Renewal and Upgrading of the TRIGA Mark II Research Reactor in Ljubljana

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Despite regulatory supervision, the owner/operator is directly responsible for safe operation of the reactor. Therefore, at the 250 kW TRIGA Mark II research reactor in Ljubljana ever since the beginning of operation in 1966 gradual modification and modernization have been taking place. Further more, a review and assessment of improvement programmes for the instrumentation and control systems and related safety features of the reactor protection system was made as early as 1980 by an independent expert from the International Atomic Energy Agency. The primary goal was to modernize the instrumentation in accordance with modern industrial standards. This programme was successfully concluded in 1982 according to the IAEA expert recommendations. The IAEA also delivered part of the new instrumentation. Most emphasis was laid on standardization, flexibility, reliability and service and repair possibilities. Since development in electronics is rapid, provision should be made for some changes in the future. Standard units and modular systems make it easier to carry out these changes. Therefore new analog instrumentation fulfilling all these demands was chosen from the Hartman and Brawn company. Besides modernization of the four nuclear channels, an additional safety channel (fuel temperature meter), a water level indicator, an instrument integrator which measures the power of the reactor (digital display) and a reactivity meter were also introduced.

Although the reactor was designed very carefully in order to be used for research and training, during the last twenty years many improvements were introduced, such as:

- a dry central thimble for target irradiations (isotope production)
- a new pneumatic facility for loading and unloading samples into a new rotary specimen rack or the central thimble, and
- automatic data logging by a configuration based on two microcomputers (already in 1978).

Furthermore, it was decided in 1989 to upgrade our reactor for pulsing mode operation and pulse registration. A two-person project group (reactor operators) and partly also other personnel from the Reactor Physics Division of our Institute participated in the project. The technical experience that has been gained during the last 25 years was utilized in planning and installing a new control console, and into developing a sophisticated system for pulse mode operation.

The project was carried out in strict compliance with the quality assurance programme which is required by Slovenian law for constructing, upgrading and operating nuclear installations. The QA program was divided into three phases: design and construction, pre-operational functional tests and start-up physical tests. It covered all important aspects of the project: organization, procurement, documentation, etc. The QA and QC activities were carried out by Institute staff, supervised by inspectors of the national regulatory body.

In 1991 our reactor was almost completely reconstructed and upgraded. The reconstruction consisted mainly of replacing the grid plates, the control rod mechanisms and the control unit. Also a new PC based system was adapted and developed to collect the operational radiation data of the reactor. New wiring of the electric power supply system and a new air-exchange system in the operations room were installed in 1993 and 1994.

Within the scope of the reactor renewal and upgrading project, a new spent fuel storage facility was built in the basement of the reactor building. The storage is of pool type with a capacity of 630 spent fuel elements. Detailed safety analyses of the spent fuel storage was performed by applying the same principles as are required by international standards for power reactor spent fuel pits. Particular attention was paid to criticality safety calculations.

However, the main novelty in the reactor physics and operational features of the reactor was installation of the pulse rod. Having no previous operational experience in pulsing, a detailed and systematic sequence of tests was defined in order to check the predicted design parameters of the reactor against measurements. The following experiments were conducted: initial criticality, excess reactivity measurement, control rod worth measurement, fuel temperature distribution, fuel temperature reactivity coefficient, pulse parameter measurements (peak power, prompt energy, peak temperature). Flux distributions in steady state and pulse mode were measured as well. The experiments were performed with completely fresh fuel of 12 w% Standard Stainless Steel type. The core configuration was uniform (one fuel element type, including fuelled followers) and compact (no irradiation channels or gaps), as such an array is particularly convenient for testing computer codes for TRIGA reactor calculations.

After successful renewal and upgrading of the TRIGA Mark II research reactor in Ljubljana in 1991, a new safety report was presented to the Slovenian Regulatory Body. A very detailed review of all the safety related systems was performed by the Regulatory Body. After receiving the final approved document from the authority, the reactor started to operate again at the beginning of 1992.

