Radiation Protection Aspects of Water Chemistry and Source-Term Management with a view of an ISOE Expert Group

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Introduction

Since 1992, the Information System on Occupational Exposure (ISOE, see www.isoe-network.net), which was launched by the OECD Nuclear Energy Agency (NEA), has provided a forum for radiation protection professionals from nuclear electricity utilities and national regulatory authorities worldwide to share dose management information and operational experience to improve the optimisation of worker radiological protection at nuclear power plants. Since 1993, the International Atomic Energy Agency (IAEA) has co-sponsored the ISOE Programme, thus allowing the participation of utilities and authorities from non-NEA countries. The ISOE programme, with its participating utilities and regulatory authorities, is a key organisation in developing safe, sustainable and socially acceptable strategies for emerging issues in the field of occupational radiation protection.

Water chemistry, operational procedures and material choice approaches in different design of NPPs vary in results and consequences in terms of radiation protection performance. It was suggested that radiation protection aspects of primary system water chemistry and source-term management could be discussed in detail by the participation of ISOE utilities with an establishment of an expert group. The Expert Group on Water Chemistry and Source-Term Management (EGWC) has been mandated to address the experience of various ISOE utilities with various water chemistry regimes to explore if experience exchange could help to improve radiation protection performances. It was proposed to discuss a few of the most commonly used water chemistry approaches (e.g. zinc injection, pH control, iron injection, hydrogen water chemistry, operational procedures (shut down and start up operations) and material choices (steam generator tubes, cobalt inventory, surface preconditioning), etc.) to focus the exchange of experience discussions.

The expert group mainly focuses on the following topics:

- Description of strategies and techniques aiming to limit the level of activity in the primary coolant (prevention of contamination),
- Performance indicators to assess results from the above strategies and techniques; measurement techniques and performance assessment (monitoring),
- Description of strategies and techniques for the decrease of activity build-up on the primary system surfaces or circuit decontamination (remediation of contamination).

The outcome of the work will be a new ISOE publication, which is planned to include information and practical experience available in the nuclear industry on addressing operational aspects of primary water chemistry and source-term management of nuclear reactors with special emphasis on effects on the management of occupational exposures, identification of factors and aspects which play key roles in achieving good practices in water chemistry management and analysis on impact on worker doses and operational costs. Another objective of the work is also to improve radiation protection staff knowledge regarding source-term management. In addition, specific case studies will be included in the document to demonstrate the various approaches used at various utilities to achieve source term and dose rate reduction. While it is recognized that each plant has unique characteristics, it is through these case studies that practical application of these methods will be illustrated.

The ISOE Programme

Membership in ISOE includes representatives from nuclear power utilities and national regulatory authorities. Members supply their occupational exposure data and experience to the world-wide

system, which contributes to a well-established and growing global base of radiological protection information and experience. This information base provides an important resource to members for optimising exposure management through benchmarking comparisons, exchange of experience and networking of members. As of 2011, the ISOE programme included the official participation of 70 utilities comprising 323 operating units and 40 shutdown units in 29 countries, as well as the participation of 27 regulatory authorities in 24 countries (official participation requires formal acceptance of the ISOE Terms and Conditions). This global participation facilitates experience exchange and the building of linkages between ISOE regions to develop a global approach to ALARA work management.

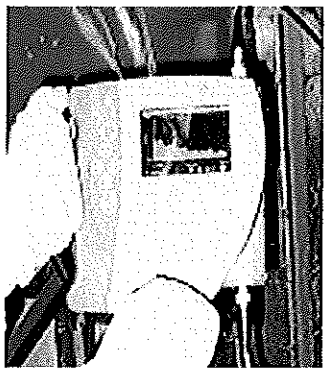
ISOE facilitates occupational exposure management at nuclear power plants world-wide through the collection and analysis of occupational exposure data and trends, and the exchange of experience amongst participating radiological protection professionals (symposia, workshops and web forum).

