RADIOLOGICAL PROTECTION AND ALARA ORGANIZATION DURING THE DISMANTLING OF VANDELLÓS-1 NPP

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1.- INTRODUCTION

From the point of view of Radiological Protection, the overall Decommissioning and Dismantling Plan (DDP) for the Vandellós-1 Nuclear Power Plant (CN-V1) cannot be considered in isolation, without taking into account the evolution of the radiological characteristics of the installation and the site itself from previous states.

The above, along with the fact that this is a highly specific type of natural uranium-graphite-gas plant (NUGG) and that ownership of the facility has been transferred for dismantling (from HIFRENSA to ENRESA), implies a series of preliminary considerations that, for the purposes of this article, are compiled in the following:

a) Phase prior to transfer,
b) Preparatory phase, and
c) Dismantling phase.

This last phase is the one in which the tasks corresponding to the Active Parts Dismantling Plan (APDP) and the Conventional Parts Dismantling Plan (CPDP) are fully centred. Both are currently under way and will end with Level 2 dismantling and the beginning of the initial stage of Level 3 (Latency Period). The Radiological Protection Organization and the implementation of the ALARA culture are described for each of these phases.

2.- PHASE PRIOR TO TRANSFER

During this phase, the Radiological Protection Organization is based on the management standards corresponding to the Owner's applicable procedures in force. Consideration should be given to the need for optimization of resources (technical and human) due to the personnel leaving the organization for various reasons.

Described here are all the activities performed prior to the date on which ownership was transferred to ENRESA (February 1998) and of radiological significance from the point of view of dismantling activities. These may be summarized as follows:

- **Installation Radiometric Study Campaigns**, the objective of these campaigns (promoted by ENRESA) is to make available knowledge of the radiological situation of the entire site and its installations, oriented towards dismantling, on the basis of experimental measurements taken in the buildings, walls, functional or system components (conventional and radiological) and external areas.

  Two campaigns were performed during this phase, in 1993 and 1995, including analyses and measures in the field. The measures performed were of gamma radiation levels and of air-borne and surface alpha/beta contamination. Gamma spectrometry determinations were made on the samples taken, along with specific analyses to determine weak alpha and beta emitters. These campaigns allowed these elements to be radiologically classified. See section 5.

- **Conditioning of Operating Wastes**, this was an important preliminary activity required of the Owner prior to the Transfer Phase. It is important to underline the correct, accurate compliance by the Installation with the requirements established by the Regulatory Bodies. The final state was as follows:

  - Packages of irradiated parts deposited in underground housing shafts
  - Silo for drums, partially filled with drums containing miscellaneous engineered wastes.
  - Silos for Graphite and resins pits, empty. Graphite in ATOC store in containers.

- **Emptying and cleaning of the Pools Hall**, following removal of the nuclear fuel from the site. These activities increase releases of liquid effluents and of wastes generated during their treatment.

Overall, all these activities had been completed by the end of December 1997. An important radiological aspect to be underlined is the decay of the "activity spectrum" and the need for chronological updating, due to the extended period of time, more than 8 years, that had elapsed since the definitive shutdown of the reactor in October 1989.

Furthermore, 1) the adoption by ENRESA of ICRP publication 60 in the new Radiological Protection Manual, 2) the application of the new dose limits established therein and 3) the application of the new limits for surface contamination (total) established by the Nuclear Safety Council (CSN) for:

- α emitters = 0.04 Bq/cm2, and
- $\beta\gamma$ emitters = 0.4 Bq/cm2

at values ten times lower than those traditionally applied in the past, led (between December 1997 and February 1998) to a new compilation of the radiological data for the installation, and of the results of the radiological control and surveillance programs.

In particular, the following was revised:

- The status of the final radiological classification by zones of the previous phase and site zones affected.
- The logistics, radiological status and administrative control of the active materials existing on site, a large part of which had arisen as a result of the recently completed waste conditioning work (graphite sleeves).

A summary of the radiological status of the main radiological zones of the Installation, at the end of this stage and at the time of transfer, is included in table 1.