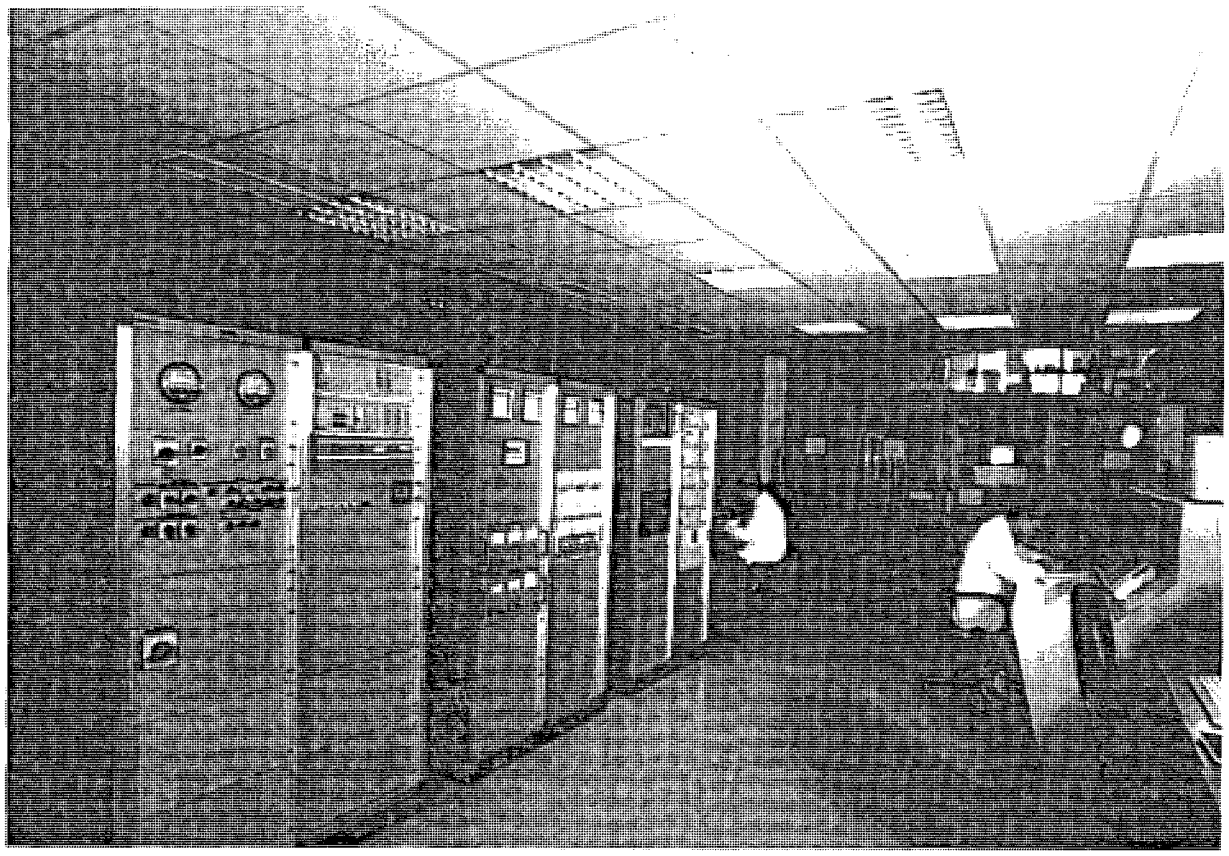

Fig. 1 General view of the control room

