ALARA Approach at the Krško PWR Plant

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For the period of seventeen years of the Krško Nuclear Power Plant operation, the area of maintaining low radiation exposures was included in the plant policy. The benefits of this effort are be reducing risks to nuclear workers, and better work planning and work performance. The Krško Plant ALARA organisation has been revised recently and built on different levels of hierarchy. Considering plant operation and ALARA issues, the most critical components during these years were steam generators and their maintenance. There have been various maintenance activities carried out to enable plant operation at full power – also during the last year of operation before replacement of steam generators. A review of exposure reduction actions and lessons learned related to steam generators are presented in this article.

1. Work Management

1.1 ALARA Work Planning

The ALARA work planning at the Krško Plant is performed by the radiation protection department and by introducing formal ALARA groups. These groups are composed of responsible engineers and technicians from job related departments and supported by the radiological protection engineer.

For the jobs with projected dose lower than 10 man mSv or individual exposure below 5 mSv, the administrative control is provided by radiation work permit. For more exposed jobs, ALARA planning is performed by radiation protection personnel or by the ALARA groups when an interdisciplinary approach is necessary. The contractor's responsible engineer and job leader participate in the planning process and in the pre-job briefings. Post-job reviews are used to improve the practice.

Those jobs having projected collective dose over 0.3 manSv are reviewed by the plant technical director. This review ensures that sufficient planning, resources, and actions are applied to the job.

1.2 Radiation Safety or ALARA Committee

There are two committees in the Krško organisation to cover ALARA planning issues – Operating Committee and Radiation Safety Committee.
The plant management has supported the improvements in efficiency and structure of the latter Committee to also include the scope of ALARA and to function as an ALARA Committee. The members of this Committee are now appointed from the middle management level staff, responsible for work planning in the controlled area, for plant operation, radiation protection, engineering support and licensing. The Committee is under patronage of the plant director and managed by his deputy, the technical director.

2. Steam generators

Considering plant operation and ALARA issues, the most critical components during the years were two steam generators and their maintenance. There have been various maintenance activities also carried out to enable plant operation at full power during the last year of operation before replacement of steam generators, which is scheduled for the year 2000.

2.1 Maintenance activities

The tubes of Inconel 600 material are susceptible to stress-corrosion, and tubes plugging was required. Later on, some plug designs proved unacceptable, and tubes deplugging was performed.

In 1993, the Krško NPP experienced a tube leak event which resulted in a forced shut down and an outage dedicated to steam generator tubes repair. Due to an increasing number of tube defects on one side and a new plugging criteria on the other, it was decided to unplug a greater number of tubes to either bring them back into service or to save them for further operation by installing sleeves. Besides eddy current testing and nozzle dam installation, plugging, deplugging and sleeving were the main activities that required radiation work related to the steam generators.

2.2 Contractor issue

Selection of the contractor and the techniques to be applied is important regarding lower radiation exposures. A long-term agreement for services is preferred in order for steam generator service contractors to invest in the equipment and practices to lower dose.

2.3 Exposure reduction techniques

The following features have been developed and implemented during the years of steam generator tubes maintenance:

- improved tools and manipulators for plugging and sleeving
- special tools designed for removal of plugs, pulled tubes, and testing of tubes
- remote control of manipulators
- quick replacement of tools
- the same crewmen
- training on a mock-up
- work preparation on the platform below manways
- new pneumatic nozzle dams
- shielded doors on the manway
- preparation of equipment in a clean area
- weldless sleeving

2.4 ALARA indicators

Figure 1 shows the evolution of collective doses related to the jobs. There are two most important dose reductions evident, i.e. one due to nozzle dams installation and the other one related to plugging, sleeving and deplugging.

After introducing pneumatic nozzle dams in 1993, the dose for this job has become about one third of the previous value. The last two years, the weldless sleeving method resulted in a dose reduction due to a reduced number of required activities compared to the previous welding method. The dose of the plugging, sleeving and deplugging is normalised with the number of items performed each year, and the value in mSv per item is shown at the top of the columns in Figure 1. This normalised dose became lower by about a factor of three.

