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INTERNATIONAL ATOMIC ENERGY AGENCY

REPORT OF THE

FOLLOW-UP INTEGRATED SAFETY ASSESSMENT OF RESEARCH REACTORS (INSARR) MISSION

TO THE

SLOVENIA TRIGA MARK- II RESEARCH REACTOR

Jožef Stefan Institute (IJS)
Ljubljana, Slovenia
25-27 November 2015

Conducted under IAEA Technical Co-operation Project: SLO1006
Carrying Out a Feasibility Study and Installing the Thermal Neutron-Driven 14 MeV Neutron Converter into the TRIGA Research Reactor

DEPARTMENT OF TECHNICAL COOPERATION
Division for Europe

DEPARTMENT OF NUCLEAR SAFETY AND SECURITY
Division of Nuclear Installation Safety

INTERNATIONAL ATOMIC ENERGY AGENCY

ORIGINAL: ENGLISH

Mission date:	25-27 November 2015
Location:	Ljubljana, Slovenia
Facility:	250 kW TRIGA Mk-II Reactor
Organized by:	IAEA
Conducted by:	Mr A. M. Shokr (IAEA/NSNI, Team Leader) Mr A. J. D'Arcy (IAEA/NSNI)

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1. INTRODUCTION

1.1 BACKGROUND

The mission was conducted at the TRIGA MARK-II research reactor, which is operated by the **Jožef** Stefan Institute (IJS), Ljubljana, Slovenia and has a nominal steady state power of 250 KW, and of a maximum pulse power of 1000 MW. The reactor is subject to a Project and Supply Agreement, under which the Agency's Safety Standards apply to the reactor operation. The agreement covers the reactor and the associated facilities. According to the agreement, the reactor is subject to application of the IAEA safety standards and measures as defined by the INFCIRC 18/Rev.1.

The reactor was commissioned in 1966 and has undergone a series of modifications and refurbishments since that time, including a conversion to the use of LEU fuel. Refurbishment activities also included modernization of the Instrumentation and Control (I&C) system, and renovation of the reactor core components and the control rod drive mechanisms.

In 1991, the reactor was reconstructed and upgraded to pulse operation mode. The spent fuel was shipped back to the country of origin, including shipment of spent fuel to USA (219 spent fuel elements) in 1999, and France (10 fresh fuel elements and 600 kg ADU yellow cake in 2007).

The reactor is primarily used for research and development in physics and engineering, including radiation hardness studies, neutron radiography, production of trace elements, neutron activation analysis (NAA) and for education and training. The education and training aspects are particularly focussed on supporting nuclear engineering and radiation protection courses, on the training of future nuclear power reactor operators in Slovenia and on the training of fellows under different IAEA programmes on research reactor safety and operation. The current operating schedule of the reactor is about 700 hours per year. This schedule may vary depending on user's requests.

An INSARR mission was conducted at the reactor during the period from 12 to 16 November 2012. The mission provided recommendations and suggestions for safety enhancement in the following areas: Reactor management, safety committee, safety analysis report (SAR), safety analysis, operational limits and conditions (OLCs), conduct of operations, maintenance, safety of the utilization programme and modifications, operational radiation protection and waste management, emergency planning, quality assurance programme, and decommissioning planning.

1.2 OBJECTIVE AND SCOPE OF THE MISSION

The objective of the follow-up INSARR mission was to review progress in the implementation of the recommendations provided by the main INSARR mission conducted at the reactor in November 2012 and to provide additional guidance and recommendations where it was deemed necessary.

1.3 BASIS AND REFERENCES FOR THE REVIEW

The following documents were used as references for the review:

a) Guidelines for the Review of Research Reactor Safety, IAEA Service Series No.25, IAEA, 2013;
b) Safety of Research Reactors, IAEA Safety Standards Series No. NS-R-4, IAEA, 2005;
c) Maintenance, Periodic Testing and Inspection of Research Reactors, IAEA Safety Standards Series No. NS-G-4.2, IAEA, 2006;
d) Core Management and Fuel Handling for Research Reactors, IAEA Safety Standards Series No. NS-G-4.3, IAEA, 2008;
e) Operational Limits and Conditions and Operating Procedures for Research Reactors, IAEA Safety Standards Series No. NS-G-4.4, IAEA, 2008;
f) The Operating Organization and the Recruitment, Training and Qualification of Personnel for Research Reactors, IAEA Safety Standards Series No. NS-G-4.5, IAEA, 2008;
g) Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors, IAEA Safety Standards Series No. NS-G-4.6, IAEA, 2008;
h) Ageing Management for Research Reactors, IAEA Safety Standards Series No. SSG-10, IAEA, 2010;
i) Safety Assessment for Research Reactors and Preparation of the Safety Analysis Report, IAEA Safety Standards Series No. SSG - 20, IAEA, 2012;
j) Use of a Graded Approach in the Application of the Safety Requirements for Research Reactors, IAEA Safety Standards Series No. SSG-22, IAEA, 2012;
k) Safety in the Utilization and Modification of Research Reactors, IAEA Safety Standards Series No. SSG-24, IAEA, 2012;
l) Safety Analysis for Research Reactors, IAEA Safety Report Series No. 55, IAEA, 2008;
m) INSARR Main Mission Report, IAEA, November 2012;
n) Report on the Progress on Implementation of the INSARR Mission Recommendations, IJS, 2015;
o) Safety Analysis Report of the IJS TRIGA Mk II, IJS 2015;
p) Information from SNSA Related to the Revised Safety Analysis Report, 2015;
q) Operational Limits and Conditions for the IJS TRIGA Mk II, IJS, 2015;
r) Set of operating procedures, IJS, 2015;
s) Operational Radiation Protection and Radioactive Waste Management Programme of IJS (revised version), IJS, 2015;
t) Reactor Operation Logbook, IJS;
u) Procedures and Checklists for Surveillance of the I&C System, IJS;
v) Organization Chart of the IJS Reactor Department, IJS, 2015;
w) Revised Terms of Reference of the Reactor Safety Committee, IJS, 2015.

