Radioactive Substances Series

PARCOM Recommendation 91/4 on Radioactive Discharges

Spanish Implementation Report

OSPAR Commission

2007

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

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

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1. Introduction

PARCOM Recommendation 91/4 states that contracting parties agree "*to respect the relevant Recommendations of the competent international organisations and to apply the Best Available Technology to minimise and, as appropriate, eliminate any pollution caused by radioactive discharges from all nuclear industries, including research reactors and reprocessing plants, into the marine environment. Contracting Parties shall present a statement on progress made in applying such technology every four years in accordance with the guidelines annexed to this recommendation*".

After the third round of implementation reporting on PARCOM Recommendation 91/4, the OSPAR Radioactive Substance Committee agreed revised guidelines at its 2004 meeting in La Rochelle (France). The new guidelines were included as Annex 6 to the summary report of the meeting.

This document, which is the fourth submitted by Spain, has been elaborated according to the new guidelines and contains information, over the six-year period 1998-2003 inclusive, on the Spanish nuclear facilities located in the OSPAR Convention Area.

2. General Information

2.1 National legislation and bases for regulation

In Spain the basic laws governing nuclear activities are the Nuclear Energy Act (1964) and the 15/80 Law, by which the Nuclear Safety Council (CSN) was created, partially modified by the 14/99 Law governing the public prices and fees for services provided by the CSN. They are further developed in regulations that provide the framework for standards, guidelines and objectives in this field, namely:

- Regulations on Nuclear and Radioactive Installations, which establish the licensing requirements and procedures to be applied for the different types of permits considered in the legislation (Royal Decree 836/1999, December 3rd 1999), amending former regulations approved in 1972.
- Regulations on Sanitary Protection against Ionising Radiation (RSPIR) (Royal Decree 783/2001, July 6th 2001), amending previous regulations approved in 1992.

As a member Estate of European Union, Spain is subject to the terms of the Euratom Treaty, which makes provision for basic Community standards to protect the health of workers and general public against the dangers arising from ionising radiation. After their review in 1999 and 2001 respectively, the above-mentioned regulations fully implement the EU 1996 BSS Directive.

The policy and main precepts governing in Spain the protection of the environment are laid down in the Royal Legislative Decree 1302/1986, amended by the Royal Decree-Law 9/2000, on the evaluation of the environmental impact. The Decree involves a wide range of activities, including the generation of nuclear energy and requires the submission of a "Declaration of Environmental Impact" report in the licensing process.

2.2 Implementation of BAT/BEP in terms of the OSPAR Convention in Spanish legislation and regulation

The requirements on the system applied to limit emissions and discharges are established in the RSPIR, where several articles deal with the system of limitation, surveillance and control of radioactive effluents. It is specifically stipulated that facilities generating radioactive wastes must be provided with adequate treatment and removal systems in order to ensure that doses due to releases are lower than the limits established in the administrative licences and that they are kept at the lowest possible value.

A specific authorisation is needed for every facility, setting up specific limits, surveillance requirements and conditions for the releases. The authorised limits guarantee that in normal operating conditions, the doses to members of the public will be in accordance with the ALARA principle that is applied in the design of the treatment systems.

During operation, licensees have to demonstrate that every reasonable effort is made, from the generation of wastes to the operation proceedings of the effluent treatment systems, to reduce releases and to keep the radiological impact as low as is technically and economically feasible. They are required to develop a Continuous Safety Assessment Programme (CSA) taking into account the evolution of the normative, the progress in technology (BAT), and the operational experience.

According to that, a semi annual report is submitted to the CSN including the design modifications proposed, implemented or/and going on. Furthermore, the licensee is required to analyse the applicability of the new regulations of the country origin of the design and, according to that regulations, to propose the necessary modifications.

As a result, many operational and procedural improvements have been introduced in order to minimise the production of radioactive waste and their discharge into the environment.

Licensees are also required to perform a Periodic Safety Review (PSR) programme on a ten years basis, following the recommendations of the CSN Safety Guide 1.10[1], intended to analyse the global behaviour of the plant over a long period, to guarantee that lessons learned from the analysis of the operational experience have been properly implemented and to evaluate the applicability to the facility of relevant changes in the new generation plants. The documentation submitted and the results of the evaluation performed by the CSN are taken into account in the renewal of the operating permits. The effluents control and environmental monitoring programmes are included among the programmes to be considered in the PSR, according to the GS-1.10.

Additionally, the CSN has established “Reference Levels” (RL) for liquid and gaseous effluents, set up in terms of activity for groups of nuclides that indicate optimal operation of the reactor in terms of radioactive wastes generation and discharges into the environment.

These values are reviewed regularly after a critical examination of the history of discharges and emissions and their relationship to the authorised limits, and the status of the current techniques and operating procedures adopted by the facility in radioactive waste management (technology and best practice).

2.3 Dose constraint/limits for nuclear facilities

In Spain, the regulatory dose limits for members of the public are an effective dose of 1mSv/y and equivalent doses to the skin of 50 mSv/y and to the lens of 15 mSv/y.

The effective dose in a period of 12 consecutive months have to take into account the contribution of the external exposure in that period along with the committed dose, over a period of 50 years, due to the ingestion and inhalation of radioactive substances occurred in that period.

Since 1993, the dose constraint is set as an effective dose of 0,3 mSv/y for nuclear power plants and other fuel cycle installations.

Therefore, the Spanish regulatory system in the field of controlling radioactive substances, sets up a framework for the effective application of a clearly stated policy under which the equivalent of BAT is required, which follows closely the requirements and recommendations of competent international bodies, and which adopts principles calculated to ensure the application of the precautionary principle and the prevention of pollution.

1 GSG-1.10: “Periodic Safety Review in Nuclear Power Plants”. ISBN 84-87275-60-5.

2.4 Discharge limits

Regarding the discharge limits, an effective dose value of 0,1 mSv/y applies both during operation and to facilities that are being decommissioned. This value, that it is applicable to liquid and gaseous effluents considered as a whole, was established as a proper percentage of a Dose Constraint previously defined by the CSN for the nuclear power plants and fuel cycle facilities (0,3 mSv/y), and the dose limit for public required in Spanish legislation.

In the nuclear power plants, the discharge limit is distributed between gaseous and liquid effluents. A different apportionment has been applied in each plant, based on specific site characteristics.

The values that were determined taking into account an optimisation process of the effluents treatment systems are:

- Almaraz NPP: Liquid effluents .... 0,02 mSv
  Gaseous effluents .... 0,08 mSv
- José Cabrera NPP: Liquid effluents .... 0,08 mSv
  Gaseous effluents .... 0,02 mSv
- Trillo NPP: Liquid effluents .... 0,04 mSv
  Gaseous effluents .... 0,06 mSv

The discharge limit, which is being applied in the nuclear power plants since 1997, has been established in the Juzbado fuel fabrication plant last year. So, since 2006, all the Spanish nuclear installations have their discharge limits established in terms of doses, on annual basis, considering 12 consecutive months.

Previously, the Juzbado fuel fabrication plant had its discharge limits set in terms of gross alpha activity, being established the following values:

- Liquid effluents: 1,20 E+10 Bq/year
  6,01 E+09 Bq/quarter
  1,20 E+09 Bq/day
  2,25 E+05 Bq/m^3
- Gaseous effluents: 1,92 E+08 Bq/year

These activity limits derived from an annual dose of 0,25 mSv/y to the most exposure member of the critical group.

The system of limitation, surveillance and control of radioactive effluents is included in the operation permits as part of the Technical Specifications, which comprise the discharge limits, the sampling and analysis programmes required to verify compliance, the conditions on the operability of the on-line monitoring instrumentation and the effluent treatment systems operability requirements. The procedural details of these Radiological Technical Specifications are developed in an official document, the Off Site Dose Calculation Manual (ODCM). According to the CSN Safety Guide 7.9[2], the ODCM also includes the methodology and parameters used in estimating offsite doses due to the radioactive emissions and discharges and in calculating the monitoring alarm/trip set points.

Since discharge limits in NPP are formulated in terms of dose, operators shall demonstrate compliance with them by estimating monthly cumulative doses in the last twelve consecutive months considering as source terms the results provided by the effluent sampling and analysis programmes and following the procedures specified in the ODCM.

2 GSG-7.9: “Off-site dose calculation manual of nuclear installations”.

2.5 Monitoring programmes of environmental concentrations of radionuclides

The environmental radiological monitoring in Spain consists of three networks.

a) The network associated to nuclear installations.

b) The national monitoring network.

c) The network made up of the so-called “specific programmes”.

The specific programmes are those that arise as consequence of an incident, a society request, or an interest in knowing a radiological situation.

Examples of these programmes are the programme that is being developed in Palomares (Almeria), the programme of radon measurement in dwellings, and the programme that was carried out following the Chernobyl accident.

PROGRAMMES AROUND NUCLEAR INSTALLATIONS

Environmental radiological monitoring programmes in the vicinity of nuclear facilities were implemented at the beginning of the Spanish nuclear programme, and they are being developed according to the different lifetime stages of the facilities: pre-operation, operation, dismantling and decommissioning.

The basic goals of these programmes are:

- To provide representative measurements of radioactivity in the most relevant exposure pathways to man.
- To verify the effectiveness of the effluent monitoring programmes.
- To allow verifications of model-based dose calculations.
- To provide data for reporting to relevant national and international bodies and to inform to the public.

The main requirements for the nuclear power plants environmental monitoring programmes are defined in the CSN Safety Guide 4.1[3] and include:

- A minimum sampling, analysis and measurement programme, within a 30 km radius zone around the installation.
- Quality assurance and quality control programmes including the existence of written procedures related to all the programme stages and the analysis of duplicated samples by two different laboratories, usually over a range of 5%-15% of the total programme samples. The site operator coordinates this analysis of duplicated samples. (Internal Quality Control Programme).

The requirements of the environmental radiological monitoring programmes, are set out in the operation permits as part of the Technical Specifications, which comprise, the environmental monitoring programme, the quality control programme and the land and water use census. The procedural details are developed in the Offsite Dose Calculation Manual ODCM, where requirements about Lower Limits of Detection (LLD) and the existence of procedures related to the phases of the programme are included. The OCDM also includes “Reporting Levels” (RL) of isotopic activity concentrations in environmental samples of air, drinking water, milk, meat, vegetables, fishes, seafood and soil. RL are derived activity concentration values put in place by the CSN on the basis of effluent discharge limits. If these values are exceeded, the facility has to report it to the CSN and undertake a study to determine a possible relationship with the plant’s releases according to the origin of the radionuclides detected. Until the present moment only fallout isotopes (^{137}Cs and ^{90}Sr) have been reported.

3 SG-4.1: “*Design and development of environmental radiological monitoring programmes for nuclear power plants*” CSN. 1993

The number and location of sampling points, the type of samples to be selected and the required analysis are defined in the preoperational stage, intended to characterise the site radiologically, before the facility's operation. The main pathways of human exposure to radiation are monitored as well as other ecosystem elements that are good indicators of the evolution of radioactivity in the terrestrial and aquatic environments.

The programmes are updated periodically during the different lifetime phases of the facilities.

Tables 1 and 2 respectively, summarise the sampling and analysis programme required for nuclear power plants and the fuel fabrication plant of Juzbado.

Table 1. Generic Environmental Monitoring Programme around Nuclear Power Plants

Sample	Frequency	Measurement/analysis
Air (Aerosols) Iodine	Continuous (weekly)	Gross- β ^{90}Sr γ Spectrometry [1] I-131
Gamma radiation (TLD)	Continuous (quarterly)	Dose rate
Rain water	Continuous (monthly)	γ Spectrometry [1] ^{90}Sr
Drinking water	Fortnightly o more frequently	Gross-β Residual β ^{90}Sr ^{3}H γ Spectrometry [1]
Surface and ground water	Monthly or more frequently (river or coastal water). Ground water quarterly	Gross- β Residual β ^{3}H γ Spectrometry [1]
Soil, sediment and biological indicators	Soil (yearly), sediment and biological indicators every six months	^{90}Sr γ Spectrometry [1]
Milk and fruits, vegetables and cereals.	Milk fortnightly on grazing season and monthly the rest of the year. Fruits, vegetables and cereals on harvest time.	^{90}Sr γ Spectrometry [1] ^{131}I (milk, leafy vegetables)
Meat, eggs, fish, seafood and honey.	Every six months	γ Spectrometry [1]

1. Minimum nuclide library for gamma-spectrometry: ^{54}Mn, ^{58}Co, ^{60}Co, ^{59}Fe, ^{65}Zn, ^{95}Nb, ^{95}Zr, ^{131}I, ^{134}Cs, ^{137}Cs, ^{140}La, ^{144}Ce.

Table 2. Environmental monitoring programme around Juzbado FFP

Sample	Measurement/analysis
Air (Aerosols)	Gross- α Uranium α spectrometry
Gamma radiation (TLD)	Dose rate
Ground water, river water and drinking water.	Gross-α Gross β Residual β (river and drinking water) Uranium α spectrometry
Soil	Gross- α Uranium α spectrometry
Sediment and biota	Gross- α Uranium α spectrometry
Food (Vegetables, meat, milk and fishes)	Gross-α Uranium α spectrometry

The following table 3 shows, related to OSPAR zone nuclear installations, the number of sampling stations for each of the pathways sampled in every site.

Table 3. Number of sampling stations. Nuclear installations OSPAR Zone

Type of sample	Trillo NPP	José Cabrera NPP*	Almaraz NPP	Juzbado FFP
Air	6	6	6	7
Gamma Radiation (DTL)	21	23	21	21
Soil	8	7	7	9
Rainwater	5	4	6	4
Drinking water	6	4	3	1
Surface and ground water	5	4	10	9
Sediments and Biological indicators	6	6	10	4
Fish	3	3	3	2
Milk	5	5	7	3
Honey	2	2	2	---
Vegetables, meat and eggs.	6	10	10	8
Total number	**73**	**74**	**85**	**68**

* NPP under decommissioning.

