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Radiological Work Management Aspects influencing Dose Reduction at the Ignalina NPP during Outages and coming Decommissioning

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Introduction

Lithuania has few nuclear facilities. There are two non-upgradeable nuclear reactors of RBMK-1500 series (light water –cooled graphite-moderated channel type reactors, LWGR (RBMK)). Also one on-site dry spent nuclear fuel interim storage facility is located at Ignalina NPP[1]. All these facilities are located in the north–eastern part of Lithuania, near the borders with Belarus and Latvia, 160 km distance from the capital city Vilnius, on the banks of the lake Druksiai. The first Unit of Ignalina NPP went into operation at the end of 1983, the second Unit in August 1987.

Lithuania signed a Nuclear Safety Grant Agreement in 1994 stating, inter alia, the commitment of the Republic of Lithuania to close both units of the Ignalina NPP at the time of so called “gap closure” and therefore not to use the designed technical lifetime of the reactor units by re-channeling the fuel channels.

The decision to shut down the Unit 1 is already taken by law, and it is planned to stop the Unit 1 before the 1 January 2005. In November 2002 the Government of Lithuania adopted the decision which states that preferred option for the decommissioning of Unit 1 is the immediate dismantling. It means that the process of dismantling of the Unit 1 will start right after shutdown of the reactor and the process will continue at least for 30 years. From the radiological point of view, this process can be treated as big extended outage of the unit with constantly changing working environment that might cause high individual and collective doses to the workers.

The draft of the Final Decommissioning Plan, as a part of the licensing requirements needed to start the decommissioning process, already exists. It has been preliminary estimated by the operator that during immediate dismantling of the Unit 1, the total exposure approximately will result in 35 manSv.

Due to unique construction, the occupational exposure results for the reactors of RBMK (LWGR) type are one of the highest if comparing with reactors of other types. The outages of both units each year usually last 2-4 months. The main “contributors” to the annual collective dose are the annual outages of the units. Keeping the occupational exposure in accordance with legal requirements, the operator needs to establish an effective radiological work management programme during the outage periods, which shall serve as a part of the radiation protection programme.

Both legal requirements and practical experiences applied at Ignalina NPP related to radiological work management aspects influencing dose reduction during outages and radiation protection measures planned to be applied during coming decommissioning of both units is discussed in the paper.

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[1] The heat cycle of the Ignalina NPP reactors is identical to the Boiling Water Reactor (BWR) cycle extensively used throughout the world, and is analogous to the cycle of thermal generating stations. However, compared to BWRs used in Western power plants, the Ignalina NPP and other plants with the RBMK-type reactors have a number of unique features. The Ignalina NPP uses an RBMK - type channelized reactor. This means that each nuclear fuel assembly bank is located in a separately cooled fuel channel (pressure tube). There are a total of 1661 of such channels and the cooling water flow rate must be equally divided among associated feeder pipes. After crossing the core, these pipes are brought together to feed the steam-water mixture to separator drums. The nuclear fuel assemblies of the Ignalina NPP are changed without shutting down the reactor. This is possible only for channel type reactors. It is possible to disconnect one of them at the time from the reactor cooling system, change the fuel assembly, and then reconnect the channel.

Legislation

The main laws and regulations of the Republic of Lithuania establishing radiation protection requirements are the Law on Radiation Protection (passed in 1999) [1], the Lithuanian Hygiene Standard HN 73:2001 "Basic Standards of Radiation Protection" [2] and HN 87:2002 "Radiation Protection in Nuclear Facilities" (hereinafter – HN 87:2002) [3] and other supplementary radiation protection legislation.

The HN 73:2001 establishes radiation protection requirements for practices, classifies the radiation workers, sets the dose limits that are in accordance with EU requirements and international recommendations on radiation protection [4, 5]. The effective dose limit for the occupational exposure is 100 mSv in a consecutive 5 year period, subject to a maximum effective dose of 50 mSv in any single year [2]. Annual public dose constraint set for the operation and decommissioning of nuclear facilities, is 0.2 mSv [3].

