ALARA DEVELOPMENT IN MEXICO

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ABSTRACT

Even though the ALARA philosophy was formally implemented in the early 1980s, to some extent, ALARA considerations already had been incorporated into the design of most commercial equipment and facilities based on experience and engineering development. In Mexico, the design of medical and industrial facilities were based on international recommendations containing those considerations. With the construction of Laguna Verde Nuclear Power Station, formal ALARA groups were created to review some parts of its design, and to prepare the ALARA Program and related procedures necessary for its commercial operation. This paper begins with a brief historical description of ALARA development in Mexico, and then goes on to discuss our regulatory frame in Radiation Protection, some aspects of the ALARA Program, efforts in controlling and reducing of sources of radiation, and finally, future perspectives in the ALARA field.

INTRODUCTION

The peaceful uses of atomic energy in Mexico include medical, industrial, research projects, and supplying electrical power across the country. The main users are the Comision Federal de Electricidad (CFE) with the Laguna Verde Nuclear Power Station; the Instituto Nacional de Investigaciones Nucleares (ININ), at the Nuclear Center; the Instituto Mexicano del Petroleo (IMP), and many major hospitals, located in big cities like Mexico City, Guadalajara, and Monterrey.

Among those institutions, CFE at the Laguna Verde Station is the only one that has a formal ALARA program. For this reason, this paper mainly focuses on the development, current work, and future perspectives of ALARA topics there.

Laguna Verde has two 675 MWe BWR-5 units from General Electric, with turbine-generators supplied by Mitsubishi. Construction started by 1976 in the Laguna Verde area, 70 km north of Veracruz City, on the Gulf of Mexico. The original architect-engineer, Burns and Roe later was replaced by Ebasco, but the CFE was directly responsible for construction since the beginning. Unit 1 has been connected to the grid since April 1989, and entered commercial service in July 1990. In March 1994, its third refueling outage ended. Unit 2 is in the pre-operational test stage, and it is planned to start operations by the middle of 1995.

REGULATIONS

Based on the regulatory law on nuclear affairs, (published in February 1985) as a part of article 27 of the Mexican Constitution, the National Nuclear Safety and Safeguards Commission (Comision Nacional de Seguridad Nuclear y Salvaguardias, CNSNS) as the regulatory body in Mexico, is responsible for issuing licenses to use radioactive and nuclear materials; for assuring the implementation of radiological safety systems in all activities involving nuclear energy, including planning, operations, waste management, and decommissioning; and for inspecting all licensed facilities during normal operations and abnormal situations.

Qualitative Optimization

Due to difficulties in implementing these quantitative methods, we considered that the use of qualitative optimization, based on knowledge, experience, and judgement is a powerful tool. Hence, at Laguna Verde Station we have been developing data bases to identify the main irradiation sources, the mistakes in design, critical groups, and related information. Even this process is very difficult for us at present, because we do not have enough historical information because Laguna Verde is the first nuclear power plant in operation in Mexico. Most of the radiological conditions are new for us, so we have been using information supplied directly from other nuclear plants, or organizations like the Institute of Nuclear Power Operations (INPO), and the IAEA, together with advice from experts.

DOSE REDUCTION AT LAGUNA VERDE

At Laguna Verde, the work of the Radiation Protection group focuses on preventing workers receiving doses higher than reasonable values, and ones that always lower than administrative limits (1 Rem/quarter and 4 Rem/year whole body dose). Efforts in collective dose reduction are directed by the RP Analysis (ALARA) group, and include two kinds of activities: Implementation of the ALARA Program (related to work practices), and the Source Reduction program (related to controlling radioactive sources).

ALARA Program

The ALARA Program at Laguna Verde is focused on maintaining doses at optimum levels, based on workers' training and work practices mainly in high radiation and contamination areas, or long-stay jobs. Implementation of the program is one of the biggest challenges at Laguna Verde because workers have not yet had enough "ALARA Culture," even recognizing that important advances have been achieved. To help in solving this problem, our periodic ALARA meetings have been very helpful for plant workers. At those meetings, we discuss the health impact of radiation, the benefits of work planning, and we resolve any doubts they may have about our dose-reduction activities. For contractor workers, it is more complicated to control their doses because, most often, they are not well trained in radiation protection practices. This problem becomes critical during refueling outages when the number of contractor workers increases significantly.

Another important part of the ALARA program is dose tracking by work groups and high dose job. For example, during 1992 we established annual goals for normal operation (2 person-Sv) and refueling outage (3 person-Sv). In addition, the goals for work groups during normal operation were distributed as follows: Maintenance (with 60 % of the total estimated dose), Radiation Protection (25%), Operations (7%), and Others (8%). We note that Radiation Protection group at Laguna Verde includes groups concerned with decontamination and with handling radioactive waste.