1.4 CONDUCT OF THE MISSION

The mission was conducted in accordance with the IAEA procedures for INSARR missions, which are based on the IAEA safety standards. The mission team was composed of two IAEA staff members: Mr A. M. Shokr (Head of the IAEA Research Reactor Safety Section) and Mr A.J. D’Arcy (Consultant, Research Reactor Safety Section). The main counterpart of the mission was Mr B. Smodiš, (Head of the Reactor Infrastructure Centre (RIC)).

During the entry meeting, the IAEA team reviewed the mission objectives, scope, and expected results. This meeting was held with the participation of Mr J. Lenarčič, Director of the IJS, the Head of RIC, Mr L. Snoj, Reactor Manager and the senior technical staff of the IJS reactor.

Following the entry meeting, the technical counterparts made a presentation to the IAEA team which covered the safety status of the reactor and the status of the implementation of the recommendations of the main INSARR mission. The presentation prompted discussions within the framework of the mission activities.

In addition to the documents mentioned above (Section 1.3), several operation and maintenance documents and records were also reviewed during the mission, with direct translation made by the reactor technical staff from Slovenian to English. The reactor management and the operating personnel made presentations on each of the review areas, mentioned above in Section 1.2. These presentations provided an overview of the safety status of the relevant review areas and the status of implementation of the recommendations of the main INSARR mission. These presentations were followed by detailed discussions in the frame of the mission activities.

For the actual conduct of the mission, the following procedures were used:

- Examination and assessment of technical documentation;
- A detailed walkthrough of the reactor facility;
- Discussions with the reactor management and operating personnel;
- Discussions among IAEA team members;
- Preparation and review of the draft mission report by the IAEA team members.

During the first day of the mission, the IAEA team and the technical counterparts conducted a detailed walkthrough of the reactor and associated facilities. The walkthrough was an opportunity to verify in the field the physical status of the reactor facility and the progress made regarding the implementation of the recommendations of the main INSARR mission. During the walkthrough, the team discussed with the technical counterparts a range of safety aspects including reactor operation procedures, reporting in the operation logbooks, fire detection and protection, and water leakage detection.

Most of the mission time was dedicated to a series of technical meetings and plenary sessions with the technical counterparts, including discussions about the implementation of the recommendations of the main INSARR mission and addressing its comments and suggestions.

The follow-up mission conclusions and main recommendations were discussed with the reactor management, the IJS technical staff and the reactor operating personnel during the exit meeting held on 27 November 2015 with the participation of Ms A. Peršič and Mr I. Grlicarev of the Slovenia Nuclear Safety Authority (SNSA). There was general agreement by the counterparts on the mission recommendations.

2. CONCLUSIONS AND SUMMARY OF THE MAIN RECOMMENDATIONS

The IAEA team noted with satisfaction the significant progress made by the IJS towards the effective implementation of the recommendations and suggestions of the INSARR mission. This included in particular those related to improvement of the functioning of the safety committee (SC), revision of the SAR, establishment of new OLCs to ensure the safety of the utilization programme, revision of operating procedures, improvements to operational radiation protection and fire safety, and installation of a detection system for water leakage from the reactor systems and components.

It is also important to note the good practice adopted by the SNSA by requiring the IJS to implement the recommendations of the INSARR mission along with the actions to address the findings of the periodic safety review recently performed at the IJS reactor.

The discussions in the follow-up INSARR mission showed that most of recommendations concerning the organizational improvements have been implemented, including revision of the terms of reference of the reactor SC in accordance with the IAEA safety standards on the list of items to be reviewed by the committee and its independence from the reactor management. The responsibilities, functions, and duties of the RIC, the reactor manager and operating staff have been formalized and included in the SAR. However, the duties of the reactor manager are still not covered by a full-time position within the IJS organization, and that situation should be resolved without further delay to ensure the reactor operational.

The IAEA team also noted the progress achieved in the revision of the safety analysis in accordance with the IAEA safety standards, including analysis of the relevant postulated initiating events (PIEs) that were not originally considered, and improvements in the descriptions of the event consequences in the SAR. A significant improvement was also noticed concerning installation of fire detection system and a systematic fire hazard assessment is planned. Progress was also achieved in the revision of the SAR, which is at present under regulatory review. The team highlighted the importance to safety of adequate implementation of the requirements arising from the regulatory review.

