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Nuclear Technology Courses in Nuclear Training Centre Ljubljana

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ABSTRACT

The paper presents experiences from performing nuclear technology courses at Nuclear Training Centre Ljubljana. There are two types of important courses, conducted for Krško NPP staff and other organizations, dealing with nuclear technology. The first course is called NPP Technology (the acronym in Slovenian language is TJE) and is intended for future control room operators. This course is the first, theoretical part of the initial training of licensed operators (later stages – NPP systems and simulator training – take place at the location of the NPP). Approximately 5 months are devoted to different topics, such as nuclear and reactor physics, thermal-hydraulics and heat transfer, radiation protection, electrical engineering, materials, and nuclear safety.

The second course, Basics of Nuclear Technology (in Slovenian OTJE) is suitable for other NPP technical personnel, technical support organizations, regulatory body, etc. In 2022 the 43rd edition of the course was conducted. This course consists of two parts: theory (4,5 weeks) and NPP Systems (3,5 weeks).

The paper will present the course organization, materials preparation, course content and results, and feedback from participants.

1 INTRODUCTION

The Nuclear Training Centre Milan Čopič (the acronym in Slovenian language is ICJT), a part of the Jožef Stefan Institute (IJS), started with the training of the nuclear workers at the beginning of commercial use of nuclear technology in Slovenia. Jožef Stefan Institute is also an authorised institution in the field of Radiation protection and Radiation protection training in Slovenia (authorisation was issued by the Radiation protection administration of the Republic of Slovenia). The Nuclear Training Centre has been certified according to ISO 9001:2015 quality standard since December 2006. ICJT already used several QA procedures before the certification process and therefore the whole certification process was easier.

In ICJT the most important course is NPP technology course (TJE), intended for training of future Krško NPP control room operators. This course is the first, theoretical part of the initial training of licensed operators (later stages – NPP systems and simulator training – take place at the Krško NPP). The course is designed to give in 20 weeks the necessary fundamentals to ensure understanding of different topics. Most of the time is spent in the classroom, practical exercises are performed in the laboratory, on the simulator and on the research reactor TRIGA. The second course, Basics of Nuclear Technology (in Slovenian OTJE) is suitable for other NPP technical personnel, for technical support organizations, regulatory body, etc. This course consists of two parts: theory and NPP Systems.

2 NPP TECHNOLOGY COURSE (TJE)

This is the most important course in ICJT, intended for training of future Krško NPP operators. In the past (until 2000) two parts of the course were performed in ICJT. First 5 to 6 months were devoted to the theoretical training and in the second part, which also lasted almost half of the year, all technological systems of Krško NPP were described in detail.

2.1 Content of the course

This year (in February 2022) 18th edition of the course was conducted. At the beginning this course was called Power Reactor Technology (the acronym in Slovenian language was TMRT). Since the establishment of ICJT, there have been 18 TJE courses and 282 trainees have successfully completed it.

This course is designed to give the necessary fundamentals training to ensure an understanding of each subject shown in Table 1. Most of the time is spent in:

- Classroom;
- Practical exercises are performed in the laboratory, simulator or on the research reactor TRIGA (Figure 1).

Table 1: Modules od the TJE course

Subject	**Hours**
Review of mathematics and physics	8
Introduction to nuclear technology	8
Nuclear Physics	26
Nuclear Physics, Laboratory (4 trainees/group)	13
Reactor Physics	78
Reactor Physics, Laboratory (4 trainees/group)	30
Radiological Protection	31
Radiological Protection, Laboratory	10
Chemistry	12
Thermo- and Hydrodynamics	70
Materials in NPP	24
Electricity	36
Instrumentation and Control	22
Nuclear Safety	27
English language	50
Review of selected topics (scheduled)	42
Exams (written)	44
Exams (oral)	2
TOTAL	**533**

Figure 1: Exercises on the simulator (on the left) and on the research reactor TRIGA (on the right)

2.2 Preparation of course materials

Course materials for all courses are regularly updated. Materials preparation process consists of several steps, which are supervised by the project leader and approved by the head of ICJT. All materials have specific name and a specific code. In Figure 2 a lecture material (Secondary system), which is used for licenced operators training (LO) is shown. At the end all materials are archived by the secretary as a computer file with a specific name on the ICJT server and as a hard copy.