As an example of dose tracking by job during 1991, Laguna Verde personnel got about 0.5 Person-Sv in a collective dose during repairs to leaks in the Turbine building. Therefore in 1992, General Management decided to implement a priority program to attack only the most significant leaks, based on collective doses, increases in water inventory, increases in environmental temperature around vital areas, and repair costs. In addition, we budgeted a maximum dose for repairing leaks in that year, and established monthly goals to control this job. Consequently, the 1992 total collective dose for such repairs was near 0.4 Person-Sv. This value was not as low as we wished. Therefore, since our second refueling outage, at the end of 1992, Laguna Verde started a valve life load seals replacement program for valve load seals that decreased the total number of leaks and the 1993 total collective dose to about 0.2 Person-Sv.

Other aspects of our ALARA program are the ALARA planning and ALARA post-job review, undertaken when estimated and/or obtained collective doses are higher than 0.01 Person-Sv (1 Person-rem), because this allows us to plan in more detail the activities involved in particular jobs, and to fix individual and collective

In November 1988, the Mexican government issued the General Nuclear Safety Regulation (Reglamento General de Seguridad Nuclear[1]) that must be observed by persons and companies working with radioactive materials in Mexico, in accordance with the specific requirements contained in guidelines and rules.

The requirements for radiation protection in the Mexican Regulations, conform entirely with the recommendations of the International Commission on Radiological Protection (ICRP) and the Basic Safety Standards for Radiation Protection of the International Atomic Energy Agency (IAEA). The full dose-limitation system of justification, optimization, and setting of individual limits is included in the regulations. In dose limitation, optimization is the most complicated task because is greatly influenced by personal interpretation, social concerns, and technical and economic resources. Because of the limited applicability of quantitative methods, this kind of optimization is not required by law; however, the requirements for optimization are complied with through design and operation in conformity with existing international standards.

In the case of the Laguna Verde Station, since the licensing stage, the Mexican government decided to use the U.S. Nuclear Regulatory Commission standards and guidelines; specifically, radiation protection and ALARA practices are based on 10 CFR parts 20, 50, and related regulatory guides.

OPTIMIZATION

The optimization process is directed toward achieving reasonably low individual and collective doses under the condition that individual dose-equivalent limits are not exceeded. This is a logical step if it is assumed that every exposure, irrespective of the dose, has a harmful effect.

Since Laguna Verde was designed in 1975, when the ALARA philosophy was not implemented, its plan was based on separating and shielding the major radiation sources, but without almost any specific ALARA analysis. However, since 1984, the Engineering office of CFE through its Applied Physics group carried out some limited ALARA reviews of systems and areas inside the plant. In addition, since 1987, the ALARA group of the Operations Team started working on the confirmatory ALARA review of the design, and on preparing the ALARA program and related procedures.

QUANTITATIVE OPTIMIZATION

The differential cost-benefit analysis proposed in ICRP publication 37[2] can be used as a tool for quantitative optimization. This method commonly is presented as a system of mathematical expressions, relating to the function of optimization, and also to constraining or limiting functions. In such equations, the parameters alpha and beta are included, which are numerical constants related with the monetary value of the collective doses of the population exposed as a result of certain practices. The alpha parameter should be unique and invariable in a given country, while the appropriate selection of the multiple values of the beta parameter makes it possible to take into account sociological considerations, such as the type of persons exposed (workers, the public, nationals, or foreigners), the dose levels (high or low), the spatial and temporal distributions of exposure, and the normal and random nature of events.

Alpha and Beta Values at Laguna Verde

To date, the Mexican regulatory body has not established a national value for the alpha parameter. Therefore, Laguna Verde established and used its own values. During the design stage, we used a value of US$ 10/Person-Sv (US$ 1000/Person-rem) in all cases analyzed. Recently, we changed that value to US$ 53/Person-Sv (US$ 5300/Person-rem)[3] for all groups of dose levels. In future, we plan to implement a basic alpha value for Laguna Verde, consistent with the value that will be fixed by the CNSNS, and different beta values depending on the dose-level group of the workers involved in the assessment.

Detailed work procedures involving significant personnel radiation exposure were submitted to the DOC's Management Safety Committee (MSC) chaired by the DOC Project Manager. During these reviews man-rem estimates frequently were challenged as being too high. These procedures and estimates were revised based on technical guidance received from the MSC. When the procedure and new man-rem estimate was found acceptable, they were approved for use. During the performance of work, changing conditions were promptly addressed. If required, procedures were revised before work could continue. Frequent use was made of classroom and mockup training. The training included a review of the detailed work procedure followed by use of the procedure during mock-up training. Mock-up training helped ensure worker familiarity with the procedure, and the incorporation of good ALARA work practices.