Following the main INSARR recommendations, a formal preventive maintenance programme has been established and the reactor operation procedures have been revised and further developed, including operators' response to transients and emergency situations including fire, earthquakes, flood, and loss of coolant. However, efforts are still needed to further improve the procedures for core configuration change, to develop step-by-step instructions and acceptance criteria for maintenance activities, and to establish procedures for operators' response to loss of electrical power supply.

For further safety enhancement, efforts need to continue to be exerted by IJS to ensure implementation of the identified actions to fully address all the recommendations of the INSARR mission. In this regard, SNSA follow-up on these actions is of a high importance.

In addition, the IAEA team made the following recommendations based on the activities of the follow-up INSARR missions.

- The procedures on core configuration change should be revised to require that any proposed change in the core configuration should be subject to an adequate analysis verifying compliance of the proposed configuration with the relevant OLCs, including in particular the values of the maximum excess reactivity and minimum reactivity shutdown margins. This analysis should also cover the transition core configurations ensuring that they are less reactive than the proposed core configuration.

- Actions should be taken to reconstitute the design basis of the water filter (scrubber) associated with the reactor emergency ventilation system, including its function, specifications and performance requirements. On that basis adequate analysis should be performed to ensure effective removal of iodine in accidental situations.

- Procedures should be established for monitoring of radiation fields and contamination levels at the reactor supervised areas to confirm the continued validity of the characteristics of these areas from radiation protection point of view.

- For further improvement of housekeeping:
    - Reactor systems and equipment should be tagged with appropriate labels;
    - The non-used items located in the reactor basement (e.g. Type A containers for transport of fresh fuel) should be removed;
    - The radiation warning signs of items should be revised to reflect the actual radiation and contamination levels.

The IAEA team also suggested that a safety reassessment of the reactor is suggested to be performed in light of the lessons learned from the accident at the Fukushima Daiichi nuclear power plant, following the guidance provided by the IAEA Safety Report Series No. 80. The results of such reassessments performed for other similar facilities would be useful in this regard.

Section 3 provides the detailed results of the mission, which is structured in the same manner as the main INSARR mission report.

3. RESULTS OF THE MISSION

3.1 FACILITY WALKTHROUGH

The IAEA team visited the IJS TRIGA MARK-II reactor on 25 November 2015, during which the reactor was in the shutdown state. The visit familiarized the team with the reactor facility and allowed for the verification in the field of the implementation of the recommendations, as well as an update on the safety status of the reactor facility. During the visit, the team discussed with the operating personnel the different aspects of the safe operation of the reactor. The following reactor areas were visited:

- Reactor control room;
- Reactor pool-top;
- Reactor experimental area;
- Water treatment system and area of cooling systems components;

- Ventilation system area;
- Hot cells and chemical laboratories.

During the walkthrough, the team discussed with the technical counterparts a range of safety aspects including reactor operation procedures, operational radiation protection, reporting in the operation logbooks, fire detection, and water leakage detection. The team acknowledged the technical knowledge of the reactor operating personnel and their awareness of the reactor technical and safety status. The team also noted the god housekeeping and cleanness of the reactor facility. The team also made a recommendation for further enhancement of the housekeeping within the reactor facility, as provided below "Recommendation of this Mission[1]".

Recommendation of this Mission:

FR1) For further improvement of housekeeping:

- o Reactor systems and equipment should be tagged with appropriate labels;
- o The non-used items located in the reactor basement (e.g. Type A containers for transport of fresh fuel) should be removed;
- o The radiation warning signs of items should be revised to reflect the actual radiation and contamination levels.

3.2 FOLLOW-UP OF THE IMPLEMENTATION OF THE RECOMMENDATIONS OF THE INSARR MISSION

This Section provides the results of the follow-up of the implementation of the INSARR mission recommendations. The results are presented for each recommendation in each of the Issue areas covered by the main INSARR mission. The text of the original Recommendation or Suggestion from the main INSARR mission report is quoted *(indicated in italics)* in each case and the follow-up process, the observations made by the team and a summary of their discussions with the counterpart personnel are provided under the **"Implementation**" part of the text below.

3.2.1 Facility Walkthrough

"*R1) The reactor fire safety should be strongly improved. The fire hazard analysis should be completed as soon as possible and, accordingly, fire detectors (or automatic extinguisher as necessary) should be installed at all areas of the reactor building with potential fire risk including control room, reactor hall, experiments area, ventilation and primary pump areas, and electrical switchboard room. The fire safety programme should be included in a revised version of the SAR. All non-used items of potential fire risk should be removed from the reactor building.*"

[1] The recommendations and suggestions identified by the follow-INSARR mission are indicated, where applicable, at the end of the relevant sub-sections under "**Recommendations of this mission**" or "**Suggestions of this mission**." These are numbered for recommendations as FR1, FR2, and for suggestions ad FS1, FS2.

Implementation:

Significant progress was achieved in the implementation of this recommendation. The reactor building was equipped with adequate fire detectors and it is planned to perform fire hazard assessment. Open actions remain valid and should be implemented as planned.

"R2) The emergency ventilation system should be equipped with charcoal filters. The specifications of the filters and criteria of verification of their efficiency should be established and included in the OLCs."

