33 Years of the Nuclear Training Centre ICJT, Ljubljana

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ABSTRACT

Nuclear Training Centre Ljubljana ICJT has been operating for more than 30 years. Its main mission is training of future NPP operators and it is one of two institutions in Slovenia authorized to perform radiation protection training.

Practically all current control room operators in Krško NPP have begun their training at ICJT, as well as many others from technical support organizations, regulatory body, radwaste agency etc., both from Slovenia and Croatia.

In order to conduct all sorts of training in an effective and professional manner, a quality assurance system has been in place. This system is based on a set of procedures, databases of trainings, trainees, training materials and exam questions, as well as constant monitoring of feedback from trainees. Significant effort is also devoted to regular follow-up of modifications in NPP Krško and adequate updates of training materials.

An important advantage of training at ICJT is the use of TRIGA research reactor for practical exercises in nuclear physics, reactor physics and radiation protection. The use of TRIGA reactor also provides hands-on experience with a nuclear installation.

The paper presents the main achievements of ICJT in the last three decades, the QA system and the set of exercises on TRIGA. It also provides an overview of the continuous training improvement process that is in place.

Keywords: *nuclear training, research reactor, quality assurance*

1 INTRODUCTION

Jožef Stefan Institute in Ljubljana has a long tradition of nuclear training. It started with courses in radiation protection. After the decision to build the nuclear power plant, nuclear technology courses for top staff of NPP Krško were organized in 1971 and 1972. The first course for future control room operators took place in 1975. At this time also the first textbooks in Slovenian language ("*green books*") were written.

One of the lessons of the Three Mile Accident (1979) was that operators need a more profound training, with emphasis on better knowledge and deeper understanding of physical mechanisms in nuclear reactor. This led to Slovenian-Croatian agreement to build a nuclear training centre in Ljubljana (and a nuclear medicine and radiation protection clinic in Zagreb). At this time, the training centre was foreseen as a central institution for a series of 3 or 4 nuclear power plants that were planned in Yugoslavia at that time.

The construction of the building started in 1987 at the TRIGA reactor site 10 km northeast of Ljubljana. At that time, plans to build further nuclear power plants in Yugoslavia were cancelled. In January 1989, the first course started in the new premises and in October 1989, the Milan Čopič

Nuclear Training Centre or ICJT (abbreviation for *Izobraževalni Center za Jedrsko Tehnologijo*) was formally established as one of the units of Jožef Stefan Institute.