SOME EXAMPLES OF GOOD ALARA PRACTICES

Removal of Radioactive Piping System

The original Decommissioning Plan required the removal of all radioactive piping systems in total containment. The practice of using total containment was simplified by the Decommissioning Operations Contractor's use of a vacuum system equipped with a HEPA filter. The first cut into the radioactive piping was made in total containment. All future cuts were made with the piping system under a negative pressure and exhausted through a HEPA filter. Therefore, containment was not required for subsequent cuts and personnel exposure for the installation and removal of local contaminates was eliminated. A further improvement of this technique was the use of a specially designed saddle valve. The saddle valve was used to drill a hole into a radioactive piping system prior to the first cut. This valve permitted the draining of any residual water left in the piping and provided an adapter so that a vacuum could be applied to the piping internal diameter. Therefore, the first piping cut could be made without containment.

Installation of the Reactor Pressure Vessel Head

When the DOC accepted responsibility for the Shippingport Atomic Power Station from Duquesne Light Company, the radioactive contaminated reactor pressure vessel head was in its storage pit. The reactor pressure vessel was left in a defueled condition, with the reactor internals in place and the pressure vessel full of water. In order to prepare the pressure vessel for removal from its containment chamber, it was necessary to re-install the pressure vessel head and bolt it to the pressure vessel. This operation was estimated to take 12 man-rem of exposure based on performance of this operation in the past.

The detailed procedure and man-rem estimate initially developed for installation of the reactor pressure vessel head was reviewed by the DOC Management Safety Committee. A challenge ALARA goal of 2 man-rem was established for the operation.

In the past, the pressure vessel head which was contaminated with loose surface radioactivity, was installed in total containment. The installation procedure was modified to "fix" the loose surface contamination with paint using a remotely operated, commercially available paint spray gun. The procedure, equipment, and personnel used to perform the painting and installation were trained on a full-size wood mock-up of the pressure vessel head. Once all training was completed, the pressure vessel head was installed successfully. The resulting exposure for the operation was less than the 2 man-rem goal.

Management Involvement

A key element for a successful ALARA program is the leadership and direction provided by management. Management and supervisory personnel's continued involvement in the program is essential to obtain the full endorsement of the workers.

Prior to the start of physical decommissioning, the DOC Project Manager established an ALARA challenge goal of 503 man-rem for the total decommissioning effort. This was one-half the 1,007 man-rem estimate established in the Decommissioning Plan. The new challenge goal was plotted versus time based on the sequence of work activities defined in the Decommissioning Plan. Through March 1987, total actual personnel exposure was maintained below the new challenge goal. In April 1987, a new challenge goal of 225 man-rem was established. The Shippingport Station Decommissioning Project was completed with a total man-rem exposure of 155. The curves of the original 1,007 man-rem estimate, the two challenge goals of 503 and 225 man-rem, and the actual man-rem exposures are shown in Figure 3.

Personnel radiation exposure was controlled at levels far below the SSDP Decommissioning Plan's original estimates. This is attributed to several elements: positive involvement of management, endorsement of the ALARA program by the workers, and the DOC's initial generation of strict radiation control standards and procedures. These elements when combined with innovative work practices will help keep personnel radiation exposures As Low As Reasonably Achievable.

KEY LESSONS LEARNED

Key lessons learned in the application of ALARA at the Shippingport Station Decommissioning Project were:

- Establish "stretch" ALARA goals
- Obtain the full endorsement and support of the ALARA Program by management, supervision and the workers.
- Implement an effective personnel training program
- Monitor compliance of work procedures and work practices
- Challenge the "status quo" of procedures and estimates for both new and repetitive operations.

CONCLUSION

The Shippingport Station Decommissioning Project was completed ahead of schedule and under budget. The Decommissioning Plan estimated 1,007 man-rem exposure. The actual man-rem exposure was 155. The decommissioning was completed without any significant radiological impact on the workers, the public, or the environment. This successful record was the result of an aggressive ALARA Program.

Author Biography

Frank P. Crimi has over 36 years of experience in the nuclear industry. He received his B.S. degree in Mechanical Engineering from Ohio University and joined the General Electric Company (GE) in 1955. He spent the first twenty-five years of his career at the Knolls Atomic Power Laboratory (KAPL) where he held management assignments in nuclear equipment and plant design, plant operations and maintenance, and facility decontamination and decommissioning. Mr. Crimi was responsible for developing and implementing the master plan for decommissioning KAPL's surplus nuclear facilities. Decommissioning projects included low level and high level radioactive waste storage facilities, reactor test facilities, and fuel fabrication shops. In 1981, he transferred to the General Electric Nuclear Energy Division. He was GE's Project Manager for