# THE EXERCISE OF THE ALARA PRINCIPLE AT THE INSTALLATION OF THE PRIMARY NEUTRON SOURCES INTO THE FUEL ASSEMBLIES AT THE TEMELÍN NPP

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The Temelín NPP consists of two units VVER 1000 type V320, each with a rated thermal power of 3 000 MW. The original Soviet design has been modernised in the early nineties and the original instrumentation and control system, the diagnostics as well as the complete radiation control system have been replaced. The modifications touched also the supply of the nuclear fuel. Currently, both Units are in the stage of commissioning, Unit 1 in the power ascension testing stage at a power of 100 % $N_{rated}$, Unit 2 is in the stage of zero and low power testing.

## Installation of the primary neutron sources into the fuel assemblies

A unique working operation not ever repeated later during the unit operation is connected with the process of the reactor fuel loading preparation, namely the process of the primary neutron sources (PNZ) installation into two determinate fuel assemblies. Those fuel assemblies are located in a cylindrical container with another fuel assemblies containing the nuclear fuel. The reactor core of the Temelín NPP VVER 1000 unit incorporates altogether 163 fuel assemblies, comprising 312 fuel rods each with fuel enrichment max. 5% $^{235}U$ (the first loading has an average core enrichment of 2,22 %). The complete fuel loading is 92 t and the cycle of the fuel replacement is four years.

Prior to commencement of the fuel loading into the reactor vessel, it is necessary to install into two concrete fuel assemblies one primary neutron source into each consisting of a long supporting metal wire with a capsule containing $^{252}Cf$ in the form of a wire of Pd-$Cf_2O_3$. The fuel supplier in accordance with relevant working procedures performs these working activities. From the experience acquired at the course of the installation of PNZ designated for the Unit 1, which was carried out in the first half of 2000 it follows that the future unit operator must be actively involved both into the preparation and into the implementation of the activities related to the installation of the primary neutron sources themselves. For one thing experience acquired during the works made by them supplier‘s workers and particularly an out of proportion high value of the collective effective dose (KED) and the individual effective dose (IED), that received the workers during the installation of the primary neutron sources led to such conclusions.

## The status of the ALARA principle implementation at the Temelín NPP prior to the fuel loading into Unit 1

At the time of the primary neutron sources installation for Unit 1, the utility control document regulating the requirements for the ALARA principle application at ensuring activities involving ionization radiation sources has been already in the process of the development. Also, an ad-hoc instruction of the plant director has been already issued for the organizational and technical provision of the ALARA principle implementation at the Temelín NPP, on the other hand however, conditions have not yet been set up for its full accomplishment in the practice.

Series of activities related to the process of the PNZ installation into the fuel assemblies having been performed, as a consequence of such situation, more or less spontaneously and ad hoc without having performed due analyses of potential impacts of the operations course on the radiation situation at the workplace. The result of above described situation was the necessity of an flexible temporal closure of a part of the building with the declared and defined temporal controlled zone, where the fuel assemblies‘ container with installed PNZ was located till the fabrication of a sufficient additional shielding of the container where the container has been located with the fuel assemblies before the fuel loading into the reactor core. The shielding container in the form of a cylinder is comprised of a vessel with double walls 30 cm of each other. The created ring is filled with boric acid solution with a concentration of 50 g/kg.

The lack of enough experience and not completely sufficient preparedness of the workers involved in the assembly of PNZ and the insufficient implementation of the ALARA principle resulted in a personal effective dose of neutrons of 6,73 mSv of one worker during the mounting of the primary neutron sources into the fuel assemblies on May 18, 2000. Subsequently, on June 2, 2000 during the installation of the container of the fuel assemblies containing primary neutron sources into the shielding cylinder, another two workers received individual effective doses of neutrons 1,55 mSv and 1,43 mSv. Outside the temporary controlled zone, where all manipulations have been performed and where the access was restricted only for a limited group of workers, the radiation protection staff did not measure any increase of the equivalent dose rate level (PED) from neutrons due to performed working operations above the level of the natural background. This was verified even based on the official measurement made by workers of the Czech Metrological Institute.

**The status of the ALARA principle implementation at the Temelín NPP prior to the fuel loading into Unit 2**

During 2000 and 2001, a marked positive shift occurred at the Temelín NPP in the field of the ALARA principle implementation. It came to restructurization and to personal replenishment of the department of the Radiation Protection Control and its staff got involved into the realization of the project TC RER/9/063 Occupational Radiation Protection at Nuclear Power Plants. By means of participation at the 5th and 6th workshop of the project they acquired both generally valid information in the area of the issue of ALARA principle implementation at the NPPs and, in particular, established personal contacts to the workers of other NPPs of the VVER and RBMK types.