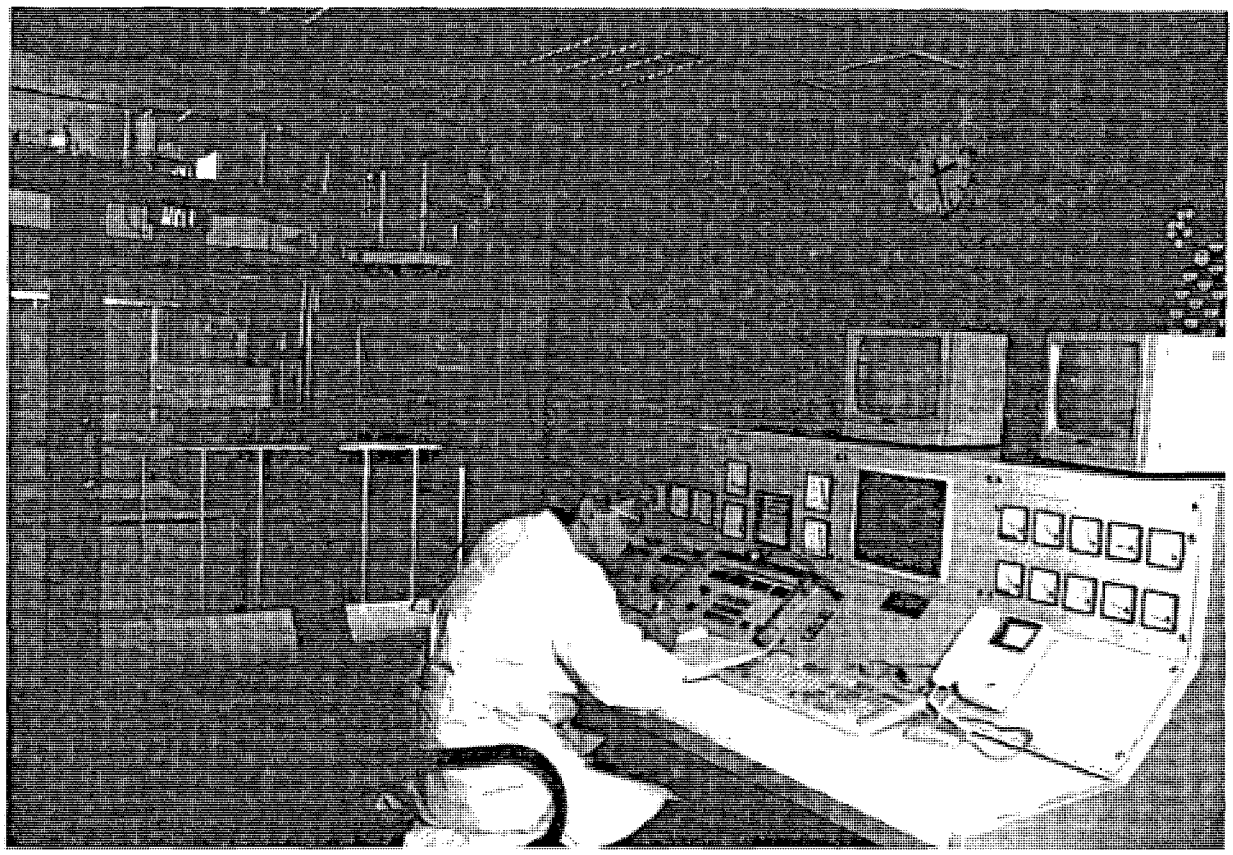

Fig. 2 TRIGA's Control System

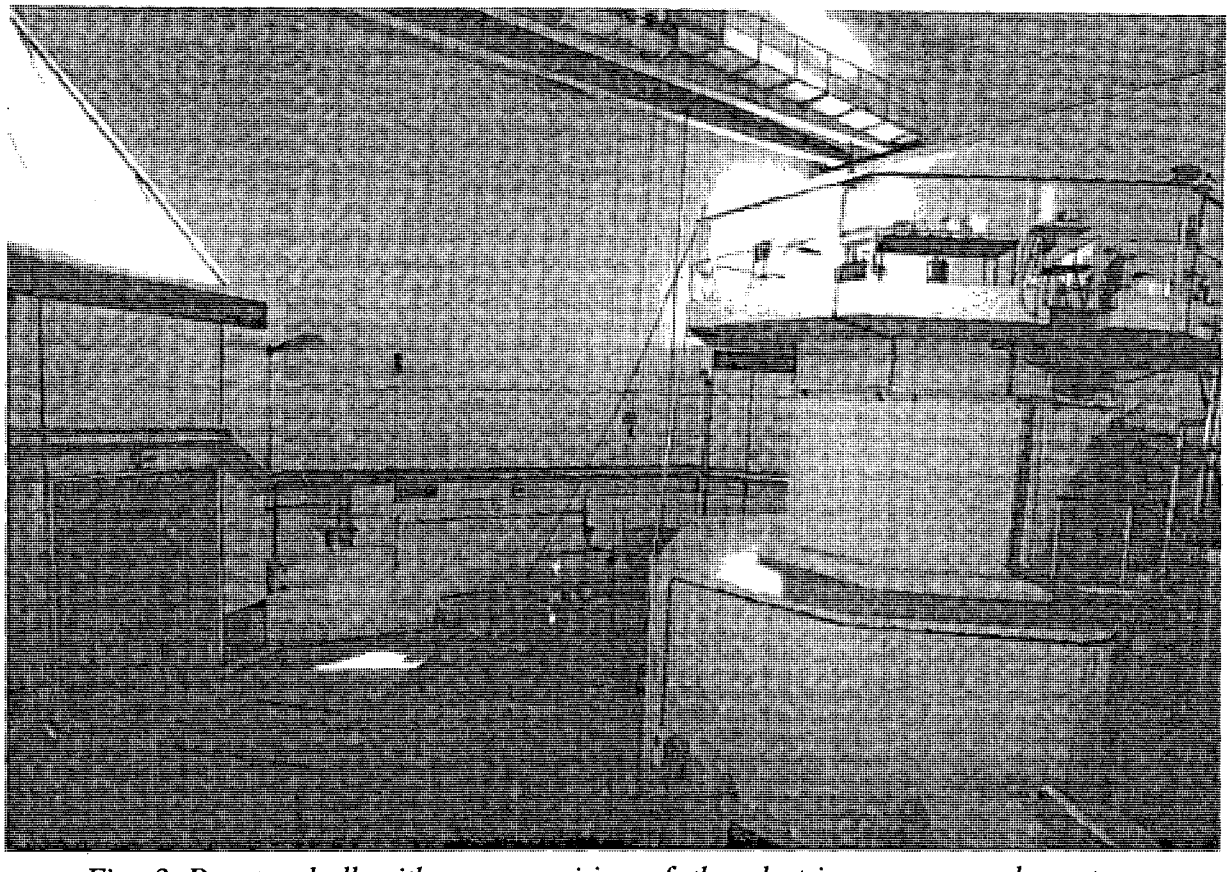

Fig. 3 Reactor hall with a new wiring of the electric power supply system (on the wall)