TABLE –1

RADIOLOGICAL STATUS OF THE INSTALLATION ON TRANSFER

Regulated Zones	Radiological Risk	Status
1.-Reactor Pile	Irradiation / Contamination Red Zone	- Closed. Internal air environment - Fuel unloaded
2.- Reactor Building and Auxiliary Areas (CO_2)	Irradiation / Contamination Yellow Zone (Building Free Zone)	- Radioactive material placed in certain areas
3.- Building BCI: (Fuel storage areas, fuel lock, pool water treatment areas).	Irradiation/Contamination Red/Yellow Zones	- Fuel lock and areas closed - Fuel removed
4.- Pools Hall and hot cell	Irradiation/Contamination Red/Yellow Zones	- Pools emptied of water - Contaminated material in one of the pools - Hot cell (IFH) closed
5.- Building BIC: Effluent station, material decontamination rooms and resin drumming plant.	Irradiation/Contamination Yellow/Green Zones	-Diverse active materials deposited in them - Resin pits empty - Resins removed from site
6.- Graphite silos	Irradiation/Contamination Yellow/Green Zones	- Silos 1,2 and 3 empty of graphite and closed.
7.- Graphite Treatment Workshop (ATC).	Irradiation/Contamination Red, Yellow, Green Zones	- Installation shut down - Discharge and crushing cell closed
8.- Graphite containers store (ATOC).	Irradiation Yellow/Red Zones	- Closed, housing graphite containers
9.- Affected site zones	Irradiation Controlled Zone	- Surroundings of graphite store and BIC. - Beaconed at 2.5 µSv/h
10.- Miscellaneous: - Electrical workshop - Graphite silos (adjacent zone)		 - Radioactive material temporarily deposited - Radioactive material temporarily deposited

Other radiological zones: Drums silo, Active laundry and Waste storage pits.

3.- PREPARATORY PHASE

This is the period between the transfer of ownership in February 1998 to the beginning of the APDP, in April 1999. The following was basically performed during this phase:

- Initiation of the dismantling of conventional parts (CPDP).
- Preparation for dismantling of active parts (APDP).

This phase included the implementation of the new RP Organization, in accordance with what had previously been established and planned, the aim being to provide the Project with the technical and human resources required to undertake a process of this magnitude.

From the point of view of Radiological Protection, the most important preparatory activities carried out during this period were as follows:

A - Updating of radiological source term and adaptation for Operational RP (radiological surveillance and radioactive effluents instrumentation) for declassification of materials and characterization of radioactive wastes. The results for Operational RP are shown in table 2. Mention should be made of the significance of the following data:

1) Pure-β emitters and Fe-55,
2) Actinides (α emitters and Pu-241) in:
   - Pools and water treatment Hall, and
   - Functions and systems associated with liquid effluent treatment,
3) Co-60 dominant in Reactor installations, zones and functions, and
4) Cs-137, dominant in liquid effluent treatment installations.

TABLE –2

OPERATIONAL RP SOURCE TERM (RELATIVE AVERAGE VALUES)

Data used in calculation	Radionuclides	Reference Radionuclides	Average Value	Application
Contamination smears	Fe-55	Co-60	2.77	Cont. surface/atmospheric surveillance Gaseous effluents
Contamination smears	Ni-63 (*)	Co-60	2.68	Cont. surface/atmospheric surveillance Gaseous effluents
Contamination smears	C-14 (*)	Co-60	0.6	Cont. surface/atmospheric surveillance Gaseous effluents
Contamination smears (except POOLS and IFH Cell)	Sr-90 (*)	Co-60	0.41	Measurable (β)
Smear IFH Cell and POOLS	Sr-90	Co-60	473	Measurable (β)
Contamination smears	Sr-90	Cs-137	2.67	Measurable (β)
Contamination smears	Pu-241 (*)	Am-241	29.1	Cont. surface surveillance
Ambient	Pu-241	Am-241	<10.5 (~9.9)	Cont. ambient surveillance Gaseous effluents
Ambient	Sr-90	Cs-137	0.62	Measurable (β) Gaseous effluents
Contamination smears +Ambient + Liquid	α	Am-241	1.9	Laboratory analysis
Liquid	Pu-241	Am-241	39	Liquid effluents
Liquid	Fe-55	Co-60	43	Liquid effluents
Liquid	Ni-63	Co-60	1.3	Liquid effluents
Liquid	C-14	Co-60	16	Liquid effluents
Liquid	Sr-90	Cs-137	0.8	Measurable (Analysis)
Graphite	C-14	Co-60	0.8	Measurable (low efficiency) Gaseous effluents

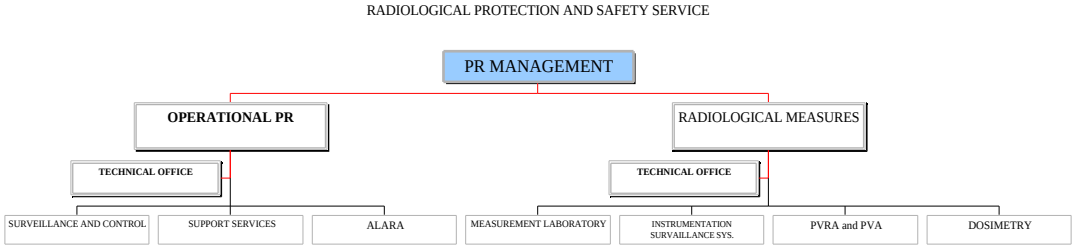
(*) β emitters

B - **Radiological reconfiguration of the installation**, with the identification and signposting of "radiological functions", the implementation of a new logistical approach to accessing radiological zones, the relocation and control of radioactive materials and their shielding, and the removal of their influence from the site.

