energy, Environment and Technology Research Centre).

7.2 OPERATOR'S LABORATORIES FOR ENVIRONMENTAL SAMPLES

7.2.1 MASL

The Almaraz NPP has contracted the MASL (Laboratorio de Medidas Ambientales S.L. at Medina de Pomar) laboratory in Burgos to analyse environmental samples. It carries out the analysis of the PVRA programme on behalf of the operator.

Once the samples have been received at the laboratory, every sample is examined, identified by a standardised reference code and recorded in a sample file of the computer application specifically designed for radiological analysis. The reference code is recorded in the sample file and on all the sample containers. The sample preparation, which takes place prior to the measurement, differs depending on the matrixes and analysis to be performed. Table X below details the sample measurements and table XI the laboratory equipment.

Table X. MASL sample measurements

MEASUREMENT	MEASUREMENT DEVICE	COUNTING TIME
I-131	Alpha - beta low level counter	Air: 300 minutes Liquid food: 500 minutes Solid food (wide leaf vegetables): 300 minutes
Sr-89/90	Alpha - beta low level counter	Air: 300 minutes Liquid food: 180 minutes Solid food: 300 minutes Water: 180 minutes Soil/sediment: 800 minutes Vegetable (non-edible): 300 minutes
H-3	Ultra low level liquid scintillation spectrometer	Water: 70 minutes
Ba-140, Be-7, Bi-214, Ce-141, Ce-144, Co-58, Co-60, Cs-134, Cs-137, Fe-59, K-40, La-140, Mn-54, Nb-95, Pb-212, Pb-214, Sb-125, Tl-208, Zn-65, Zr-95, I-131	Gamma detector	Air: 20000 seconds Liquid food: 20000 seconds Solid food: 25000 seconds Water: 50000 seconds Soil/sediment: 30000 seconds Vegetable (non-edible): 50000 seconds
Gross beta/gross beta without potassium contribution	Alpha-beta low level counter	Air: 300 minutes Water: 500 minutes
Radiation dose	TLDs and TLD reader	Non applicable

Table XI. MASL measurement devices

MEASUREMENT DEVICE	MANUFACTURER	TYPE	CALIBRATION AND MAINTENANCE	STANDARD USED	CALCULATION OF RESULTS
Gamma detector (8)	CANBERRA	HPGe detector	Energy and efficiency calibration Efficiency checks Background measurements Liquid nitrogen charge MASL Lab. procedures ref. MLPMA-208 and MLPMA-253	Mixed gamma ray sources traceable to a national standard body	Computer application for radiological analysis
Alpha - beta low level counter (4)	BERTHOLD	Gas filled proportional counter	Efficiency calibration Efficiency checks Background measurements PR gas charge MASL Lab. procedure ref. MLPMA-205 and MLPMA-206	Sr-89/ Sr-90 – Y-90/ I-131/ Am-241 sources traceable to a national standard body	Computer application for radiological analysis
Ultra low level liquid scintillation spectrometer (1)	PERKIN-ELMER	Liquid scintillation counter	Efficiency calibration Efficiency checks Background measurements MASL Lab. procedure ref. MLPMA-204	H-3 source traceable to a national standard body	Spreadsheets
TLDs and TLD reader (1)	HARSHAW – BICRON	Thermolu minescence dosimetry (material - LiF:Mg, Cu, P)	Calculation of reader calibration factor (RCF) and element correction coefficients (ECC) MASL Lab. procedure ref.: MLPMA-209	Cs-137 irradiation unit traceable to a national standard body	Spreadsheets

Data are printed on paper as well as stored in a database on the MASL intranet. A validated computer application is used for the calculation of the activity results (except for tritium). Validated spreadsheets are used for the calculation of the radiation dose and tritium activity results.

MASL laboratory reports the results to Almaraz NPP. The analysis are performed according to established detection limits. Moreover, there are notification levels established for the activity

results. In the case that such notification levels are exceeded, the MASL laboratory should notify the corresponding results immediately to the nuclear power plant

After the analysis, the sample is stored to verify any result if required. Every analytical result is subject to quality assurance checks by the MASL laboratory staff. Various methods are applied in connection with quality assurance, such as

- Comparison of the calibration checking results
- Comparison of the background measurements
- Control of blank samples
- Analysis of unknown and duplicated samples
- Comparison of the measurements carried out by two different laboratories on the same sample
- Participation in national and international proficiency tests
- Weekly control of the detection limits and notification levels
- Control of process indicators
- Systematic comparison between the analytical results and the historical values of activity and detection limits
- Inspection of every analytical process

The MASL laboratory quality assurance system is certified by DNV (Det Norske Veritas) according to the international standard ISO 9001. The laboratory is undergoing accreditation for radioactivity measurements (gross beta, gross beta without potassium contribution, gross alpha and tritium) according to the international standard ISO 17025. It takes part in national intercomparisons organized by the CSN and international proficiency tests prepared by the IAEA.