The regulatory authority in the field of radiation protection is the Radiation Protection Centre, RPC. It co-ordinates the activities of executive and other bodies of public administration and local government in the field of radiation protection, exercises state supervision and control of radiation protection, including nuclear facilities, performs monitoring and expert examination of public exposure. The functions and responsibilities of the Radiation Protection Centre are described in Article 7 of the Law on Radiation Protection.

Requirements for Occupational Radiation Protection in Nuclear Facilities – Radiation Protection Programme

According to the requirements set out in [3], the radiation protection programme shall be established at the nuclear power plant. The radiation protection programme addresses following issues:

- classification of working areas and access control;
- local rules, measures of supervision of safety at work and order of organization of work;
- procedures of monitoring of workplaces and individual monitoring of workers;
- individual protective equipment and procedures for their application;
- main premises, control systems for assurance of radiation protection;
- requirements for management of radioactive waste;
- radiation protection in the case of accidents;
- application of optimization principle (ALARA) and measures on exposure reduction;
- programs of health surveillance;
- compulsory training of workers and their instructions.

The radiation protection programme implemented at the Ignalina NPP basically conforms with the programme given in [6]. In accordance with the INPP management procedure "Radiological Protection", QA-2-005, in the frame of the INPP Radiation Protection Programme, a set of procedures was created.

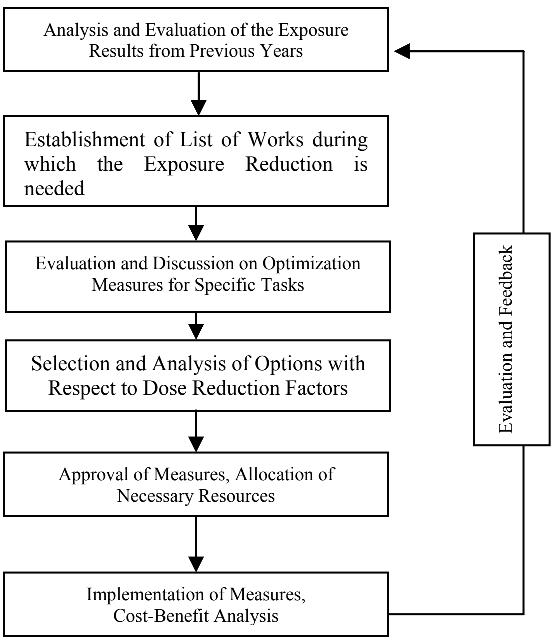

Fig. 1. The ALARA procedure at the Ignalina NPP

ALARA Strategy at the Ignalina NPP. ALARA Group and ALARA Programme

The process for implementing of the ALARA procedure at the Ignalina NPP is given in Fig. 1.

The implementation of ALARA programme started at Ignalina NPP in 1996. The Programme defines the procedure for exposure planning, definition and implementation of necessary measures and financial resources needed for exposure reduction. The establishment and implementation of the ALARA programme is required by [3]. Since 1998 the ALARA Group is established at the plant. The main task of the group is to plan the occupational exposure doses and to establish necessary recommendations for the dose reduction. In order to effectively control the doses of personnel, the ALARA Group plans the daily, monthly and annual doses. Planned annual doses with doses associated with specific tasks during the outages are established and agreed with the Radiation Protection Centre. The effectiveness of the ALARA Programme is monitored by the ALARA Group through the whole duration of the work year of the plant. The evolution of actual individual and collective doses is compared to the evolution of the predicted values. The results of the radiological protection measures implemented during the outages, results of occupational exposure are discussed, and possible ways and main areas for improvement of working conditions when performing specific jobs are evaluated and discussed in the regular meetings of all workshops, especially after outages. The results of the ALARA Programme are addressed in reports generated after outages and sent to the Radiation Protection Centre and other regulatory authorities for evaluation.