C - **Radiological control of vehicles leaving site**, installation of an automatic gates system and manual control of vehicles in support of it.

D - **Implementation of the new RP organization**, maintaining the two basic sections of: 1) Operational RP and 2) Radiological Measurement, and dimensioning new functional areas such as ALARA, Support Services and the Technical Office. Reinforcement of personnel assigned to the service, at all levels, including the operational RP personnel. Figure 1 shows the organizational flowchart of the Radiological Protection Service.

FIGURE –1



E - **Implementation of necessary additional resources**:

- New Radiological Measurements Laboratory,
- New Radiation Surveillance System,
- New liquid and gaseous effluent release control monitors,
- Updating of personnel and equipment radiological control systems (digital dosimetry, contamination control portals and portable instrumentation),
- Protective resources and clothing,
- New modular access to radiological zones associated with the Reactor Building, Fuel Building and Pools Hall.
- New Modular Laundry (Washing of Active Clothing).
- New liquid effluent treatment system (filtration and ion exchange).
- Readaptation of PVRA sampling network.

There were also other modifications made to the installations, such as the readaptation and extension of the materials decontamination workshop, the joining of the reactor building and pools hall radiological zones and the construction of a hot workshop for the cutting of active materials, all of which were relevant from the point of view of RP for dismantling.

F - **Revision of Basic RP Documentation**, general revision of the application procedures and the development of other specific procedures. In total some 80 procedures were revised and drawn up.

This phase also included the performance of activities complementary to those performed during the previous phase, such as the following:

- Second pools hall tidying and cleaning campaign.
- Third radiometric study campaign.
- Continuation of the characterization and removal of engineered wastes.

Finally, mention should be made of the RP training work carried out throughout this period, for all the personnel, both the PR Service and the rest of the Organization. This training was at all levels and was accomplished in coordination with the Training and Communication Service. In particular, the activities performed (mainly B, C and E) were carried out with the added and simultaneous objective of serving as specific training for the newly incorporated RP Service personnel.

In total, 175 training courses were delivered as from February 1998. These totalled 600 classroom hours and a full dedication of 3,250 man-hours, and were attended by 900 people. Special mention should be made of the ALARA-specific training, with 15 courses, 150 classroom hours, a dedication of 300 man-hours and 100 people attending.

4.- ACTIVE DISMANTLING PHASE

a) OPERATIONAL ADAPTATION OF THE RP ORGANIZATION

On completion of the preparatory phase, and its approval by the Regulatory Body (Nuclear Safety Council – CSN) in March 1999 (approval of final report on testing of the different systems implemented), this phase began in April 1999. The work to be performed during the phase was as follows:

- Dismantling of active parts.
- In situ decontamination of specific elements.
- Isolation of reactor pile.
- Decontamination of walls.
- Decontamination of conventional parts.

It was during this phase that the wheels started to turn from all points of view. As regards Radiological Protection and Safety, the work initially started on the following:

- ♦ Performance of preliminary studies of application to the different Work Zones.
- ♦ Preparation of necessary documentation on initial conditions.
- ♦ Adaptation of RP and MCDE Manual.
- ♦ Development of specific procedures.
- ♦ Completion of implementation of miscellaneous modular buildings,.
- ♦ Optimization of RPS organization.
- ♦ Provision of protective equipment and clothing.
- ♦ Implementation of PVRA and PVA.

b) RELATIONS WITH CONTRACTORS

One of the fundamental aspects when addressing a project of this scope is the relationships existing between the RP Service and the contractor companies. Fluent communications are necessary with the RP Organization from the very beginning- process of incorporations and deletions, including attempts to speed up all the necessary arrangements – and right through the different multidisciplinary meetings for the coordination of the work, up to planning on the basis of different Radiological Intervention Units (RIU's).