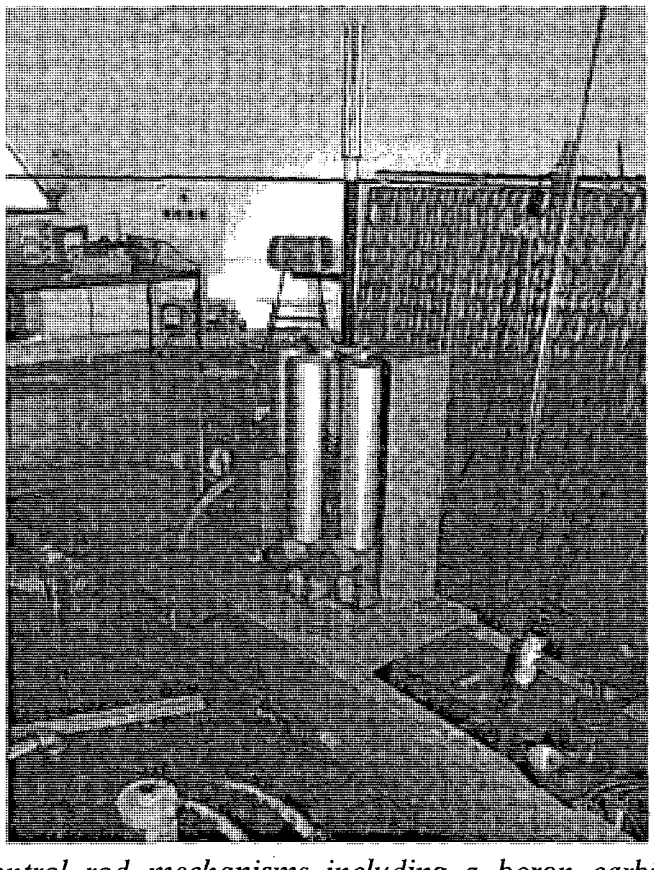

Fig. 4 New control rod mechanisms including a boron carbide pulse rod with compressed air drive (transient rod)

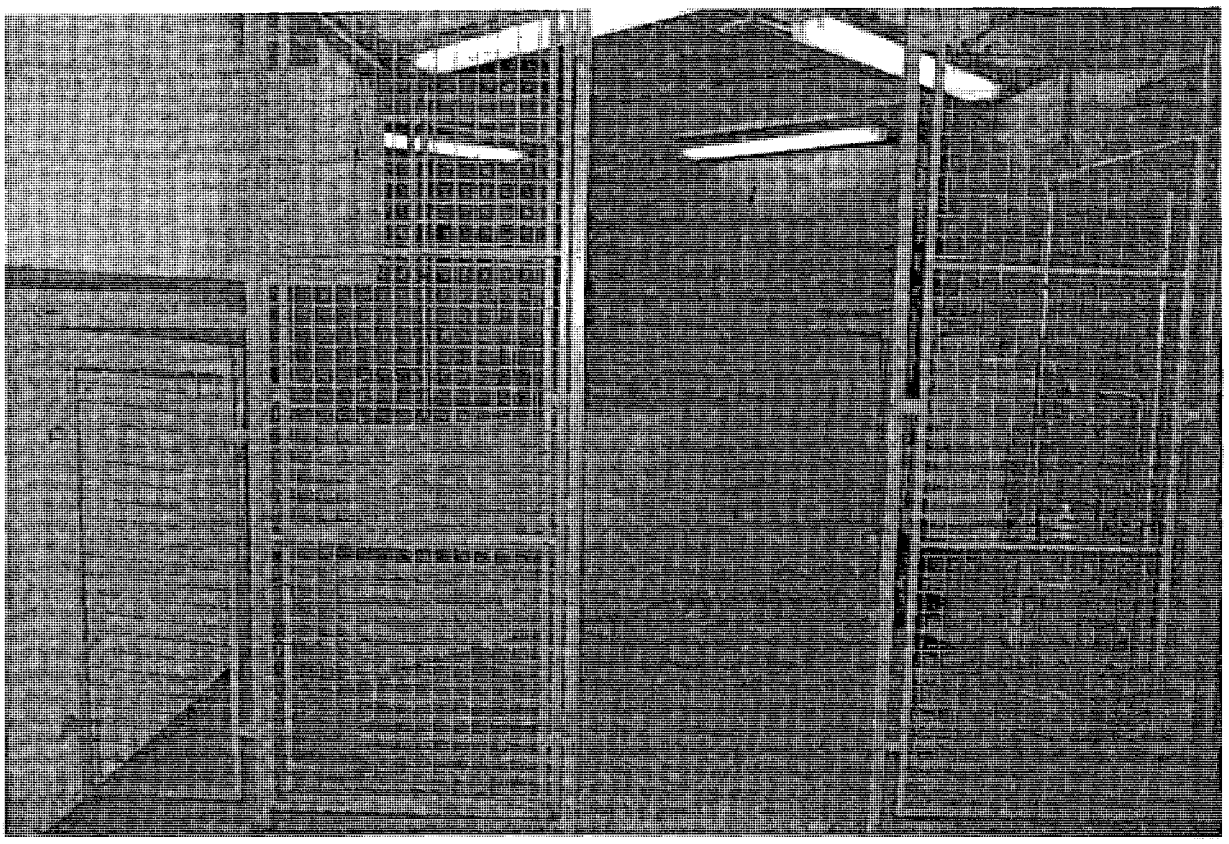

Fig. 5 New wet spent fuel storage facility with a capacity of 630 spent fuel elements