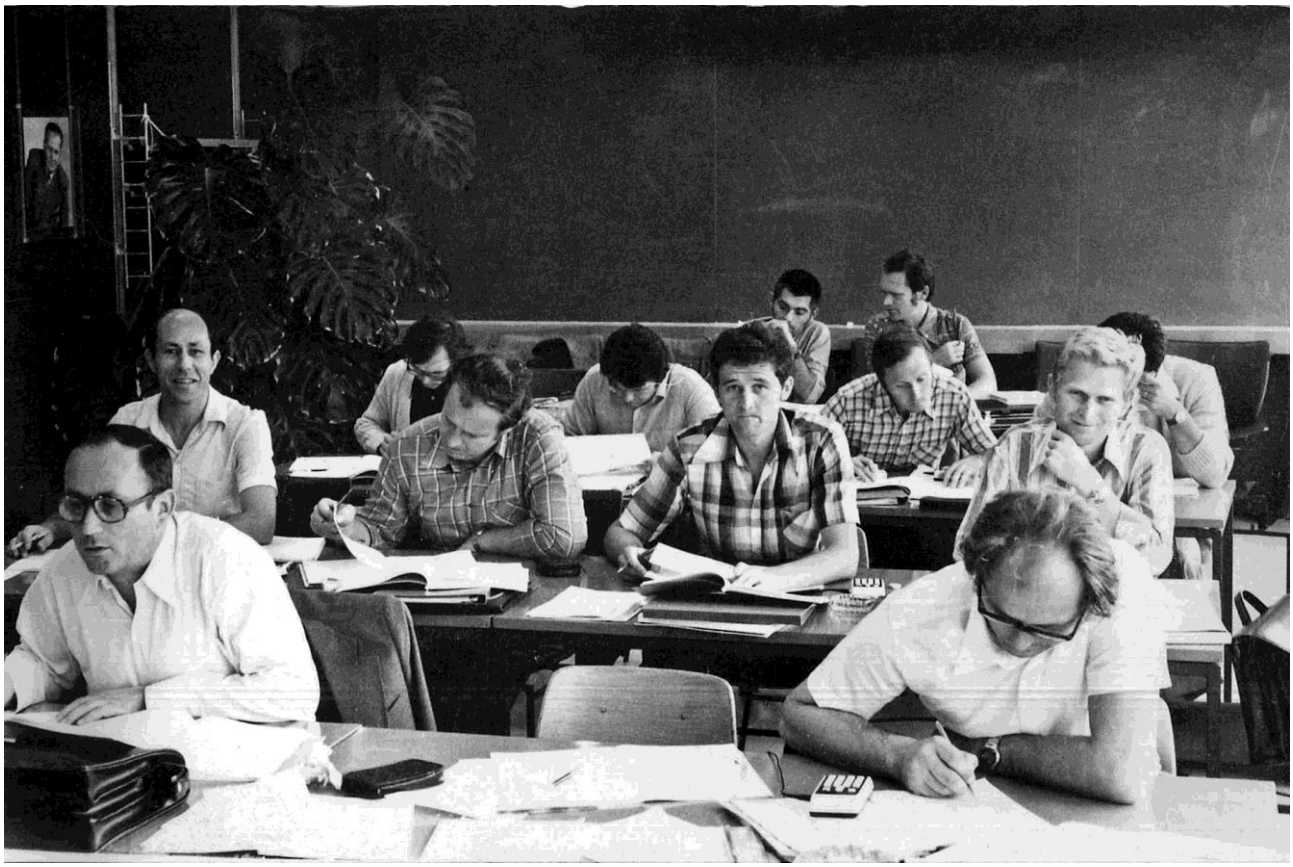

Figure 1: The first course for control room operators, 1975

In the beginning of nineties, ICJT was focused mainly on training of future control room operators. In parallel, training in the framework of IAEA's technical assistance was organized. For other technical staff of NPP, as well as for staff of regulatory body and technical support organizations, a shorter course (so called *Basics of nuclear technology* or OTJE) was developed.

Training in nuclear technology was complemented with radiation protection training, with specific courses for industry, medicine and research.

In the basement of ICJT building, an exhibition on nuclear energy was set up. This is the backbone of ICJT public information activity.

2 THE ACTIVITIES OF NUCLEAR TRAINING CENTER ICJT

Today, the activities of ICJT are based on four main pillars: training of nuclear technology, radiation protection training, international courses and public information. The vision of ICJT is to be a trusted and respected source of knowledge and information about nuclear energy in Slovenia, both for future professionals and general public.

2.1 Training of nuclear technology

The most important is the *Nuclear Technology* course (in Slovenian language *Tehnologija jedrskih elektrarn* or TJE) which is the first, theoretical part of training of licenced personnel. It lasts 20 weeks. The modules of the TJE course are given in Table 1. Since the establishment of ICJT, there have been 18 TJE courses and 282 trainees have successfully completed it.

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**

A shortened version of the above course is called the "Basics of Nuclear Technology" and is divided into two parts – theory (4 weeks) and NPP systems (4 weeks). This course is intended for other NPP technical staff (local operators), as well as personnel of regulatory body, technical support organizations, radwaste agency etc. Specialized courses on some specific issues of NPP operation are organized upon demand. There have been 43 OTJE courses with a total of 654 participants.

2.2 Radiation protection training

In Slovenia, radiation protection training of exposed workers is required by law, and ICJT is one of two institutions in the country authorized to conduct such training. A list of courses offered by ICJT in given in Table 2.

Table 2: Radiation protection courses at ICJT

Category	hours
Radiation protection department staff	200
Exposed workers in NPP[1]	40
Nuclear medicine	24
Industrial radiography	36
Measurement of roadway density and humidity	20
Handheld XRF spectroscopy	20
High Activity Sealed Sources	20
Unsealed sources	12
Baggage screening systems	8
Industrial and other practices	8
Natural sources of radiation	4

[1] This module is embedded in Nuclear technology courses TJE and OTJE.

