Improving occupational radiation exposure using ALARA tools: performance indicators

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ABSTRACT

Over the last 8 years, many administrative and procedure level measures, have been implemented, to improve total collective dose. The most important global result is reducing station dose from 520 man mSv in 2007 to 388 man mSv in 2015, for two units.

Involving working group ALARA coordinators in planning and tracking exposure is contributing in achieving both individual and overall department goals. The excellent results in collective radiation exposure have been obtained also, by improving working group good practices.

Radiation workers, ALARA coordinators, first line supervisors, and managers are directly responsible for controlling and reducing radiation doses. Working group ALARA coordinators have monthly meetings to discuss personnel performance indicators and any other ALARA initiatives to improve radiation protection personnel work practice.

Radiation protection department permanently monitors workers performance inside radiological area. All radiation protection deficiencies are daily analyzed and rapid corrective action are implemented, if necessary. Periodically (quarterly), radiation protection trend analyses are performed to monitor the evolution of the radiation protection deficiencies. 12 categories of deficiencies including: radiation protection work practices (monitoring, contamination control, rad waste collection), contamination control (both personal and material), use of protective equipment, RWP/work planning and ALARA performance indicators have been identified and followed. The most significant improvement has been achieved in radioactive materials control, after implementing a corrective action plan when number of events decreased from 15 events in 2nd quarter 2013 to none in 4th quarter 2015.

All trend analysis and action generated to improve poor working practice revealed the importance of individual behavior inside radiological area.

1.0 INTRODUCTION

CNE Cernavoda management is committed to continuously improve the safety standards in order to protect personnel, public and environment. ALARA is an important element of the global approach to radiological protection and plant management commitment to ALARA has been clearly stated by the reference document "Radiation Protection Principles, Policy and Regulation". Keeping exposures ALARA is first a way of thinking, rather than a formula. It is very important for radiation protection personnel to collaborate closely with working groups and make them aware for being responsible for doses they received. Radiation workers, ALARA coordinators, first line supervisors, and managers are directly responsible for controlling and reducing radiation doses.

During 20 years of operation, most of the exposures were below the Recording Level and the majority of recordable doses were less than 1 mSv. No legal or administrative individual dose limit

has been exceeded. The actual levels of individual and collective effective doses due to external and internal exposures reveal the effectiveness of implementation of the Radiation Safety Policies and Principles established by the management of the Cernavoda NPP. Despite the increased number of professionally exposed workers after starting the operation of Unit 2 in 2007, the collective doses did not increased accordingly.

Collective dose provides indication about plant radiological condition in connection with personnel behavior. Best dose performance is a result of a balanced combination between those two factors, which represents the philosophy of ALARA principle. ALARA principle has much qualitative and less quantitative connotations, that's why its implementation is opened to several methods or particular approach.
First level of implementation is using microALARA techniques converted into radiation protection measures for every radiologic risk activity. An aggressive policy to reduce individual exposure was applied since 2005, including:

- a strict control of D_2O leaks and leaks reduction program
- providing dryers availability
- optimization of personnel access in R/B
- using appropriate RP protective equipment
- hot spot management program
- implementation of RWP system

Collective dose improving results needed also an improved personnel behavior inside radiological area. And to improve human behavior, we needed to find out the exactly near-misses made during activities. Two directions were considered with the aim of correcting personnel behavior: define ALARA performance indicators for working groups and elaborate periodically trend analyses for radiation protection deficiencies.

In the beginning trend analysis addressed only human performance deficiencies with direct and significant radiological impact. The results of those analyses were corrective actions for causative working group staff.

Analyzing abnormal conditions reports on radiation protection violation, we extend this trend analysis to include any kind of deviation from RP procedures. Currently trend analysis include: quarterly value for strategic performance indicators, monthly distribution of abnormal condition reports grouped by type of deficiency and number of deficiencies evolution for the last four quarters.

2.0 ALARA PERFORMANCE INDICATORS

After implementing ALARA and RWP programs, a continuous station focus on collective radiation exposure reduction has resulted in top industry performance for CANDU designed reactors over the last 8 years, reducing station dose from 271 man mSv / unit in 2007 to 194 man mSv / unit in 2015.
The station's exposure control program continues to be in full compliance with the regulatory requirements. In particular, the station exposure control level of 14 mSv/calendar year is below the single year regulatory limit of 20 mSv / year.

The main indicators to be looked at are the collective dose and the distribution of individual doses. The targets for these indicators are obtained through a generic description of the major radiological jobs that are planned to be performed (based on a rough estimate of the frequency of the jobs performed, their duration, dose rates and number of workers exposed) correlated with statistical (historical) values.

After three consecutive years - 2004, 2005 and 2006 - of major concern on individual and collective internal doses (contributing with up to 60% to the total dose), due to the increase of tritium dose rate in the Reactor Building, important steps were done to decrease this type of exposure.