The environmental monitoring programmes around nuclear installations are undertaken by the operators and the CSN implements an independent programme, the scope of which has been established generally over a rage of 5-15% of the number of total samples. (External Quality Control Programme) The independent monitoring programme of the CSN includes the same sampling locations and types of samples and analysis as the operator's programme.

Until the year 1998 sampling was carried out by the CSN staff and the analysis performed at the laboratories of the Research Centre for Energy, Environment and Technology (CIEMAT).

From 1999, the independent programme, sampling and analysis, has been entrusted to laboratories from universities.

Related to the OSPAR zone installations, the laboratories involved are the following:

- NNPPs Trillo and José Cabrera - Castilla-La Mancha University
- NNPP Almaraz - Cáceres University.
- FFP Juzbado - Salamanca University.

The university laboratories inform directly to the CSN the results obtained.

The CSN also performs periodic inspections and audits to verify that the facilities comply with the programmes, which are revised annually. Operators are requested to send annual reports to the CSN including the results obtained and the evaluation of the radiological conditions of the environment.

The results obtained from each of the programmes (main programme, internal quality control and external quality control programmes) are stored in the CSN's environmental radioactivity measurement database (KEEPER). Every year the CSN evaluates the data received.

NATIONWIDE MONITORING NETWORK

CSN runs a nation-wide environmental radiological monitoring network. This network is independent form the network associated with nuclear facilities.

This network operates since 1992 (rivers since 1984) and has the following goals.

- o Ascertain the distribution and evolution of radioisotopes present in the environment and the levels of environmental radiation.
- o Provide an environmental database to be able to obtain reference levels at any time.
- o Provide data for estimating the potential radiological impact on the population.
- o Provide data for reporting every year, to the Parliament, and to the public on the radiological quality of the environment.

In order to achieve these goals, two networks have been implemented by the CSN:

- o A network for automatic environmental radiological surveillance (REA).
- o A network of sampling stations (REM).

The REA network consists of 25 automatic stations with a nation-wide distribution. Most of the CSN managed stations are located in measurement stations of the National Meteorology Institute. The radiological and meteorological data are recorded and stored every 10 min at the stations and are transmitted through the switched telephone network to the Emergency Management Room (SALEM) at the CSN premises in Madrid. Specifically designed software for the network operation and data evaluation is operated from this room.

The radiological data measured, are gamma dose rate, ^{131}I, ^{222}Rn, α and β levels, radon progeny contribution discounted. The meteorological data recorded are wind speed, wind direction, air temperature, relative humidity, rainfall and atmospheric pressure.

The data are transmitted daily to the European Commission Joint Research Centre according to the program EURDEP (European Union Radiological Data Exchange Platform), since the year 2003. Also the results obtained from this network are being published by the CSN. At the present moment the results from the years 2000, 2001, 2002 and 2003 have been published.

The monitoring of the environmental radioactivity in the European Union is carried out by the Radioactivity Environmental Monitoring (REM) programmes, which have been established in the EU Member States to comply with legal national precepts established in accordance with the requirements of the EURATOM Treaty. These programmes provide relevant information on radioactivity levels in all compartments of the biosphere to ensure that concentrations of radioactive materials do not constitute a risk to the humans or the environment. The monitoring system that is currently being developed in Spain, consists of two complementary networks: the REM-dense network with numerous sampling points covering the entire national territory, and the REM-sparse network with a limited number of selected locations.

Table 4 shows the sampling and analysis programme that is currently being developed in Spain.

Table 4. National Monitoring Network (REM). Sample types and measurements

Dense Network	Sparse Network
AIR Gross-α, Gross-β, ^{131}I (Weekly) γ-Spectrometry. (Monthly) ^{90}Sr. (Quarterly)	**AIR** ^{7}Be, ^{137}Cs (Weekly)
DRINKING WATER Gross-α, Gross-β,γ-Spectrometry (Monthly) ^{90}Sr (Quarterly)	**DRINKING WATER** Gross-α, Gross-β, Residual-β, ^{3}H,^{90}Sr, ^{137}Cs (Monthly) Natural radionuclides (Every two years)
MILK. ^{90}Sr,γ-Spectrometry (Monthly)	**MILK.** ^{90}Sr, ^{137}Cs (Monthly)
SOIL. Gross-β,^{90}Sr,γ-Spectrometry (Annually)	**MIXED DIET**. ^{137}Cs, ^{90}Sr (Quarterly)
SURFACE WATER Gross-α, Gross-β, Residual-β, ^{3}H, γ-Spectrometry	**SURFACE WATER.** ^{137}Cs.

Minimum nuclide library for gamma-spectrometry: ^{54}Mn, ^{58}Co, ^{60}Co, ^{59}Fe, ^{65}Zn, ^{95}Nb, ^{95} Zr, ^{103}Ru, ^{106}Ru, ^{131}I, ^{134}Cs, ^{137}Cs, ^{140}La, ^{144}C, ^{7}Be, ^{40}K, ^{208}Tl, ^{212}Pb, ^{214}Bi, ^{214}Pb.

The surface water network comprises the river and the coastal networks 80 sampling stations cover the main rivers of the country. Table 5 shows the number of sampling stations and samples taken during the year 2003, in the OSPAR zone rivers.

Table 5. National Monitoring Network (REM). Surface water. Hydrological basin rivers. OSPAR zone. Year 2003.

Hydrological Basins	Dense Network	
	Number of sampling points	Number of samples
Miño and North Spain rivers	10	96
Duero	13	124
Tagus	22	163
Guadiana	5	15
Guadalquivir	12	83
Total	**62**	**481**

The Spanish coast is surrounded by a series of fourteen sampling stations, seven of them in the OSPAR zone. The Centre of Civil Works Studies and Experimentation (CEDEX) of the Ministry of Public Works, by means of a collaboration agreement with the CSN, is conducting the programme of radiological monitoring of the aquatic medium.

The following tables 6 and 7 summarise some of the results obtained during the 1998-2003 period. The coastal waters surveillance programmes show no influence of radioactive releases.

All data from the REM network, is also stored in the CSN's database KEEPER.

Table 6. National Monitoring Network (REM). Coastal waters. Gross-α and ^{3}H concentrations 1998-2003 period

Location	Gross-α concentrations Bq/m³						Tritium concentrations Bq/m³					
	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003
Cabo de Ajo 3ª 34´ 41” W 3ª38´04”N	7,0+01	8,0+01	7,3+01	6,2+01	8,2+01	8,7+01	2,2+02	2,4+02	1,9+02	1,9+02	1,6+02	1,7+02
Cabo de Ortegal 7º 48´ W 43º 52´N	7,0+01	7,5+01	7,3+01	6,7+01	7,5+01	8,7+01	2,0+02	1,8+02	1,9+02	1,4+02	1,4+02	1,3+02
Cabo Villano 9º 22´W 43ª 0´	7,3+01	8,0+01	7,3+01	6,7+01	7,3+01	8,5+01	2,1+02	1,5+02	1,9+02	1,4+02	1,6+02	1,5+02
Cabo Silleiro 8º 52´W 42º 15´N	6,0+01	7,3+01	7,3+01	6,8+01	7,5+01	8,7+01	2,3+02	2,0+02	2,0+02	1,9+02	1,5+02	1,5+02
Isla Cristina 7º 20´W 37º 3´N	7,0+01	7,5+01	7,3+01	6,8+01	8,0+01	8,0+01	2,1+02	1,8+02	1,7+02	1,4+02	1,5+02	1,5+02
Puerto de Cadiz 6º 19´W 36º 35´N	7,3+01	7,8+01	7,8+01	7,2+01	8,0+01	9,0+01	2,0+02	1,5+02	1,6+02	1,7+02	1,6+02	1,3+02
Estrecho de Gibraltar 5º 22,7´W 36º 6,20´N.	7,5+01	7,3+01	7,8+01	7,2+01	8,7+01	8,7+01	1,9+02	1,7+02	2,0+02	1,6+02	1,7+02	1,2+02

Table 7. National Monitoring Network (REM). Coastal waters. Gross-β and Residual-β concentrations 1998-2003 period

Location	Gross-β concentrations Bq/m³						Residual-β concentrations Bq/m³					
	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003
Cabo de Ajo 3ª 34´ 41" W 3ª38´04"N	1,3+04	1,3+04	1,5+04	1,4+04	1,4+04	1,44+04	LLD	LLD	1,1+03	*<0,9+3*	*<0,9+3*	1,2+3
Cabo de Ortegal 7º 48´ W 43º 52´N	1,3+04	1,3+04	1,5+04	1,4+04	1,4+04	1,43+04	LLD	LLD	1,0+03	*<0,7+3*	*<0,7+3*	*<0,8+3*
Cabo Villano 9º 22´W 43ª 0´	1,3+04	1,4+04	1,5+04	1,5+04	1,4+04	1,44+04	LLD	LLD	1,4+03	*<1,0+3*	*<0,8+3*	*<0,9+3*
Cabo Silleiro 8º 52´W 42º 15´N	1,3+04	1,3+04	1,4+04	1,4+04	1,4+04	1,36+04	LLD	LLD	1,4+03	*<0,7+3*	*<0,8+3*	*<0,7+3*
Isla Cristina 7º 20´W 37º 3´N	1,3+04	1,3+04	1,6+04	1,5+04	1,5+04	1,41+04	LLD	LLD	1,4+03	*<1,0+03*	*<0,9+3*	*<0,9+3*
Puerto de Cadiz 6º 19´W 36º 35´N	1,3+04	1,4+04	1,5+04	1,5+04	1,4+04	1,44+04	LLD	LLD	LLD	*<0,9+03*	*<0,9+3*	*<0,9+3*
Estrecho de Gibraltar 5º 22,7´W 36º 6,20´N	1,4+04	1,4+04	1,5+04	1,5+04	1,5+04	1,47+04	LLD	LLD	LLD	*<0,7+03*	*<0,8+3*	*<0,8+3*

CSN reports annually to the Parliament about the results obtained from this network. In compliance with the requirements on environmental surveillance issued by the European Commission in article 36 of the Euratom Treaty, CSN sends annually these results to the European Commission. The results are held on the REM data bank at the CEC Joint Research Centre in Ispra. The European Commission periodically publishes these data.

CSN, by means of the CSN publications plan, is editing the results of the environmental radiological monitoring programmes. (Nuclear installations and REM programmes).At the present moment seven technical documents with the results from the 1980-2004 period have been published.

2.6 Environmental norms and standards

Measuring radioactivity in environmental samples involves a complex and lengthy process that includes several steps, from collection and preparation of representative samples and their chemical analysis, to calibration of measurement equipment. Representative samples have to be taken and the treatment in the laboratory should guarantee that the final data reproduce as close as possible the contents of radioactivity in the environment.

A working group, formed by staff of the main environmental laboratories of the country and coordinated by the CSN staff, has been established to develop monitoring standards and procedures for the main stages of the environmental sample radioactivity measurement process: sampling, sample preservation and preparation, analytical methods and measurement equipment. It was considered convenient that this working group will carry out their activities in coordination with AENOR (Spanish Organisation of Standardisation and Certification) given rise to a group of environmental Spanish norms and CSN publications.

The procedures and norms already produced are listed below.

Sampling	**Conservation and handling**
Soil- Superficial layer(UNE-73311-1) Aerosols and radio iodine in air (UNE-73320-3) Continental and sea sediments (UNE-73320-2)	Soil samples (UNE-73311-5). Aerosol filters and charcoal cartridges.
Analytical methods	**Measuring equipment**
Gross β in water by proportional counter (UNE-73311-4) Residual β in water by proportional counter (UNE-73340-2). Determination of $^{89-90}$Sr in soils and sediments. (UNE-73340-3). Gross α in water. Coprecipitation and evaporation methods.	γ spectrometry with semi-conductor detectors (UNE-73350-1). α spectrometry with semi-conductor detectors (UNE-73350-2). Liquid scintillation detectors. (UNE-73350-3).

There are no edited norms or standards at the present moment for the protection of the environment from a radiological point of view. Nevertheless, Spain is participating within the international projects to develop a framework for the assessment of environmental impact of ionising radiation in ecosystems.

The Spanish Research Centre in Energy, Environment and Technology (CIEMAT) participated in the FASSET project (Framework for the Assessment of Environmental Impact), launched in November 2000 under the EC 5th Framework Programme and finished in 2003.

Now the CIEMAT is participating in the ERICA project (Environmental Risk from Ionising Contaminants: Assessment and Management) under the EC 6th Framework Programme.

The CSN supports partially the CIEMAT participation in these projects and receive all the information generated in them

Juzbado fuel fabrication plant in order to continuously improve its environmental performance implemented since April 1999 an Environmental Management System that has been certified by AENOR, in accordance with the requirements of Standard UNE-EN ISO 14001:1996. Moreover, the factory obtained the AENOR verification of its Environmental Management System and Environmental Declaration, pursuant to the requirements of European Regulation[4] 761/2001, EMAS(VDM-03/10).

In order to comply with the requirements of EMAS, the Environmental Declaration validated by AENOR, is prepared and published on a yearly basis.

Almaraz and Trillo Nuclear Power Plants had also implemented, certified by AENOR, since November 2005, an Environmental Management System in accordance with the requirements of UNE-EN ISO 14001.

2.7 National authority responsible for supervision of discharges

The CSN is, according to its chart law, the only Spanish authority competent in nuclear safety and radiation protection matters. It is independent from Government, reports only to the Spanish Parliament.

The Ministry of Industry, Tourist and Commerce is responsible for granting permits to nuclear and radioactive facilities, but the legislation requires a mandatory and binding report from the CSN prior to any authorisation.

The CSN establishes the system of limitation, surveillance and control of radioactive effluents and the environmental monitoring programs to be applied by the licensees, and guarantees its proper application by means of evaluation of the data and inspection of the facilities. The basic requirements for the effluents monitoring programmes are defined in the CSN Safety Guide 1.4[5].

2.8 Nature of inspection and surveillance programme

The nuclear installations are inspected regularly by qualified CSN experts, verifying different aspects in relation to effluent treatment and discharge systems, monitoring and analytical instrumentation, data included in the effluent and environmental programmes reports, and procedures applied to the different processes. The CSN Resident Inspector performs an additional control in the nuclear power plants.