7.2.2 CIEMAT

CIEMAT laboratory is located in Madrid. Unit of Environmental Radiology and Radiation Monitoring (URAyVR) carries out the analysis of the Almaraz NPP quality control programme. The unit is accredited by ENAC (UNE EN ISO/IEC 17025; accreditation number ENAC 144/LE471). URAyVR/CIEMAT have a quality assurance department that performs internal audits, reviews the procedures and maintains the quality system. Table XII details the analyses carried out and Table XIII the laboratory equipment. URAyVR retains the samples and reports in electronic format at least for 5 years after analysis and reporting.

Table XII. CIEMAT sample measurements

SAMPLE	RADIONUCLIDE	DEVICE	COUNTING TIME
Air, water, soil, sediments and biota	Gross beta activities	Proportional counters	1 000 min
Water	Gross beta activities excluding potassium	Atomic emission spectrometry	1 000 min
Air, water, soil, sediments and biota	Gamma emitters	Gamma spectrometry	60 000 s
Water	H-3	Scintillation counters	300 min
Air, water, soil, sediments and biota	Sr-90	Proportional counters	2 000 min
Air, water and biota	I-131	Gamma spectrometry	60 000 s

Table XIII. CIEMAT measurement devices

DEVICE	MANUFACTURER	TYPE OR MODEL	NUMBER
HPGe detectors	Canberra	GR2920, GR3321, GR4022, GX3519, BE5030, GC2518, GC3251, BE5030, GX4020, X10022 and GCW3521	11 detectors
Proportional counters	Berthold	LB-770 B	3 devices (30 detectors)
	Canberra	LB4200-8	1 device (8 detectors)
Scintillation counters	Packard	Tricarb 2750 TR/SL, Tricarb 2770, Tricarb 3100 and Tricarb 3110 TR	4 detectors

7.3 REGULATOR'S LABORATORY FOR SITE-RELATED ENVIRONMENTAL SAMPLES

7.3.1 LARUEX

The regulator's laboratory for site-related environmental samples is the LARUEX (Environmental Radioactivity Laboratory, University of Extremadura), located in Cáceres. It carries out the PVRAIN programme. It is a laboratory involved in environmental radioactivity monitoring (studies and routine programmes). Additionally It carries out the COPUMA programme for the Autonomous Government of Extremadura.

CSN carries out a control of the operator's PVRA by means of its own independent monitoring programme PVRAIN. In the case of the Almaraz NPP, this programme is assigned to the LARUEX. Sampling and measurements are performed independently from the NPP by the LARUEX, which reports the results directly to the CSN.

When the samples arrive at the LARUEX they are identified by an internal identification code. All information generated during this process are stored on paper and digitally. After the reception and identification of the samples, they are divided into aliquots and sent to the corresponding radiochemistry laboratories.

LARUEX has three sample measurement laboratories: one dedicated to the measurements by gamma spectrometry; another dedicated to the measurements of alpha-beta emitters and another for the measurements by atomic absorption spectrophotometry.

For gamma spectrometry, six detectors are available (Table XIV below). The devices are calibrated using mixed radionuclide sources. Energy checks are performed with the peaks in the samples. Efficiency controls are performed once every month using different IAEA reference samples or well-known activity concentration samples. Background is measured once per month (minimum two days).

Table XIV. LARUEX gamma spectrometry systems

DET. ID	TYPE DETECTOR	RELATIVE EFFICIENCY (%)	MANUFACTURER	DATA ACQUISITION AND EVALUATION	MCA
1	XtRa HPGe	42	Ortec	Gammavision	DSPEC plus
2	Coaxial reverse	25.6	Canberra	Gammavision	DSPEC plus
3	Coaxial HPGe	56.8	Ortec	Gammavision	DSPEC
4	Coaxial HPGe	37.3	Ortec	Gammavision	DSPEC
5	Coaxial HPGe	34.2	Canberra	Genie 2K 3.3	Inspector2K
6	XtRa HPGe	45	Canberra	Genie 2K 3.3	DSA1000

The laboratory has two Quantulus 1220 LSC devices. Tritium determination in water is carried out using the Optiphase Hisafe 3 cocktail in the proportion (aqueous sample/scintillator) 8/12, with counting time of 2400 s.

For gross alpha and beta measurements as well as for the determination of Sr-89/90 and I-131 in radiochemically prepared samples, three gas proportional counters (Berthold LB770-2 10 channel low-level counter) with a PC interface are used.

Finally, LARUEX has an Atomic Absorption Spectrophotometer (Perkin-Elmer AANALYS700) for the determination of different stable cations, including potassium.

The laboratory has established a system for the evaluation of the measurement results as well as for the realization of the reports established in the internal procedure PGC-14: “Procedure for the issuance of test reports”.