The contractor companies play an important role in the ALARA program set up for the PDC, and are responsible for promoting the ALARA culture, proposing and implementing the necessary ALARA techniques and methods and ensuring the training of their personnel.

c) MULTIDISCIPLINARY STRUCTURE

As conceived, the driving engine or cell for this phase is based on a multidisciplinary structure. The person responsible for the Performance area is also responsible for coordinating the other members of the team (Operations and Maintenance Service, Engineering, Quality Assurance and Documentation, Radiological Protection and Safety), with a view to obtaining a product of maximum quality and safety (scope of on-going work) within the time period established (compliance with program schedule).

The members of the different Services, within their respective organizational structures and in compliance with specific procedures, participate in achieving the same end. These teams have been structured in the following functional areas:

1. Performance,
2. Materials Classification and Control,
3. Decontamination,
4. Radioactive Waste Management, and
5. Conventional Materials.

d) ALARA PROGRAM

The ALARA program is performed within the framework of the RP program of the Installation and is based on the objectives and scope of the document "ALARA Program for the CN-V1 Decommissioning and Dismantling Project", in turn based on the "Manual for the Application of the ALARA Principle in ENRESA Projects and Activities". The application of this Dose Reduction Program is dealt with in a specific procedure.

The objective of this program is for all the dismantling activities associated with radiation sources to be performed in such a way that the exposures to the workers and the general public lead to doses as low as reasonably achievable, taking into account social and economic factors.

As established in the ENRESA ALARA Manual, the organizational structure varies from one installation and activity to the next, depending on the degree of complexity involved, and is defined for each particular case. For the dismantling of CNV-1, the organizational structures established are: 1) ALARA Committee and 2) ALARA Group.

The **ALARA Committee** is made up of the Site Management and of different members of the organization. Its main tasks are the revision and analysis of ALARA work and methods, and the coordination of the different groups involved.

The **ALARA Group** is an interdisciplinary group set up specifically for the most significant tasks, and is made up of the ALARA Coordinator and those responsible for task performance. This group is in charge of specifying all ALARA-related aspects, tracking of work and revision of the results obtained. The Coordinator belongs to RP and undertakes the coordination necessary for compliance with the ALARA Program.

The systematic operational approach begins with previous analysis of the work by the ALARA Area of the RP Service, which estimates collective dose on the basis of the data provided by those responsible for the work.

When the estimate is below 10 mSv p, authorization for the work is undertaken using ordinary procedures; otherwise, a specific ALARA study will be performed.

Likewise, and in view of the peculiarities of dismantling, the RPS Manager may decide to apply the Program to whatever tasks he feels require this, even though the values obtained from the dose estimate do not require the application of a reduction study. The reasons for this may be, among others, the estimated distribution of the individual doses or significant dose values, significant area and/or contact dose rates, work entailing the risk of internal contamination and zones of prohibited access.

The criteria established will oblige the performer of the work (contractor and/or Organization) to submit the corresponding ALARA Study prior to initiation of the work. This needs to be accepted before the corresponding work may begin. The following criteria are indicated:

CONCEPT (per RWP)	**CRITERION**
1.- Collective dose (mSv p):	10
2.- Maximum individual dose (mSv):	2
3.- Area dose rate (mSv/h):	2.5
4.- Removable surface contamination:	
◊ **Beta/gamma** (Bq/cm2)	200
◊ **Alpha** (Bq/cm2)	20
5.- Ambient contamination (LDCA):	10

RWP Radiation Work Permit

Finally, on completion of the work, a study is made of the results obtained and these are analyzed along with the people responsible for them. Likewise, information is gathered on forecasts, actual work performance, deviations and their causes, along with recommendations for improvement in the event of repetition or the performance of similar work.

e) CLASSIFICATION BY ZONES AND TIMEFRAME

One of the differences with respect to an operating installation is the frequent changes made to the radiological classification of the different Areas, Rooms and Buildings, depending on the work performed (change of risk and its quantification). This makes it necessary to reclassify areas more frequently and to keep the Organization informed. The following instrumentation is used for the control and surveillance of CN-V1:

Portable instrumentation

- Radiation meters and contamination measuring equipment,
- Portable gamma spectrometers (HPGe).

Fixed instrumentation

- Radiation Surveillance System,
- Laboratory Equipment, and
- Declassification Equipment.

f) RISKS: IRRADIATION AND CONTAMINATION

The control and surveillance of the risk of irradiation is widely known and the measures for its prevention and minimization are known and controllable. In dismantling, this risk is perfectly identified as regards its different Areas, and tracking is similar to that applied at operating plants.