Inspections are carried out according to the CSN procedures PT.IV.251[6] and PT.IV.252[7].

Regarding the radioactive effluents, throughout the inspections, the CSN inspectors verify:

- Compliance with the authorisation procedure (sampling, measurement and analysis) prior to a discharge as well as witness the control performs in order to ensure compliance with the discharge limits. As a part of the inspection, samples can be collected and analysed by the methods normally applied by the operator.
- Applicable actions required when monitors have not been operable.
- Actions carried out when alarm set points have been exceed.
- Operability of the radioactive effluent treatment systems.

4 Regulation (EC) nº 761/2001 of 19 March 2001 allowing voluntary participation by organisations in Community eco-management and audit scheme (EMAS).

5 GSG-1.4: “Radiological surveillance and control of liquid and gaseous effluents from nuclear power plants”. IBSN 84-87275-25-7

6 PT.IV.251: “Treatment, surveillance and control of liquid and gaseous radioactive effluents”

7 PT.IV.252: “Environmental radiological surveillance program”

Moreover, CSN inspectors analyse the results of the radioactive effluent monitoring instrumentation surveillance requirements carried out to ensure the operability of that instrumentation and the implementation of the design modifications.

Checks on chosen samples in order to verify the data transmission chain between initial measurements of the sample and final reporting to the CSN and on the information submitted every month by the facilities are carried out.

To complement the results found during the inspections, the CSN is carrying out an independent analysis of the gamma spectres obtained in the measurement process to verify the suitability of the results reported by the facilities.

Regarding the environmental monitoring programmes, throughout the inspections, the CSN inspectors verify among others the following subjects:

- Existence of adequate equipment for sampling, its operability, and the calibration and maintenance process carried out in the course of the period.
- The implementation of the quality control programme according to the previous programme approved by the CSN.
- The correct use of the procedures in the sampling of previously selected samples by the CSN. In some cases shared samples are taken and analysed by two different laboratories.
- The correct application of the procedures to the phases of treatment, conservation, identification and transport of samples.
- Trace ability of the information throughout all the process.
- The programme of audits carried out by the operator, internal audits about the monitoring programme development, and external audits to the analytical laboratories involved.

The quality of the information coming from the environmental monitoring programmes, as basic data for the assessment of the potential risk to the public or the environment, has been a continuous CSN concern. To evaluate regularly the reliability of the data produced by the laboratories, the CSN organises in collaboration with CIEMAT annual inter-laboratory exercises where all the Spanish laboratories analysing environmental samples participate.

The exercises carried out in the period 1998-2003, were the following, collected in Table 8.

Technical documentation has to be provided by each of the laboratories participating in the sampling stations network (REM) to the CSN. This documentation must include the following.

- o Description of sampling, detection and measurement equipment.
- o Sampling, analysis and measurement procedures used by the laboratory.
- o A quality assurance programme for the measurements made.
- o Results of participation in analytical intercomparison exercises organised by the CSN.

Table 8. Quality Control Programme. Intercomparison exercises, 1998-2003

Exercise	Number of Laboratories	Type of sample	Analysis
1998	31	Soil	^{40}K, ^{226}Ra, ^{137}Cs, ^{90}Sr, $^{(239+240)}Pu$
1999	31	Water	^{3}H, ^{90}Sr, ^{230}Th, ^{241}Am, ^{60}Co, ^{137}Cs
2000	30	Soil	^{90}Sr, ^{40}K, ^{226}Ra, ^{228}Ac, ^{137}Cs, $^{(239+240)}Pu$, ^{241}Am, ^{134}Cs
2001	9	TLD	H* (10)
2002	33	Sea fish meat	^{40}K, ^{137}Cs, ^{90}Sr, ^{60}Co,^{99}Tc, $^{(239+240)}Pu$, ^{241}Am,^{238}U, ^{234}U, ,^{235}U, ^{226}Ra,^{210}Pb
2003-2004	39	Water	Gross-α, Gross-β,Residual-β,^{3}H, ^{90}Sr $^{(239+240)}Pu$, ^{241}Am, ^{137}Cs.

In 1997 the CSN required formally to the laboratories involved in the REM network, implement a quality system and develop Quality Manuals and a programme for establishing, implementing and optimising them. The quality system integrates the organisation's structure, responsibilities, processes and resources required for suitably managing quality. The CSN staff periodically audits the laboratories.

In order to verify that established quality programmes are properly enforced, internal controls are introduced into the organisation and external actions are taken, such as the participation in inter-laboratory exercises and audits.

Under Article 35 of the Euratom Treaty, The European Commission has the right of access to facilities in Member States for monitoring the levels of radioactivity in air, water and soil, in order to verify their operation and efficiency. None visit has been in the period 1998-2003.

3. Site specific information

3.1 Nuclear Power Plants

Three Spanish nuclear power plants discharge their radioactive liquid effluent into rivers that flow into the Atlantic Ocean: José Cabrera NPP, Almaraz 1 & 2 NPP, and Trillo NPP.

Each of them belongs to a different generation of the Spanish nuclear power stations, being José Cabrera the oldest and Trillo the newest. By a government decision, José Cabrera has ceased its operation at the end of April 2006.

3.1.1 Discharges

The information to be submitted in accordance with the BAT Guidelines is given in Annex I.

3.1.1.1 Application of BAT

The radiological protection principles and regulatory arrangements described above have been applied in the Spanish facilities in order to reduce the levels of discharges and the radiological impact to both humans and the environment. The principal radionuclides arising in liquid waste are tritium and, to a much lesser degree, activation, corrosion and fission products.

The general policy practised to decrease releases is focussed on some key issues, namely:

- Reduction of the radioactive wastes produced by means of improving the surveillance and control of defects in the fuel cladding during operation and refuelling, and the chemical quality and conditions of the coolant systems.
- Changes in the components materials to reduce the activation products.
- Modifications of the effluent treatment systems, incorporating state of the art components leading to more effective purification of the streams treated.
- Reinforcement on the maintenance programmes.
- Revision of the operating procedures, optimising the methods applied.

Additionally, specific changes have been introduced in the Spanish facilities to minimise discharges as it is described in Annex I.

On the other hand, the CSN assesses the monthly information submitted by the operators and analyses the evolution of discharges and emissions to study their trends. Likewise, the compliance with the Reference Levels (RL) is analysed. Even though RL values were well below the limitations, the operator is asked to justify any ever-increasing tendency and to restore the original values if feasible. Moreover, data on the highest activity detected by monitors are also reviewed to check if any alarm set point has been exceeded; if yes, the operator is asked to explain the reason and the actions adopted. Depending on the findings importance, the operator response to the finding is analysed and verified by the CSN immediately or during the next inspection to the plant.

Moreover, during the normal operation of the plant, licensees carry out a self-continuous evaluation program. This program requires analyses of detected problems and so applicable corrective actions are defined in order to assure that those problems will not happen anymore. The following subjects are considered in this program:

- Overflows and abnormal releases;
- Repetitive cases of inoperable radioactive monitoring instrumentation;
- Deviations between activity measured by monitors and analysed activity for batch discharges;
- Increasing trends in activity releases.

By making the operators to apply the best available technologies and to improve the operation procedures releases are minimised, maintaining the quality of the natural environment.

3.1.1.2 Quality assurance of retention systems performance and data management

The performance of the retention systems is assured by controlling the pressure before and after the filters as well as the fluid activity after treatment.

Liquid effluents can be divided in continuous and non-continuous discharges. Continuous discharges are continuously monitored. If an alarm set point is exceeded, the discharge pump is stopped, automatically or manually, and the liquid is sent to the radioactive liquid treatment system. In addition a weekly bulk composite sample is collected with an automatic sampling system for laboratory analysis.

Non-continuous discharges are only carried out after gamma spectrometry analyses to determine the isotopic composition and the dilution factor in the discharge channel. Before the sample is taken, the liquid in the tank is recirculated for enough time to guarantee homogeneity. If the sample activity is not enough low for discharge, the tank content is redirected to the liquid treatment plant.

During the discharge, the control room is able to control the flow and thus the dilution factor in the discharge channel. There is also an activity monitor in the discharge line, so the control room is able to monitor the actual discharge activity. If this activity deviates more than 50% from the activity result based on the tank sample, the discharge is stopped. Additionally, there is an automatic discharge cut-off if the activity exceeded a certain value. If the monitor is not functioning, the discharge is automatically stopped.

Regarding emissions, gases are also continuously monitored. Likewise discharges, if an alarm set point is exceeded, the emission can be stopped, automatically or manually. Charcoal and particulate filters to quantify the emissions activity are replaced weekly and analysed to determine the isotopic composition.

Instrumentation for continuous discharges and emissions monitoring is calibrated periodically using standard sources. Beside, several checks are carried out, with different periodicity, in order to ensure that monitors works properly.

On the other hand, the laboratory instrumentation used for discharges and emissions activity quantification is periodically calibrated using standards. For gamma spectrometry systems, detector efficiency Q/A plots are produced on a weekly basis in order to control system stability. The system performs an automatic background correction based on a weekly background measurement.

Laboratories from the nuclear power plants participate in intercomparison exercises.

Data and parameters related to treatment, discharges and emissions are kept in notebooks and computer files. Data from laboratory analyses are kept in computerised databases.

The facilities quality control program also includes procedures and instructions for the suitable data management, as well as their correct filed according to the applicable regulations. During the inspections the CSN inspectors performs checks on chosen samples in order to verify the data transmission chain between initial measurements of the sample and final reporting to the CSN. On the other hand, the CSN checks the information submitted every month by the facilities (on paper and electronic format), according to the CSN Nuclear Safety Guide 1.7[8], to validate the data and identify discrepancies and mistakes.

[8] GSG-1.7: “Information to be submitted by owners to the CSN regarding the NPP operation”

3.1.2 Doses

Assessments of doses to the critical group are carried out to verify that discharge limits are complied with and to estimate the radiological impact on the members of the public due to the radioactive releases into the environment.

Data to be submitted in accordance with the BAT Guidelines are given in Annex I.

3.1.2.1 Critical Group

For every facility a critical group, as described in ICRP-60, is established. The critical groups are intended to be representative of individuals likely to receive the highest doses. The critical group includes three age groups: infant (1-2 years), children (7-12 years), and adult (>17 years); according to EC Radiation protection 129[9], these are the three groups who receive the highest doses.

The critical group can vary from one year to another. For a specific year, the critical group is that age group that has received the highest doses due to the releases of that year.

The critical group is hypothetical but realistic, having combinations of habits, both high and average, based on local knowledge and plausible assumptions. Food consumption rates are based on the result of site-specific habit surveys carried out by the CSN/CIEMAT in 2001. Inhalation rates from ICRP-71[10], water ingestion rates from ICRP-23[11], and exposure time to shoreline deposits from EUR 15760[12] are considered.

3.1.2.2 Exposure Pathways

The assessment of doses takes into account the following exposure pathways:

- External exposure to the cloud (only noble gases are considered);
- Inhalation;
- External exposure to deposits on the ground (gaseous effluents) and on the shorelines (liquid effluents);
- Drinking water;
- Consumption of fish, seafood and shellfish;
- Consumption of leafy vegetables;
- Consumption of cereals, vegetables, roots and fruits;
- Consumption of meat (beef, goat, pork);
- Consumption of goat and cow milk.

All releases exposure pathways are individually considered and the total dose is calculated by adding the contribution of each of them.

Taking into account productions, food consumption, occupancy and other usage of the region in the vicinity of the plant site, the specific pathways considered in the assessment of doses for the critical group of each nuclear power plant is specified in Annex I.

3.1.2.3 Basis for Methodology

The methodology used to estimate doses, defined in the ODCM's, is the same in all Spanish NPP and it is based on calculation models given in the NRC- Regulatory Guide 1.109[13]. To this end, a computer program was initially developed by the adaptation of the NRC computer programs LADTAP and GASPAR, which was updated in 2001, after the radiation protection Regulations

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9 EC Radiation protection 129: "Guidance on the realistic assessment of radiation doses to members of the public due to the operation of nuclear installations under normal conditions"

10 ICRP-71: "Age-dependent doses to members of the public from intake of radionuclides: Part 4 inhalation dose coefficients"

11 ICRP-23: "Reference man: anatomical, physiological and metabolic characteristics"

12 EUR 15760: "Methodology for assessing the radiological consequences of routine releases of radionuclides to the environment"

13 Regulatory Guide 1.109: "Calculation of annual dose to man from routine releases of reactor effluents for the purpose of evaluating compliance with 10CFR part 50, Appendix I"

transposing the 1996 BSS Euratom Directive, came into force. A deep review of the off site dose calculations was accomplished, modifying not only the dose coefficients, but also different factors such as the food ingestion rates, after the study of the national values mentioned above.

The general aspects of this methodology may be summarised as follows:

- local characteristics, population habits, and land and water usage are site specific;
- for atmospheric dispersion, Gaussian models-straight line trajectory are used;
- hydrological dispersion considers the specific characteristics of the effluent receiving water body (river, pond, sea, etc.);
- Generic values, such as period of animals on pasture, time from production and consumption, etc., are used;
- Local specific values, such as food consumption rates, irrigation rates, humidity, etc., and site specific exposure pathways, are also used.

The dose coefficients used in the calculation of doses to members of the public are:

- For intake by ingestion and inhalation, those specified in the Euratom 96/29 Directive;
- For external exposure to the cloud those specified in the BSS (Safety Series No. 115);
- For external exposure to deposits on to the ground and to shoreline deposits, those included in the US EPA Federal Guidance Report 13, CD Supplement.

3.1.2.4 Site-specific Factors for Significant Nuclides

Site-specific activity-dose factors for all nuclides included in libraries used in laboratory analyses, have been calculated in Almaraz 1&2 and Trillo NPP for estimating doses to the critical group. In José Cabrera, doses are calculated every month using the activity-dose conversion factors included in the Regulations.