A key aspect of the ISOE programme is the collection, recording and tracking of annual occupational exposure data from the ISOE participating utilities for trend analysis, benchmarking, comparative analysis and experience exchange amongst ISOE participants. In addition to the detailed operational dose data (at the site, unit, job and task level) provided annually by participating utilities for inclusion in the ISOE occupational exposure database, data from some non-NEA countries has also been made available to the database through the IAEA. The ISOE database thus includes information and data for 482 reactor units in 29 countries (401 operating; 81 in cold-shutdown or some stage of decommissioning) covering about 91% of the world's operating commercial power reactors.

The strength of ISOE is based on its combination of occupational dose data, dose reduction experience, analyses, information exchange and its ability to provide a common forum of utilities and regulators. While the collection and analysis of occupational exposure data remains a central pillar of the ISOE programme, it is the exchange of this information and related experience that brings the full value of ISOE to its participants. To achieve a sustainable long-term strategy to improve information flow and meet user needs, ISOE takes full advantage of web-based and other relevant technologies to deliver a cohesive, integrated and accessible portal of all ISOE assets in a forward-looking manner. The ISOE Network plays an increasingly important role in building an effective mechanism for directly reaching end users, providing participants with one-stop access to all the ISOE assets currently distributed across various media and locations, as well as those to be developed in the future, and an ability to consult, in real- time, the global ISOE membership of radiation protection professionals through the same system. An important goal of this work is to develop a programme that builds on ISOE strengths to make it a primary information source and communications network for the occupational radiation protection community.

The work of the Expert Group on Water Chemistry and Source Term Management (EGWC)

An important element to consider regarding the creation of this group is the memorandum of understanding between Electricité de France (EDF) and the ISOE Management Board, which was signed in April 2011 to jointly share information, operating experience, and data to advance the understanding of the impact on NPP materials aging on corrosion product generation, transport and deposition on ex-core piping and components. In fact, EDF possesses knowledge and know-how in the form of information, data and experience in the development and use of CZT Gamma Spectroscopy (fig 1) technology and measurements in all EDF NPPs. EDF is interested in facilitating the use of CZT measurement technology and EDF protocols in other NPPs to permit the increase in the knowledge, data and understanding of successful methods to reduce the formation, transport and deposition of corrosion products which reduces occupation radiation exposure, and additionally, improving NPP equipment reliability and fuel performance. Within the MOU, EDF agrees to transfer previous results for CZT measurements taken in each of the 58 EDF NPPs and permit restricted access to this information by utility members of ISOE through the ISOE Network. ISOE and its technical centres agree to facilitate the transfer of NPP CZT measurement data and posting on the ISOE-Network (for utilities only), now and in the future.



(a)

(b)

Fig.1: The EDF portable CZT gamma spectrometer.
(a) : The acquisition module (connected to the CZT probe via a 20 m cable),
(b) : Placing the uncollimated CZT probe on a component.

The EGWC focuses on three topics dealing with water chemistry, source term management and remediation techniques (fig 2). One key objective of the EGWC is to provide current knowledge regarding these topics and to address clearly related radiation protection issues. In that mind, the report prepared by the EGWC will be reviewed by radiation protection experts. In order to address various designs, PWRs, BWRs, PHWRs and VVERs are addressed within the document. Additionally, available information address current operating units and lessons learnt are outlined with choices that have been made for the design of new plants.

