Nuclear Industry Experiences in Occupational Exposure

M. Lips, R. Coates, J. Hondros, J. Takala, J. Zic, K. Maruyama
World Nuclear Association, Tower House, 10 Southampton Street, London, WC2E 7HA, UK
mlips@kkg.ch

1. Introduction and occupational exposure trends

The international nuclear industry has for many years had an impressive record of controlling and reducing occupational exposure, as measured by average individual exposure and collective dose. See as examples figure 1 showing the collective dose trend for NPPs in recent years [1] and figure 2 the corresponding data for uranium mining and milling. Whilst there are variations across the individual sectors within the nuclear fuel cycle, the industry has been able to demonstrate the central importance of exposure optimisation, and the nuclear industry has in fact been the leading sector across all industries/employers in this respect. Current average worker doses are around 1 mSv per year for the whole nuclear fuel cycle, which is within the variability of natural background radiation. We hope for regulatory acknowledgement of this success through less pressure for formal optimisation assessments on our occupational exposures where the doses are already very low.

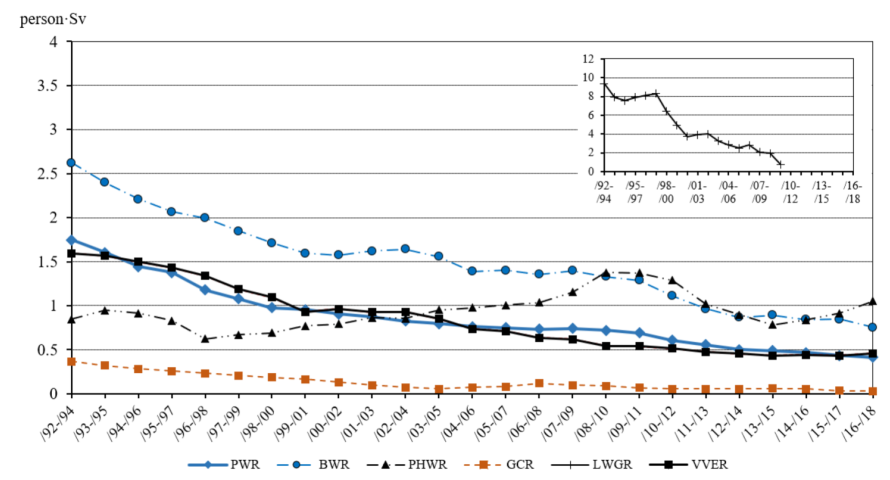

Fig. 1: Three-year rolling average collective dose per reactor for all operating reactors (person·Sv/reactor)

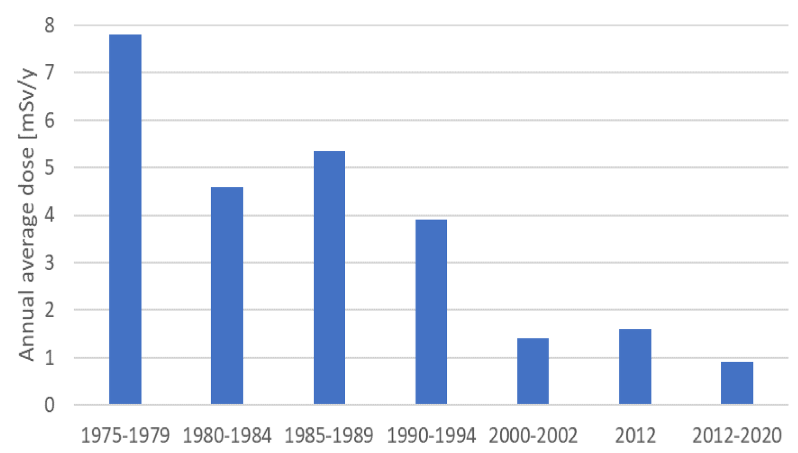

Fig. 2: Annual average person dose from mining and milling. Sources: UNSCEAR, IAEA, National and Company Data

2. Management of occupational exposure

The industry is committed to maintaining the highest performance standards for occupational exposure, although further reductions will be challenging. We are committed to the concept of 'continuous improvement' and the avoidance of complacency, and most of our sites participate in peer review processes. Our improvement processes focus on learning from our peers and on improving and developing our overall safety culture. We expect our improvement plans to be based on demonstration of clearly defined value benefits, and we must not move towards 'minimisation' of exposure.

2.1. All-hazards approach

It is important to ensure that we take an 'all-hazards' approach to occupational safety (see figure 3). Radiation is just one of several hazards that face our workforces and keeping risks in perspective is what industry does well. Over-prioritising the radiation risk would send mixed messages and reinforce the perception that low radiation levels are particularly dangerous. When low doses have been achieved it can be more fruitful to focus further improvements on making the overall safety system more efficient and robust. This allows for appropriate resources to be used to address other risks, including reducing the risks of failures that could result in increased occupational exposures.

