ALARA IN THE DISMANTLING OF NUCLEAR FACILITIES

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1.- INTRODUCTION

At present, approximately a quarter of the electricity that we consume in Spain is generated by the eight reactors existing at the country's seven nuclear power plants (and two reactors in decommission phase). In addition, there are near two thousand medical, research and teaching and industrial facilities authorised to use radioisotopes.

In Spain, the Government decided in 1980 to set up an organisation to control the safety and radiological protection of people and the environment. As a result, the Nuclear Safety Council was constituted as the organisation competent in such matters, and 1984 saw the creation of the Empresa Nacional de Residuos Radiactivos, S.A. (ENRESA), a public, non-profit making organisation responsible for radioactive waste management in Spain, including the decommissioning of nuclear facilities.

The development of techniques and applications deriving from nuclear energy reached its peak as from the second half of the 20th century. This led the countries that used such technologies to establish formulae guaranteeing the protection of people and the environment against both the risks implied in their use and the wastes generated.

The basic philosophy of the ALARA criteria may be summarised in the following sentence: "individual doses, the number of persons exposed and the probability of potential exposures occurring should be kept as low as reasonably possible, taking into account economic and social factors", as set out in article 4 of the "Regulation on the Protection of Health against Ionising Radiations".

This basic principle is applicable to any activity in which there is a risk of exposure, which shall have been justified prior to performance in accordance with the basic principles of Radiological Protection.

Application of the ALARA principles in all ENRESA projects and activities implying a risk of exposure to radiation, whatever its magnitude, is accomplished by means of a formal procedure included in the "Handbook for application of the ALARA principles in ENRESA projects and activities". Given the potential diversity of these projects and activities, the aforementioned document establishes general guidelines, leaving the detailed application of each for inclusion in programmes and procedures specific to each of the projects.

Implicit to the concept of ALARA is the need for strong support from the Management in its widest sense, as well as its direct participation in the programme implemented. The Management is responsible for ensuring compliance with the requirements of the competent authority, and in so doing may delegate certain functions to its subordinates, acting via the hierarchical framework.

The commitment of the Management of ENRESA is clearly reflected in the approval by the Technical Director of the ALARA Handbook, which, as has been pointed out above, establishes the basic courses of action for application of the ALARA criteria. Likewise, each Manager responsible for ENRESA's projects and installations approves the specific programmes and procedures, and the Managers of the Installations the corresponding dose reduction procedure.

This commitment by Management is undoubtedly the most important basic characteristic of any successful ALARA programme. This commitment includes the appointment of a Coordinator for each programme, with the responsibility and authority required for its performance, and the assignment to the hierarchical chain applicable in each case of the responsibility and authority required for implementation of ALARA practices, involving all those participating in the activity or installation in question.

2.- APPLICATION OF THE ALARA PRINCIPLE IN DISMANTLING

Progressively, the dismantling projects undertaken in Spain have allowed a degree of experience to be acquired and accumulated that has provided a reasonable understanding of the technical problems involved. Uranium mills (FUA), experimental reactors (ARBI, PIMIC) and commercial power reactors (Vandellós 1 NPP, José Cabrera NPP) have been or are being dismantled in the country, this having allowed Enresa (Empresa Nacional de Residuos Radiactivos), the organisation responsible for such activities, to reflect on and develop working methods for future projects.

The management of radioactive waste in dismantling projects is a general concept that embraces many sub-processes: waste characterisation, identification, treatment and conditioning, packaging, transport, storage and disposal.

This presentation will focus on the aspects related with the radiological protection in particular with the ALARA criteria in the decommissioning projects

The application of the ALARA principle in dismantling does not imply any significant novelty with respect to the way it is applied at other operating facilities, although in practice several differences arise. In this respect, the objectives of Radiological Protection and ALARA, the basic criteria for application and the regulatory responsibilities are identical in both cases. There are, however, differences as regards the regulatory requirements and documentation and the adaptation of the organisation, as well as the human and material resources and the mechanisms for coordination with the rest of the organisation.

There are also other conditioning factors that influence the approach and the methodology for application of the ALARA principle, such as the type of facility to be dismantled, the time that has elapsed since its shutdown, the level of dismantling to be achieved and the remaining surveillance and protection systems and the possibilities for their use in the project.

The first need manifested is the adaptation of the organisation to the objectives of the project, this implying the need for the implementation of a matrix-based operational approach among the different services and an increase in the number and diversity of the specialists involved. Furthermore, it should be remembered that many of the organisations and workers involved may not be accustomed to working in radiological scenarios. It is essential that the contractors and the organisation overall be required to fulfil their part of the responsibility for application of the ALARA principle, offering the assistance required to simplify methods for the analysis and assessment of alternatives and prioritising optimisation criteria over strict compliance with the initial dose objectives. Likewise, it will be necessary to adapt the objectives and requirements of the training in radiological protection of the professionally exposed workers participating in dismantling.