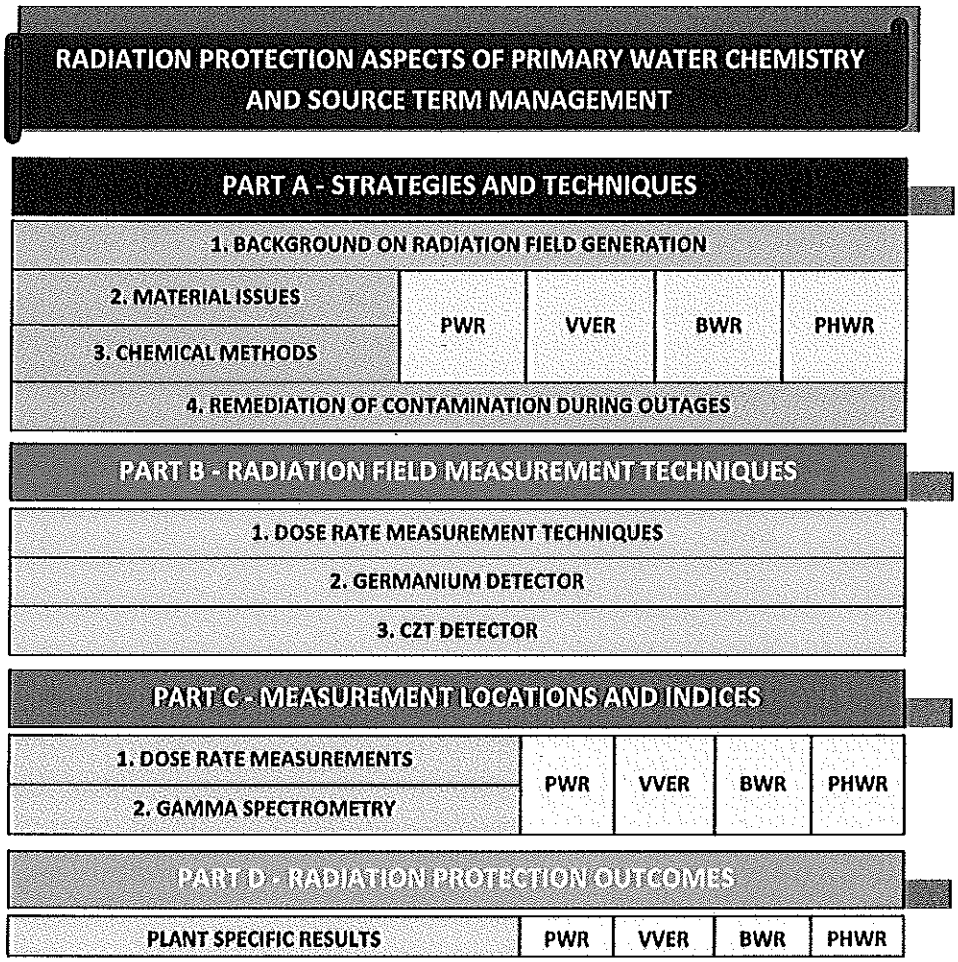


Fig.2 : Summary description of the draft report

The first part of the document addresses current practices regarding primary chemistry management for different design - how to limit activity in the primary circuit and to prevent contamination -. General information is provided regarding activation, corrosion and transport of activated materials in the primary circuit (background on radiation field generation). Primary chemistry aspects that are related to radiation field generation are addressed, such as material issues (steam generator, cobalt inventory, surface preconditioning and fuel support material) and chemical methods (pH control, zinc injection, shut down and start up operations and purification) are also addressed. Specific contamination with ^{110}Ag or ^{124}Sb are also discussed. The second chapter - monitoring of radiation fields - provides information regarding measurement techniques and mapping strategies (such as EPRI methodology or EDF RCA index) that are used in order to precisely follow radiation field evolution within the RCA and to detect abnormal elevation of dose rate. Routine measurements within common techniques such as routine dose rate meters are discussed as well as more complex techniques such as CZT detectors or germanium detector. Advantages and disadvantages of both techniques are presented. In the follow up of the document, techniques for full system and component remediation are discussed with quantitative datasets "remediation of contamination". Finally, experiences of various sites for source terms management are provided, addressing the topics previously discussed in the report in section titled as plant specific results. These will include different applications of the topics presented in this work, including examples of elevated zinc injection programs, use of speciality resins, and removal of cobalt contributing components. For example, a refuel outage was recently completed which included full scale steam generator inspections for less than 300 mSv (30 person-rem) as a result of implementation of practices discussed in this work..