Alara during Equipment Removal Activities and Decontamination of Spent Fuel Pools at Vandellós 1 Nuclear Power Plant

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Introduction

The Vandellós 1 nuclear power plant is a gas-cooled natural uranium reactor unit located in Tarragona, and operated from1972. The plant, of French design, was constructed as part of a turnkey project and the operator was a mixed Spanish-French company (HIFRENSA), which continues to own the site. Following the incident that occurred in turbine-generator set No 2 in October 1989, the Ministry of Industry issued a Ministerial Order decreeing the definitive shutdown of the plant, and commissioned the Spanish national radioactive waste management company (ENRESA) to undertake dismantling. The plan put together by ENRESA consists of disassembling and demolishing the plant buildings and systems, with the exception of the concrete reactor shroud, which will remain confined. This is equivalent to Level 2 Decommissioning, as defined by the International Atomic Energy Agency, and implies releasing 80% of the site within five years.

Prior to ENRESA's activities, Hifrensa was required to remove the nuclear fuel and condition the radioactive wastes produced during the operating phase. One of the activities carried out by Hifrensa between 1996 and 1997 was the disassembly and conditioning of the equipment and structures located inside the spent fuel storage pools. These activities caused particles to be dispersed to various areas of the building, and the levels of alpha contamination in the air increased significantly when there were personnel and equipment movements. In addition, the loss of leak-tightness inside the building and the presence of strong winds at the site might cause alpha contamination to become re-suspended, increasing the levels of atmospheric contamination.

On initiation of its activities at the site, ENRESA continued the decontamination tasks being performed in the pools, the final objective being to use these as a temporary store for the radioactive wastes generated during dismantling. In order to achieve this objective, it was necessary to reach a level of decontamination such that work might be performed in the building without special breathing apparatus requirements.

From the radiological protection point of view, the main aspect to be taken into account was preventing the incorporation of the radioactive material, keeping the doses as low as possible and preventing the dispersion of contamination. To achieve these objectives in practice, a specific ALARA program was drawn up and submitted to the Regulatory Authority (Nuclear Safety Council) as part of the Action Plan required by this body. This paper describes the radiological protection program and the ALARA techniques implemented to reduce the internal contamination of the workers, as well as the mechanisms put into place to detect any possible incorporation as quickly as possible. Likewise, the existing levels of radiation and contamination are described, along with the dosimetry controls established and the results obtained.

Radiological protection program and ALARA

Organization

Application of the ALARA principle in all ENRESA projects and activities implying the risk of exposure to radiation, regardless of its magnitude, is formally established in the „Manual for the application of the ALARA principle to ENRESA projects and activities".

Given the diversity of these projects and activities, the aforementioned document establishes a set of general courses of action, the detailed application in each case being developed through specific programs. In the specific case of the dismantling of Vandellós 1 NPP, an ALARA program was developed for application in the disassembly of the active parts. The radiological conditions of the pool building, however, required specific adaptation and the development of an ALARA program for performance of the work.

The commitment of ENRESA management to application of the ALARA principle is reflected in the approval by the Operations Manager of the ALARA Manual and in the participation of the person responsible for each activity, installation or project in the development and approval of the specific programs. Likewise, the management appoints an ALARA program coordinator and equips him with the resources required for his

function, as well as guaranteeing coordination with the other groups participating in performance of the work. In the specific case of the work carried out in the pools building, a multi-disciplinary ALARA team was set up, including the technical management, the operations and maintenance service, the radiological protection service and the contractor company in charge of the work.

The essential functions of this ALARA group were as follows:

- Analysis of specific tasks to be performed and work planning.
- Tracking of work performance and of the degree of compliance with the objectives established.
- Analysis and acceptance of work procedures and modifications proposed.

The ALARA program also involved the contractor company, which had the following responsibilities in this area:

- Promotion of the ALARA culture amongst its personnel.
- Implementation of ALARA techniques and measures.
- Work analysis and review from the point of view of ALARA.
- Proposing whatever improvements might be required.
- Ensuring attendance of the personnel at ALARA training and indoctrination sessions.

The ALARA objectives defined for the work were as follows:

- Prevention of all doses due to internal contamination.
- Prevention of cases of external contamination which might cause a significant skin dose.