In the period 1989-2021, there were 523 radiation protection courses, with a total of 4964 participants.

2.3 International courses

The International Agency for Atomic Energy (IAEA) organized some regional and inter-regional courses and workshops at JSI TRIGA reactor already in the 1980s. After ICJT was established, the collaboration with the IAEA was especially intensive in late 1990s and early 2000s when yearly up to 12 training courses and workshops were held.

Similarly, international courses were organized also with EU, US NRC and some other organizations. In the last years, experimental reactor physics courses are organized in collaboration with JSI Reactor physics division for students of various foreign universities.

There were 119 international courses with 1977 participants coming from 94 countries.

2.4 Public information

In addition to professional training, ICJT has been actively involved in public information about nuclear energy. Organized groups, mostly schoolchildren, are invited to ICJT where they listen to a live lecture, attend a demonstration of radioactivity experiments and visit a permanent exhibition. Several different lectures for various audiences (from pre-school to university) are offered. Printed materials and the web site www.icjt.org are also a respected source of information for the media and the general public.

Most of the visitors are coming from elementary schools (age 12-14). Around 7000 youngsters visit ICJT each year, which represents roughly 40% of one school generation. There have been 195582 visitors since 1993. Figure 2 shows the distribution of visitors from local communities in Slovenia.

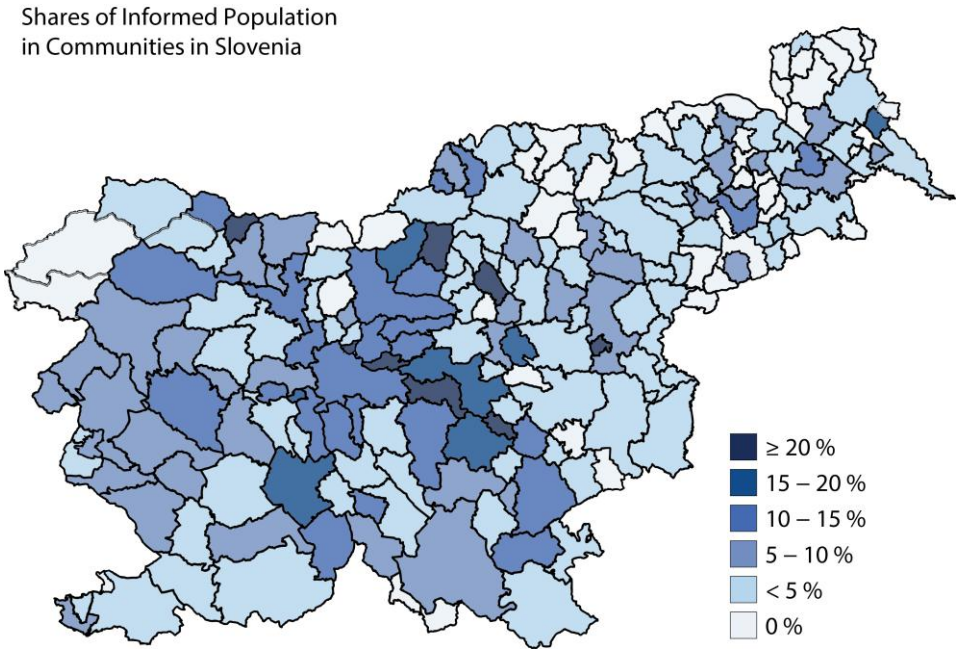

Figure 2: Percentage of population of local communities that have visited ICJT since 1993

Public opinion polls indicate that the youngest age groups, 18-35 years, exhibit the highest degree of knowledge about nuclear, as well as the highest support for a second unit of NPP Krško among all age groups. This can be attributed to public information activities of ICJT in the last three decades, because a significant part of respondents in the youngest age groups visited ICJT when they were still in school.

3 QUALITY ASSURANCE SYSTEM

A large number of training courses with different scope, duration, audience etc. requires solid management in order that the training is effective and of high quality. From the very beginning the first elements of quality assurance were introduced and were further formalized in 2006 when ICJT received an ISO 9001 certificate for the field of Nuclear and radiation protection training and for different expert evaluation tasks.