3.1.2.5 Quality Assurance of Processes Involved in Dose Estimates

The licensees have verified the computer programs suitability through validation process and these validations have been supervised by the CSN inspectors and periodically, during the inspections, the CSN inspectors check the dose estimates for a particular month.

On the other hand, the CSN has evaluated the suitability of the site-specific parameters considered in calculations.

Furthermore, parallel calculations have been carried out by the CSN, both with own computer programs and excel sheets.

3.2 Nuclear Fuel Fabrication

Juzbado is the only installation manufacturing nuclear fuel in Spain.

3.2.1 Discharges

The information to be submitted in accordance with the BAT Guidelines is given in Annex II.

3.2.1.1 Application of BAT

The radiological protection principles and regulatory arrangements described above have been applied in Juzbado FFP in order to reduce the level of discharges and the radiological impact to both humans and the environment.

Some procedures have used to minimise the production of waste such as the revision of the operating procedures, optimising the methods applied, and the conversion of wet process into dry process via dry technique.

Regarding improvements in waste treatment, a centrifugation was installed for treatment of the floor decontamination water in order to remove the suspended particles.

3.2.1.2 Quality assurance of retention systems performance and data management

As for nuclear power plants, the performance of the retention systems is assured by controlling the pressure before and after the filters as well as the fluid activity after treatment. In this case only total alpha analyses are carried out at the laboratory.

Only batch discharges of radioactive liquid effluents take place in the facility after a total alpha analysis in order to determine the activity to be released and the required dilution factor.

Gases are only emitted in a continuous way through monitored release points. Calibration with standard sources and other additional test are periodically performed to ensure that the monitors operate properly. Alpha particulate filters in the ventilation system are weekly replaced and analyse to determine the total alpha activity released into the environment.

The laboratory instrumentation used for discharges and emissions activity quantification is periodically calibrated using standards.

Data and parameters related to treatment, discharges and emissions, as well as data from laboratory analyses, are kept in notebooks and computer files.

The facility quality control program also includes procedures and instructions for the suitable data management, as well as their correct filed according to the applicable regulations. During the inspections the CSN inspectors performs checks on chosen samples in order to verify the data transmission chain between initial measurements of the sample and final reporting to the CSN.

3.2.2 Doses

Regarding doses, all the statements made for nuclear power plants are also applicable to dose calculations to members of the public living in the vicinity of the Juzbado fuel fabrication plant.

As only total alpha activity is measured, the isotopic composition to estimate doses is calculated from that of the processed uranium. This approach is valid because only mechanical processes take place in the facility.

Data to be submitted in accordance with the BAT Guidelines are given in Annex II.

Annex 1: Nuclear Power Plants

1. Almaraz 1 & 2 Nuclear Power Plants

1.1 Site Characteristics

1.1.1 Name of site

Almaraz

1.1.2 Type of facility

Almaraz is a nuclear power plant with two twin pressurised water reactor, PWR, (Westinghouse). Hiberdrola with 53%, Endesa (36%) and Unión Fenosa (11%) are the owners of Almaraz I and II.

Within the site there are two Reactor buildings, but both units share the other auxiliary buildings (Turbine, Auxiliary, Electric, etc buildings).

1.1.3 Year for commissioning/licensing/decommissioning

Almaraz 1 was critically in 1981, starting the commercial operation in 1983. Almaraz 2 was critically in 1983, starting the commercial operation in 1984.

1.1.4 Location

The plant is located in the municipal area of Almaraz, province of Cáceres, at 180 km WSW from Madrid.

1.1.5 Receiving waters and catchment area

The Almaraz 1&2 reactors are cooled, through an open circuit, by water from the Arrocampo reservoir, on the Tajo river. Discharges take place into this reservoir whose capacity is 3,55E+07 m^3.

1.1.6 Production

The installed electrical capacity is 977 MW(e) 980 MW(e). The annual electrical output is given in table I.1.1

1.1.7 Other relevant information

There is no other relevant information

1.2 Discharges

1.2.1 Systems in place to reduce, prevent or eliminate discharges and emissions

Almaraz 1&2 NPP share a liquid radwaste treatment plant so the liquid wastes from both units are treated together and no independent data can be reported.

In Almaraz there are two types of radioactive liquid wastes: quality reactor and non-quality reactor. Quality reactor wastes, also called primary system wastes, are processed by the boric acid recovery system and the coolant water cleanup system. After treatment, these liquids are mainly reused for reactor makeup water but sometimes can be discharged. The treatment system for this type of wastes consists of two lines with a parallel design including retention tanks, double system of filters and two evaporators with a treatment capacity of 4 m^3 each. Slurries are treated in the solid waste plant and the condensed effluent is sent, after new demineralisation and filtration, to a decay tank and from this one to the surveillance tank prior to discharge.

Non-quality reactor wastes represent the main contribution to the liquid effluents discharged by the plant. These wastes, that include laundry, shower and floor drains, are clarified, flittered and demineralised. Effluents from the liquid waste treatment system are directed, along with other non-contaminated water streams, to the discharge structure.

Regarding emissions, three types of radioactive gaseous effluents are considered in Almaraz NPP: gaseous wastes; air-ejector gases and gland-seal effluents; and building ventilation gases.

Gaseous wastes, after treatment, are retained in decay tanks where are stored throughout the life of the plant; it is not foreseen their emission but if took place, they would be released through the Auxiliary building roof vent where it is previously passed through a bank of filters (coarse+HEPA+carbon bed). The condensed vapour formed in the catalytic recombination process is drained to radioactive liquid treatment system.

Air-ejector gases and gland seal effluents are discharged through the Turbine building roof vent of each unit. After condensation of the steam, depending on the activity level, the residual gas pass through a HEPA filter, a carbon bed and another HEPA filter to remove suspended particles and retain much of the iodine.

The third category of gaseous wastes consists of large volumes of ventilation air, which serve to reduce the radioactivity concentration inside different buildings (Reactor, Fuel, Auxiliary, Safeguards, etc). All these gaseous effluents are released through three roof vents or stacks of the Fuel building of each unit and of the Auxiliary Building, that both units share it. Before being released, the air is passed through particle filters (coarse and HEPA) and carbon beds as it is shown in point 1.2.2. Moreover, the different contributions reaching these emission points are also suffered previous filtration to remove suspended particles and retain the iodine.

1.2.2 Efficiency of abatement systems

This information is shown in Table I.1.2.

1.2.3 Annual liquid discharges

Information on absolute annual activity is given in Table I.1.3 while a semi-logarithmic representation of data is given in Figure I.1.1.

The absolute total activity excluding tritium shows a decreasing trend throughout the considered period of time, being the values in range or lower than the considered references. Tritium activity also shows a global decreasing trend but most values are higher than the references considered.

A policy to minimise the production of waste has been applied in Almaraz 1&2 throughout these years. Besides the measures previously mentioned, specific actions have been applied in this plant, such as:

- Segregation and piping of drains
- Use of low radioactive water for conditioning of solid wastes instead of demineralised water
- Improvements in the ion-exchange resin treatment system according to the liquid waste characteristics
- Improvements in the procedures of sampling and analysis
- Improvements in the procedures of the effluent management, control and evaluation
- Decay of the primary coolant prior to its evaporation treatment in the boric acid recovery system.

Normalisation of discharge data can be a convenient way of comparing discharge values between sources of a similar type. Table I.1.4 shows normalised liquid discharges from Almaraz 1&2 for the period 1998-2003. Table I.1.5 shows average figures given by EC and UNSCEAR reports. For total activity excluding tritium, figures in both tables are comparable. Nevertheless, for tritium, Almaraz data are higher than references.

Table I.1.6 shows absolute and normalised tritium emissions from Almaraz 1&2 for the period 1998-2003. Almaraz figures are higher than reference data, except in 2003 when they are comparable. There is a steady trend until 2003 when a decrease is observed. Measurement of C-14 in airborne effluents is carrying out since January-2007.

1.3 Environmental Impact

1.3.1 Concentrations of radionuclides of concern in representative samples of water, fish and sediment.

In tables I.1.7, I.1.8 y I.1.9 are presented respectively the ^{137}Cs, ^{60}Co and ^{54}Mn mean activity concentrations in river water, sediments and fishes in the area surveyed around Almaraz NPP.

1.3.2 Environmental monitoring programme.

The environmental monitoring programme of Almaraz NPP is run by the operator of the plant in an area within a 30 km radius. The main pathways of human exposure to radiation are monitored, as well as other ecosystem elements that are good indicators of the behaviour of radionuclides in the environment. The following table I.1.10 details the type of samples, the sampling frequency and the analyses included in the programme.

1.3.3 Systems for quality assurance of environmental monitoring.

Systems for quality assurance applicable to Almaraz NPP have been detailed in sections 2.6 and 2.8.

1.4 Radiation Doses to the Public

Information on annual effective dose to the most exposure member of the public is given in Table I.1.11 and Figure I.1.2. Doses have been recalculated with the updated methodology that takes into account the 1996 BSS Euratom Directive.

The exposure pathways considered in these calculations are:

- Liquids: Exposure to river shoreline deposits, and Ingestion of fish, goat/sheep milk, and meat (beef, goat/sheep).
- Gases: Inhalation, Exposure to the cloud, Exposure to deposits on the ground, and Ingestion of vegetables (leafy and non leafy vegetables, fruits, grain), goat/sheep milk, and meat (beef, goat/sheep).

Critical group / Main exposure pathways:

- Liquids: Adult (>17 years) / Fish consumption and goat/sheep milk.
- Gases: Adult (>17 years) / Non leafy vegetables and Inhalation.

Effective doses are well bellow the present authorised limit. Taking into account liquid and gaseous effluents, the average dose is 6,12E-4 mSv that represents a 0,31 % of the release limit. There is a decreasing trend along the considered period of time.

The critical group is the adult being the main exposure pathways fish consumption (40%) and goat/sheep milk (32%).

Table I.1.1. Almaraz 1&2 NPP. Annual electrical output in GW(e)a

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Gross Electrical Output: Almaraz 1	0,946	0,828	0,886	0,966	0,883	0,892
Almaraz 2	0,693	0,958	0,877	0,900	0,964	0,784
Net Electrical Output: Almaraz 1	0,917	0,798	0,853	0,931	0,848	0,856
Almaraz 2	0,673	0,928	0,845	0,867	0,931	0,757

Table I.1.2. Almaraz 1&2 NPP. Abatement system and their efficiency

Abatement system/ Management	**Efficiency of abatement system**		**Comments**
	Decontamination Factor	**Other measure of efficiency**	
Discharges:			
Steam-Generator Blow down: ▪ Filter	98% for particles (2 µm)		
▪ 2 Mixed ion exchangers in series	Respectively each one: 100/ 10 for anions 10/ 10 for Cs, Rb 100/ 10 for other		
▪ Filter	98% for particles (25 µm)		
Quality Reactor Wastes Treatment: ▪ Filter	98% for particles (25 µm)		
▪ Evaporator		Concentration from 10-2500 (entrance) to 21000 ppm of boron (exit)	
▪ Mixed ion exchanger	100 for anions 10 for Cs, Rb 1000 for other		
▪ Filter	98% for particles (25 µm)		
Non Quality Reactor Wastes Treatment: ▪ Filter	1 for corrosion products 98% for particles (25 µm)		
▪ Mixed ion exchanger	100 for anions 2 for Cs, Rb 100 for other		
▪ Filter	98% for particles (25 µm)		
Recovery Boron System: ▪ Ion exchanger	2 for Cs, Rb 10 for other		
▪ Filter	98% for particles (5µm)		
▪ Evaporator		< 10 ppm in condensate	
▪ Ion exchanger	2 for Cs, Rb 10 for other		
▪ Filter	98% for particles (25 µm)		
Coolant Water Drains System: ▪ Mixed ion exchanger	10 for anions 2 for Cs, Rb 10 for other		
▪ Cationic exchanger	1 for anions 10 for Cs, Rb 10 for other		
▪ Filter	98% for particles (25 µm)		
Emissions:			
Reactor building purge: ▪ Coarse filter	≥ 80% for particles		
▪ Charcoal bed	≥ 95% for iodine		
▪ HEPA filter	≥ 99,97%		

Hydrogen purge from reactor building: ▪ Coarse filter	≥ 90%		
▪ Charcoal bed	≥ 99 %		
▪ HEPA filter	≥ 99 %		
Reactor building ventilation: ▪ Coarse filter	≥ 80%		
▪ HEPA filters	≥ 99,97 %		
▪ Charcoal bed	≥ 99,9 %		
Safeguard building ventilation: ▪ Coarse filter	≥ 80%		
▪ HEPA filters	≥ 99,97 %		
▪ Charcoal bed	≥ 99,9 %		
Fuel building ventilation: ▪ Coarse filter	≥ 80%		
▪ HEPA filters	≥ 99,9 %		
▪ Charcoal bed	≥ 99,9 %		
Purge treatment building ventilation: ▪ Coarse filter	≥ 80%		
▪ HEPA filters	≥ 99,9 %		
▪ Charcoal bed	≥ 99,9 %		
Ejector gases: ▪ HEPA	N.A.		
▪ Charcoal bed	90 %		
Gland-seal effluents: ▪ HEPA filter	99,9 %		
▪ Charcoal bed:	90 %		

Table I.1.3. Almaraz 1&2 NPP. Annual liquid effluent activity (GBq/year)