LARUEX is a laboratory accredited to ISO/IEC 17025:2017 (Accreditation No. 628/LE1260). The laboratory has different types of quality assurance through the use of appropriate reference materials for the demonstration of the validity of the methods. It has implemented a series of internal quality controls to ensure the reliability of the results of the samples. The laboratory has an annual plan of participation in intercomparison exercises that allows having an external reference in the evaluation of the results.

8 VERIFICATIONS

8.1 ALMARAZ NPP ON-SITE ENVIRONMENTAL RADIOACTIVITY MONITORING

8.1.1 On-site emergency dose rate monitor

The verification team visited the emergency dose rate monitor installed inside the plant area. This station has a measurement range from 10 nSv/h to 10 Sv/h. It is equipped with an Envinet dose rate monitor with two low dose rate and one high dose rate GM-tubes. Similar stations have been installed in all Spanish nuclear power plants after the Fukushima accident. The stations have radio communications (automatic transmission to the central computer and to the CSN emergency centre (SALEM) in Madrid), a 72h battery and a heavy seismic support structure on a 3x3m concrete baseplate.

No remarks.

8.1.2 On-site monitoring stations

The verification team visited one of the PVRA monitoring stations located close to the plant area fence. The station has the following equipment:

- Air filter station PSX-RAD-DF-05 (particulate and iodine filters, about 31 litres/min, calibrated flow rate monitor)
- TLD number 31
- Rain water collector (1×1 m), partially under a tree, monthly sample

Identical equipment is situated at the three other on-site monitoring stations.

No remarks.

8.2 ALMARAZ NPP OFF-SITE ENVIRONMENTAL RADIOACTIVITY MONITORING

8.2.1 RAE station at the Arrocampo dam

The RAE station is situated on a building close to the Arrocampo dam, and consists of an external dose rate probe, modem and a local dose rate display.

No remarks.

8.2.2 RAE and RAR stations at the Almaraz village

The RAE station at the Almaraz village is located at the permanently manned Guardia Civil office. It consist of a dose rate probe at the building wall, modem and a local dose rate display.

The RAR station at the Almaraz village is located at the same permanently manned Guardia Civil office as the RAE station. It consist of a dose rate probe on the building roof, modem and a local dose rate display.

No remarks.

8.2.3 RARE station at Serrejon

The RARE station at Serrejon is an air-conditioned container placed in a schoolyard. The following monitoring systems are available:

- Berthold air radioactivity detection system (BAI 9100-D) with a rolling filter paper (particulates) and a charcoal cartridge (iodine)
- Bubbler sampler for monitoring H-3 and Iodine in air
- Meteorological monitors (temperature, rainfall, wind speed and direction)

Electrical back-up (UPS) is available for 3-4 hours of operation.

No remarks.

8.2.4 RAE station at the Arrocampo water monitoring building

The RAE station at Arrocampo is located on the roof of the water monitoring building. There is a doserate probe and a temperature sensor. Data is transmitted via a radio modem; a local dose rate display is available.

No remarks.

8.2.5 RARE station at Saucedilla

The RARE station at Saucedilla is housed in an air-conditioned container with continuous video camera surveillance. It is equipped with a Berthold air monitoring system based on $LaBr_3$ and NaI detectors allowing advanced nuclide identification capabilities. There is also an Iodine monitor using an automated carbon cartridge changer. In the event of an emergency, the system airflow can be increased for more rapid monitoring.

The verification team commends the advanced monitoring systems available at this station.

8.2.6 RAE and PVRA stations at Casatejada

The RAE station is located at the barracks of the Guardia Civil. There is a dose rate monitor with local display and a modem.

The PVRA station at Casatejada has the following equipment:

- Air filter station PSX-RAD-DF-08 (particulate and iodine filters, about 30 litres/min, calibrated flow rate monitor)
- TLD number 4
- Rain water collector (1×1 m), monthly sample

No remarks.

8.2.7 REM station in Cáceres

The REM station in Cáceres is located close to the LARUEX laboratory. The station has a high-volume air sampler (50×50 cm heated particle filter) and a medium volume air sampler with particle and iodine filters. All filters are changed weekly. Airflow is monitored by flowmeters; a certified flow calibrator is available for calibrating the flowmeters.

The verification team commends the availability of the flowmeter calibration equipment.

8.2.8 TLD monitors

Verification team verified the presence of TLDs at several locations (farmhouse tree, bush next to the road, building wall…etc.). TLDs are changed every three months.

Locations of some off-site TLDs are exposed in the public domain and therefore there is a risk of tampering or theft[5].

The verification team suggests placing back-up TLDs close to the current units in the most exposed locations.