Generally, the ALARA approach addresses the following basic parts described below:

(a) **Work Organization.** Types of jobs, during their performance the staff receives high individual doses, are described in specific work description list. Mainly there are: works on metal control; repair works of the Main Forced Circulation Circuit; works on cutting of SNF rods, rods of additional absorbers; decontamination, treatment and removal of radioactive waste. At the end of each year, the INPP departments and outside organizations prepare the collective dose plan for each radiological work and present and discuss it with the representatives of ALARA Group. The summarized dose plan for coming year is prepared by the RP Department and approved by the RPC. Specific jobs are performed by well-trained teams, whose members have enough experience in performing of complex tasks in the fields with high dose rates.

(b) **Training for personnel**

(c) **Improvement of working environment**

(d) **Perfection of technological processes**

(e) **Implementation of quality assurance programme**

(f) **Safety culture.** Since 1997 the active development of safety culture among staff has begun. Safety Culture indicators are used for timely prevention of hidden deficiencies and also in such cases when the positive trends towards increase of safety level occur. Six indicators of safety culture used at INPP are identified: Indicator 1 - Safety culture seminars; Indicator 2 - Recommendation of Safety Committee; Indicator 3 - Deficiencies identified during audits; Indicator 4 - Repeated events; Indicator 5 - Human error; Indicator 6 - Proposals on safety improvement. The evaluation of these indicators is carried out together with Safety culture assessment.

(g) **Evaluation and avoidance of influence of „human factor".** For the evaluation of influence of human factor as errors and incorrect operations of personnel, that can cause a unjustified exposure, necessary means such as barriers, locks, preventive signaling systems, posters and signs are used.

Radiological Work Management Approaches and Means of Reducing Exposure during Execution of Specific Task during Outages

Work Permits

The planning of work to be undertaken in the controlled area where it is possible that levels of radiation or contamination may be significant, is an important mean of keeping doses ALARA. This approach is taken into account if the tasks within the controlled area necessitate radiological precautions, and they are allowed only if work permits are issued. The work permits consist of specific measures to be implemented and applied by workers when they carry out the works with high dose rates and in complex working environment.

Following order for the filling up and approval of the work permit is applied:

- the health physicist investigates and estimates the radiation conditions within the premises (measures the dose rates, estimates the surface, air contamination levels etc.);
- operational workers prepare the workplaces;
- if there is possibility for external, internal or air contamination, appropriate protective equipment to be used is described and appointed by the work permit;
- before the beginning of works, in order to perform them as short as possible, the team members are instructed how to perform particular jobs, how to optimize particular operations;
- work permits are issued and approved by the Shift Head of Work Safety Department.

Use of the work permits allows effectively manage radiological works and therefore serves a basis for exposure optimization.

Decontamination of Systems

Good practice used at Ignalina NPP during the outages giving positively results in reduction of the dose rates, is the decontamination of systems. An example of decontamination factors obtained after the flush out of the pipes of the main forced circulation circuit during the outage of Unit 2 in 2003 are presented in Table 1.

Table 1

Room No.	Gamma dose rate, mSv/h		Decontamination factor
	Before decontamination	After decontamination	
$117/_{1\text{-}7}$	1-400	0.6-1.2	1.7-330
$409/_{1}$	50-400	2-2.3	25-170
213; $214/_{1,2}$; 215	1.5-100	0.2-1.1	7.5-90

Installation of Temporary Radiation Shielding

All tasks subject to high dose levels are evaluated for the effectiveness of installing temporary radiation shielding. Lead blankets are mostly used. Temporary shielding is installed only in those cases, if the results of evaluation show that the averted dose will be higher than received during the installation of temporary shielding. Table 2 shows the examples of reduced dose rates after the installation of temporary radiation shielding during the repair of pipes Du-300 during the outage of unit 2.

Table 2

Room No.	Gamma dose rate, mSv/h	
	Without radiation shielding	With radiation shielding
$506/_{1,2}$, near the blind pipes	5.0-2000	5.0-45.0
$208/_{1}$, near the joints 6,8 of headers of the emergency cooling system	8.0-400	8.0-70

Training of Personnel

A knowledge workforce is one of the fundamental elements in the radiation protection programme for the optimization of protection and control of exposure. In addition to the general training, on all planned works the advanced training for personnel is organized. The procedure for self-checking and self-assessment has been improved owing to regular special training. Everyday, before the maintenance works, the conditions for carrying out of each work are discussed with workers during operational meetings. 240, 60 and 30 hours training in radiation protection is required before starting the work first time, for persons responsible for radiation protection and for workers accordingly. The frequency of training is 5 years. Specific ALARA questions are included in personnel training programme. In 2002, the educational book on radiation protection was introduced. The draft Lithuanian edition of the book is prepared. Training on mock-up of equipment is very intensively applied, which allows to obtain experience and to become personally „familiar'' with the work before its execution in fields with high dose rates.