Nuclide	1998	1999	2000	2001	2002	2003
Gross Alpha						
H-3	**6,74E+04**	**4,86E+04**	**6,74E+04**	**4,92E+04**	**2,90E+04**	**4,51E+04**
Co-58	2,23E+00	2,54E+00	1,46E+00	7,03E-01	7,06E-01	7,04E-01
Co-60	2,37E+00	2,07E+00	1,89E+00	1,70E+00	1,57E+00	1,22E+00
Zn-65	1,32E-02		3,87E-04			2,44E-03
Sr-90						
Zr/Nb-95	6,27E-02	3,22E-01	2,91E-01	1,34E-01	2,83E-01	1,40E-01
Ru-106						
Ag-110m	1,66E-01	3,55E-01	2,95E-01	9,44E-01	3,77E-01	2,01E-01
Sb-125	2,57E+00	6,25E-01	1,05E+00	8,78E-01	9,32E-01	3,61E-01
Cs-134	6,44E-01	1,42E-01	2,52E-01	2,29E-01	1,83E-01	9,71E-02
Cs-137	1,49E+00	4,71E-01	1,05E+00	1,10E+00	7,59E-01	6,65E-01
Ce-144	1,59E-03	9,06E-03	7,04E-04			
Other nuclides	1,44E+00	5,75E+00	5,69E+00	3,30E+00	1,16E+00	7,88E-01
Total Activity excluding H-3	**1,10E+01**	**1,23E+01**	**1,20E+01**	**8,98E+00**	**5,97E+00**	**4,18E+00**

Table I.1.4. Almaraz 1&2 NPP. Normalised annual liquid effluent activity (GBq/GWa)

Year	1998	1999	2000	2001	2002	2003
Total activity without H-3	6,91E+00	7,12E+00	7,05E+00	5,00E+00	3,35E+00	2,59E+00
Tritium	4,24E+04	2,82E+04	3,97E+04	2,73E+04	1,63E+04	2,80E+04

Table I.1.5. Normalised releases EC – UNSCEAR (GBq/Gwa)

Year	EC Report	UNSCEAR Report	
	1995-99	1990-94	1995-97
Total activity without tritium (liquids)	3,78E+00	1,90E+01	8,1E+00
Tritium (liquids)	1,71E+04	2,2E+04	1,90E+04
Tritium (gases)	1,05E+03	2,30E+03	2,40E+03
C-14 (gases)	1,96E+02	2,20E+02	- -

Table I.1.6. Almaraz 1&2. Absolute and normalised Tritium emissions

Year	1998	1999	2000	2001	2002	2003
GBq/y	7,58E+03	7,66E+03	8,10E+03	7,97E+03	8,78E+03	3,32E+03
GBq/Gwa	4,77E+03	4,44E+03	4,77E+03	4,43E+03	4,94E+03	2,06E+03

Table I.1.7. Almaraz 1&2. ^{137}Cs, ^{60}Co and ^{54}Mn mean concentrations in river water (Bq/m^3)

Isotope	1998	1999	2000	2001	2002	2003
^{137}Cs	< 45,9	*< 49,5*	*<44,0*	*<48,3*	*<57,9*	*<85,9*
^{60}Co	<55,8	*<67,0*	*<59,7*	*<62,2*	*<60,4*	*<76,8*
^{54}Mn	*<49,1*	*<50,8*	*<44,1*	*<47,4*	*<58,3*	*<70,8*

Table I.1.8. Almaraz 1&2. ^{137}Cs, ^{60}Co and ^{54}Mn mean concentrations in sediments (Bq/kg.dry.wt)

Isotope	1998	1999	2000	2001	2002	2003
^{137}Cs	29,5	26,2	23,3	16,4	11,8	13,2
^{60}Co	32,2	15,8	16,8	17,8	12,9	28,4
^{54}Mn	1,03	1,23	*<0,6*	*<0,6*	0,91	1,23

Table I.1.9. Almaraz 1&2. ^{137}Cs, ^{60}Co and ^{54}Mn mean concentrations in fishes (Bq/kg.wet.wt)

Isotope	1998	1999	2000	2001	2002	2003
^{137}Cs	0,84	0,58	0,47	0,50	0,54	0,37
^{60}Co	0,19	0,14	*<0,22*	*<0,24*	0,18	*<0,13*
^{54}Mn	*<0,12*	*<0,14*	*<0,18*	*<0,20*	*<0,16*	*<0,11*

Table I.1.10. Environmental Monitoring Programme around Almaraz NPP

Sample	Frequency	Measurement/analysis
Air (Aerosols) Iodine	Continuous (weekly)	Gross- β ^{90}Sr γ spectrometry I-131
Gamma radiation (TLD)	Continuous (quarterly)	Dose rate
Rain water	Continuous (monthly)	γ spectrometry ^{90}Sr
Soil	Yearly	γ spectrometry ^{90}Sr
Drinking water	Fortnightly	Gross-β Residual-β ^{90}Sr ^{3}H γ spectrometry
Ground water	Quarterly	Gross- β Residual-β ^{3}H γ spectrometry
Surface water	Monthly. Continuous in one station	Gross- β Residual-β ^{3}H γ spectrometry
Sediment and biological indicators[1]	Half-yearly	^{90}Sr γ spectrometry
Milk[2]	Fortnightly	^{90}Sr γ spectrometry ^{131}I
Crops[3]	Harvest season	^{90}Sr γ spectrometry ^{131}I (leafy vegetables)
Meat[4] and eggs	Half-yearly	γ spectrometry
Fishes[5]	Half yearly. Monthly in one station	γ spectrometry
Honey	Yearly	γ spectrometry

1. Scirpus, typha, retama // **2.** Goat, sheep and cow milk samples // **3.** Tomato, pepper, eggplant, chard, lettuce, cabbage, onion, melon, watermelon // **4.** chicken, lamb, pig, beef // **5.** Barbel, carp.

Table I.2.11. Almaraz 1&2. Annual effective dose to the critical group (mSv/y)

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Liquids	8,04E-04	5,78E-04	5,84E-04	5,42E-04	3,90E-04	3,15E-04
Gases	8,47E-05	8,08E-05	8,50E-05	8,23E-05	8,95E-05	3,53E-05
Total	8,88E-04	6,58E-04	6,69E-04	6,24E-04	4,79E-04	3,50E-04

Figure I.1.1. Almaraz 1&2 NPP. Annual liquid effluent activity (GBq/year)

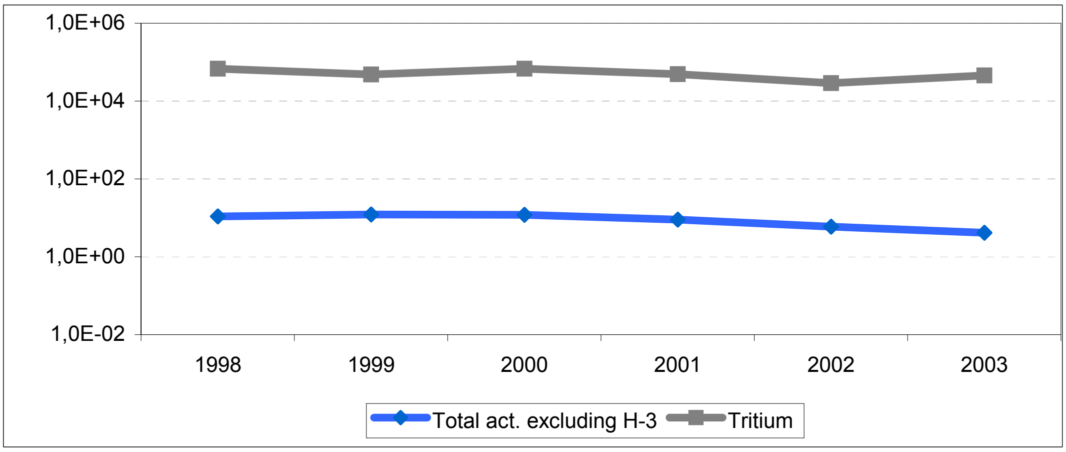
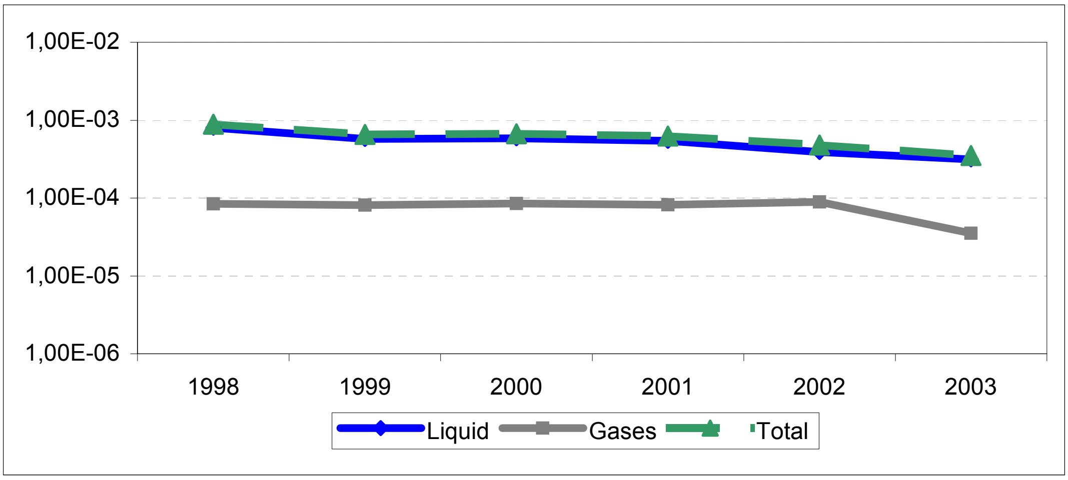


Figure I.1.2. Almaraz 1&2 NPP. Annual effective dose to the critical group (mSv/y)



2. Jose Cabrera Nuclear Power Plant

1.5 Site Characteristics

1.5.1 Name of site

José Cabrera

1.5.2 Type of facility

Essentially, the plant is made up of a nuclear steam supply system designed and supplied by Westinghouse, consisting of a pressurised water reactor (PWR). Unión Fenosa operates the facility.

The main installations within the site are: Reactor building, Turbine building, Auxiliary building, Decontamination plant building, Evaporator building and the new Solid radioactive waste management building.

1.5.3 Year for commissioning/licensing/decommissioning

The reactor was critically in 1968, starting the commercial operation in 1969. The plant, also called Zorita, has been shut down on 30th April 2006 in execution of a command emitted by the Spanish Ministry of Economy the 14th October 2002.

1.5.4 Location

José Cabrera is located in the municipal area of Almonacid de Zorita, in the province of Guadalajara, approximately 66 km E from Madrid.

1.5.5 Receiving waters and catchment area

The plant is cooled through a close circuit by water from the Zorita reservoir, on the Tajo river.

Radioactive liquid effluents flow into the Tajo river through two successive reservoirs (Zorita and Almoguera). The plant discharges into the Zorita reservoir from where the water flows into the Almoguera reservoir that is located 20 km downstream from the nuclear power plant.

The Zorita reservoir capacity is 2,7E+06 m^3, while the Almoguera´s capacity is 6,5E+06 m^3. The average annual flow rate of the Tajo river is 9,5 m^3/s.

1.5.6 Production

The installed electrical capacity is 160 MW(e). The annual electrical output is given in Table I.2.1.

1.5.7 Other relevant information

There is no other relevant information.

1.6 Discharges

1.6.1 Systems in place to reduce, prevent or eliminate discharges and emissions

High-level activity liquids are purified by ion exchange. To this end, the plant is provided with five filter demineralises: one of them for cationic retention; two, in parallel, for anionic retention; and finally two, in parallel, provided with mixed cation and anion exchange resins. After that, the liquids are treated by evaporation.

Although initially the evaporation was planned for the high activity liquid treatment, the policy of the plant changed and throughout the considered period of time all the radioactive liquid waste has been treated by that technique.

Only the liquid phase of the steam generator purge is discharged directly into the discharge structure if the activity level is low enough; if not, it is derived to the radwaste treatment system.

The radwaste treatment system is provided with several storage tanks but the most important, due to its capacity (1135 m3), is the one where the clean distillate from the evaporator is storage. This tank allows to choose not only the volume to be discharged, but also the moment when the release can be done, in order to minimise the environmental radiological impact.

Regarding emissions, the José Cabrera gaseous effluents are release through one stack with a height of 60 meters, except the vapour phase of the steam generator purge that is emitted through a Turbine building roof vent.

The radioactive gaseous treatment system processes the primary system gases. They included gases vented from the CVCS and from clean liquid waste hold-up tanks. For collecting these gases the system is provided with five storage tanks that allow their decay before being released into the environment. Prior to tanks, the gases are filtered for the retention of particles and iodines. To this end, coarse and HEPA filters for retention of particles and charcoal beds for adsorption of iodines.

Ventilation air is the large contribution to the stack releases, particularly from: Auxiliary building, Reactor building, Evaporator building, and Solid radioactive waste management building. Before been discharged through the stack, the air passed through particulate filters and charcoal beds. Detailed information on the available filters in each line is included in the point 2.2.2.

1.6.2 Efficiency of abatement systems

This information is shown in Table I.2.2.

1.6.3 Annual liquid discharges

Information on absolute annual activity is given in Table I.2.3 while a semi-logarithmic representation of data is given in Figure I.2.1.

The absolute total activity excluding tritium shows a decreasing trend apart from 1999 when the evaporator had some problems and did not work at its optimum level during the refuelling period. Tritium remains stable except a small increase in 2003; this year due to the reduction of the primary circuit leakage, tritium activity in the primary coolant, and therefore in the liquid wastes, was higher. This fact, along with the necessity of discharging a big volume of liquid effluents for operational reasons, gave to an increase of the tritium activity discharged.

A policy to minimise the production of waste has been applied throughout these years. Besides the measures previously mentioned, specific actions have been applied in this plant, such as: the planning of works which require primary cooling system drainages in order to get their co-ordination; the change of the primary treatment system spent ion-exchange resins before their saturation level; the use of dry decontamination processes; the dry decay of clothes for a year to minimise the laundry wastes; and the application of the ALARA criteria to reduce the liquid wastes produced by works carried out in refuelling shutdown.

Normalisation of discharge data can be a convenient way of comparing discharge values between sources of a similar type. In Table I.2.4 the normalised liquid discharges from José Cabrera are shown for the period 1998-2003. Table I.2.5 presents the average figures given by EC and UNSCEAR-2000 reports. Figures in both tables show that José Cabrera NPP normalised total activity excluding tritium is lower than the international references considered, while tritium is the same range.

Table I.2.6 shows absolute and normalised tritium emissions from José Cabrera NPP for 1998-2003. Figures in both tables show that tritium emissions from José Cabrera NPP are lower than the international references considered.