Implementation:

During the facility walkthrough, the IAEA team observed a unit connected to the emergency ventilation system which includes a water filter (scrubber). During the discussions with the reactor staff, it appeared that the unit was understood to have the function of removing Iodine from the emergency ventilation air stream, but that there was no adequate information on the function, specifications, or performance requirements of the scrubber. The reactor documentation and records don't contain adequate information on this component. In addition, the reactor staff mentioned that it is technically difficult to install a charcoal filter as this requires replacement of the whole existing emergency ventilation unit and there are difficulties to find a supplier for such a component. During the mission, the IAEA team together with the reactor technical staff, consulted some scientific publications on the use of scrubbers in nuclear facilities.

On the basis mentioned above, the IAEA team is of the opinion that the intent of the recommendation R2), namely to contain any accidental iodine release, remains valid but the recommended action on installation of a charcoal filter cannot be confirmed. A new recommendation, replacing the R2) recommendation was therefore made as stated in FR2) below.

"R3) Monitoring of reactor water leakage from reactor pool, beam tubes, primary pumps and heat exchangers should be improved by installation of adequate detection and monitoring system".

Implementation:

The implementation of the recommendation is ongoing. Most of equipment has been purchased and its installation is ongoing. Installation of such equipment requires regulatory approval. The IAEA team concludes that progress has been made in the implementation of this recommendation but efforts are still needed to fully implement it.

Recommendation of this mission

FR2) Actions should be taken to reconstitute the design basis of the water filter (scrubber) associated with the reactor emergency ventilation system, including its function, specifications and performance requirements. On that basis adequate analysis should be performed to ensure effective removal of iodine in accidental situations.

3.2.2 Operating organization and reactor management

"R4 The roles and responsibilities of the Head of RIC, the Technical Manager (reactor manager) and operating staff, should be defined in a precise and formal manner. The duties and responsibilities of the reactor manager should be covered by a full time position in the IJS organization. The definition of roles and responsibilities for ensuring safe operation of the TRIGA MARK II reactor should be integrated in the SAR and OLCs".

Implementation:

Progress was achieved in the implementation of this recommendation. The roles and responsibilities of the reactor manager and operating staff have been defined in a precise and formal manner and included in a revised version of the SAR. However, the reactor management mentioned that the function of the reactor manager is still not covered by a full-time position within the IJS organization. The reactor management also mentioned that this issue is beyond the IJS jurisdiction as this needs additional financial resources to be provided by the Government (see also the comments on implementation of recommendation *R5* of the main INSARR mission, below).

"*R5) Recommendation to the Government of Slovenia: Necessary funds should be ensured by the Government for enhancing safe operation of the reactor, which requires that the reactor manager ensures his duties in a full time position within the IJS".*

Implementation:

The recommendation is not yet implemented, remains valid and should be fully implemented without further delay. The reactor management mentioned that this recommendation has been communicated with the government and no response was received to date.

3.2.3 Safety committee

"R6) The terms of reference of the SC should be revised in accordance with the IAEA Safety Standards NS-R-4 to include in its functions the advisory role to the IJS Director, and to include the following in the list of items to be reviewed:

- *Proposed changes to the safety documents (SAR, OLCs, and emergency plan);*
- *Violations to the OLCs and to operating procedures of safety significance;*
- *Reports on routine releases of radioactive materials to the environment, and dose to personnel and public;*
- *Events that required to be reported or have been reported to regulatory body;*
- *Periodic reviews of the operational safety performance of the reactor (which could be in the form of review of the annual report of reactor operation);*
- *Regulatory inspection reports.*

The OLCs should be revised accordingly".

Implementation:

This recommendation is fully implemented and considered as closed. The IJS document "Rules on the Safety in the reactor TRIGA Mark II nuclear installation" was revised in accordance with the IAEA safety standards No. NS-R-4, and issued on 5 March 2015. The list of items mentioned above has been included in the SC terms of reference (Article 31-a, c, d, f, g, and f). The revised terms of reference of the committee need to be included in the revised version of the OLCs.

The IAEA team checked the minutes of the last meeting of the SC. The IAEA team observed that the SC is functioning in accordance with the revised terms of reference. The discussions during the mission led to a suggestion that the regular meetings (currently established to be once per year) of the SC need to be held in fixed dates with an agenda to review the routine reports on the reactor safety performance, and ad-hoc meetings could be held as needed to obtain SC advice to the reactor management or the IJS Director on specific issues.

The main INSARR mission also provided the following suggestion:

"S1) The revised terms of reference of the SC should indicate that the chair of this committee should delegate his role to another member when the committee reviews issues in which he has direct involvement"

Implementation:

This suggestion was also implemented as per Article 34 of the SC's terms of reference. The Chairman of the reactor SC is not involved in the operation or utilization of the reactor.

3.2.4 Safety Analysis Report

"R7) The technical contents of the revised version of the SAR should be in accordance with the international practices established by the IAEA Safety Standards SS No. 35-G1. The contents of SAR should provide the reviewer adequate information to assess the safety of the reactor facility. The team comments (observations and recommendations) presented in different Sections of this mission report should be resolved in the revised version of the SAR including, among others, revised safety analysis, OLCs, and safety of experiments".