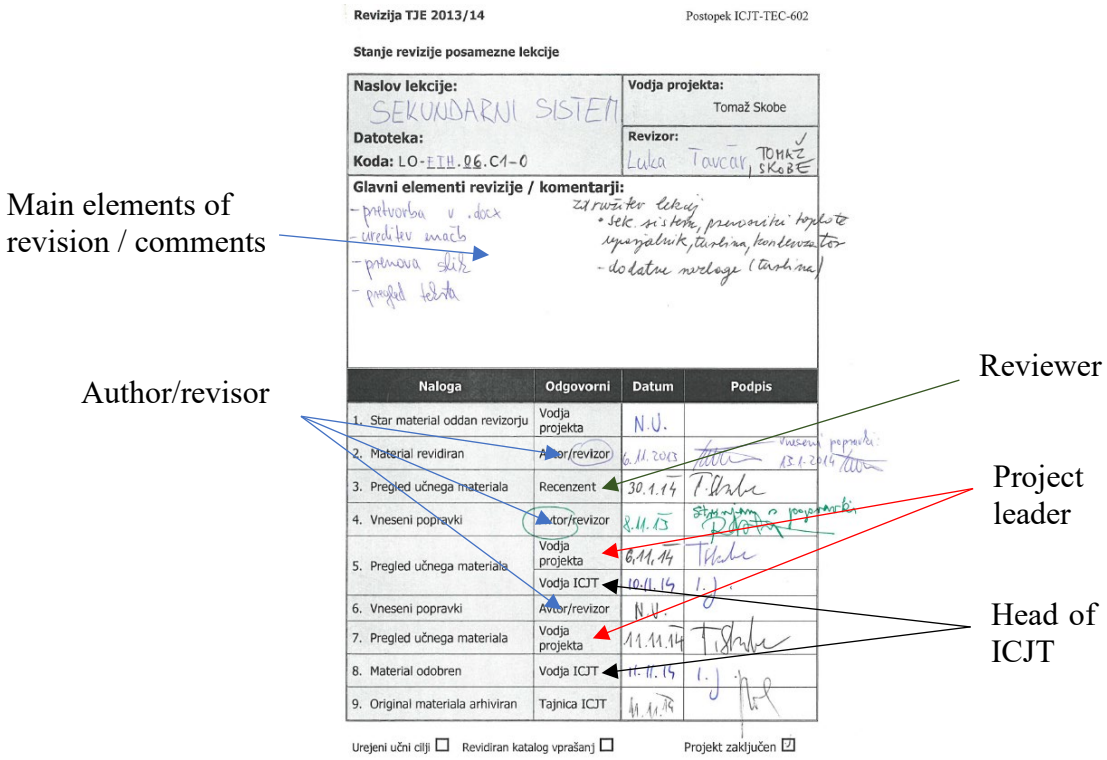

Figure 2: Procedure for course materials

2.3 Course organization

The course organization procedure includes 85 steps, which should be performed before the course, and steps or tasks during and after the course. A procedure is prepared for all kinds of training courses (also for international courses). Course coordinator and course administrator are responsible for course implementation. Supervision is carried out by QA representative and head of ICJT. After the termination of the course (and also after all other projects in the ICJT) a final report is prepared.

2.4 Participants results

The trainees' progress on nuclear technology courses is evaluated weekly by a written exam (test) or at the end of the training on radiation protection courses. Exams for nuclear technology courses are on schedule each Friday in the morning (2 hours for NPP technology course and 45 min for Basics of Nuclear Technology course). The experience in the past has shown that exam at the end of the week is the best solution since this enables participants to relax during weekends.

In Table 2 results of all 18 NPP technology courses for licensed operators from 1993 till 2022 are presented. The final result for first 12 courses includes results from weekly tests (40%), final written test (30%) and final oral exam (30%). In TJET13 monthly oral exams were introduced. The final result now includes results from weekly tests (25%), monthly oral exams (25%), final written test (25%) and final oral exam (25%). Participants must achieve a result of at least 80% in to pass a written or oral exam.