1.7 Environmental Impact

1.7.1 Concentrations of radionuclides of concern in representative samples of water, sediment, and fish

In tables I.2.7, I.2.8, and I.2.9 are presented respectively the ^{137}Cs, ^{60}Co and ^{54}Mn mean activity concentrations in river water, sediments and fishes in the area surveyed around Jose Cabrera NPP.

1.7.2 Environmental monitoring programme

The plant operator in an area within a 30 km radius conducts the environmental monitoring programme of Jose Cabrera NPP. The main pathways of human exposure to radiation are monitored, as well as other ecosystem elements that are good indicators of the behaviour of radionuclides in the environment. Table I.2.10 details the type of samples, the sampling frequency and the analyses included in the programme.

1.7.3 Systems for quality assurance of environmental monitoring

Systems for quality assurance applicable to Jose Cabrera NPP have been detailed in sections 2.6 and 2.8.

1.8 Radiation Doses to the Public

Information on annual effective dose to the most exposure member of the public is given in Table I.2.11 and Figure I.2.2. Doses have been recalculated with the updated methodology that takes into account the 1996 BSS Euratom Directive.

The exposure pathways considered in these calculations are:

- Liquids: Exposure to river shoreline deposits, and Ingestion of potable water, vegetables (leafy and non leafy vegetables, fruits, grain), milk (goat/sheep, cow), meat (beef, goat/sheep), and fish.
- Gases: Inhalation, Exposure to the cloud, Exposure to deposits on the ground, and Ingestion of vegetables (leafy and non leafy vegetables, fruits, grain), milk (cow, goat/sheep) and meat (beef, goat/sheep).

Critical group / Main exposure pathways:

- Liquids: Children (1-2 years) / Potable water and Cow milk.
- Gases: Children (1-2 years) / Exposure to the cloud and Non leafy vegetables.

Effective doses are well bellow the present authorised limit. Taking into account liquid and gaseous effluents, the average dose is 6,8E-4 mSv that represents a 0,68 % of the release limit. There is no trend along the considered period of time apart from a small increase in 2003 due to the discharged tritium.

The critical group is the children being the main exposure pathways ingestion of cow milk (47%) and ingestion of potable water (41%).

Table I.2.1. José Cabrera NPP. Annual electrical output in GW(e)a

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Gross Electrical Output	0,133	0,134	0,133	0,129	0,115	0,130
Net Electrical Output	0,126	0,127	0,126	0,121	0,108	0,122

Table I.2.2. José Cabrera NPP. Abatement system and their efficiency

Abatement system/ Management	Efficiency of abatement system		Comments
	Decontamination Factor	**Other measure of efficiency**	
Discharges:			
Mixed ion exchanger	1 for Noble gases, Cs, Y, Mo 10 for other nuclides except iodine		
Cationic exchanger	10 for Cs, Y, Mo		
Evaporator		Decontamination coefficient: 10^6 for liquids except I and B 10^5 for gases 10^3 for I and B	Although an evaporator has been available from the start of the operation, it was replaced with a new one to get a higher concentration factor
Store tank		Delay time 1-2 months	
Emissions:			
Gaseous treatment system: ▪ Coarse filter	50 %		
▪ HEPA filter	99,95 % (0,3 µm)		
▪ Charcoal bed	99,50 %		
▪ Decay tanks		Delay time 60 days (approximately 8 half periods)	
Auxiliary building: ▪ Coarse filter	50 %		
▪ HEPA filters	99,95 %		
▪ Charcoal bed	99,50 %		
Reactor building: ▪ HEPA filter	99,95 %		
Evaporator building: ▪ Coarse filter	50 %		
▪ HEPA filter	99,95 %		

Table I.2.3. José Cabrera NPP. Annual liquid effluent activity (GBq/year)

Nuclide	1998	1999	2000	2001	2002	2003
Gross Alpha						
H-3	**2,43E+03**	**5,93E+03**	**4,02E+03**	**4,49E+03**	**2,39E+03**	**9,53E+03**
Co-58	9,96E-05	1,11E-01	4,99E-02	3,09E-02	4,15E-03	7,35E-03
Co-60	9,46E-03	5,35E-02	6,12E-02	1,66E-02	1,62E-02	7,72E-03
Zn-65						
Sr-90				3,05E-03		
Zr/Nb-95						
Ru-106						
Ag-110m						
Sb-125						
Cs-134	8,78E-04	4,86E-04	1,32E-03			
Cs-137	4,44E-02	1,92E-01	6,31E-02	6,98E-03	2,87E-02	1,98E-02
Ce-144						
Other nuclides	2,96E-02	8,96E-02	1,46E-01	4,35E-02	8,01E-03	9,54E-03
Total Activity excluding H-3	**8,45E-02**	**4,47E-01**	**3,22E-01**	**1,01E-01**	**5,70E-02**	**4,45E-02**

Table I.2.4. José Cabrera NPP. Normalised annual liquid effluent activity (GBq/GWa)

Year	1998	1999	2000	2001	2002	2003
Total activity without H-3	6,73E-01	3,53E+00	2,56E+00	8,36E-01	5,27E-01	3,64E-01
Tritium	1,94E+04	4,68E+04	3,20E+04	3,71E+04	2,21E+04	7,79E+04

Table I.2.5. Normalised releases EC – UNSCEAR (GBq/Gwa)

Year	EC Report	UNSCEAR Report	
	1995-99	1990-94	1995-97
Total activity without tritium (liquids)	3,78E+00	1,90E+01	8,1E+00
Tritium (liquids)	1,71E+04	2,2E+04	1,90E+04
Tritium (gases)	1,05E+03	2,30E+03	2,40E+03
C-14 (gases)	1,96E+02	2,20E+02	- -

Table I.2.6. José Cabrera. Absolute and normalised tritium emissions

Year	1998	1999	2000	2001	2002	2003
GBq/y	3,06E+01	3,12E+01	4,11E+01	4,27E+01	8,40E+01	4,25E+01
GBq/GWa	2,44E+02	2,46E+02	3,27E+02	3,54E+02	7,77E+02	3,47E+02

Table I.2.7. José Cabrera. ^{137}Cs, ^{60}Co and ^{54}Mn mean concentrations in river water (Bq/m^3)

Isotope	1998	1999	2000	2001	2002	2003
^{137}Cs	< 39,2	*<52,92*	*<41,9*	*<49,8*	*<57,9*	*<67,5*
^{60}Co	<37,4	*<50,8*	*<50,5*	*<64,0*	*<60,5*	*<59,3*
^{54}Mn	*<38,3*	*<50,6*	*<42,6*	*<48,9*	*<60,5*	*<57,4*

Table I.2.8. José Cabrera. ^{137}Cs, ^{60}Co and ^{54}Mn mean concentrations in sediments (Bq/kg.dry.wt)

Isotope	1998	1999	2000	2001	2002	2003
^{137}Cs	14,4	11,1	46,6	5,72	3,39	3,16
^{60}Co	1,81	1,10	2,32	<0,39	<0,28	<0,28
^{54}Mn	<0,26	<0,21	*<0,26*	*<0,34*	<0,24	<0,25

Table I.2.9. José Cabrera. ^{137}Cs, ^{60}Co and ^{54}Mn mean concentrations in fishes (Bq/kg.wet.wt)

Isotope	1998	1999	2000	2001	2002	2003
^{137}Cs	1,03	2,52	2,82	0,54	0,14	0,34
^{60}Co	0,17	0,09	*<0,11*	*<0,15*	<0,12	*<0,09*
^{54}Mn	0,16	<0,10	*<0,11*	*<0,15*	*<0,11*	*<0,08*

Table I.2.10. Environmental Monitoring Programme around Jose Cabrera NPP

Sample	Frequency	Measurement/analysis
Air (Aerosols) Iodine	Continuous (weekly)	Gross- β ^{90}Sr γ spectrometry I-131
Gamma radiation (TLD)	Continuous (quarterly)	Dose rate
Rain water	Continuous (monthly)	γ spectrometry ^{90}Sr
Soil	Yearly	γ spectrometry, ^{90}Sr
Drinking water	Fortnightly	Gross-β Residual β ^{90}Sr ^{3}H γ spectrometry

Sample	Frequency	Measurement/analysis
Ground water	Quarterly	Gross- β Residual β ^{3}H γ spectrometry
Surface water	Monthly. Continuous in two stations	Gross- β Residual β ^{3}H γ spectrometry
Sediment and biological indicators[1]	Half-yearly	^{90}Sr γ spectrometry
Milk[2]	Fortnightly and Monthly	^{90}Sr γ spectrometry ^{131}I
Crops[3]	Harvest season	^{90}Sr γ spectrometry ^{131}I (leafy vegetables)
Meat[4] and eggs	Half-yearly	γ spectrometry
Fishes[5]	Half yearly	γ spectrometry ^{90}Sr
Honey	Yearly	γ spectrometry

1. Phragmites, Myriophyllum, Potamogeton // **2.** Goat and sheep milk samples // **3.** Chard, potato, onion, pumpkin, Pepper // **4.** Sheep meat samples // **5.** Trout, barbel, pike-fish, carp, tench.

Table I.2.11. José Cabrera. Annual effective dose to the critical group (mSv/y)

Year	1998	1999	2000	2001	2002	2003
Liquids	3,07E-04	6,03E-04	5,66E-04	5,26E-04	4,77E-04	1,09E-03
Gases	1,81E-05	1,37E-5	1,62E-5	1,72E-5	1,69E-5	1,36E-5
Total	3,25E-04	6,16E-04	5,82E-4	5,43E-4	4,93E-4	1,10E-03

Figure I.2.1. José Cabrera NPP. Annual liquid effluent activity (GBq/year)

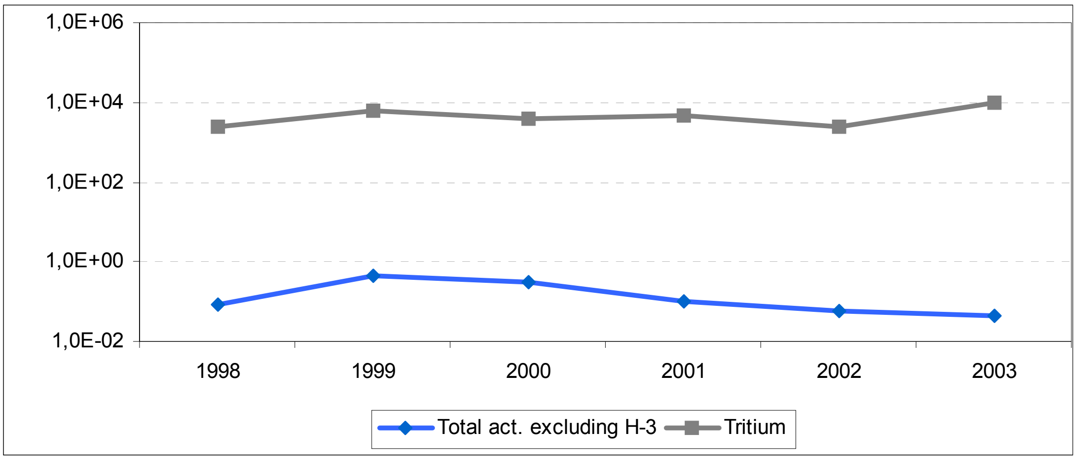
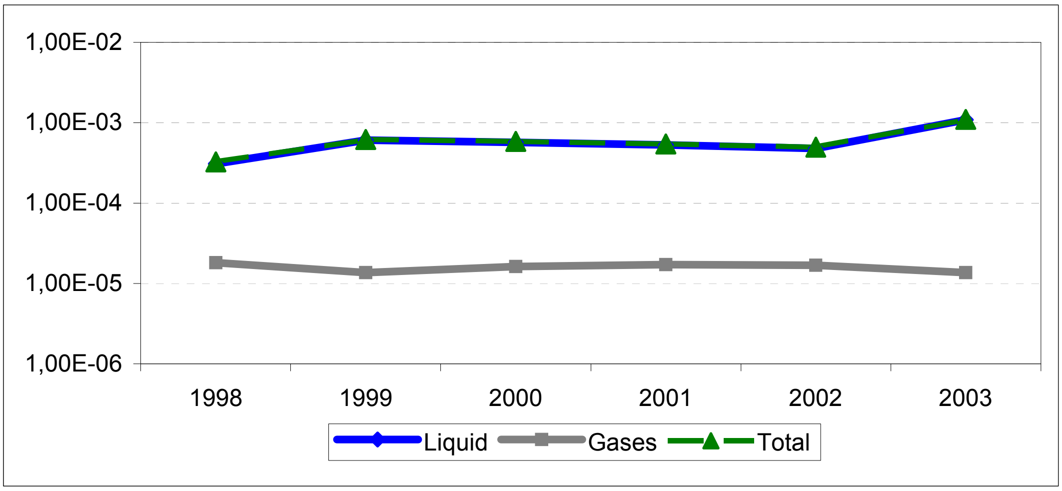


Figure I.2.2. José Cabrera NPP. Annual effective dose to the critical group (mSv/y)



2 Trill Nuclear Power Plant

2.1 Site Characteristics

2.1.1 Name of site

Trillo

2.1.2 Type of facility

Essentially, the plant is made up of a nuclear steam supply system designed and supplied by KWU, consisting of a pressurised water reactor (PWR) with three loops. Iberdrola (48%), Unión Fenosa (34,5%), Hidrocantábrico (15,5%) and Nuclenor (2%) own the facility.

The main installations within the site are: Reactor building that includes the containment structure and the annular shielding building; Turbine building; Auxiliary building; Electric building; Solid waste building; and Dry interim storage building for spent fuel containers.

2.1.3 Year for commissioning/licensing/decommissioning

The reactor was critically in May-1988, starting the commercial operation in August 1988.

2.1.4 Location

Trillo is located in the municipal area of Trillo, in the province of Guadalajara, approximately 100 km E from Madrid.