8.2.9 Operators mobile monitoring equipment

The operator of the Almaraz NPP has no mobile laboratory, but there are two sets of portable equipment (Fig. 8), which can be used to carry out radiation dose rate monitoring and environmental sampling in the plant vicinity in the event of an emergency. The equipment includes the following:

- Portable air sampler (particulate and iodine filter)

[5] Verification team was informed, that so far no TLD has been lost due to theft or tampering.

- Water sampling equipment
- Satellite telephone and a mobile phone
- Dose rate monitor
- Contamination monitor
- Personal dosimeters and protective equipment

In addition, the equipment kit contains the relevant monitoring instructions (checklists) and sampling sheets for sample documentation.

No remarks.

Figure 8. Field sampling equipment of the Almaraz NPP operator

8.3 MONITORING OF RADIOACTIVITY IN COOLING WATER DISCHARGES TO RIVER TAJO AT ARROCAMPO

The verification team visited the RARE water monitoring facility at the discharge point from the south end of the Arrocampo reservoir to the River Tajo. The facility is equipped with a $LaBr_3$-detector (2×2") gamma spectroscopy system on a 25 litre continuous flow-through sample container (Fig. 9). For electrical back-up there is a UPS (8h) and a diesel generator, which can supply also the sampling pumps. Data is transferred to the NPP via a modem; high activity alarms are sent also via SMS. There is also a meteorological station at this location.

There is also an automatic sampling station at the discharge point for the monitoring of tritium in water, which is collected and analysed on a biweekly frequency basis. The station has a device for capturing the water sample in case of high radioactivity in the water; the sample is taken manually for laboratory analysis**.**

No remarks.

Figure 9. RARE continuous water radioactivity monitor for the cooling water discharge to river Tajo

8.4 MONITORING OF RADIOACTIVE DISCHARGES AT THE ALMARAZ NPP

8.4.1 Gaseous discharges

The verification team verified the availability of the following gaseous discharge monitoring equipment:

- Vacuum condenser monitor RE-6790 (Unit 1)
- Auxiliary and safeguards buildings flue monitors TR.6799 TR- 6797 and TR-6798 (Unit 2)
  - Particle, gaseous and iodine monitor
- Containment enclosure and fuel building flue monitors TR-6796, TR-6794 and TR-6795
  - Particle, gaseous and iodine monitor
- ^{3}H and ^{14}C bubbler samplers
  - 5 systems in each unit
- FREC ventilation discharge particle sampler
- Emergency monitor RMI-RY-203-51A
  - Normal and high range monitors
  - Connected to SALEM
  - One system operational, one on stand-by
- Emergency filter system RMI-RX-PA-SP
  - Particulate and Iodine

No remarks.

8.4.2 Liquid discharges

The verification team verified the availability of the following liquid discharge monitoring equipment:

- Turbine sump discharge radioactivity monitor (Unit 2)
  - Automatic purge cut-off at high value
- Liquid waste treatment system discharge monitors (Unit 2)
  - 3 waste water tanks
- Steam generator purge treatment monitor (Unit 2)
  - Continuous beta monitors on purge tanks
  - Automatic tank isolation on high values
- Atypical liquid discharge monitor (Unit 2)
  - Automatic discharge cut-off on high values
- Coolant outflow channel monitors (Unit 2)
  - Lake discharge monitoring on discharge pipe before mixing

No remarks.

8.5 ASSOCIATED ANALYTICAL LABORATORIES

8.5.1 Operator laboratories at the Almaraz NPP

There are two radiological laboratories at the Almaraz NPP with mostly identical equipment: the 'hot' laboratory at the radiation controlled area and the 'cold' laboratory outside the controlled area. The laboratories work on 24h basis with staff of 21. The verification team visited the laboratories, which carry out the analysis of the gaseous and liquid discharge samples.

Liquid waste treatment tanks (including laundry tanks) are only discharged when the samples have been analysed and the results approved by the radiation protection group. Fractions of the samples are retained for monthly and quarterly analyses.

Quality of the analysis is controlled by the annual control programme (CC) carried out by CIEMAT and by occasional control samples sent to the CSN. In addition, the laboratory participates in intercomparison exercises for water samples (all Spanish NPPs) and for C-14 (CIEMAT).

Laboratory counting room 1 equipment includes two NaI detectors for total-gamma measurements, one HPGe gamma spectroscopy system (Canberra) and two liquid scintillation counters (Beckman CS6000SC) for beta counting (H-3, C-14 and Sr-90). Counting room 2 has identical HPGe and NaI detectors and two total alpha counters. In addition there is a radiochemistry room with equipment for radiochemical separation and other chemical analysis.

Analysis results are stored in the laboratory database for subsequent use in the dose calculations. A monthly report is prepared for the CSN, which uses this data and data from its own monitoring programmes to prepare an annual monitoring report, available to the public.

No remarks.