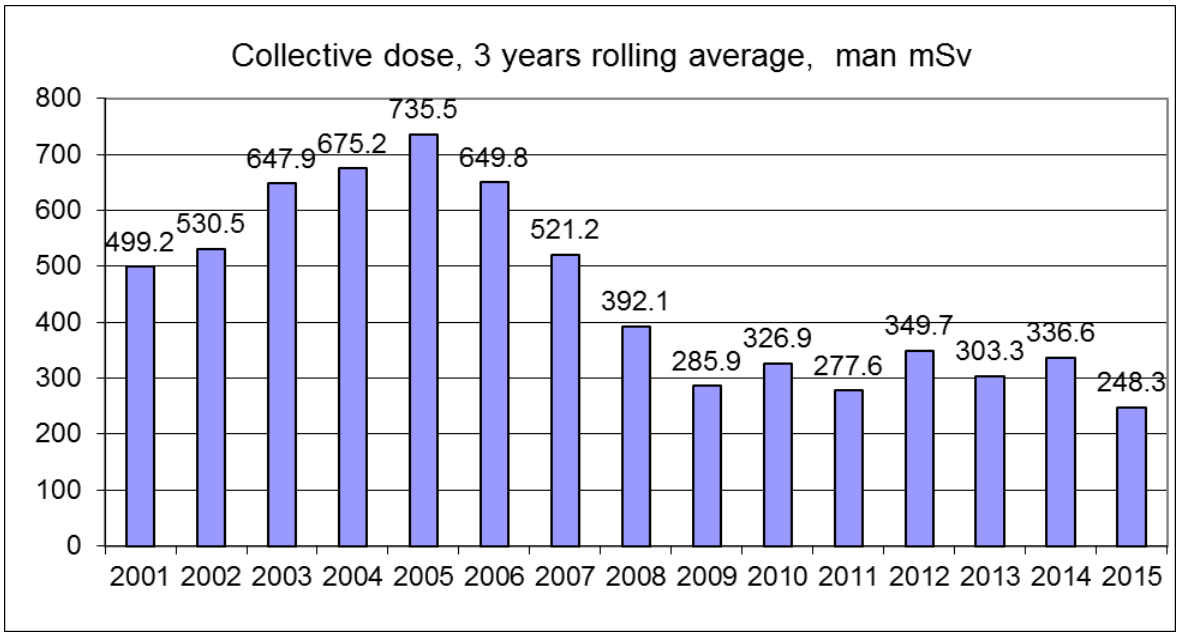

Fig. 1, Collective dose, three years rolling average

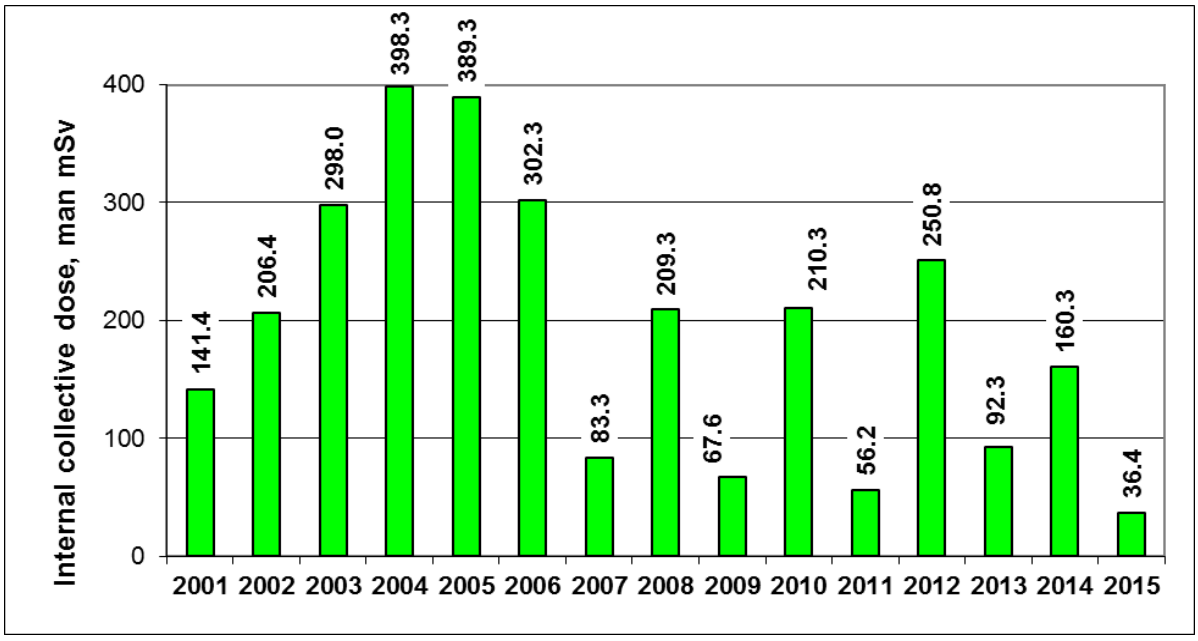

Fig. 2: Internal collective dose

An aggressive policy to reduce tritium exposure was applied since 2005 including:

- a strict control of D2O leaks,
- providing dryers availability
- optimization of personnel access in R/B,
- using appropriate RP protective equipment.