Furthermore, during dismantling the physical configuration of the facility is modified, this implying the loss of structural confinements, the modification or removal of effluent treatment systems, surveillance of radiation and auxiliary resources and the modification of access routes and appearance of new controlled areas.

During dismantling the radiological status of the facility is continuously modified, the radiological risk generally increasing as a result of the breaking down of the confinement of non-characterised systems. Likewise, the radiological area must be extended to include materials movement and storage routes, which are often located in initially non-radiological areas. Furthermore, as a result of the work performed new radiological risks not present during operation arise, one of the most relevant being the risk of exposure to alpha emitters, a risk that is associated with a variation in the chemical composition of the contaminants and an increase in the variety of particle sizes generated in the different working techniques.

When working with this risk, consideration should be given to the special individual perception of risk and the need for especially strict regulatory requirements, since in the event of incorporating minor quantities of these alpha emitters, the doses assigned may be significant. Furthermore, the need to use complex personal and collective protection resources has a repercussion on the external doses that may be received, due to a slowing down of the work. In addition, it is necessary to implement individualised worker tracking protocols including the initial and periodic bio-analysis. All this means that one of the most relevant ALARA objectives in dismantling is the prevention of any incorporation of this type.

3.- EXAMPLE OF DISMANTLING OF VANDELLÓS I NPP

The Vandellós I Nuclear Power Plant was taken out of service in 1989, subsequently entering the phase prior to the process of dismantling and decommissioning. In the wake of studies aimed at defining the most convenient strategy from the technical and economic points of view, the decision was taken in 1992 to dismantle the entire plant except for the reactor shroud (Level 2 dismantling). In 1998, following approval of the Environmental Impact Statement and issuing of a favourable report by the Nuclear Safety Council, the Government authorised the initiation of the works. These began in March of that year and were completed in June 2003.

The Level 2 dismantling of the Vandellós I nuclear power plant has meant five years of work, in which special mention might be made of the materials management process, radiological controls and Occupational Risk Prevention Plan as key factors in the operations.

On completion of the works, most of the site has been released for free use and left available to the owner utility. After 25 years the reactor shroud will be dismantled. By that time the radioactivity present will have decreased by about 95%, this implying a reduction of radiological risk and, therefore, of the costs involved.

The application of the ALARA programme in the dismantling of Vandellós 1 Nuclear Power Plant is based on the organisational framework indicated above. During the dismantling work consideration has been given to the fact that ALARA is not simply a technique but rather a way of doing things, the ultimate objective of which is to ensure that all reasonable efforts have been made to reduce doses through a systematic approach to problems, such that all their components are adequately identified. This systematic approach gives rise to the following basic steps:

- Recognition beforehand that the ALARA study is necessary and clear definition of its scope.

- Identification of the ALARA factors to be considered, separation of quantifiable and non-quantifiable factors and assessment as possible and optimum options (solutions).

- Comparison and selection of quantifiable options, such as the possible application of shielding, ventilation, filters, changing areas, sizes of working areas, exposure times, personnel and waste movement routes, estimated doses, contamination control systems, etc.

- Comparison and selection of non-quantifiable options, such as the analysis of foreseen plans, analysis of the adequacy of the radiation surveillance systems designed for the radiation intensities foreseen, evaluation of modifications with consideration given to their impact on existing surveillance, shielding, barriers and ventilation, and dose maintenance: examination and assessment of the control planned for the surveillance of doses received by the workers, etc.

The ALARA programme should begin by guaranteeing the adequate preparation and planning of the work to be performed in Radiological Zones. Following this, a mechanism should be established to control the performance of this work from the point of view of radiological protection and ensure that the results obtained are evaluated. Likewise, there should be ALARA programme feedback, such that the lessons learned are incorporated in the working procedures, in order to reduce doses in similar tasks performed subsequently. The Vandellós I ALARA organisation is shown in figure 1.

FIGURE 1

On request for the performance of a task, the ALARA section gathers the information required to define the necessary RP controls, which might be a Radiation Work Permit (RWP) or the need to perform an ALARA study on the basis of associated radiological criteria, the type of task, period for performance, etc. These criteria are summarised in table 1.

TABLE 1		
CONCEPT/CRITERION	**VALUE**	**OBSERVATIONS**
Collective dose (mSv·p)	10	Total per specific RWP
Maximum individual dose (mSv)	2	Total per specific RWP
Dose rate (mSv/h)	1	Area
Removable surface contamination (Bq/cm^2):	200 (β–γ) 20 (α)	Working areas Accessible surfaces
Environmental contamination (LDCA)	10	LDCA: limit derived for concentration in air
Classification by zones	RED Zone	
Duration of work (man-hours)	1200	Total per RW or task Limited residence zone

If an ALARA study is required, the person responsible for its performance shall prepare and submit this study for acceptance and approval by the Health-physics Manager before initiating the work. The scope of this study is as follows:

- Objective and initial scope of the work.
- Breakdown of activities and their duration.
- Initial radiological conditions.
- Foreseen operational dose (collective).
- Improvement ALARA techniques, practices and methods to be implemented.