8.5.2 LARUEX laboratory

The verification team visited the LARUEX laboratory in Cáceres. The laboratory has a staff of 20. It carries out the analysis of the PVRA programme samples and provides other analytical services for the authorities and the nuclear fuel cycle industry.

The main equipment of the laboratory is the following:

- Inductively coupled photon mass spectroscopy system (ICP-MS) for stable element analysis (for example total U)
- 6 HPGe gamma spectroscopy systems (Canberra and Ortec)
- 3 proportional counters (Berthold LB770 and 790)
- 2 liquid scintillation counters (Perkin Elmer Quantulus 1220)

- Alpha counter (Canberra Alpha Analyst, 17 chambers)

In order to avoid cross-contamination, the rooms in the laboratory building have been allocated for different measurement types and techniques; sample containers have been allocated to each room with colour codes. A separate room is available for processing, analysing and storing possible contaminated samples in the event of an emergency. The building itself is quite small, so the laboratory facility appears cramped and overfilled with samples and equipment.

The verification team commends the innovative solutions in sample management.

8.5.3 LARUEX mobile monitoring equipment

Mobile laboratory vehicle

The verification team verified the mobile laboratory of the Autonomous Government of Extremadura operated by LARUEX (Fig. 7), which is equipped for sampling and analysis of environmental samples in the event of a radiological emergency. The vehicle is equipped with a GM-detector for dose rate monitoring and a $LaBr_3$-detector for nuclide identification. In addition, there are two NaI detectors installed on both sides of the vehicle for directional radiation field sensitivity and a meteorological station.

The mobile laboratory has a diesel generator for autonomous operation, GPS positioning system and satellite communications. Altogether five staff members have been trained to use the vehicle.

Radiation monitor drone

LARUEX laboratory radiation monitoring drone is a commercial drone equipped by LARUEX to monitor radiation and identify radioactive targets (Fig. 10). The system consists of a $LaBr_3$-detector and an on-board camera, which are controlled with a mobile phone application. This allows the user to remotely take a picture of the target and measure the radiation spectrum for nuclide identification.

The verification team commends the innovative solutions in the LARUEX mobile radiation monitoring equipment.

Figure 10. LARUEX radioactivity monitoring drone

8.6 OTHER VERIFICATIONS

8.6.1 Regional emergency centre

The verification team visited the regional emergency centre, which has been built at the University of Extremadura and operated by LARUEX. This centre is used in emergency situations (nuclear, flooding, wildfires, etc.). It is very well equipped to receive and display data from several regional emergency monitoring systems.

No remarks.

9 CONCLUSIONS

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

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

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

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

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

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

(5) The Commission services request a report on any significant changes in the set-up of the monitoring arrangements before the end of 2020, in particular with regard to the new temporary spent nuclear fuel storage facility (ATI). Based on this report the Commission will consider the need for a follow-up verification.

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

ANNEX 1

VERIFICATION PROGRAMME

Date	Time	Verification target
Tuesday 17 July	9.30 – 11.00	Opening meeting (Almaraz NPP)
	11.00 – 12.30	On-site radiation monitoring • On-site Alert Network RAI
	13.30 – 17.00	Off-site radiation monitoring • RAE stations close to the NPP • Thermoluminescent dosimeters (TLD) • RARE stations close to the NPP (Serrejon, Saucedilla, Arrocampo and Valdecañas) • REA stations close to the NPP • Almaraz NPP mobile monitoring equipment
Wednesday 18 July	9.00 – 12.30	Monitoring of Almaraz NPP gaseous discharges • Containment Enclosure and Fuel Building Flue • Discharge from the Ventilation Controlled Access Area, Auxiliary Fireplace, Purges and Safeguards • Condenser Vacuum and Closure Steam Discharge • Discharge from the Controlled Zone Access Building • Discharge from the Decontamination and Hot Workshops Building • Ventilation Discharge from the FREC Room
	13.30 – 17.00	Monitoring of Almaraz NPP liquid discharges • Discharge from the Radioactive Liquid Waste Treatment System • Discharge from the Steam Generators Purge Treatment System • Discharge from the Turbine Sumps • Discharge of Atypical Liquid Effluents • Discharge from the Essential Services System
Thursday 19 July	9.00 – 12.00	Almaraz NPP laboratory for discharge samples
	14:00 – 16:30	LARUEX laboratory for environmental samples, University of Extremadura, Cáceres • Radiological laboratory • Mobile laboratory • Radioactivity monitoring drone
	16:45	Closing meeting (LARUEX laboratory)