Implementation:

Significant efforts have been exerted by IJS concerning the implementation of this recommendation. The revised version of the SAR is under the review of SNSA. It is expected that IJS will make efforts to implement any recommendation or requirement that may arise from this regulatory review. The revised version of the SAR included mainly revision of Sections 4 (safety analysis) and 7 (OLCs) of this report. Summary of the revision is as follows:

- OLCs:
  - Section 7.3.21 Limitation of the impact of experiments in reactivity changed;
  - Sections 7.3.22 (Irradiation) and 7.3.23 (Materials) changed.
- Safety of experiments:
  - In section 7.2.10 Definition of experiment was added;
  - In section 7.2.11 Dynamic and static impact on reactivity;
  - For the complete section 7 of new SAR, the opinion of an independent qualified expert was obtained (requirement of SNSA);

- Section 4.1 updated and section 4.2 "Impact analysis of experimental devices to the facility" added.

Based on a request from SNSA, the revised Sections 4 and 7 were reviewed by an independent expert. IJS agreed with SNSA to include, in the next revision of the SAR (Rev. 8), some technical information that is missing from the current revision. The IAEA team suggested that the items that were indicated in the main ISNARR mission report need to be included in Rev. 8 of the SAR. These include the history of the reactor facility, the reactor safety objectives, design requirements, specifications of the reactor materials and summary of the emergency plan.

It is important to note that the IAEA safety standards SSG-20, which superseded the SS No. 35-G1 and includes guidance on preparation and review of the SAR, was issued after the date of the main INSARR mission. This safety standards publication was considered in the preparation of the revised version of the SAR.

3.2.5 Safety analysis

"R8) *The safety analysis should be developed and included in the revised version of the SAR. The list of PIEs included in the Appendix of the IAEA Safety Standards NS-R-4 could be taken as a basis for the development of list of the PIEs specific for the TRIGA MARK II reactor. The analysis should include description of the event sequence, event consequences and comparison against acceptance criteria. The results of the safety analysis should be reflected in the establishment of the OLCs".*

Implementation:

The list of PIEs established by the IAEA Safety Standards No. NS-R-4 has been analysed and the design basis accidents were identified. The following PIEs were identified as missing:

- Accident during fuel handling (outside the pool);
- Fuel cladding failure;
- Loos of coolant accident (LOCA);
- Inadvertent control rod ejection at full pulse power.

These PIEs were analysed and described together with their consequences. The consequences of LOCA during transfer or storage of fuel are enveloped by the consequences of LOCA (which is analysed in the SAR) and fire inside a reactor hall is covered by the emergency procedures. Analysis of fire accident inside the reactor hall is not included in the SAR but covered by the emergency planning document. The event consequences are included in the SAR, and the safety analysis acceptance criteria exist (maximum dose based on the national legislation and integrity of fuel elements).

A document was also issued in 2015 (Analysis of PIEs of IJS, Document IJS-DP-11927 (Rev.1), 2015) which provides some description of the event sequences. This description needs to be revised and presented in a clear and systematic manner. In addition, there is a need to cover the sequences of all PIEs.

In 2014, Section 4 of the reactor SAR (Accidents Analysis) was revised and reviewed by an expert independent from the reactor management. The revised version was submitted to SNSA for review.

The IAEA team considers that most of the actions associated with this recommendation are implemented but there is still a need to systematically describe the sequences for all PIEs. The IAEA team also highlighted the importance of addressing any comment arising from the SNSA review.

The IAEA team also discussed the need for a safety reassessment of the reactor facility following the feedback from the Fukushima Daiichi accident. The IJS reactor staff stated that this is not required by the SNSA, and the reactor potential hazard is low so that off-site consequences are considerably low in extreme accidental situations. The IAEA team suggests consideration of performing such a reassessment based on the IAEA Safety Report Series No. 80 and use of the experience from other similar facilities that performed such a reassessment (see the suggestion FS2) of this mission, below).

Suggestions of this mission:

FS1) The description of the sequences of all PIEs needs to be further developed and presented in a clear and systematic manner.

FS2) A safety reassessment in light of the lessons learned from the accident at the Fukushima Daiichi nuclear power plant is suggested to be performed following the guidance provided by the IAEA Safety Report Series No. 80. The results of such a reassessment performed for other similar facilities (for example the safety reassessment for TRIGA reactors, Germany) would be useful in this regard.

3.2.6 Operational limits and conditions

"R9) The operating organization is recommended to establish, and include in the SAR, a complete set of the OLCs on the basis of the results of a revised safety analysis. Appendix I of the IAEA Safety Guide NS-G-4.4 could be considered as guidance to establish LCOs [limiting conditions for safe operations] applicable to the TRIGA MARK II reactor. Annex II of the IAEA Safety Guide NS-G-4.2 provides examples for periodic testing activities and could be used for establishing the surveillance requirements of the TRIGA MARK II reactor".

Implementation:

The recommendation is implemented. A detailed comparison of the OLCs of the reactor with the guidance provided by the IAEA safety standards No. NS-G-4.4 was performed by the reactor staff. The following OLCs were added (see also implementation of R13):

- Limits on reactivity worth of experiments;
- Materials forbidden to be irradiated with limits on their amounts and physical and chemical forms;
- Irradiation rules and procedures, including approval;

The revised set of the OLCs has been submitted to the SNSA for review and approval. Upon SNSA approval, the revised OLCs will be included in revision 8 of the SAR.