Table 2: Results of TJE courses from 1993 to 2022 (average over all course participants)

Code of the course	Weekly tests	Monthly oral exams	Final written test	Final oral exam	Final result	Number of participants (didn't pass the course)
TMRT01	-	-	-	-	-	18
TMRT02	-	-	-	-	-	15
TMRT03	92.0%	-	92.2%	89.4%	91.2%	14
TJET04	95.0%	-	91.3%	89.6%	93.3%	13
TJET05	94.2%	-	94.6%	90.0%	93.9%	19
TJET06	94.7%	-	89.7%	92.3%	92.5%	19
TJET07	93.7%	-	91.8%	94.2%	93.3%	11
TJET08	91.9%	-	90.3%	92.2%	91.5%	15
TJET09	96.0%	-	95.3%	97.6%	96.5%	20 (1)
TJET10	94.2%	-	92.2%	93.1%	93.3%	13
TJET11	95.1%	-	91.7%	97.0%	94.7%	20
TJET12	93.5%	-	85.9%	90.8%	90.4%	18 (2)
TJET13	95.6%	96.0%	94.1%	95.9%	95.4%	15
TJET14	93.8%	94.6%	89.7%	90.7%	93.2%	23 (1)
TJET15	94.5%	94.1%	93.4%	95.7%	94.4%	21 (1)
TJET16	96.5%	97.0%	93.5%	97.4%	96.1%	4
TJET17	94.5%	94.3%	92.5%	95.9%	94.3%	18
TJET18	95.7%	94.1%	90.8%	95.5%	94.0%	11

2.5 The evaluation of the course

Participants are requested to answer three evaluation questionnaires during the course (one questionnaire covers approximately one third of the course). The results are presented at the evaluation session during the course and at the final evaluation before closing the course. Table 3 shows some comments from TJE courses in the past. All comments are distributed to the lecturers and the plan of needed improvements is made at the end. + (Plus) in Table 3 shows most positive aspects of the course (examples of good practices), - (minus) shows most negative aspects of the course and for each course there is a column with possible improvements, suggested by participants.

Table 3: Some questionnaire results from 18 TJE courses in the past

+	-	**Improvements**
Wide knowledge of nuclear and reactor physics	To much details	More exercises on research reactor TRIGA
Time-out during NPP outage	To fast at the beginning of the course	Synchronization of lectures with exercises
Tests at the end of the week	To intensive, duration of the course	Lectures in the classroom only from 8 to 13. then reviews of certain topics
Systematical approach	Little spare time and a lot of learning, testing and nervousness before test	Exercises
Good organization of the course	Lectures after test on Fridays	Self-study
Organization, lecturers, team work, discussions	Lack of time for calculating exercises	More time to prepare for final exam
Reviews at the end of the day	Adjustment between lecture presentation (ppt) and lecture materials (doc)	Pedagogical approach of lecturers
Exercises on the simulator	More focus on that what is important and what not	Revision of out-of-date informations
	Materials on nuclear safety	More time for reviews of topics on Thursdays
	Time to prepare for final exam	More time for reactor physics
		More time for nuclear physics

3 BASICS OF NUCLEAR TECHNOLOGY COURSE

The second course, Basic of Nuclear Technology (in Slovenian OTJE) is suitable for other NPP technical personnel, for technical support organizations, regulatory body, etc. This course consists of two parts: theory and NPP Systems. At the beginning this course was called Basics of Power Reactor Technology (the acronym in Slovenian language was OTMRT(S)-T for theory and S for systems). Since the establishment of ICJT, there have been 43 OTJE courses and 654 trainees have successfully completed it.

3.1 Content of the course

The course is designed to give in 8 weeks the necessary fundamentals training to ensure an understanding of each object shown in the topic area table (Table 4). During the first theoretical part of the course most of the time is spent in classroom and practical exercises are

performed in the laboratory. A visit to the research reactor TRIGA is organised as well. During the second part of the course (NPP systems) the time is spent in classroom (lectures) and on the visits to the location of Krško NPP (2 days).

Table 4: Topic area of Basics of Nuclear Technology course

Theory topics	**Topic Area**	**Duration (hours)**
Classroom	Basics of nuclear technology	3
	Basics of nuclear physics	11
	Basics of reactor physics	10
	Basics of radiological protection	22
	Basics of chemistry	7
	Basics of thermo and hydro-dynamics	17
	Basics of electricity	17
	Basics of instrumentation and control	9
	Basics of materials	4
	Basics of nuclear safety	9
Exercises - laboratory - simulator	Nuclear physics	8
	Radiological protection	7
	Reactor physics	7
NPP systems topics	**Topic Area**	**Duration (hours)**
Classroom	Introduction	4
	Primary systems	10
	Auxiliary primary systems	4
	Engineering safety features	18
	Secondary systems	22
	Control systems	5
	Electrical systems	6
	Reactor protection systems	2
	Other support systems	16
	NPP operation	8
NPP visit		10

3.2 Materials

Each copy of printed material consists of copies of certain course topic and a USB stick with the course material (Figure 3). Very important are permanent revisions of lecture materials; according to the questionnaire results (comments from participants) we try to optimize the contents of different topics and a number of hours dedicated to certain topics/lectures.