ANNEX 2

ALMARAZ NPP LIQUID RADIOACTIVE EFFLUENTS SAMPLING AND ANALYSIS PROGRAMME

TYPE OF LIQUID DISCHARGE	SAMPLING FREQUENCY	MINIMUM ANALYSIS FREQUENCY	ACTIVITY ANALYSIS TYPE	LOWER DETECTION LIMIT (LID) OF KEY NUCLEIDS (1) Bq/m^3 (Ci/m^3)
A. Waste discharge deposits in batches (2)	P (*) Each batch	P (*) Each batch	Main gamma emitters (3) (9)	Co-60 1E+4 (2.7 E-7) Cs-137 1E+4 (2.7 E-7)
			Fe-55; Ni-63 (8) (9)	
	P One batch/M	M	Dragged and dissolved gases (Gamma emitters) (9)	Xe-135 3,7 E+5 (1 E-5)
	P Each batch	M Composite (4)	H-3 (9)	1 E+5 (2.7 E-6)
			Total alpha (9)	1 E+3 (2.7 E-8)
	P Each batch	Q Composite (4)	Sr-89, Sr-90 (9)	Sr-90 1E+3 (2.7 E-8)
B. Steam generators purge continuous discharge (5)	W Spot Sample	W (6)	Main gamma emitters (3) (9)	Co-60 1E+4 (2.7 E-7) Cs-137 1E+4 (2.7 E-7)
			Fe-55; Ni-63 (8) (9)	
	M Spot Sample	M (6)	Dragged and dissolved gases (Gamma emitters) (9)	Xe-135 3,7 E+5 (1 E-5)
	W Spot Sample	M (7) Composite	H-3 (9)	1 E+5 (2.7 E-6)
			Total alpha (9)	1 E+3 (2.7 E-8)
	W Spot Sample	Q (7) Composite	Sr-89, Sr-90 (9)	Sr-90 1E+3 (2.7 E-8)
C. Turbine sumps continuous discharge (5)	W Spot Sample	W (6)	Main gamma emitters (3) (9)	Co-60 1E+4 (2.7 E-7) Cs-137 1E+4 (2.7 E-7)
			Fe-55; Ni-63 (8) (9)	
	M Spot Sample	M (6)	Dragged and dissolved gases (Gamma emitters) (9)	Xe-135 3.7 E+5 (1 E-5)
	W Spot Sample	M (7) Composite	H-3 (9)	1 E+5 (2.7 E-6)
			Total alpha (9)	1 E+3 (2.7 E-8)
	W Spot Sample	Q (7) Composite	Sr-89, Sr-90 (9)	Sr-90 1E+3 (2.7 E-8)

(*) Before each batch

Symbols used:

Symbols	Frequency
D	Once at least every 24 hours
W	Once at least every 7 days
B	Once at least every 15 days
M	Once at least every 31 days
Q	Once at least every 92 days
SA	Once at least every 6 months
R	Once at least every 18 months
P	Once per batch
N.A.	Non applicable

TABLE NOTATION

1. The determination of detection limits and decision thresholds, as well as the expression of results, must conform to ISO/IS-11929-7. It should be noted that LDL is defined as an a priori limit (before the fact) that represents the capability of a measurement system, and not as an a posteriori limit (after the fact) for a given measurement.
2. A batch spill is the discharge of a discrete volume of liquid waste. Before taking a sample for analysis, each batch will be isolated and mixed to ensure a representative sampling.
3. The following gamma emitters shall be determined as a minimum: Cr-51, Mn-54, Co-58, Fe-59, Co-60, Zn-65, Nb-95, Zr-95, Ru-103, Ru-106, Ag-110m, Sb-122, Te-123m, Sb-124, Sb-125, I-131, Cs-134, Cs-137, Ba-140, La-140, Ce-141, Ce-144. This list does not mean that only these radionuclides should be considered. If any other gamma peaks are identified together with any of the aforementioned isotopes, they will be analysed and included in the corresponding Monthly Operation Report.
4. A composite sample is one in which the quantity of liquid sampled is proportional to the amount of liquid waste discharged, and in which the sampling method used results in a representative sample of the liquids discharged.
5. A continuous discharge is the discharge of a non-discrete volume of liquid waste; for example, the discharge of a volume from a system that contributes flow during the continuous discharge in question. Continuous emission does not presume that it should be performed without interruption during operation of the plant, but there may be periods without discharges between successive emissions.
6. Whenever there has been a spillage.
7. In order for the samples to be representative of the quantities and concentrations of radioactive materials in the liquid effluents, they must be collected continuously in proportion to the effluent flow rate. Prior to analysis, all samples collected will be mixed together to ensure that the composite sample is representative of the effluent discharged.
8. The activity of these isotopes is calculated from the Co-60 activity measured. The relationship is established from the measurement of Co-60, Fe-55 and Ni-63 in a sample taken during the previous period.
9. In cases where the results of the measurement are below the decision threshold, they should be replaced as a precaution at half the decision threshold. However, if the results of repeated measurements in the reference period are always lower than the decision threshold, it is reasonable to assume that the true value is zero, i.e., that the radionuclide is not present in the spill.

The reference period for information on radioactive discharges will be the year before the one to be considered and so far in the current year.