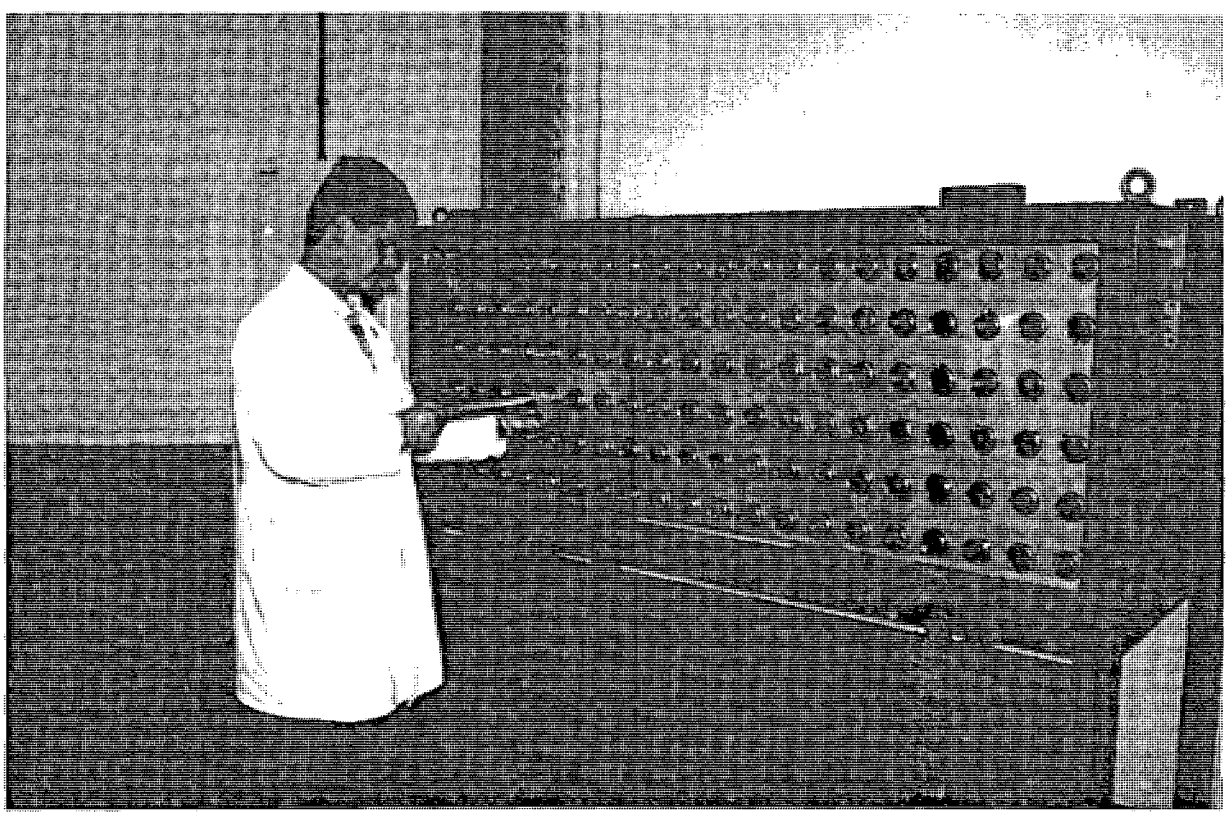

Fig. 6 Fresh fuel storage facility