3.2.7 Conduct of operations

"R10) The operating procedures should be completed to cover all the operations of safety significance including development of procedures for reactor power operation and shutting down, for the facility walkthrough, and for the operators' response to the anticipated

operational occurrences and accident conditions. A copy of the operating procedures should be made available at the control room."

Implementation:

The IAEA team considers that the implementation of this recommendation is complete, and that the recommendation is considered as closed. The revised or developed (new) procedures since the main INSARR mission include the following:

- Reactor Operation:
  - RIC-QA-903 – Check list before and after reactor operation;
  - RIC-QA-904 – Reactor power operation *(new);*
  - RIC-QA-905 – Pulse mode operation (*new*);
  - RIC-QA-945 – Order to irradiate;
  - RIC-QA-946 – Order to operate *(new);*
  - RIC-QA-909 – Refilling demineralized water *(new).*
- Fuel handling and core calibration:
  - RIC-QA-901 – Adding fresh fuel elements;
  - RIC-QA-103 – Fuel handling;
  - RIC-QA-104 – Transfer of spent fuel elements in spent fuel pool;
  - RIC-QA-902 – Thermal calibration;
  - RIC-QA-906 – Control rod calibration;
  - RIC-QA-907 – Excess reactivity measurement *(new);*
  - RIC-QA-105 – Inspection of fuel elements;
- Working instructions:
  - RIC-QA-102 – Requirement to conduct an operation at the RIC (e.g. modernization, refurbishment, new experiment, and new documentation);
  - RIC-QA-908 – Instructions on operations inside supervised area (entry, exit, samples handling, etc.);
  - Emergency procedures;
  - U1-QA-211 – A plan of action in case of an emergency.

During the walkthrough of the reactor facility, a list and copies of all operating procedures was available in control room. A copy of emergency procedures is available close to the control board.

The discussions during the mission showed also that operators' responses to the anticipated operating occurrences and accident situations such as earthquakes, LOCA, fire, flood, etc. are covered by the emergency plan. However, operators' response to loss of electrical power supply is not covered and needs to be addressed.

"*R11) The operating procedures for fuel element loading into the core should be revised so as to forbid such an operation unless it is analysed from safety point of view. Such analysis should verify compliance with the OLCs on the minimum shutdown margin, determine the value of the power peak factor, and evaluate the effect on the calibration of nuclear instrumentation. The newly configured core should not be released for routine operation unless these parameters are evaluated by appropriate measurements."*

Implementation:

Efforts were made by IJS to implement the recommendation. The existing process for core configuration change requires that newly configured core is not released for routine operation unless the safety parameters are evaluated by measurements.

Intensive discussions were held during the mission with respect to the procedures for core configuration change. The IAEA team, on the basis of the IAEA safety standards No. NS-G-4.3, is of the opinion that analyses need to be made for any proposed core configuration change to demonstrate that the safety parameters of any proposed configuration comply with the relevant OLCs (in particular those on reactivity shutdown margins and excess reactivity).

The IAEA team also clarified that the transition core configurations (the intermediate configurations that are established along the process of assembling the proposed core configuration) need to be less reactive than the proposed core configuration and this needs also to be verified by an analysis. The IAEA team further clarified that any change in the specifications or positions/locations of core component (fuel, reflectors, core instrumentation, etc.) is, by definition, a core configuration change (see also IAEA Safety Standards Series No NS-G-4.3). On this basis recommendation (FR4), below, was made.

Recommendations of this mission

FR3) Procedures should be developed for operators' response to the loss of electrical power supply.

FR4) The procedures on core configuration change should be revised to require that any proposed change in the core configuration should be subject to an adequate analysis verifying compliance of the proposed configuration with the relevant OLCs, including in particular the values of the maximum excess reactivity and minimum reactivity shutdown margins. This analysis should also cover the transition core configurations ensuring that they are less reactive than the proposed core configuration.

3.2.8 Maintenance, periodic testing and inspection

"R12) *A formal preventive maintenance programme should be established and implemented. It should cover all SSCs important to reactor safety. Maintenance procedures, including step-by-step instructions and acceptance criteria should be developed and be referenced in the revised version of the SAR".*

Implementation:

Progress has been made in the implementation of this recommendation. Actions have been completed concerning the implementation of some items covered by the recommendations and other actions are planned to be completed by the end of 2016. The following actions have been taken by IJS:

- A formal preventive maintenance programme has been established.
- In February 2015, an ageing management program was implemented (Document: Program nadzora staranja, IJS –DP-11557, February 2015, Izdaja2) and in Section 6 of the new issue of the SAR (revision 7) listed as a reference.

- For the ageing management program, the opinion of an independent qualified expert has been obtained (requirement of SNSA).

In accordance with the agreement between IJS and SNSA, step-by-step instructions and acceptance criteria, within maintenance procedures, will be developed and implemented through the implementation plan for changes and improvements in the periodic safety review (IJS-DP-11676, Izdaja3, December 2014). The deadline for these activities is the end of 2016.