The Commission Recommendation of 18 December 2003 (2004/2/EURATOM) defines "Decision threshold" as: decision quantity fixed value (random variable to decide whether the physical effect to be measured occurred or not) by which it is decided, an actual measurement of a measurand that quantifies a physical effect exceeded it, that the physical effect in question did occur. It is also established that, for practical reasons, although the decision threshold is technically less than half the detection limit actually found in a measurement, the decision threshold can be considered, as a precaution, equal to half the detection limit.

ANNEX 3

ALMARAZ NPP GASEOUS RADIOACTIVE EFFLUENTS SAMPLING AND ANALYSIS PROGRAMME

TYPE OF GASEOUS RELEASE	SAMPLING FREQUENCY	MINIMUM ANALYSIS FREQUENCY	ACTIVITY ANALYSIS TYPE	LOWER DETECTION LIMIT (LDL) (1) $Bq/m^3 (Ci/m^3)$
1.a. Containment enclosure and fuel building flue(*)	M Spot Sample (6)(9)	M (6)(9)	Main gamma emitters (NG) (2) (5)	Kr-85 1E+4 (2.7 E-7)
	B Spot Sample (**) (6) (7) (8)	B (6) (7) (8)	H-3 (Oxide and molecular) (5)	1 E+3 (2.7 E-8)
			C-14 (Inorganic and organic) (5)	1 E+1 (2.7 E-10)
1.b. Auxiliary and safeguards buildings flue	M Spot Sample (9)	M (9)	Main gamma emitters (NG) (2) (5)	Kr-85 1 E+4 (2.7 E-7)
	B Spot Sample	B	H-3 (Oxide and molecular) (5)	1 E+3 (2.7 E-8)
			C-14 (Inorganic and organic) (5)	1 E+1 (2.7 E-10)
1.c. Discharge from the condenser air evacuation system	M Spot Sample (9)	M (9)	Main gamma emitters (NG) (2) (5)	Kr-85 1 E+4 (2.7 E-7)
2. All types of discharges listed in points 1.a, 1.b and 1.c	Continuous sample (3)	W (4) Carbon sample	Iodine (2) (5)	I-131 2 E-2 (5,4 E-13)
	Continuous sample (3)	W (4) Particle sample	Main gamma emitters (P) (2) (5)	Co-60 1 E-2 (2.7 E-13) Cs-137 3 E-2 (8.1 E-13)
	Continuous sample (3)	M Composite particles sample	Total alpha (5)	1 E-2 (2.7 E-13)
	Continuous sample (3)	M Composite particles sample	Sr-89, Sr-90 (5)	Sr-90 2 E-2 (5.4 E-13)
3. Gaseous waste storage tanks	P Each tank Point sample	P Each tank	Main gamma emitters (GN) (2) (5)	Kr-85 1 E+4 (2,7 E-7)
4. Containment enclosure purges	P Each tank Point sample	P Each purge	Main gamma emitters (GN) (P) (2) (5)	Kr-85 1E+4 (2.7 E-7) Co-60 1 E-2 (2.7 E-13) Cs-137 3 E-2 (8.1 E-13)
			Iodine (2) (5)	I-131 2 E-2 (5.4 E-13)
	P Each tank Point sample	P Each purge	H-3 (Oxide and molecular) (5)	1 E+3 (2.7 E-8)
			C-14 (Inorganic and organic) (5)	1 E+1 (2.7 E-10)

5. Controlled Zone Access Building (EAZC) (Includes laundry and services ventilation).	Continuous sample	M Particles sample	Main gamma emitters (P) (2) (5)	Co-60 1 E-2 (2.7 E-13) Cs-137 3 E-2 (8.1 E-13)
	Continuous sample	M Composite particles sample	Total alpha (5)	1 E-2 (2.7 E-13)
	Continuous sample	Q Composite particles sample	Sr-89, Sr-90 (5)	Sr-90 2E-2 (5.4 E-13)
6. Decontamination and Hot Workshops Building (EDTC) (Includes general ventilation and backup ventilation)	Continuous sample	M Particles sample	Main gamma emitters (P) (2) (5)	Co-60 1 E-2 (2.7 E-13) Cs-137 3 E-2 (8.1 E-13)
	Continuous sample	M Composite particles sample	Total alpha (5)	1 E-2 (2.7 E-13)
	Continuous sample	Q Composite particles sample	Sr-89, Sr-90 (5)	Sr-90 2 E-2 (5.4 E-13)
7. FREC Room (Room ventilation)	Continuous sample	M Particles sample	Main gamma emitters (P) (2) (5)	Co-60 1 E-2 (2.7 E-13) Cs-137 3 E-2 (8.1 E-13)
	Continuous sample	M Composite particles sample	Total alpha (5)	1 E-2 (2.7 E-13)
	Continuous sample	Q Composite particles sample	Sr-89, Sr-90 (5)	Sr-90 2 E-2 (5.4 E-13)

(*) For noble gases, independent samples are taken to characterise the fuel ventilation and containment enclosure reliefs.