The QA system is based on a number of procedures that cover course organization, preparation of course materials, course evaluation, as well as some administrative matters (maintenance of the website, supervision of premises etc.).

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 the ICJT. All materials have specific name and a specific code.

The course organization procedure includes 85 steps, which should be performed before the course, and steps or tasks during and after the course. Course leader and course administrator are responsible for course implementation. Supervision is carried out by QA manager and the ICJT head. After the conclusion of the course a final report is prepared and archived.

3.1 Course results

The trainees' progress is evaluated by exam(s). In this paper, we mention only the evaluation of the TJE course. Weekly written tests on the TJE course are scheduled for 2 hours each Friday morning. From the very beginning, a final written exam and an oral exam were carried out at the end of the course. Since 13th edition of the course, monthly oral exams were also introduced. This proved to be very positive, because it enabled a continuous verification of the understanding of participants and avoided their examination nerves before the final oral exam.

The overall result is the average of weekly tests, monthly oral exams, final written and final oral exam, each weighing 25%. The minimum score to pass any exam is 80%. Table 3 summarizes the results of the TJE course in the last 33 years.

Table 3: Results of TJE courses from 1989 to 2022 (average over all course participants)

Course #	Year	Overall result	Participants	Failed
01	1989	N/A	18	-
02	1991/92	N/A	15	-
03	1993	91.2%	14	-
04	1994	93.3%	13	-
05	1995/96	93.9%	19	-
06	1998	92.5%	19	-
07	2000/01	93.3%	11	-
08	2002/03	91.5%	15	-
09	2006/07	96.5%	20	1
10	2008/09	93.3%	13	-
11	2009/10	94.7%	20	-
12	2010/11	90.4%	18	2
13	2011/12	95.4%	15	-
14	2012/13	93.2%	23	1
15	2014/15	94.4%	21	1
16	2016/17	96.1%	4	-
17	2020	94.3%	18	-
18	2021/22	94.0%	11	-

3.2 Feedback from participants

Participants are asked to answer evaluation questionnaire that covers lectures, training materials, course organization etc. Their feedback is used to further improve the training process.

A wide spectrum of information is gathered with these questionnaires and we show only one example.

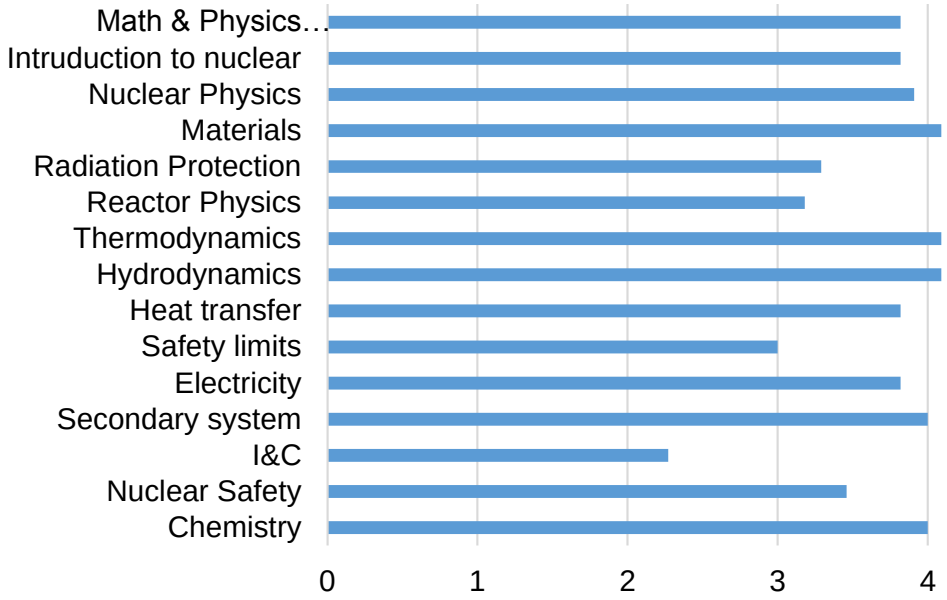

Figure 3: Evaluation of training materials for different subjects

The evaluation of training materials (Fig. 3) shows us which materials need to be improved and also points out some good practices in materials that are highly ranked.