2.1.5 Receiving waters and catchment area

The plant is cooled by water from the Tajo river through a close circuit. The plant discharges into that river. The average annual flow rate of the Tajo river is 18,1 m^3/s.

2.1.6 Production

The installed electrical capacity is 1066 MW(e). The annual electrical output is given in Table I.3.1.

2.1.7 Other relevant information

There is no other relevant information.

2.2 Discharges

2.2.1 Systems in place to reduce, prevent or eliminate discharges and emissions

Two types of radioactive liquids wastes can be found in Trillo NPP: those originated in coolant purification processes and drains resulting from maintenance operations.

Certain volume of water is withdrawn from the pressurised primary circuit and treated in the chemical and volume control system (CVCS) where gases are removed. After that the liquid passes to an ion exchanger for the removal of fission products and then to an evaporator in order to recover the boric acid. The condensed vapour can be stored for later use as coolant or sent to the radioactive liquid treatment system for its discharged to the river.

According to their origin, liquids radwastes are collected in five hold-up tanks where they are analysed to determine the chemical and radioactive characteristics. After conditioning for precipitation, control of pH, etc, liquids are evaporated. To this end, the plant has two evaporators in parallel, being assigned each unit to a type of liquid waste. Although a filter is also installed as an alternative treatment, it has never used and liquids are always treated by evaporation. Where it is considered desirable to decrease the radioactivity level further, the condensate is demineralised.

Regarding emissions, three types of radioactive gaseous effluents are considered in Trillo NPP: gaseous wastes; air-ejector gases and gland-seal effluents; and building ventilation gases. All of them are released through a stack with a height of 100 meters.

Gaseous wastes are processed by the treatment system. After a catalytic recombination process to covert the hydrogen gas into water, which is condensed and removed, gases are passed through two delay banks in series, with five charcoal beds each one, where they are retained by adsorption for noble gases decay. Most of the treated gases are reused in the plant while only 10% is released through the stack.

Air-ejector gases and gland seal effluents are emitted after a condensation process of the steam.

Ventilation air is passed through particle filters (coarse and HEPA) and carbon beds, as it is shown in point 3.2, before being released through the stack. Detailed information on the available filters in each line is included in the point 3.2.2.

2.2.2 Efficiency of abatement systems

This information is shown in Table I.3.2.

2.2.3 Annual liquid discharges

Information on absolute annual activity is given in Table I.3.3 for tritium and total activity excluding Tritium, while a semi-logarithmic representation of data is given in Figure I.3.1 This figure shows that both lines present a stable trend throughout the considered period.

A policy to minimise the production of waste has been applied throughout these years. Besides the measures previously mentioned, specific actions have been applied in this plant, such as reuse of contaminated liquids.

The licensee has established target release values in terms of annual activity for the different considered groups of radionuclides. These target values for liquid effluents are:

- Total activity excluding Tritium: 8,0E-01 GBq/y.
- Tritium: 3,0E+4 GBq/y.

Normalisation of discharge data can be a convenient way of comparing discharge values between sources of a similar type. In Table I.3.4 normalised liquid discharges from Trillo are shown for the period 1998-2003. Table I.3.5 presents the average figures given by EC and UNSCEAR-2000 reports. Figures in both tables show that Trillo NPP normalised total activity excluding tritium is lower than the international references considered, while tritium is the same range.

Table I.3.6 shows absolute and normalised tritium and carbon-14 emissions from Trillo NPP for period 1998-2003. Figures in both tables show that tritium and carbon-14 emissions from Trillo NPP are lower than the international references considered.

2.3 Environmental Impact

2.3.1 Concentrations of radionuclides of concern in representative samples of water, sediment, and fish

Tables I.3.7, I.3.8, and I.3.9 show respectively the ^{137}Cs, ^{60}Co and ^{54}Mn mean activity concentrations in river water, sediments and fish in the area surveyed around Trillo NPP.

2.3.2 Environmental monitoring programme.

The environmental monitoring programme of Trillo NPP is conducted by the plant operator in an area within a 30 km radius. The main pathways of human exposure to radiation are monitored, as well as other ecosystem elements that are good indicators of the behaviour of radionuclides in the environment. The Table I.3.10 details the type of samples, the sampling frequency and the analyses included in the programme.

2.3.3 Systems for quality assurance of environmental monitoring.

Systems for quality assurance applicable to Trillo NPP have been detailed in sections 2.6 and 2.8.

2.4 Radiation Doses to the Public

Information on annual effective dose to the most exposure member of the public is given in Table I.3.7 and Figure I.3.2. Trillo NPP is the only power plant measuring C-14, in order to compare with other Spanish installations doses due to the gaseous effluents have been represented in that figure as “Gases without C-14” and “C-14”. Doses have been recalculated with the updated methodology that takes into account the 1996 BSS Euratom Directive.

The exposure pathways considered in these calculations are:

- Liquids: Potable water consumption, Exposure to river shoreline deposits, and Ingestion of vegetables (leafy and non leafy vegetables, fruits, grain), milk (cow, goat/sheep), meat (beef, goat/sheep), and fish.
- Gases: Inhalation, Exposure to the cloud, Exposure to deposits on the ground, and Ingestion of vegetables (leafy and non leafy vegetables, fruits, grain), milk (cow, goat/sheep) and meat (beef, goat/sheep)

Critical group / Main exposure pathways:

- Liquids: Children (1-2 years) / Consumption of non leafy vegetables, fruits and grain, and cow milk
- Gases: Children (1-2 years) / Consumption of non-leafy vegetables, fruits and grain, and cow milk.

Effective doses are well bellow the present authorised limit. Taking into account liquid and gaseous effluents, the average dose is 1,11E-3 mSv that represents a 1,11 % of the release limit. There is a general decreasing trend along the considered period of time with a small increase in 2003 due to the tritium discharge.

The critical group is the children, being the main exposure pathways ingestion of cow milk (51%) and ingestion of non-leafy vegetables, fruits and grain (40%).

The licensee has established a target release value in terms of annual dose for the different considered groups of radionuclides. This target value is an effective dose of 5E-3 mSv/y taking into account the contribution of liquid and gaseous effluents.

Table I.3.1. Trillo NPP. Annual electrical output in GW(e)a

Year	1998	1999	2000	2001	2002	2003
Gross Electrical Output	0,597	0,829	0,997	0,962	0,953	0,989
Net Electrical Output	0,752	0,780	0,937	0,903	0,893	0,926

Table I.3.2. Trillo NPP. Abatement system and their efficiency

Abatement system/ Management	**Efficiency of abatement system**		**Comments**
	Decontamination Factor	**Other measure of efficiency**	
Discharges:			
Liquid Wastes Treatment: ▪ Filter	5		
▪ Evaporator		Decontamination coefficient from 100 to 1E+06	
▪ Mixed ion exchanger	3		
Coolant treatment: ▪ Mixed ion exchanger	1000		
▪ Degasification system	10-1000		
▪ Filter	particles (5 µm)		
▪ Ion exchanger	100		
▪ Evaporator	100		
▪ Degasification system		Degasification factor: 4,6E+04	
▪ Filter	98% for particles (25 µm)		
Steam-generator blow-down: ▪ Mixed ion exchanger	>15 for iodine >25 for Na-24		
Emissions:			
Containment structure purge: ▪ Coarse filter	50%		
▪ Charcoal bed	99%		
▪ HEPA filter			
Containment structure ventilation: ▪ Coarse filter			
▪ Charcoal bed	99 %		
▪ HEPA filter			
Annular shielding building ventilation: ▪ Coarse filter			
▪ HEPA filters		DIN 24184	
▪ Charcoal bed	99,9 % for ICH_3		

Auxiliary building ventilation: ▪ Coarse filter	85%		
▪ HEPA filters		DIN 24184	
▪ Charcoal bed	99% for ICH_3		
Radwaste treatment: ▪ Filter	Particles (0,1mm)		
▪ Delay banks		Delay time: 60 days for Xe 60 hours for Kr	
▪ Filter	Particles (5µm)		

Table I.3.3. Trillo NPP. Annual liquid effluent activity (GBq/year)

Nuclide	1998	1999	2000	2001	2002	2003
Gross Alpha						
H-3	**1,78E+04**	**1,05E+04**	**1,57E+04**	**2,00E+04**	**1,66E+04**	**1,94E+04**
Co-58	3,38E-02	4,89E-02	2,33E-02	3,53E-02	6,48E-02	6,61E-02
Co-60	2,18E-01	3,77E-01	3,83E-01	3,44E-01	2,98E-01	2,35E-01
Zn-65			3,49E-04			
Sr-90			4,23E-04			
Zr/Nb-95	9,90E-02	7,28E-02	2,01E-02	3,15E-02	4,96E-02	7,27E-02
Ru-106						
Ag-110m	2,00E-02	3,94E-02	7,97E-02	1,89E-01	7,56E-02	6,32E-02
Sb-125	1,87E-03	3,67E-03	9,73E-03	2,32E-02	2,18E-02	8,69E-03
Cs-134		2,41E-02	1,56E-02	2,66E-02	4,98E-03	4,67E-03
Cs-137	2,09E-02	6,01E-02	7,53E-02	2,79E-01	6,15E-02	1,22E-01
Ce-144		2,88E-04	1,07E-02			
Other nuclides	1,67E-01	1,58E-01	3,91E-02	8,30E-02	1,49E-01	2,20E-01
Total Activity excluding H-3	**5,61E-01**	**7,84E-01**	**6,58E-01**	**1,01E+00**	**7,25E-01**	**7,92E-01**

Table I.3.4. Trillo NPP. Normalised annual liquid effluent activity (GBq/GWa)

Year	1998	1999	2000	2001	2002	2003
Total activity without H-3	7,45E-01	1,01E+00	7,02E-01	1,12E+00	8,11E-01	8,55E-01
Tritium	2,37E+04	1,35E+04	1,67E+04	2,21E+04	1,86E+04	2,10E+04

Table I.3.5. Normalised releases EC – UNSCEAR (GBq/GWa)

Year	EC Report	UNSCEAR Report	
	1995-99	**1990-94**	**1995-97**
Total activity without tritium (liquids)	3,78E+00	1,90E+01	8,1E+00
Tritium (liquids)	1,71E+04	2,2E+04	1,90E+04
Tritium (gases)	1,05E+03	2,30E+03	2,40E+03
C-14 (gases)	1,96E+02	2,20E+02	- -

Table I.3.6. Trillo NPP. Absolute and normalised tritium and C-14 emissions

Nuclide	1998	1999	2000	2001	2002	2003
H-3 (GBq/y)	5,88E+02	5,97E+02	9,85E+02	6,56E+02	6,37E+02	7,31E+02
C-14 (GBq/y)	8,55E+01	9,63E+01	1,34E+01	5,69E+01	4,34E+01	4,82E+01
H-3 (GBq/GWa)	7,81E+02	7,66E+02	1,05E+03	7,27E+02	7,12E+02	7,89E+02
C-14 (GBq/GWa)	1,14E+02	1,24E+02	1,43E+01	6,31E+01	4,86E+01	5,21E+01

Table I.3.7. Trillo NPP. ^{137}Cs, ^{60}Co and ^{54}Mn mean concentrations in river water (Bq/m^3)

Isotope	1998	1999	2000	2001	2002	2003
^{137}Cs	<84,4	*<72,1*	*<66,8*	*<62,7*	*<63,4*	*<40,9*
^{60}Co	<84,5		*<64,9*	*<59,8*	*<60,4*	*<37,1*
^{54}Mn	*<83,4*	*<71,4*	*<65,3*	*<60,4*	*<61,7*	*<38,5*

Table I.3.8. Trillo NPP. ^{137}Cs, ^{60}Co and ^{54}Mn mean concentrations in sediments (Bq/kg.dry.wt)

Isotope	1998	1999	2000	2001	2002	2003
^{137}Cs	13,0	3,7	2,3	3,5	1,5	3,5
^{60}Co	1,03	3,7	1,0	0,8	1,0	1,8
^{54}Mn	<0,5	<0,4	*<0,3*	*<0,2*	<0,3	<0,2

Table I.3.9. Trillo NPP. ^{137}Cs, ^{60}Co and ^{54}Mn mean concentrations in fishes (Bq/kg.wet.wt)

Isotope	1998	1999	2000	2001	2002	2003
^{137}Cs	0,37	0,4	<0,2	0,5	0,5	0,5
^{60}Co	<0,31		<0,2	*<0,1*	<0,3	*<0,2*
^{54}Mn	<0,31	<0,2	*<0,2*	*<0,1*	*<0,3*	*<0,3*

Table I.3.10. Environmental Monitoring Programme around Trillo NPP

Sample	Frequency	Measurement/analysis
Air (Aerosols) Iodine	Continuous (weekly)	Gross- β ^{90}Sr γ spectrometry I-131
Gamma radiation (TLD)	Continuous (quarterly)	Dose rate
Rain water	Continuous (monthly)	γ spectrometry ^{90}Sr
Soil	Yearly	γ spectrometry, ^{90}Sr
Drinking water	Fortnightly and monthly	Gross-β Residual β ^{90}Sr ^{3}H γ spectrometry
Ground water	Quarterly	Gross- β Residual β ^{3}H γ spectrometry
Surface water	Fortnightly. Continuous first station downstream	Gross- β Residual β ^{3}H γ spectrometry
Sediment and biological indicators[1].	Half-yearly	^{90}Sr γ spectrometry
Milk[2]	Fortnightly and Monthly	^{90}Sr γ spectrometry ^{131}I
Crops[3]	Harvest season	^{90}Sr γ spectrometry ^{131}I (leafy vegetables)
Meat[4] and eggs	Half-yearly	γ spectrometry
Fishes[5]	Half yearly.	γ spectrometry ^{90}Sr
Honey	Yearly	γ spectrometry

1. Typha, Phragmites Communis, Lythrum Salicaria, Molina Caerulea // **2.** Cow and goat milk samples // **3.** Chard, Oats, cabbage, cucumber, tomato… // **4.** Lamb and chicken meat samples // **5**. Pike-fish, barbel, carp

Table I.3.11. Trillo. Annual effective dose to the critical group (mSv/y)