It is also important to note that inspection of reactor systems and components important to safety have been performed in the frame of the periodic safety review which was concluded in 2014. The inspection covered the reactor core structure, beam tubes, reactor tank, graphite reflector, and cooling system pipelines. Fuel elements are also inspected using visual inspection techniques. The results of these inspections showed no concern with the physical status of these components.

The following suggestions were also provided by the main INSARR mission:

"S2) For effective planning and implementation of the preventive maintenance programme, it is suggested to develop a maintenance schedule that includes all SSCs [structures, systems, and components] subject to preventive maintenance, and the planned dates of the relevant maintenance activities.

"S3) It is suggested that verification of the SSS [safety system settings] be added to the start-up checklist. This refers mainly to the operability check of the SCRAM signals initiated by the nuclear instrumentation (on the reactor power and period").

Implementation:

The suggestions S2) and S3) were considered for implementation by IJS. Implementation of S2) is planned for 2016.

3.2.9 Utilization and modifications

"R13) *Formal procedures should be established for the planning and implementation of experiments and modifications, which should require that a safety analysis be performed for every proposed modification or new experiments. The OLCs should be revised to include limits on the reactivity worth of experiments (maximum reactivity worth of a single experiments and maximum reactivity worth for all experiments). The revised version of SAR should include a chapter on the safety of experiments".*

Implementation:

This recommendation was implemented. Procedure RIC-QA-102 was revised. The proposer of the change has to:

- Describe the reason;
- Provide plans, safety criteria, additional OLCs;
- Review and evaluation on past activities;
  - Implementation phases – what, who, conditions;
- Identify needed equipment;

- Provide details of waste produced;
- Elaborate on the location of radioactive wastes.

The OLCs relating to the following have been added (see also the implementation of R9):

- Reactivity worth of experiments:
  - Dynamic reactivity: < 1 $ (to prevent prompt criticality during experiment),
  - Maximum reactivity of single experiment: < 2.5 $;
  - Maximum reactivity of all experiments: < 3 $ (3 $ pulse at full power is already analysed in SAR - Fuel temperature does not exceed 1000 °C).
- Materials that cannot be irradiated (except as further explained below):
  - Corrosive materials to reactor components;
  - Compounds that are highly reactive with water;
  - Potentially explosive materials;
- Liquid fissionable materials shall be doubly encapsulated;
  - If the capsule fails:
    Physical inspection;
    Corrective action is reviewed by the supervisor of the reactor facility;
    Further operation is approved by the supervisor.
- Each fuelled experiment shall be controlled. Maximum quaintly of fissile material (^{233}U, ^{235}U, ^{239}Pu and ^{241}Pu) is 35 mg. In case of larger amount, safety analysis has to be made and shown that in case of experiment failure, doses received by the workers and public are lower than dose limits;
- Accident scenario: the sample is caught on fire. Doses have been calculated for workers and public. In case of 35 mg, doses are below the limits. The analysis is part of the SAR;
- Explosive materials such as gunpowder, nitroglycerin, TNT or pentaerythritol tetranitrate should not exceed 25 mg. They should be packed in containers that withstand the pressure in case of material explosion;
- Quantities of materials, except fuel materials, which could off-gas, sublime, volatilize, or produce aerosols shall be limited. In case of 100 % release, the doses received by workers or public should not exceed dose limits.

3.2.10 Radiation protection and radioactive waste management

"*R14) The ventilation system area should be re-classified as a controlled area, or, otherwise access without contamination control should be denied. The over-coats used in the controlled areas should not be used in the supervised areas*".

Implementation:

The recommendation is fully implemented and considered as closed. The reactor technical staff mentioned that the radiation protection programme, including the area classification mentioned in this Recommendation, was revised in 2013 (IJS-DP-11287, OVIDS-RIC-04/13). The revised programme was checked and verified by an independent radiation protection expert, and was approved by SNSA. The radiation protection procedures were revised to restrict access to the ventilation system area from the controlled areas without contamination control. Administrative procedures were also established to prevent use in the supervised areas of the over-coats used in the controlled areas.

“R15) Handling of radioactive material during the night operation shifts should not be performed unless the radiation protection officer is available in the reactor building”.

Implementation:

Administrative procedures have been established, within the operational radiation protection programme, to ensure that handling of radioactive materials is not performed unless a radiation protection officer is available in the reactor building. Therefore, the recommendation is considered fully implemented.

Suggestions:

“*S4) It is suggested to consider establishment of administrative radiation protection rule to use over-shoes in the controlled areas to prevent potential spread of contamination.”*

Implementation:

The implementation of this suggestion has been considered. The Head of Radiation Protection mentioned that regular radiation protection surveys show that removable contamination is not an issue in Zone 1 (Reactor hall) of the controlled area and that, in accordance with the revised operational radiation protection programme, additional personnel protection measures are applied, as needed, by the Head of Radiation Protection in the case of performing operations involving potential contamination.

“S5) It is suggested to develop flooring maps for the reactor building with indication of the area classification from radiation protection point of view. These maps could be included in the revised version of the SAR.”

Implementation:

This suggestion was considered by the IJS. A new procedure was developed (RIC-QA-908, November 2015) which includes the suggested flooring maps. These maps were also included in the revised version of the SAR.