Since we keep records of questionnaires from 2003 on, parameters of different courses can also be compared. Naturally, the course evaluation depends on specific course participants and the final result is not absolutely exact, but nevertheless the comparison of training materials in the last 20 years shows gradual improvement.

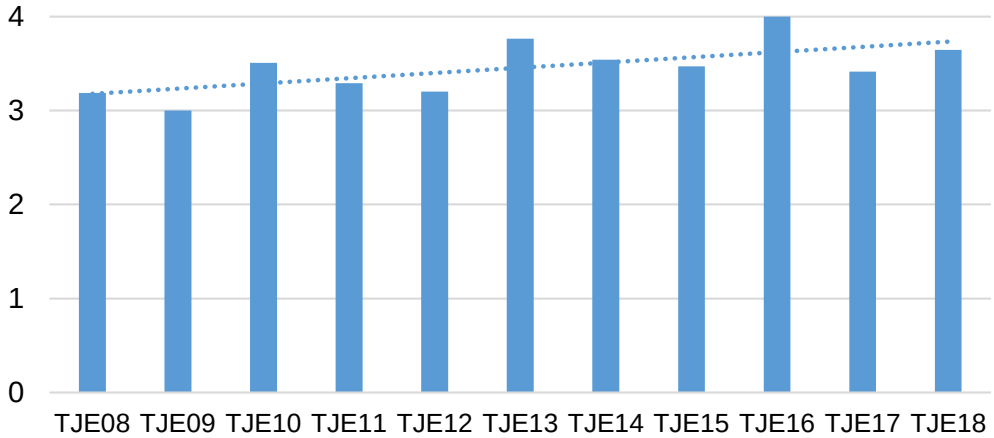

Figure 4: Overall quality of training materials from 2003 (TJE08) to 2022 (TJE18). The trendline shows gradual improvement.

3.3 Yearly ISO-9001 certification processes

Each year an internal audit, an external audit and a management review are carried out. All these reviews result in several suggestions and requirements which are implemented as soon as possible.

4 THE USE OF TRIGA REACTOR

The Ljubljana TRIGA 250 kW research reactor was the first nuclear installation in Slovenia. From the very beginning it was a source of knowledge and trained personnel in the area of nuclear energy. Several training courses include some practical work on TRIGA reactor. The learning objectives of using the research reactors span from experimental demonstration of theory in the areas of nuclear physics, radiation protection and reactor physics to hands-on experience with operation of a nuclear device and procedures to enter/exit controlled area etc. Practical work on the research reactor is an ideal complement to training on simulator. A list of reactor exercises is given in Table 4.

Table 4: Practical exercises on TRIGA reactor

Subject	Exercise
Nuclear Physics	Primary water activation
	Compensated ionization cell
Reactor Physics	Critical experiment (fuel/control rod)
	Step reactivity changes
	Temperature reactivity coefficient
	Control rod worth (rod swap/rod in)
	Xe poisoning
	Void reactivity coefficient
	In-core flux mapping
Reactor Operation	Reactor operation
	Pulse experiment

Particularly important is the Reactor operation exercise, where the trainees perform the reactor start-up, change of power level and reactor shutdown by themselves. If they pass the procedure successfully, they obtain a *Junior TRIGA operator* license (allowing them to operate the reactor under supervision of a senior operator). This can be compared with the practice that the professional pilots also obtain a sports pilot licence before operating a commercial passenger plane. Despite symbolic nature of the junior operator licence, the feedback from the trainees is very positive.

5 CONCLUSION

The nuclear training centre ICJT trained several hundred nuclear professionals in the last three decades. A quality assurance system, including ISO-9001 certificate, is in place to manage a number of training courses with different scope, duration, audience etc. The experience gathered in 30 years contributed to significant progress in training quality and effectiveness. This is further augmented by extensive experimental training on the TRIGA reactor.

In addition to professional training, ICJT is actively involved in public information. This is focused on permanent exhibition on nuclear energy, demonstration of radioactivity experiments and live lectures for groups of schoolchildren. Around 40% percent of one school generation visit ICJT each year and this has contributed to a rather reasonable acceptance of nuclear energy in Slovenia.

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