In 2001, the control document Quality Assurance Procedure 27.08.01 Radiation Protection Control has been issued at the Temelín NPP, which defines the statute of the newly established ALARA Commission. The control document defines among others the so-called works with an increased radiation risk, to the realisation of which is necessary the development of the Program of the Radiation Protection Assurance (PZRO). PZRO precisely describes and determines the radiation protection measures leading to assurance of the radiation doses optimization at performing activities connected with radiation exposure risks. All departments involved in the planned activity co-operate on the PZRO development. An authorized expert of the radiation protection performs the final approval of the PZRO after an analysis of the complete program.

In the same time, a workplace has been established and provided with appropriate computer and audiovisual instrumentation at the Temelín NPP that set up conditions for providing for training, consulting and pre-work meetings of the workers in the frame of the so-called PRE JOB TRAINING.

**Installation of the primary neutron sources into the fuel assemblies for Unit 2**

Prior to commencing the assembly of the PNZ into the fuel assemblies for Unit 2, it has been already proceeded in accordance with in advance established rules introduced in the frame of the ALARA principle implementation at the Temelín NPP. Detailed procedures of manipulations have been developed, assessments of individual effective doses from neutrons for individual workers involved in the manipulations with PNZ have been made and the organizational measures to provide for safe development of the complete operation have been taken. All measures have been included into the Radiation Protection Assurance Program No. 00 00 11/2001 (see Annex 1), that was binding for all workers participating on the manipulations with the PNZ.

One day before the commencement of the assembly itself, training of all persons involved in the manipulations in the material contents of the radiation protection program approved to the activity. In the same time, simulated drill has been performed of working operations related to the assembly of PNZ into the fuel assemblies and preparatory works for loading of the fuel assemblies' container into the shielding container. The second drill of the PNZ assembly has been performed one hour before commencing the manipulations themselves. Both drills have shown that all working operations connected with the primary neutron sources installations into the fuel assembly may be performed in a significantly shorter time period then assumed by the developed Radiation protection assurance program. For conservative reasons, however, it has been still adhered to the original time schedule from the point of view of forecast doses.

**Evaluation of the primary neutron sources installation for Unit 2 in accordance with the developed PZRO**

All manipulations planned in accordance with the PZRO took place precisely in compliance with the working procedures. Duration of all activities has been substantially shorter then originally assumed, in particular due to performed training and drills. The real PED of neutrons at the workplace has been also lower than the original conservative assumption, which was based on calculations and results of measurements carried out at manipulations for Unit 1. The doses received from neutrons have been therefore due to shorter times and lower neutron PED lower than assumed, too.

All involved persons have been provided with neutron, film and electronic personal dosimeters. The radiation protection department staff by means of portable radiometers has continually monitored the radiation situation in the space of manipulations. The received doses have been for all participating workers below the sensitivity lower limit of the neutron and film dosimeters. The maximum IED of the gamma radiation registered by electronic personal dosimeters of the EPD1 type reached the value of 9 µSv.

During the manipulations, all involved workers have been in an environment wit a maximum PED of neutrons 400 µSv/h and of gamma radiation 6,5 µSv/h. The stays of individual workers in the maximum field of neutron PED did not exceed 90 seconds.

Annex 1: Form of the Radiation Protection Assurance Program

**RADIATION PROTECTION**

**ASSURANCE PROGRAM**

**For the work at**

☒ **increased radiation risk**

☐ **long-term**

**PZRO No. 00 00 11/2001**

| The coloured fields to be filled by the Program developer | |
|---|---|
| Title of the working activity: | **Assembly of the primary neutron sources and relocation of the fuel assembly container with primary neutron sources into the water shielding** |
| Technological procedure (title, developer, No.): | VVantage-6 Primary Source Site Assembly and Installation Procedure |
| Place of the working activity (room/equipment): | BAPP-01/134a |
| Radiation work permit No.: | |
| Date of the work: | October 31, 2001 |
| Work leader (name, dept. ETE/company): | Ernst Daniel, dept. 4521 |
| The assumed time of the works (number of workers, number of hours necessary to perform the work): | Ref. to text |

| Description of the working operations, list of rooms, work duration in individual rooms, numbers of workers: |
|---|
| 1. Live assembly of the primary neutron sources into the fuel assembly containers in SÈP (fresh fuel storage)<br>2. Transfer of the container for the fuel assemblies with mounted primary neutron sources into the cylindrical water shielding in SÈP (room 134a)<br>Annexes:<br>Annex 1: Detailed description of activities, times and an doses estimate for both operations<br>Annex 2: Expression of the dependence of neutron PED from both PNZ on the distance<br>Annex 3: Working procedure of the performed activities |
| **Technical and administration measures to ensure the radiation protection:** |

***General measures:***

1. Prepare the cylindrical shielding with the boric acid solution with a concentration of 50 g/kg, all necessary aids and tools, to make marks for manipulations prior to the works commencement.