The corresponding ALARA Group is set up on the basis of this study, holding at least one launch meeting, one tracking meeting and another on closure. Throughout dismantling of Vandellós 1 NPP, 93 ALARA Group meetings have been held and 19 of the Committee. Likewise, a total 30 ALARA studies have been carried out, covering 74% of the collective doses received in performing dismantling. Figures 2 and 3 show the estimated and actual collective doses in two of the tasks with the highest collective dose, corresponding to the doses of tasks with a significant radiological risk.

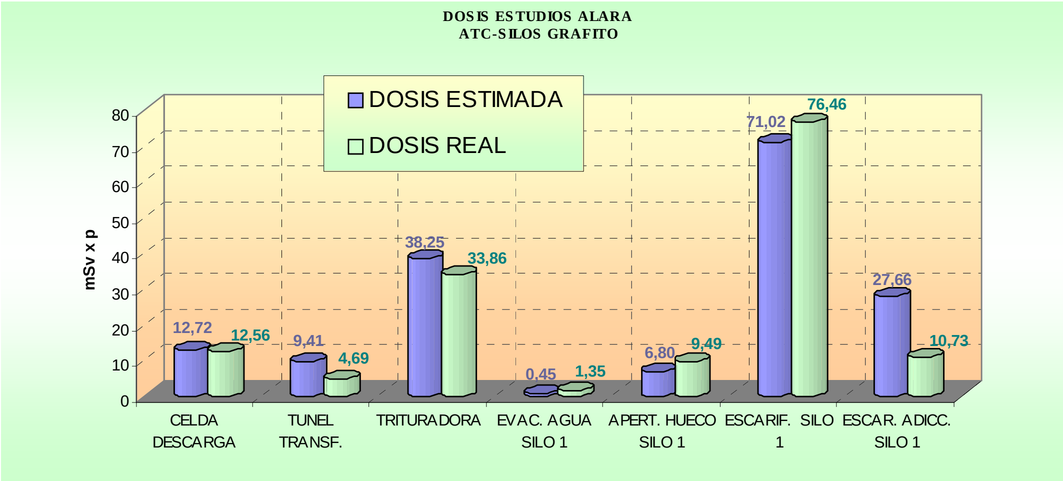

FIGURE 2

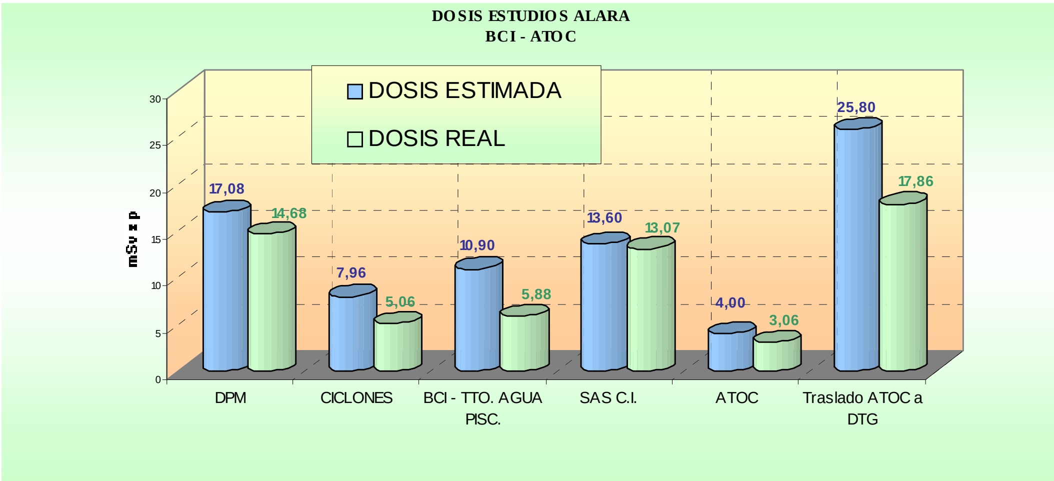

FIGURE 3

Figure 4 represents the evolution of collective dose and a comparison between actual and estimated doses during both the project and the dismantling itself. The collective dose was lower than foreseen due to the application of dose reduction techniques and to the performance time.