Figure 3: Course materials

For better understanding of the nuclear power plant to all lectures simplified schemes of NPP systems and a number of pictures from the plant were added (Figure 4). After the course participants are able to understand the basic operation of particular system and connectivity between different systems.

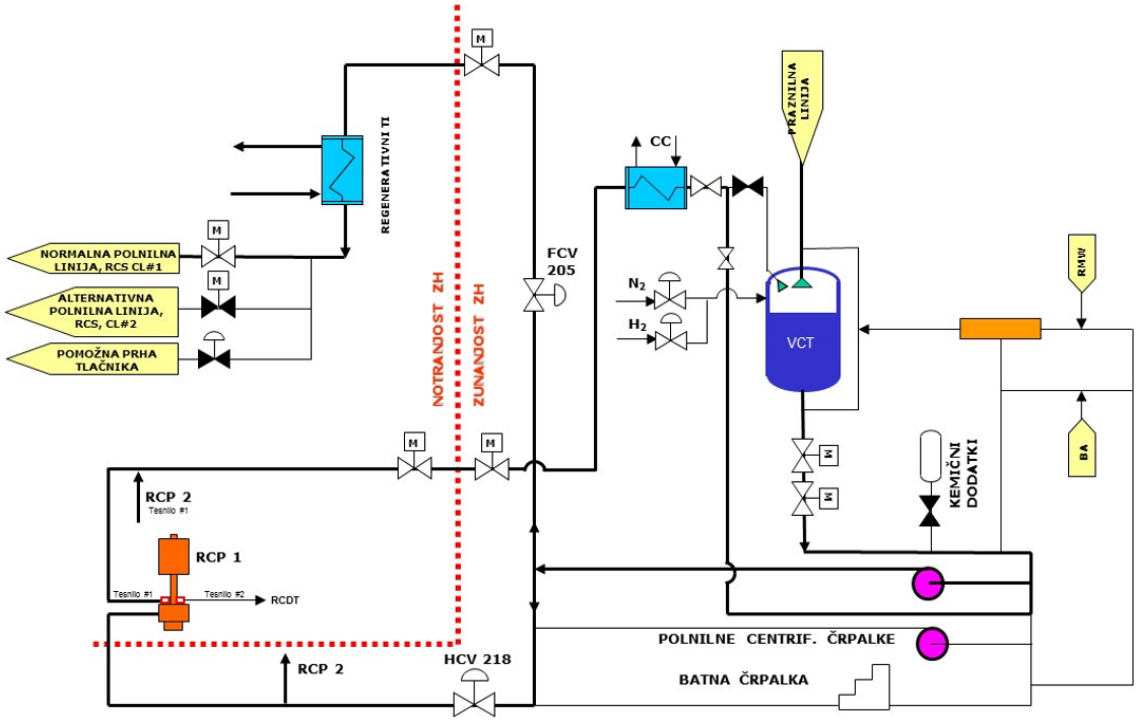

Figure 4: An example of simplified scheme (Chemical Volume Control System-CVCS)

3.3 The evaluation of the course

Similar to the operator course, participants are requested to answer evaluation questionnaire at the end of the first part (theory) and second part (NPP systems) of the course. Results are presented at the evaluation session before closing the course. All comments are distributed to lecturers and the plan of necessary improvements is made at the end.

4 CONCLUSION

In more than thirthy years of Nuclear Training Centre 18 operator courses (NPP technology) and 43 Basics of nuclear technology courses were successfully performed. We constantly tried to improve the organization, contents and materials of the course. Results of questionnaries from participants have shown that courses were performed on very high level and also participants basic knowledge about nuclear technology was on very high level (according to exam results).

The introduction of ISO standard helped us to use a systematic approach for all ICJT activities. Improvements were introduced into all main and supporting working processes at ICJT as a result of ICJT staff suggestions, inputs from internal and external audits and from management reviews.

REFERENCES

[1] Nuclear Training Centre. Course Summary Reports. 1989 - 2022