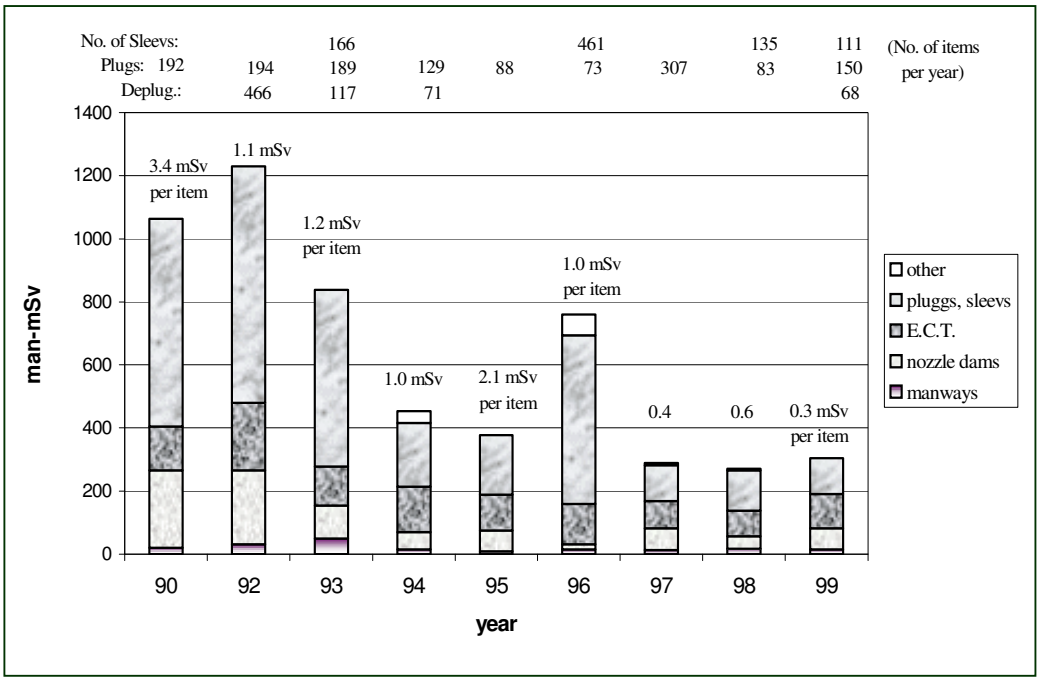

Figure 1: Collective dose per year resulted from steam generator maintenance activities. The dose of the plugging, sleeving and deplugging is normalised with the number of items installed each year, the value in mSv per item is shown at the top of the columns. The legend at the side indicates the jobs, and at the top are numbers of items installed per year. Eddy current test is marked as E.C.T.

2.5 Foreign material exclusion & fuel integrity

The removal of foreign material from the reactor vessel bottom in the outage 1996 showed mainly fragments of chips from previous deplugging activities. Most chips were ≤ 0.5 cm^2 each, with a few others up to 1 - 2 cm^2. A program of foreign material exclusion has been introduced with careful washing and cleaning of steam generators' channel heads.

After extensive steam generator tubes deplugging, there were nine defective fuel rods in eight fuel elements found during fuel inspection in 1995. One element containing a defective rod of a one-year burnt-up fuel was removed from the core.

The Figure 2 shows a total activity of noble gases released from the plant. It illustrates the situation with a fuel leak and recovery after corrective actions were implemented.

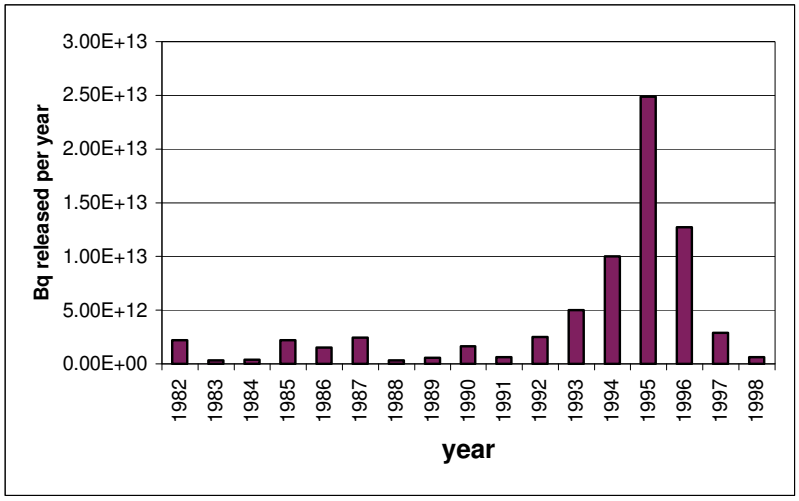

Figure 2: Total activity of noble gases released per year from the plant

3. Perspective for the future

The actions that will result in lower plant collective doses, are:

- installation of new steam generators in outage 2000
- new structure materials of fuel elements
- improving shutdown chemistry procedures

Low Cobalt contents in the alloy of the new steam generators and eliminating the old steam generators will be most important for lower collective exposures. The replacement of Inconel alloy mid-grids in fuel elements with Zircaloy is anticipated in the future. Also some actions have been recently started to benchmark the shutdown chemistry procedures.

Currently the collective dose in a typical year of operation is controlled to be below 2 manSv, the goal and long-term average is below 1.5 manSv. The preliminary dose assessed for the replacement of steam generators is about 1 manSv. After the replacement the annual goal is expected to be 1 manSv.

4. Acknowledgment

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