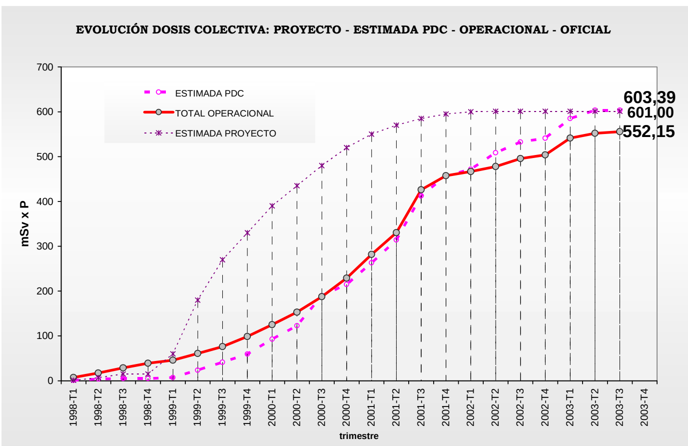

FIGURE 4

It should be pointed out that the most important radiological risk during this dismantling was the presence of alpha emitters in different areas and systems. For this reason the protective measures were reinforced to the maximum in order to minimise this risk. The following ALARA techniques were implemented to achieve this:

– Confinement and ventilation: by means of the use of structural confinement guaranteeing an important level of dynamic depression and ensuring a flow of air from the least contaminated zones to those with the highest levels of contamination. The use of transparent materials to construct these structures facilitated the supervision and control tasks and communications between the interior and exterior.

– Establishment inside the confinement structure of areas conditioned for the loading, closure and removal of the waste containers and drums used for the dismantling and secondary wastes.

– Conditioning of personnel accesses and exits, with sufficient space for the incorporation of sequential dressing and undressing phases, with the corresponding staging allowing for activities to be performed with sufficient comfort and safety. It has been demonstrated that these are the phases with the highest risk of internal contamination. In this respect it was considered essential that individual discipline in the sequence of undressing be rigorous, as a result of which increasing the awareness of the participating workers became especially relevant.

– Introduction of improvements in working techniques liable to generate or increase surface and airborne contamination. Thus, the advisability of using rotary or thermal cutting equipment and techniques was evaluated, with a view to reducing the risk of dispersion and re-suspension of contaminated aerosols. In this respect it was concluded that the use of other techniques slowed down the work, with the corresponding increase in external doses, as a result of which it was better to use the quickest methods, performed by expert personnel using all adequate protection and confinement measures.

– Implementation of airtight bagging techniques for the “in-situ” conditioning of depleted portable ventilation system filters, especially when used in areas with alpha contamination.

– Use of peelable paints to fix surface contamination prior to work and protect areas already decontaminated.

– Use of special protective equipment guaranteeing a sufficient degree of isolation under all conditions. This was integral semi-autonomous equipment with an external air supply including a mask with a particle filter.

– Cold training on the use of special protective equipment and on how to undress.

– Implementation of individualised tracking protocols for professionally-exposed workers, including the performance of periodic bio-analysis to assess the possible incorporation of alpha contaminants. These programmes were designed such that the entry conditions were established for the personnel (initial target) and the end times and sampling frequencies were adjusted depending on the type of work performed.

– Use of special surveillance techniques such as portable beacons for the real-time measuring of airborne contamination, with alpha-beta-gamma detection capacity and remote control and viewing, in all areas liable to pose a risk of environmental contamination. The beacons were positioned fundamentally in the zones posing the highest risk of internal contamination for the workers, such as the passage areas and places for undressing and disconnection of the breathing equipment, inside or outside the confinement structures, and incorporated the capacity to generate an alarm in the event of unexpected airborne contamination.

The application of all these measures has provided highly favourable results, since doses due to internal incorporation have affected only 7 workers, with levels far below the dose limits, and the collective dose has amounted to 24.21mSv.p. In total 771 controls have been performed on 289 workers, this corresponding to 61,073 man-hours of work with the risk of internal contamination due to alpha emitters.

4.- CONCLUSIONS

- The application of the ALARA principle at ENRESA has been firmly established since the company was set up. ENRESA has opted for the development of a manual for application of the ALARA principle from the design phase of its installations, in the development and performance of dismantling projects and at its operating facilities.

- The application of the ALARA principle in the dismantling of facilities does not differ basically from the way it is applied at operating facilities, although in practice many differences arise.

- The dismantling of the Vandellós I nuclear power plant has required the adaptation of the entire Radiation Protection programme established during normal operation. This adaptation has ranged from documentary aspects to an increase in the human and technical resources and the reorientation of operating practices.

- The ALARA principle should be taken into account from the moment in which work is planned, and all the agents involved should participate in its application.

- Regardless of the level of risk of external radiation that might exist at the facility, maximum attention should be given to the risk of internal contamination, which increases considerably with respect to normal operation because of the disassembly tasks performed, the removal from service of the ventilation and confinement systems and the performance of interventions on equipment and components that have never been handled before.