Corrective and preventive actions and recommendations, aiming both work planning (exposure control) and technical aspects, worked efficiently.

Bad performance of both collective and internal doses became triggers to decide implementing of exposure reducing policy, more interactive and in relationship with working groups. In addition with pre and post job activities evaluation, a set of performance indicators was defined, in order to closely monitor the personnel behavior related with radiation exposure inside working area.

3.0 NEW ALARA PERFORMANCE INDICATORS

Starting with 2008 we operated two units, and in its first meeting in 2008, ALARA Technical Committee approved challenging values for collective dose and internal dose contribution: 688 man mSv (with Unit # 1 planned outage) and 30 %, respectively.

In order to further improve plant performance related with exposure of radiation workers ALARA committee approved the implementation of some new performance indicators for the major work groups and for the plant:

- Unexpected acute individual external exposures;
- Unexpected acute individual internal exposures;
- Maximum individual dose;
- Internal contaminations with radio-nuclides other than tritium;
- Unexpected contamination of surfaces;
- Personnel contamination identified at the exit of the RCA.

2008 dose results confirmed the first good steps of ALARA principle implementation. Station collective dose and internal collective dose started to decrease and plant management commitment to ALARA has been clearly stated by the reference document “Radiation Protection Policy and Programs”. The awareness of Radiation Protection in the station became a topic in planning meeting agenda. Twice a month, collective dose distribution by working groups is presented to plant management, including senior supervisors of working groups, who can analyze spent dose budget versus monthly target.

Also, first ALARA Annual Report has been issued for 2008 to present station ALARA performance. This report pictured the exact state of radiation programs efficiency and areas to be improved have been identified.

In the following years we defined a few more ALARA performance indicators based on EPRI and WANO/INPO guides. In present, 10 ALARA performance indicators are monthly reported and analyzed with working group ALARA Coordinators. New 4 (four) ALARA performance indicators are:

- Inadequate response to EPD’s dose rate / dose alarms
- Maximum individual internal dose
- Personnel Contamination Events (inside Radiation Controlled Area - RCA)
- Unexpected exposures: external and effective over 0.1 mSv

They are assessed and reported periodically to reflect the objectives and permanently mark out achievements and breakdowns. Depending on the performance, every year all performance indicators values are analyzed and they could be redefined or targets readjusted to reflect the efficiency of professional exposure control process. Though, radiation protection ALARA personnel record every deficiency and investigate all events which exceed target values. Corrective and preventive actions and recommendations aim both work planning (exposure control) and technical aspects, so that work conditions (especially radiation work) to be improved.
Five years dose reduction plan has been developed and approved by senior management to provide oversight and resources for dose reduction initiative.
After 2010, ALARA reports showed a negative trend for "Unexpected acute individual external exposures", measured by personnel response to EPD dose alarm. Event analysis revealed weaknesses in applying EPD dose alarm response, even when worker knew his PAD alarm had been activated. To improve this performance has been necessary to come closer to the workers, identify steps with radiation protection impact and give them support to avoid unnecessary exposure.

4.0 TREND ANALYSIS RESULTS

Integrated root cause analysis for inappropriate response to EPD dose / dose rate alarms opened our vision to identify all radiation protection deficiencies, group them against causal factors, follow the trend and make conclusions or corrective actions whenever are needed.

Since 2013, quarterly trend analysis are made and discussed with working groups from Production Division during radiation protection and industrial safety meeting.
Radiation protection deficiencies identified till now, are:

1. Heavy water leaks
2. Use of RWP and work planning
3. Contamination control
4. Radioactive material control
5. Radiation protection work practice
6. Inappropriate EPD alarm response
7. Adverse trend for ALARA indicators
8. Protective individual equipment deficiencies
9. Radiological conditions
10. Work practices during high radiological risk activities
11. Personal contamination events
12. RP fundamentals