Given the nature of the work performed during dismantling: cutting of internally contaminated and/or activated elements, previous decontamination of highly contaminated equipment, segregation, transport and stowage of materials, the risk of contamination increases, making this different from the situation in operating installations. It is for this reason that control and surveillance are required and that all measures leading to efficient protection for the workers intervening in the different tasks be implemented, for example:

- Specific protection resources,
- Use of hermetically sealed suits with external air supply,
- Control and surveillance by means of the bioanalytical tracking of the workers involved.

g) RADIOLOGICAL SURVEILLANCE AND CONTROL FOR SPECIAL TASKS

An integral part of the Project consists of certain tasks that require greater tracking and special controls, from the radiological point of view and due to the risks associated (irradiation and/or contamination). Mention should be made of the additional controls, surveillance and protection measures (clothing and breathing apparatus) and the surveillance of the workers (bioanalysis program) applied to work entailing significant risk of contamination by artificial alpha emitters. The following especially may be singled out:

- ♦ Decontamination and transfer of sludges from liquid effluent treatment system (SROA 01RV y 02RV).
- ♦ Decontamination and dismantling of the integrated fuel movement machine.
- ♦ Decontamination and dismantling of the irradiated fuel handling and management cell (IFH cell).
- ♦ Decontamination and dismantling of AES AVAL and AES AMONT.

These tasks have included specific RP training for the workers involved, in which different aspects to be taken into account during work performance were covered: radiological conditions, associated risk, in-situ confinement structures, establishment of step depressions, dressing and undressing sequence, passage zones, materials management and minimization of waste volumes.

All these tasks have implied the setting up of specific ALARA Groups for planning and tracking, with the participation of the disciplines associated, and contractor involvement.

h) RADIOLOGICAL CHARACTERIZATION

In addition to the radiological control and surveillance carried out during the different phases of performance of the PDC in areas, rooms and buildings, it is necessary to gain insight into the radiological characterization of the different materials, structures, buildings, systems and/or functions of the installation, in order to classify them in different spectra. This aspect is very important in relation to declassification.

In order to assign the corresponding spectra, the RPS established a sampling campaign for the different systems and functions, with a view to determining the existing radionuclides (β-γ emitters, weak and/or pure β emitters and α emitters) and, on the basis of statistical criteria and criteria of representativity, establish the different correlations between the measurable and non-measurable radionuclides.

Following correlation of the measurable and non-measurable radionuclides, these may be compared with the different values for declassification (unconditional or conditional) established by the Regulatory Body and, following verification of compliance, initiate the process of declassifying materials, areas, walls, structures, buildings, land and the site.

i) RP INSTALLATIONS

During this phase, the RP Service Installations described for the previous phase are fully operative.

5.- RESULTS

The following data of interest may be summarized:

A) INITIAL RADIOLOGICAL CHARACTERIZATION

The characterization campaigns corresponding to the a993 and 1995 radiometric studies, the scope of which covered:

- All functions (conventional and radiological),
- All buildings, and
- All exterior zones

Gave a total 6,884 determinations, divided as follows:

		INTERIOR EDIFICIOS	EXTERIOR EDIFICIOS	PROCESS FUNCTIONS	BACK-GROUND	TOTALS
TOTAL Nº POINTS		1223	482	189	52	*1946*
TOTAL Nº DETERMINATIONS	NORMAL	3502	1211	1593	236	*6542*
	QUALITY CONTROL	192	42	97	11	*342*
TOTAL		*3694*	*1253*	*1690*	*247*	*6884*

B) DOSIMETRY

The radiological load (official collective dose) involved in the different stages (40% of PDC performed) to date is as follows:

1. Transfer Phase: 30.04 mSv·p
2. Active Dismantling Phase (Apr-99 to Dec-99): 32.75 mSv·p
3. **TOTAL (Feb-98 to Dec-99) =** **60.79** mSv·p

6.- FINAL RADIOLOGICAL STATE - LEVEL 2

On completion of the Level 2 Dismantling Phase, the Latency Period begins. During this phase, and until such time as Level 3 is initiated (dismantling of Reactor Pile and Internals), it will be necessary to undertake surveillance of the buildings located inside the protected area and classified as Radiological Zones. The final radiological inventory will be obtained from these data, and the land and structures will be declassified and released for any type of use.

The interior of the remaining installation will be classified on the basis of the radiological data into the following surveillance units:

- Clean units,
- Decontaminated units, and
- Contaminated units.

7.- REFERENCES

1. Final Safety Analysis Report. 051-ET-EN-001.
2. RP Manual 051-PR-EN-001.
3. Control Plan for Declassified Materials. 051-PG-EN-0002.
4. Operational RP source term 051-IF-CV-0594.