Training

Education and training is one of the most relevant aspects of any ALARA program. For the work to be performed in the pools building a specific training program covering the following aspects was developed:

- Radiological status of the pools building.
- Personal protective clothing and breathing apparatus.
- Entry to and exit from the building, access control and sequence of clothing and protective equipment removal.
- Radiological control of the personnel (control of internal and external contamination) and of the work.
- Minimization of the production of secondary radioactive wastes and control thereof.
- Complete work performance sequence.

All the personnel involved in the work, both in performance and in radiological protection, attended this initial training. Likewise, indoctrination activities were carried out during performance of the work, specifically when the bioanalysis controls detected positive analyses.

ALARA techniques

Prior to initiating work, a detailed analysis was made of the radiological conditions of the pools building, and of the risks associated with the work to be performed. The ALARA techniques to be applied were established on the basis of this analysis:

- Adaptation o the points of access and exit, including re-routing such that the exit path at no time crossed the entry. This meant establishing access from the old buildings located in the south-eastern part of the site and the conditioning of these areas.
- Erection of a confined, negative pressure enclosure prior to exit from the building for removal of part of the protective clothing and prevent the dispersion of contaminants from the building, while minimizing the risk of contamination that this interface might imply.
- Preparation of a breathable air supply network by means of quick connections and fitted with all the extensions required o avoid the operators having to travel any distance inside the building without an air

supply. In implementing this network, a compressor with a high capacity tank was used, fitted with the corresponding safety alarm.

- Preparation of a confined enclosure with filtered extraction for the segregation and conditioning of the secondary wastes generated during leaning operations.

- Suspension of work whenever air-borne contamination levels of 10 DLCA were reached or the depression of the building could not be guaranteed.

Likewise, the work procedures submitted by the contractor were revised prior to the performance of work. These procedures were required to meet the following criteria:

- Rejection of methods that might contribute to the re-suspension of radioactive aerosols.

- Rejection of the use of chemical compounds with the potential to generate physical risks or increase radiological risk.

- Use of equipment and tools minimizing the possibility of vibrations, knocking, etc.

- Rejection of the use of rotating or thermal cutting tools or any other that might complicate radiological conditions due to the mobilization of aerosols.

Finally, the general sequence of the decontamination operation was defined, which would be repeated until the established levels were reached or until the necessary effort and resources did not compensate the results obtained. This sequence was as follows:

- Dry, channeled suction, via HEPA filters, to the ventilation system in the event of the presence of dry contamination with a high potential for air-borne removal.

- Wet wiping (with a decontaminating solution), manually or using a machine.

- Controlled suction and channeling of liquid wastes generated.

- Repetition of the wet decontamination process.

- Manual drying with absorbent material.

During the performance of the work, various situations or circumstances arose requiring the adoption of new measures or the modification of those initially foreseen. These measures were established fundamentally to prevent the appearance of levels of alpha contamination in the building atmosphere and the dispersion of contamination to the outside, and consisted of the following:

- Confinement of all material with significant levels of contamination.

- Improvement to the ventilation system, increasing extraction and negative pressure inside the building.

- Prevention of systematic cleaning of areas of passage when the levels of contamination did not require it, and in any case increase of the amounts of liquid solution used.
- Increased control of the alpha contamination in the air, with the implementation of more continuous measuring equipment.

- Incorporation of a confined enclosure for the removal of clothing in two independent areas, these acting as an airlock and being equipped with independent air supply intakes.

- Establishment of passage areas at different locations in the building, close to the areas in which the work was performed, for the removal of outermost clothing.

- Light cleaning of griddles with damp cloths, prior to entering the confined exit enclosure.

- Control, cleaning and replacement of plastic coverings and confined enclosures, especially those used for waste conditioning

Radiological control

Radiological control and protection of personnel

The radiological control of the personnel was carried out as follows:

- Use of direct reading dosimeters with alarm and of personal thermoluminescent dosimeters.
- Control of internal contamination by means of a whole body counter.
- Control of the incorporation of radioactive material by means of nasal smears at the end of the working day.
- Determination by bioanalysis of possible cases of incorporation and associated internal doses.

In view of the characteristics of the work, it was necessary to use personal protection equipment in order to prevent the incorporation of radioactive material. The protective equipment used was as follows:

- Protective clothing: working clothes plus over-clothes of one or two elements, and PVC suits, with or without air supply.
- Protective breathing equipment depending on the atmospheric contamination: full-face mask with filter (< 0.1 DLCA o 1 DLCA, hour averaged over the working day) or air line/autonomous breathing equipment (between 1 DLCA and 10 DLCA).