Occupational Exposure Results During Outages in 2003

The outage of Unit 1 lasted 12/07/03-21/10/03, the outage of Unit 2 – 05/04/03-01/06/03. There was also one short unplanned outage of Unit 2 performed – from 1 to 6 of November 2003. As it has been planned by the operator at the end of 2002 and approved by the RPC, following activities have mostly contributed to the annual collective doses during the annual outages of Unit 1 and Unit 2 in 2003:

- Replacement of reactor fuel (technological) channels;
- Maintenance of primary system pipes Du-300 (d=300 mm);
- Maintenance of primary system pipes Du-800 (d=800 mm);
- Control of metal;
- Replacement of spherical valves used for measuring of outlet water flow (SHADR-32M) and replacement of removable parts of regulation valves;
- Repair of pipes of the main circulation circuit, reactor emergency cooling system, blow-off and cooling system of the reactor;
- Insulation works;

– Installation of temporary shielding.

The radiation works during the normal operation of both units (between the outages) usually contributed not more than 20 percent to the annual collective dose. This tendency is observed for a several years.

The planned collective dose for plant personnel was 7.59 manSv, for contractors – 2.57 manSv, actual collective dose was 6.66 manSv and 1.88 manSv respectively (less than 12 % and 27 % accordingly than planned). In 2003 the total number of 4458 employees was individually monitored for radiation, including contractors and visitors. The average individual dose was 2.25 mSv for plant personnel and 1.25 mSv for contractors.

There were following achievements gained in radiation protection in 2002-2003 at Ignalina NPP:

new whole body counter "ACCUSCAN 2260-G2KG" was putted into operation. In 2003 the monitoring of internal exposure was carried out for 2659 workers. There was no overexposure, exceeding limits, detected.

– new system for training of personnel in the field of radiation protection has been introduced. With support from Sweden the educational book „Radiation Protection" in Russian and Lithuanian is issued. Amended programmes for training and checking of knowledge of personnel have been applied.

– replacement of equipment for measurement of radioactive contamination at the exits from controlled area (RZB-04 have been replaced to new RTM-860, PPM-1, PMW-3e);

– set of dosimetric equipment is renewed (50 items of RAD-62-, 4 items of TELETECTOR, 2 items of FH 40 G with detector FHT 752).

Some of the main measures for optimization of exposure implemented during the outages in 2002-2003 were as following:

Replacement of fuel (technological) channels	Installation and training on mock-up Purchase of equipment and putting into operation of non cable connection Installation of equipment for removal of filing Preparation and implementation of additional equipment for replacement of fuel channel
Maintenance of pipes Du-300, Du-800	Training of personnel from Centralized Maintenance Workshop on replacement of welded seams on the mock-up Purchase of equipment and training of welders on welding of pipes with equipment of type VAS 120 Purchase of equipment for cutting and replacement of parts of pipes Du-800 Training of personnel on repair technology of pipes Du-300 on the mock-up Application of automatic welding for pipes Du-300
Replacement of spherical valves used for measuring of outlet water flow (SHADR-32M) and replacement of removable parts of regulation valves	Training of personnel on repair technology on the mock-up

Planned Decommissioning Activities and ALARA Approach

With reference to in the middle of 2002 amended National Energy Strategy and other related legislation, in November 2002 the Government of Lithuania adopted the decision stating that preferred option for the decommissioning of Unit 1 is the immediate dismantling. The process of dismantling of the Unit 1 will continue at least 30 years. From the radiological point of view this process can be treated as big extended outage with constantly changing working environment that might cause high individual and collective doses to the workers.