Recommendation of this mission:

The discussions during the follow-up mission showed that no routine contamination survey is performed in the reactor supervised areas. These areas are equipped with personal and environmental detectors that are read monthly, but no routine measurements of external radiation levels using portable radiation detectors are performed. The reactor technical staff is of the opinion that it is unlikely to have increased radiation or contamination levels in these areas to more than the background values, but they agree with the IAEA team that these areas need to be subjected to routine monitoring. In this regard, the following recommendation was made:

FR4) Procedures should be established for monitoring of radiation fields and contamination levels in the reactor supervised areas to confirm the continued validity of the characteristics of these areas from the radiation protection point of view.

3.2.11 Emergency Planning

"*R16) In view of the recommended revision of the safety analysis (see Section 3.6[of the main INSARR mission report]), the emergency plan should be revised accordingly to ensure coherence with the identified PIEs. The emergency plan should consider the beyond design basis accident which could be determined using the design basis accident with degradation of the facility (e.g. degradation of the filtration system)".*

Implementation:

The recommendation was implemented. The emergency plan has been revised in 2014 (Document NUID-U1-QA-2011). The revised version considered all the events considered in the safety analysis of the reactor, including severe damage of a fuel element during manipulation, LOCA, fire, increased radiation levels, personal contamination or overexposure, extreme natural events (earthquake), and security events. The revised version of the emergency plan includes an accident classification system and, for every emergency class, the emergency procedures (including actions required to be taken by the reactor operators), provide criteria for declaration of an emergency situation. The intervention levels and protective actions are also described.

The emergency plan was developed on the basis of the national regulations and is consistent with the IAEA publication EPR-METHOD 2003.

A fire drill was performed in November 2015 with the participation of off-site emergency teams (local fire brigades), reactor staff and radiation protection unit of the IJS. The drill was aimed at examining the effectiveness of external cooperation, and at testing infrastructures for water supply and for reporting and communication.

3.2.12 Quality Assurance

There were no recommendations associated with this area in INSARR mission. However, the following suggestion was made:

"S6) It is suggested to establish a document presenting the different disciplines and competencies needed for the operation and utilization of the reactor, the existing qualified human resources to perform the corresponding activities and those to carry out the associated QA control. This will help identify possible gaps for the effective application of QA procedures".

Implementation:

The suggestion was taken into account and was implemented by the IJS. The revisions were covered, among others, by the revised version of the QA programme for the RIC (Document: RIC-QA-101-2, May 2015).

3.2.13 Decommissioning

There were no recommendations associated with this area in the INSARR mission. However, the following suggestion was made:

"S7) It is suggested to use the records of different environmental radiation measurements to establish a baseline data for the ultimate decommissioning of the reactor facility. In the case of gaps in these data, actions have to be taken to complete them".

Implementation:

The suggestion is considered for implementation by IJS, and it is planned to cover the suggested actions in the next revision of the decommissioning plan, planned to be completed before the end of 2016 (as per the actions identified from the recently completed periodic safety review – which required that the existing preliminary decommissioning plan (issued in 2007) be revised to comply with the new national regulations).

ANNEX I: AGENDA

Wednesday 25 November 2015	
09:00-12:00	• Introduction (Counterpart, IAEA) • Presentation on the safety status of the IJS RR and the implementation of the recommendations of the INSARR mission (IJS) • Walkthrough of the IJS TRIGA reactor facility and observation of the implementation of selected recommendations of the INSARR mission (All)
12:00-13:00	Lunch break
13:00-15:30	• Follow-up of the implementation of the recommendations of the INSARR mission in the following areas: - Operating organization and reactor management - Safety committee - Training and qualification
15:30-17:00	• Follow-up of the implementation of the recommendations of the INSARR mission in the following areas: - Conduct of operations - Maintenance periodic testing and inspection - Radiation protection and radioactive waste management
Thursday 26 November 2015	
09:00-12:00	• Follow-up of the implementation of the recommendations of the INSARR mission in the following areas: - Safety analysis report - Safety analysis - Operational limits and conditions - Utilization and modifications
12:00-13:00	Lunch break
13:00-17:00	• Follow-up of the implementation of the recommendations of the INSARR mission in the following areas: - Emergency planning - Quality assurance - Decommissioning
Friday 27 November 2015	
09:00-12:00	• Preparation of the draft mission report
12:00-	• Discussions of the conclusions and recommendations of the mission with the counterpart • Exit meeting

ANNEX II: LIST OF PARTICIPANTS

IJS

Mr J. Lenarčič, IJS Director
Mr B. Smodiš, Head of the RIC
Mr L. Snoj, TRIGA Mk II Reactor Technical Manager
Mr D. Kavšek, Reactor Senior Operator
Mr A. Gyergyek, QA Manager
Mr M. Stepišnik, Head of Radiation Protection
Mr M. Leskovar, Chairman of the Reactor Safety Committee
Mr. A. Jazbec, Reactor Operator
Mr. L. Fabjan, IJS QA Manager
Mr M. Rosman, Reactor operator

IAEA

Mr A. M. Shokr, RRSS/NSNI
Mr A. D'Arcy, RRSS/NSNI