Radiological control of work

The radiological control of the work included the surveillance of radiation levels and of surface and atmospheric contamination. Of these surveillance procedures, the most important was the control of air-borne alpha contamination. This control was accomplished by means of the following mechanisms:

- Continuous sampling throughout the working day at fixed points in the building.
- Continuous sampling for short periods during specific operations.
- Measurement of filters in the laboratory, establishing correlations between overall alpha activity and the results for gamma emitters, in order to ensure the immediate availability of data without waiting for radon daughters to decay.
- Specific measurement of alpha emitters in the filters showing the highest values.
- Continuous measurement of air-borne alpha and beta contamination using specifically designed beacons allowing for the subtraction of radon daughters. The setpoints of these beacons were as follows:

- A 2 and 25 DLCA in working areas and in confined clothing removal enclosure.
- A 0.5 and 2 DLCA in the building access and exit areas.

Results obtained

Atmospheric contamination

During the performance of work inside the building, high levels of air-borne alpha contamination were detected, averaged over the working day, these amounting to over 2 DLCA with peak values in excess of 25 DLCA. These values were confirmed by the results obtained in the laboratory, although in certain cases the highest values were due to the contamination of the head of the continuous measurement device.

Likewise, the increases in atmospheric alpha contamination were confirmed by the presence of higher concentrations of other beta-gamma emitters, fundamentally Cs-137 and Co-60. On the other hand, due to the fact these are much less restrictive isotopes, they did not pose any problem from the point of view of radiological protection.

The measures performed at the exit from the building, on the other hand, generally remained below 10% of the DLCA, with very few values above 0.5 DLCA. Likewise, the values at the access to the building remained below 1 DLCA.

Dose

The external dosimetry results obtained were low, as was expected on the basis of the dose rate levels existing in the building. The estimated dose for the work was 4 mSv.p, the final collective dose achieved being 2.39 mSv.p. Likewise, the maximum individual doses were kept far below 20 mSv.

As regards internal dosimetry, it should be pointed out that positive results were detected only in four bioanalyses, of the 62 carried out on a total 20 workers. Of these analyses, only in the case of two workers were the doses above the recording level. The effective collective commitment dose was 16 mSv.p, the dose limits not being threatened in any case, bearing in mind the doses accumulated by the workers in question in other tasks. It should be pointed out that these results were obtained during the intermediate phase of the work, all the other results being negative up to completion of the work. In none of the nasal smears performed were levels of contamination in excess of the detection level detected, the same being true of the whole body counter measurements carried out.

Surface contamination

As regards surface contamination, it should be pointed out that substantial improvements were achieved for most of the surfaces, although there were areas of higher accumulation of contamination on the cable trays, ventilation ducts and supports, as well as on rails and channel ducts. In any case, only 1% of the measurements of alpha contamination presented values above the reference level (0.4 Bq/cm^2), for beta contamination this value was 6%.

Conclusions

From the point of view of ALARA, the main conclusion is that the work has been performed as foreseen and that, although it has not been possible to achieve the initial objective of zero internal dose, such doses have affected only two workers, and to an extent far below the dose limit.
Furthermore, other conclusions may be drawn from the performance of the work and the results obtained:

- If there is significant dispersion of contamination, it is very difficult to eliminate it completely.
- Residual surface contamination may be re-suspended, committing atmospheric contamination, especially in the presence of alpha emitters.
- The dimensions of the building and the existence of equipment and components, some of them very complex, leads to the assumption that there may be points of accumulated contamination, to which it has been possible to gain access during the work.
- The decontamination and cleaning methods used have been adequate for many surfaces, but for others it would have been necessary to use others, which were not authorized because of the risk of increasing atmospheric contamination.
- The radiological surveillance resources, methods and routines applied to the work and to the workers have been useful and efficient. The continuous control of air-borne alpha contamination has been especially useful to optimize work times.
- The personal and collective protection resources and equipment have been very efficient in preventing the superficial contamination of the workers. It is more difficult to assess their effectiveness in preventing internal contamination, although this would appear to have been fairly adequate.
- The conditioning of personnel accesses and exits by different routes and with sufficient space has been a basic tool for the prevention of contamination dispersion and for the prevention of the incorporation of radioactive materials during clothing removal operations.
- The control of possible incorporations of radioactive materials by nasal smears makes it possible to rule out the possibility of major incorporations, but should be completed with periodic bioanalysis-based controls to rule out the possibility of any incorporations.

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