The draft of the Final Decommissioning Plan, as a part of the licensing requirements needed to start the decommissioning process, already exist. It was preliminary shown by the operator that during immediate dismantling of the Unit 1 the total exposure will result in 35 manSv [7].

Therefore, for the operator (Ignalina NPP) it will be important to plan the radiological works well in advance before the dismantling of the equipment will start, predict occupational exposure results during particular dismantling, decontamination and other operations, as well as to show for the regulatory authorities that doses to the workers are kept ALARA. The implementation of the radiation protection and ALARA programme during the decommissioning will be a main issue of concern in order to keep the occupational doses within the established limits. In case of immediate dismantling, dose commitment to staff dedicated to core and primary circuit equipment dismantling is of concern.

Preparatory Activities and Interfaces with ALARA Commitment During the Decommissioning

The compliance with the ALARA policy objectives for the plant personnel basically relies on 2 key issues that, actually, are already implemented during the routine operation of INPP:

- The preparation of the tasks to be carried out in the controlled area with a high level of details, and carrying out of mitigation measures;
- The monitoring of the individual and collective doses during the execution of the tasks and the implementation of corrective actions in case of violation of the pre-established ALARA objectives.

These key issues will still remain applicable during dismantling works.

Keeping the personnel exposure in accordance with ALARA principle during decommissioning will require:

a) Careful engineering, technical, administrative preparations of the activities to be carried out;

b) The monitoring of their implementation in the controlled area and implementation of corrective actions in case of individual and collective dose exceed the ALARA objectives.

The preparatory activities involve all the engineering, technical and administrative preparatory tasks to be conducted prior to carrying out activities in the controlled area such as:

a) Authorization of works in the controlled area by work permits;

b) Establishing the dose maps in the to be accessed areas;

c) Carrying out computer simulations of the activities to be performed in the controlled area. These simulations enable, for example, to evidence specific tasks or sub-tasks that leads to high individual and collective exposures;

d) Assessing, accordingly, the need to implement countermeasures to reduce the background: decontamination, installation of temporary shielding, use of remotely operated equipment, additional ventilation capacities, additional confinement zones, etc.;

e) Careful review of the lessons to be learned from previous similar activities already carried out either at INPP or at other NPPs and, when relevant, adaptation or optimization of the operation procedures;

f) Definition of dosimetric objectives;

g) Instructions and training of the operators;

h) Checklists of the specific tools and equipment (including additional radiation monitoring equipment, needed in the controlled area);

i) Checklists of the equipment to be consigned (isolated).

In order to comply with the strategic ALARA objectives, Ignalina NPP is going to implement complementary tools in the frame of the decommissioning project, such as e.g. computer software (LLWAA DECOM software, VISIPLAN 3D ALARA software etc.). Experience gained in radiological works management during the outages in normal operation of the units will be also considered, as it was discussed above.

Conclusions

1. A set of procedures, forming of the radiation protection program, was created and is effectively implemented at INPP. Good radiological work management procedures applied during the outages give successful results in reduction of occupational exposure.

2. Keeping the personnel exposure in accordance with ALARA principle during the decommissioning of Ignalina NPP will require careful engineering, technical, administrative preparations of the activities to be carried out. Positive experience gained in optimization of protection during the normal operation of the Ignalina NPP will be taken into account.

References

[1] Law on Radiation Protection of the Republic of Lithuania, No. VIII-1019 (1999).

[2] Lithuanian Hygiene Standard HN 73:2001 "Basic Standards of Radiation Protection" (2001).

[3] Lithuanian Hygiene Standard HN 87:2002 "Radiation Protection in Nuclear Facilities" (2002).

[4] International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No.115, IAEA, Vienna (1996).

[5] Council Directive 96/29/EURATOM of 13 May 1996 laying down Basic Safety Standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation, No L 159, vol. 39 (1996).

[6] Radiation Protection and Radioactive Waste Management in the Operation of Nuclear Power Plants, Safety Standards Series, Safety Guide No. NS-G-2.7, IAEA, Vienna (2002).

[7] Final Decommissioning Plan. Draft 4 A1.4/FDP/0004.