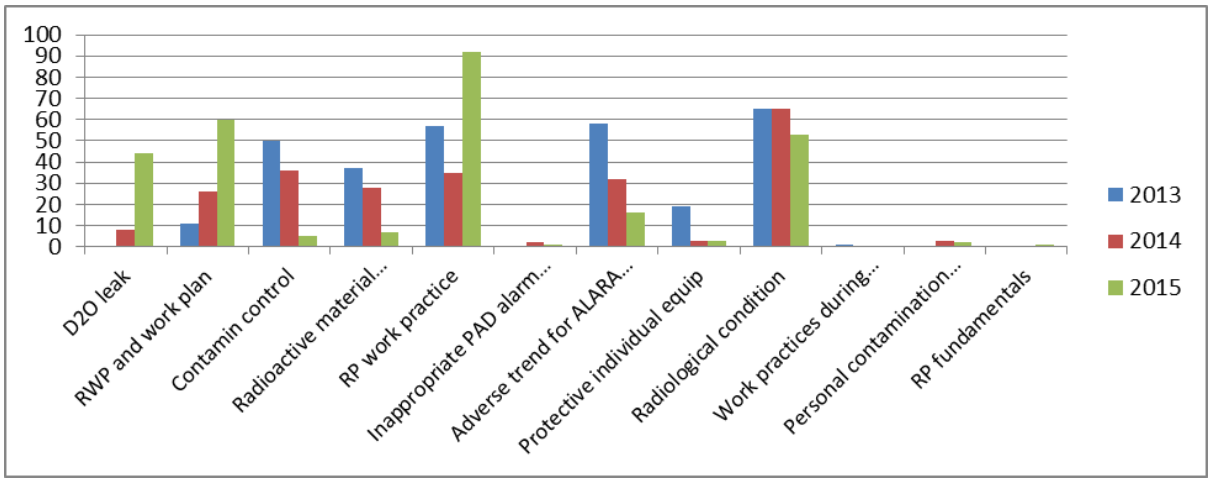

Fig. 3 Evolution of radiation protection deficiencies

A three years picture of radiation protection deficiencies shows improvements in contamination control, radioactive material control, adverse trend for ALARA indicators and radiological condition. Contamination control has been a hot issue in 2013 and RP department developed an action plan to reduce number of violations of procedure and this theme is annually analyzed into a focused self-assess report. Same idea was applied also to reduce radioactive material control deficiency in addition with many observations and coaching sessions developed for this topic.

“Radiological conditions” and “Heavy water leaks” deficiencies accounts for equipment defects generating increased radiation dose rates. In order to improve radiological conditions, radiation protection department implemented a program for hot spot management and upgraded tritium in air monitoring system in Unit #1. Also, we made efforts to accelerate implementation of support system with good impact in radiological condition: portable dryers, installing air dehumidifier in reactor building. These deficiencies are carefully followed in order to identify necessary systems improvements and the efficiency of leaks management.

Starting 2015, during monthly meetings, Technical ALARA Committee analyses from radiological point of view every job if a difference higher than 25% between estimated and received doses is registered. This is considered a radiation protection deficiency and, if necessary, corrective actions are established in order to improve the performance.

Three more categories were added as new type of abnormal condition occurred: D2O leaks, personal contamination events and RP fundamentals. To correct personnel behavior it is under implementation a RP fundamentals training course as a prerequisite of periodical radiation protection skills testing. RP Fundamentals for RP personnel and workers will be reinforced with special attention to high radiological risk jobs, in particular radiography and high activity materials manipulation. Radiation protection themes are included in “Subject of the week” training materials of Operation and Maintenance Departments.

The awareness of Radiation Protection in the station and ownership of dose have been increased by placing in key high traffic areas of the plant specific information: charts, bulletin, newsletter on RP stations goals, ALARA initiatives, RP policies and procedures.

5.0 CONCLUSIONS

ALARA is an important basic principle of radiological protection. Keeping exposures ALARA is first a way of thinking, rather than a formula. It is very important for radiation protection personnel to collaborate closely with working groups and make them aware for being responsible for doses they received. Making radiation workers, ALARA coordinators, first line supervisors, and managers directly responsible for controlling and reducing exposures open up for better dose performance.

ALARA performance indicators are useful if they are used to identify the low level errors generated by poor radiation protection working practice with exposure consequences. RP personnel grant support and coaching for high radiological risk, but worker alignment are important to achieve exposures that are kept ALARA. Since the objective of the optimization of radiological protection is to keep individual and collective doses below the appropriate dose constraints, the most relevant indicator is the dose (collective or individual). Good results for dose are the outcome of good adherence to the radiation protection procedures.

Making periodic trend analysis of RP deficiencies and related corrective action plans could also contribute to performance improvement. This is demonstrated by our improved performance for contamination control (50 deficiencies in 2013, 5 in 2015 and 0 in 1st quarter of 2016) and radioactive material control (37 deficiencies in 2013, 7 in 2015, 2 in 1st quarter 2016).

There is still room for improvement, we must stay focused on “Radiation protection work practices” (57 deficiencies in 2013, 92 in 2015 and 27 in 1st quarter 2016), particularly on: monitoring equipment used in zone 1, RP individual equipment abandoned in the work areas (half masks, gloves), temporary storage of contaminated materials, arrange and working in rubber area.

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