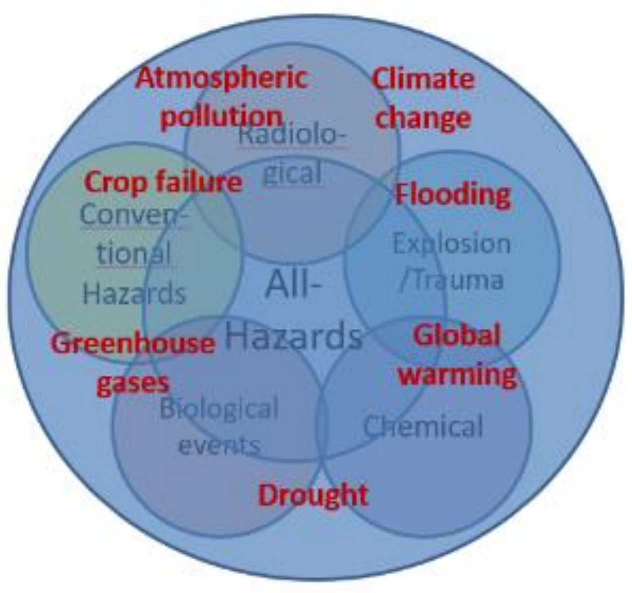

Fig. 3: Conceptional approach of an all-hazards consideration

2.2. Safety culture

Our experience shows that successful optimisation of occupational exposure depends on many factors but developing a strong radiation protection culture as part of an overall safety culture is foundational to success. An organization with a strong safety culture will have a management that supports the development of technical excellence and a robust monitoring program along with a drive for continual improvement. At the individual worker level, a sound culture recognises that knowledgeable and skilled workers can optimise how they complete their tasks.

2.3. Technical competency

In addition to the cultural approaches, optimisation comes from having technical competence and a high-level understanding of all processes. Examples include:

- NPP primary circuit chemistry. As cooling water interacts with primary circuit components, radiological conditions will depend on chemistry and material composition. Optimal conditions apply when deposition rates of radionuclides on component surfaces and release rates of activated nuclides from material exposed to high neutron fluxes are both at minimum. Dose rate reductions up to one order of magnitude were achieved by adapting chemical regimes (see figure 4).

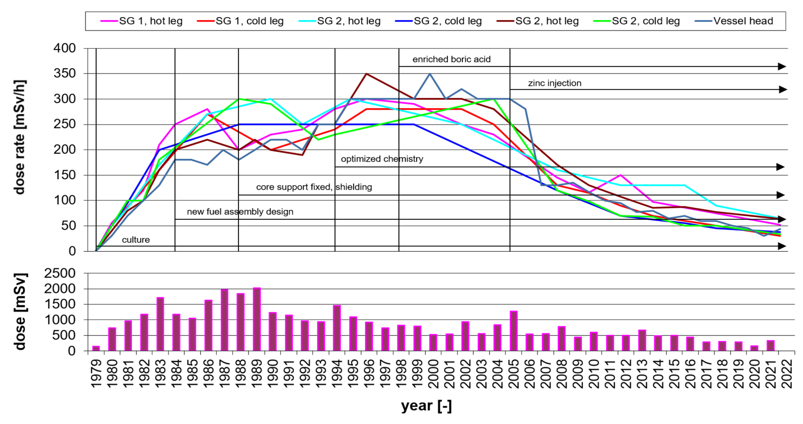

Fig. 4 (upper part): Influence of water chemistry on dose rates in the primary circuit
Fig. 4 (lower part): Influence of water chemistry, technical developments, safety culture on plant collective dose Source: Goesgen NPP

- Uranium mining and production methods have evolved in recent decades. One of the main modern methods is in situ recovery where workers remain isolated from the orebody. For underground mines, sophisticated ventilation systems provide an active control for a range of airborne hazards, of which airborne radioactivity is but one. Uranium production facilities are generally self-contained processes, thereby separating the source of exposure from the workers.

3. Future challenges

In order to maintain this impressive record, there are several key future challenges for occupational exposure within the industry:

- Continuing to develop an appropriate and strong radiation protection culture in sectors and activities outside of those that have traditionally been required to address radiation protection issues
- Managing the higher doses of some key skill groups – for example key NPP outage workers who move from site to site. One aspect is to focus our optimization efforts on such groups and not on the administration of worker doses with minimal exposure, although this may require regulatory acceptance. Another aspect is the need for global harmonization, as these key skill workers who move across borders are being faced with different regulations or even limits.
- There is increasing engagement on decommissioning, with less repetitive routine work and more hands-on intervention, which could lead to increasing exposures. This also results in an emphasis on waste management and the need for efficient waste processes, including effective clearance systems. Clearance provides additional options for management of material which supports sustainability through providing for recycling and re-use of material and reducing the amount of radioactive waste to be managed. This helps to efficiently decrease occupational exposure received during handling bulk waste.
- Mining and uranium production has a different set of exposure conditions, resulting in worker total doses of the order of one to a few mSv. This is higher than for the rest of the nuclear fuel cycle; however, the doses remain very low and well controlled. For this sector it is critical to ensure that the low doses remain in perspective with other workplace hazards and hence a balanced all-hazards approach is necessary. The challenge is that any push to further reduce doses unnecessarily imbalances the safety focus.
- Many countries have developed programs for long term operation of their nuclear fleet. This may require enhanced maintenance and plant retrofits and probably the need for further RP actions to be taken. It may also be a chance to improve RP aspects in the wake of a retrofit
- We must ensure ongoing consideration of radiation protection in design, through such approaches as remotely controlled operations, inherent and passive safety features, ease of maintenance and smart design, which progressively minimise workplace hazards.
- We must continually adapt operational and radiation practices to fully take advantage of technological advances, such as in remote sensing, computing and Artificial Intelligence.

4. Conclusion

- The nuclear industry has a good record of managing occupational exposure across a wide range of facilities. There are many different approaches which must be utilised, as well as challenges for the future. However, it is important that improvement plans are based on clearly defined-value benefits based on judgements of reasonableness, and not in response to external pressures to 'minimise exposure'.

References:

[1] Nuclear Energy Agency (OECD), Occupational Exposures at Nuclear Power Plants Twenty-Eighth Annual Report of the ISOE Programme, 2018, OECD 2021, NEA No. 7536