   Ensured by: 4521, 4414

2. Close and evacuate the building 801/01 including closing of the access to the pavement along the building 801/01, to the access roads to the entrances to 116a, 130a, 132a and on the roof of the building 801/01 on October 31, 2001 from 06:00 till 16:00 hours.

   - provide for presence of 1-2 workers at the entrance from 801/02 to 801/01
   - provide for presence of 2 workers along the building 801/01

   Ensured by: 4020

   Provide the pavement and access roads closure around the building 801/01 for by the band with the notice „No entry – dangerous invisible radiation„.

   Ensured by: 4542, TPRK

3. Perform continual monitoring of neutron PED and of gamma PED for the complete time of manipulations with the PNZ. The TPRK, which will perform the monitoring including recording of the times of individual working operations, will be as close to the involved persons as possible and won't approach to the PNZ at a distance lower than 5 m. In case of a sudden neutron PED or gamma PED increase he will give order to stop the work and to leave to a safe distance. The work continuation may be permitted only after finding and possible removal of the reason of the PED increase or after re-assessment of the occurred radiation situation by a radiation protection expert.

   Ensured by: 4542, TPRK, radiation protection specialist

4. Measure the neutron PED at the outer side of the BAPP-01 (auxiliary) building in the middle of the walls of the room 132a after removal of the PNZ from the transport container, during the assembly of PNZ into the fuel assembly and during its transport into the cylindrical shielding. Provide for presence of a ÈMI (Czech Metrological Institute) worker, assign him the measurement location. Perform neutron PED monitoring from the outer side of the BAPP-01 building in the following order: wall 113a, wall 123a, wall 132a.

   In case of neutron PED increase outside of the BAPP-01 building above 2,5 µSv/h, pass TPRK1 this information to TPRK2 inside BAPP-01. Then, TPRK1 will perform the check of the radiation situation on the border of the defined space and, if necessary, will extend the space so that the neutron PED is not higher than 2,5 µSv/h on the border of the space. The instant of PNZ removal and end of the manipulations will announce TPRK2 inside BAPP-01 by means of a transmitter.

   Ensured by: 4542, TPRK2 inside BAPP-01 announcement of the start and completion of the manipulations, TPRK1 outside BAPP-01 assignment of the places for measurements, the VSRK on duty by means of a transmitter.

5. All workers present at the manipulations with PNZ will keep as far as possible away from the PNZ. If they won't directly perform the PNZ assembly and transport, they won't approach nearer than 5m.
6. Record the course of manipulations with the PNZ by means of a video camera. Ensured by: 4541.
7. Provide for the co-ordination of the activities. Ensured by: 4541.

*8.* Adhere to the work conditions with the electronic dosimeter and know the procedures at the increase signalling. Adhere to the procedure described in the Instruction for the electronic dosimeter use, which is kept on the bulletin board Radiation Protection. Ensured by: All workers

*Equipment by special dosimeters*:

In addition to standard electronic and film dosimeters, equip all workers present at the manipulations with PNZ also with neutron dosimeter and TLD dosimeter.

Set up the alarm levels for personal electronic dosimeters:

- low alert: Hp(10) 800 µSv, PED 800 µSv/h
- high alert: Hp(10) 1 mSv, PED 1 mSv/h

Ensured by: 4544

*Use of supplemental OOP (personal protection aids) in accordance with the measured radiation situation*:

None

*Changes, modifications and measures (description, the modifications have been entered by - date, name, first name, signature):*

None.

*List of workers' names providing for manipulations:*

4414
Ing. Jiøí Bigas, Miroslav Koláø, Duš an Sadílek, Evž en Sznapka, Karel Vidlák

4541
Jaroslav Hak, Mgr. Jiøí Vokálek

4521
Ing. Daniel Ernst

WEC
John Wood, John Meskanick

4542
Františ ek Pokorný, Daniel Janovský

| Maximum IED (mSv): | 1,33 | Planned KED (mSv): | 7,94 |
|---|---|---|---|
| Developed by: | | | |
| Name: | Department: | Date: | Signature: |
| Vokálek Jiøí | 4541 | October 25, 2001 | |
| Endorsed by: | | | |
| Name: | Department/compan: | Date: | Signature: |
| Hak Jaroslav | 4541 | October 25, 2001 | |
| Approved by: | | | |
| Name: | Department: | Date: | Signature: |
| Ing. Koc Josef | 4540 | October 26, 2001 | |