(**) Sampling must coincide with one relief at minimum.

Symbols used:

Symbols	**Frequency**
D	Once at least every 24 hours
W	Once at least every 7 days
B	Once at least every 15 days
M	Once at least every 31 days
Q	Once at least every 92 days
SA	Once at least every 6 months
R	Once at least every 18 months

TABLE NOTATION

(1) The determination of detection limits and decision thresholds, as well as the expression of results, must conform to ISO/IS-11929-7. It should be noted that LDL is defined as an *a priori* limit (before the fact) that represents the capability of a measurement system, and not as an *a posteriori* limit (after the fact) for a given measurement.

(2) The following gamma emitters shall be established as a minimum:

a. In noble gases: Ar-41, Kr-85, Kr-85m, Kr-87, Kr-88, Kr-89, Xe-131m, Xe-133, Xe-133m, Xe-135, Xe-135m, Xe-137 and Xe-138.

b. In particles: Cr-51, Mn-54, Co-58, Fe-59, Co-60, Zn-65, Nb-95, Zr-95, Ag-110m, Sb-122, Sb-124, Sb-125, Cs-134, Cs-137, Ba-140, La-140, Ce-141 and Ce-144.

c. In Iodine: I-131, I-132, I-133 and I-135.

This list does not mean that only these radionuclides should be considered. If any other gamma peaks are identified together with any of the aforementioned isotopes, they will be analysed and included in the corresponding Monthly Operation Report.

(3) The relationship between the sample flow rate, and the flow rate sampled for the period of time covered for each dose or dose rate calculation made in accordance with ODCM Controls 2.2.2.1 and 2.2.3.1 shall be known.

(4) Samples will be changed at least once every 7 days and analyses will be performed within 48 hours after the change or after their removal from the sampler. Sampling shall also be carried out at least once every 24 hours for at least 7 days after each stoppage, start-up or THERMAL POWER variation greater than 15% of NOMINAL THERMAL POWER in a 1 hour period, and analyses will be completed within 48 hours. When analysing samples collected over 24 hours, the corresponding LDLs can be increased by a factor of 10. This requirement does not apply if:

(a) analysis shows that the EQUIVALENT DOSE in I-131 in the reactor coolant has not increased by more than a factor of 3; and

(b) the noble gases monitor shows that effluent activity has not increased by more than a factor of 3.

This will apply to all gaseous effluent emission routes that could be affected by the stoppage, start-up or THERMAL POWER variation greater than 15% of NOMINAL THERMAL POWER in a 1 hour period.

Explanatory notes to point (4):

The reference sample to be considered in the case of point (a) is the last one taken before the power variation, stoppage or start-up. In the case of monitor reading (b), the same consideration will apply (last value prior to the condition). In the case of start-ups, the reference sample is not the last one taken before the power change (zero power at stoppage, power greater than zero at start-up), but the one corresponding to the plant situation prior to stoppage.

Starting on the eighth day, sampling and analyse will continue if at least one of the two defined conditions (a) and (b) is not met.

The sampling and analysis programme will not be executed when the two defined conditions (a) and (b) are simultaneously fulfilled.

(5) In cases where the measurement results are below the decision threshold, they should be replaced as a prudent precaution at half the decision threshold. However, if the results of repeated measurements during the reference period are always lower than the decision threshold, it is reasonable to assume that the true value is zero, i.e. that the radionuclide is not present in the spill.

The reference period for information on radioactive discharges will be the year before the one to be considered and so far in the current year.

The Commission Recommendation of 18 December 2003 (2004/2/EURATOM) defines "Decision threshold" as: decision quantity fixed value (random variable to decide whether the physical effect to be measured occurred or not) by which it is decided, when it is exceeded by an actual measurement of a measurand that quantifies a physical effect, that the physical effect in question did occur. It is also established that, for practical reasons, although the decision threshold is technically less than half the detection limit actually found in a measurement, the decision threshold can be considered as a precaution, to be equal to half the detection limit.

(6) Sampling and analysis shall also be carried out after each stoppage, start-up or THERMAL POWER variation that exceeds 15% of the NOMINAL THERMAL POWER in one hour.

(7) Tritium will be sampled and analysed at least once every 24 hours when the refuelling cavity is flooded.

(8) It will be sampled for a minimum of 72 hours and tritium and C-14 analysed at least once every 15 days, from the fuel building ventilation discharge as long as there is spent fuel in the pool.

(9) The frequency of sampling and analysis of main gamma emitters (GN) may be modified depending on the operating circumstances of the plant, and is regulated by plant procedure PS-PV-09.07.