Year	1998	1999	2000	2001	2002	2003
Liquids	9,95E-04	1,05E-03	1,11E-03	7,37E-4	1,54E-03	8,24E-04
Gases	1,04E-04	1,02E-04	1,59E-05	5,94E-05	4,57E-05	5,08E-05
Total	1,10E-03	1,15E-03	1,13E-03	7,96E-04	1,59E-03	8,75E-04

Figure I.3.1. Trillo NPP. Annual liquid effluent activity (GBq/year)

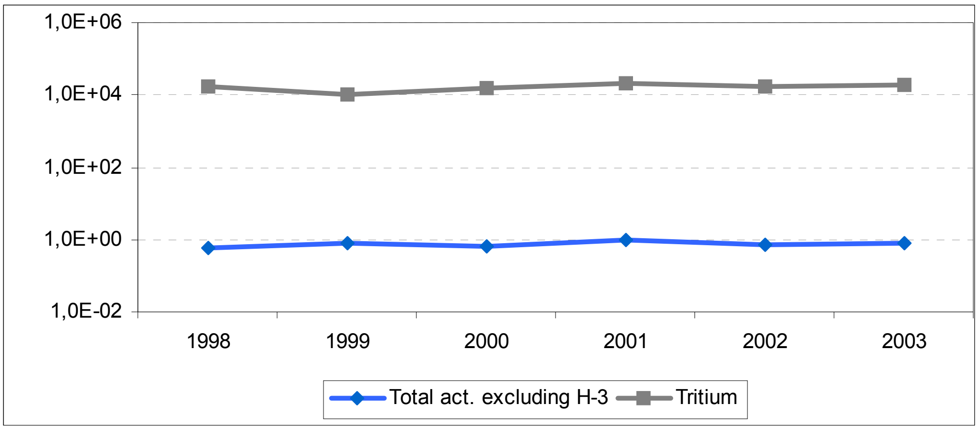
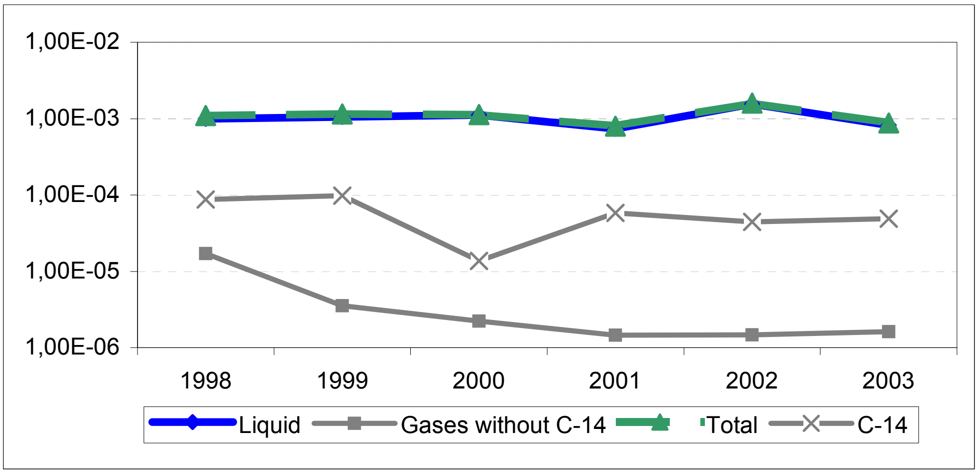


Figure I.3.2. Trillo NPP. Annual effective dose to the critical group (mSv/y)



Annex 2: Fuel fabrication plants

1. Juzbado fuel fabrication plant

1.1 Site Characteristics

1.1.1 Name of site

Juzbado

1.1.2 Type of facility

Juzbado is a facility where fuel for light water reactors (PWR, BWR, WER) is manufactured. The plant has three fabrication lines for U_2O fuel and another line for gadolinium oxide. The plant is operated by Enusa Industrias Avanzadas, S.A.

The main installations within the site are: Fabrication building, Radioactive liquid effluent treatment building, Auxiliary building, and Environmental radioactivity laboratory.

1.1.3 Year for commissioning/licensing/decommissioning

The plant was commissioned in 1985.

1.1.4 Location

The plant is located in the municipal area of Juzbado, in the province of Salamanca, at a distance of 26,55 km from Salamanca city.

1.1.5 Receiving waters and catchment area

Radioactive liquid effluents are discharged into the Tormes river, tributary to the Duero river. The average annual flow rate of the Tormes river is 23,2 m^3/s.

1.1.6 Production

The annual capacity is 500 tonnes. The production, expressed as amount of processed Uranium, is given in Table II.1.1

1.1.7 Other relevant information

There is no other relevant information.

1.2 Discharges

1.2.1 Systems in place to reduce, prevent or eliminate discharges and emissions

Floor cleaning water is initially treated by centrifugation. Although the system treatment includes a filter, this has not been used since November-1994 when the centrifuge was installed. After sample and analyse, this treated water passes to the liquid waste treatment plant where, along with all other facility radioactive liquid wastes, undergo other filtration processes. After that, the radioactive liquid wastes are newly analysed and then discharged, directly or after storing in an outdoor pond, to the Tormes river.

1.2.2 Efficiency of abatement systems

This information is shown in Table II.1.2.

1.2.3 Annual liquid discharges

Information on annual alpha activity and percentage of the limit is given in Table II.1.3, while a semi-logarithmic representation of data is given in Figure II.1.1.

A policy to minimise the production of waste has been applied throughout these years. Besides the measures previously mentioned, specific actions have been applied in this plant, such as the conversion of wet process into dry process and the centrifugation of the floor decontamination water to remove the suspended particles.

During the considered years, some improvements have been introduced in the plant during the considered period of time. Some of them to get better control of the liquid effluents such as the substitution of outdoor pipes to reduce the leakage probability in the year 2000, or to cover the bottom of the outdoor pond, where radioactive liquid effluents can be stored between their treatment and discharge, with a new impermeable layer in 2002. Other introduced improvement tried to reduce the liquid radwaste volume and, at the same time, to preserve their bacteriological quality. To this end, the outdoor pond was covered in 2003 to prevent the entrance of rainwater and organic matter. Also, in 2003, a new liquid effluent sampler flow rate-measuring device was installed to get better control of the radioactive discharges.

For Juzbado FFP, discharges have remained reasonably constant over this period. The range for total alpha activity in the discharges is 1,24E-2 – 3,54E-2 Bq/y. Discharges are well below the authorised limit. There is no clear trend. As no reference data are published for fuel fabrication plant, normalised discharged data have not been calculated.

1.3 Environmental Impact

1.3.1 Concentrations of radionuclides of concern in representative samples of water, sediment, and fish.

In tables II.1.4, II.1.5, and II.1.6 are presented respectively the ^{238}U, ^{234}U and ^{235}U mean activity concentrations in river water, sediments and fish in the area surveyed around Juzbado FFP.

1.3.2 Environmental monitoring programme.

The environmental monitoring programme of Juzbado FFP is conducted by the plant operator in an area within a 10 km radius. The main pathways of human exposure to radiation are monitored, as well as other ecosystem elements that are good indicators of the behaviour of radionuclides in the environment. The Table II.1.7 details the type of samples, the sampling frequency and the analyses included in the programme.

1.4 Radiation Doses to the Public

Information on annual effective dose to the most exposure member of the public is given in Table II.1.8 and Figure II.1.2. Doses have been recalculated with the updated methodology that takes into account the 1996 BSS Euratom Directive.

The exposure pathways considered in these calculations are:

- Liquids: Exposure to river shoreline deposits, and ingestion of potable water, vegetables, milk, meat and fish.
- Gases: Inhalation, Exposure to deposits on the ground, and ingestion of vegetables, meat and milk.

Critical group / Main exposure pathways:

- Liquids: Children (1-2 years) / Potable water (65,07%) and Vegetables (32,59%).
- Gases: Adults (>17 years) / Inhalation (88,80%) and Vegetables (10,74%).

Effective doses are well bellow the present authorised limit. Taking into account liquid and gaseous effluents, the average dose is 1,05E-5 mSv that represents a 0,01% of the present release limit. There is a decreasing trend along the considered period of time.

The critical group is the children being the main exposure pathways inhalation and vegetable ingestion.

Table II.1.1. Juzbado FFP. Annual production (t/y)

Year	1998	1999	2000	2001	2002	2003
Production	241	208	229	260	271	204

Table II.1.2. Juzbado FFP. Abatement system and their efficiency

Abatement system/ Management	Efficiency of abatement system		Comments
	Decontamination Factor	Other measure of efficiency	
Discharges:			
Floor washing water: ▪ Filter	60-70% (5 μm)		Not used since November-1994 when the centrifuge was installed
▪ Ultra centrifugation process	95%		
Liquid treatment system: ▪ Filter	10%		
Emissions:			
Building ventilations: ▪ Coarse filters	> 99,95% (0,3μm)		
▪ HEPA filters	> 99,97 % (0,3μm)		

Table II.1.3. Juzbado FFP. Annual liquid effluent activity (GBq/year)

Year	1998	1999	2000	2001	2002	2003
Total Alpha	2,03E-02	1,24E-02	3,54E-02	2,55E-02	2,06E-02	2,83E-02
% Limit	0,17%	0,10%	0,30%	0,21%	0,17%	0,24%

Table II.1.4. Juzbado FFP. ^{238}U, ^{234}U and ^{235}U concentrations in river water (Bq/m^3)

Isotope	1998	1999	2000	2001	2002	2003
^{238}U	4,8	14,0	7,6	9,3	8,3	7,9
^{234}U	7,3	17,2	12,1	15,0	12,7	13,3
^{235}U	1,5	1,0	1,0	0,9	*<2,0*	*<1,4*

Table II.1.5. Juzbado FFP. ^{238}U, ^{234}U and ^{235}U concentrations in sediments (Bq/kg.dry.wt.)

Isotope	1998	1999	2000	2001	2002	2003
^{238}U	14,6	22,1	43,3	28,9	25,9	37,4
^{234}U	18,7	26,4	65,7	40,5	38,8	*55,3*
^{235}U	0,72	1,0	2,2	1,3	5,3	2,9

Table II.1.6. Juzbado FFP. ^{238}U, ^{234}U and ^{235}U concentrations in fishes (Bq/kg.wet.wt.)

Isotope	1998	1999	2000	2001	2002	2003
^{238}U	0,18	0,22	0,27	0,11	0,05	0,08
^{234}U	0,31	0,27	0,37	0,19	0,12	0,11
^{235}U	*<0,04*	*<0,06*	0,03	*<0,02*	*<0,02*	*<0,02*

Table II.1.7. Environmental monitoring programme around Juzbado FFP

Sample	Frequency	Measurement/analysis
Air (Aerosols)	Continuous -Weekly	Gross-α. Uranium α.-spectrometry
Gamma radiation (TLD)	Continuous (quarterly)	Dose rate
Rain water	Continuous (quarterly)	Gross-α.
Soil	Yearly	Gross-α. Uranium α.-spectrometry
Drinking water	Monthly	Gross-β Residual β Gross-α. Uranium α-spectrometry
Ground water	Quarterly	Gross-α. Uranium α.-spectrometry
Surface water	Continuous-Monthly	Gross- β Residual β Gross-α. Uranium α-spectrometry
Sediment	Yearly	Gross-α. Uranium α-spectrometry
Milk[1]	Quarterly	Gross-α. Uranium α-spectrometry
Crops[2]	Harvest season	Gross-α. Uranium α-spectrometry
Meat[3]	Yearly	Gross-α. Uranium α-spectrometry
Fishes[4]	Yearly	Gross-α. Uranium α-spectrometry

1. Cow milk samples // **2.** Cabbage, corn, potatoes // **3.** Sheep and pig meat samples // **4.** Barbel.

Table II.1.8. Juzbado FFP. Annual effective dose to the critical group (mSv/y)

Year	1998	1999	2000	2001	2002	2003
Liquids	3,44E-06	5,25E-06	9,08E-06	1,67E-06	3,73E-06	2,51E-06
Gaseous	1,02E-05	5,88E-06	9,25E-06	6,27E-06	7,13E-06	3,63E-06
Total	1,23E-05	1,05E-05	1,74E-05	7,19E-06	9,93E-06	5,73E-06

Figure II.1.1. Juzbado FFP. Annual liquid effluent activity (GBq/y)

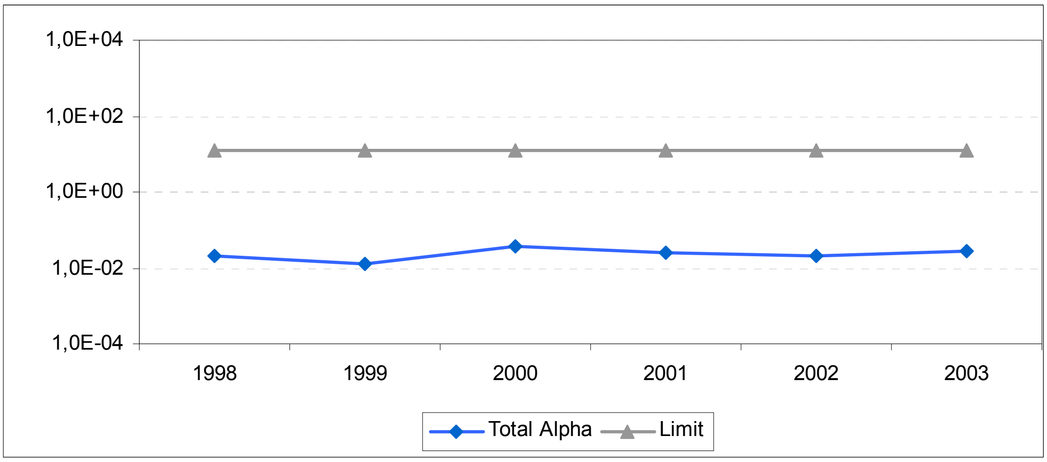


Figure II.1.2. Juzbado FFP. Annual effective dose to the critical group (mSv/y)