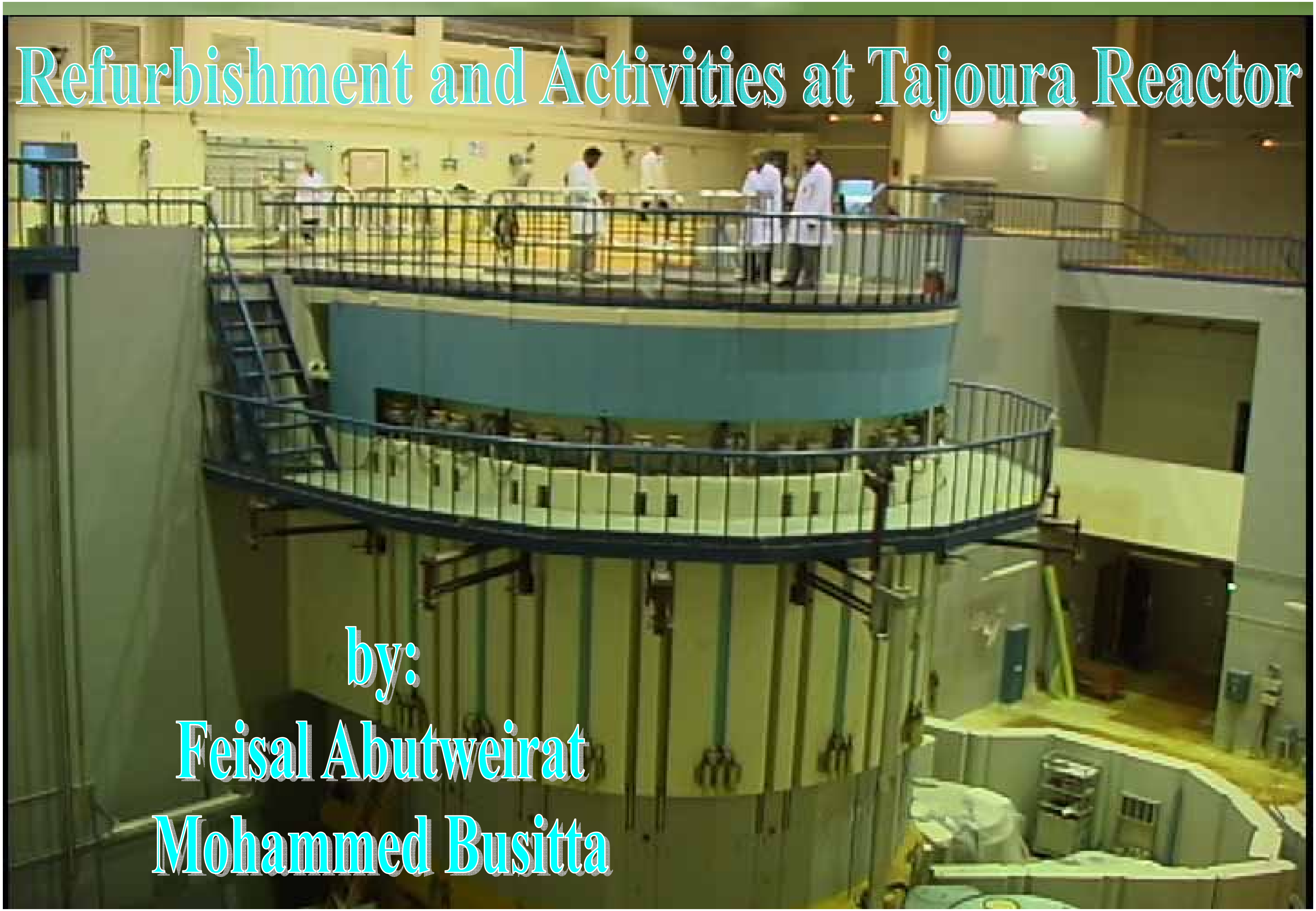
Refurbishment and Activities at Tajoura Reactor



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Introduction

- Tajoura Renewable Energies and Water Desalination Research Centre (REWDRC) is the only national research centre that provides a program of scientific activities in nuclear science and technology.
- Located outside the city of Tajoura, 35 km east of Tripoli. The Tajoura nuclear facility is part of this center and it consists of two installations, the Tajoura Research Reactor and the Critical Facility.
- The Tajoura Research Reactor is a 10 MW light water cooled and moderated and beryllium reflected, pool type reactor. The reactor was designed and constructed by the former Soviet Union, as a turn-key project. The construction of the reactor started in 1977, the power start-up of the reactor took place in 1983.

The Tajoura Reactor

Is intended to be used in:

- carrying out fundamental investigations in, nuclear physics, solid state physics, neutron physics, radiation biology, and radiation chemistry,
- carrying out the activation analysis of elemental composition of substances,
- the production of radioactive isotopes,
- study the behavior of structural materials directly in the process of irradiation.

Reactor irradiation positions & beam tubes

- The reactor is equipped with eleven horizontal channels for extractions of neutron beams. f1
- In the reactor core there are more than 50 vertical irradiation positions in the stationary and removable reflector.
- With different core configurations it is possible to introduce neutron traps at the center or in the corners of the core with very high thermal neutron flux.
- For sample transfer from the core to the hot cell the reactor is provided with an under water taxi.
- The reactor is also equipped with a pneumatic rabbit system for short and intermediate half-life isotopes for activation analysis measurements.

f1 two are the ends of a through channel with a diameter of 150 mm. the largest is a radial channel with a diameter of 230mm intended for radiation biology studies. The rest are 100mm radial and tengential channels.During the eighties these beam tubes were utilized by physicists to study nuclear structure of some elements, and to study local materials in shielding.

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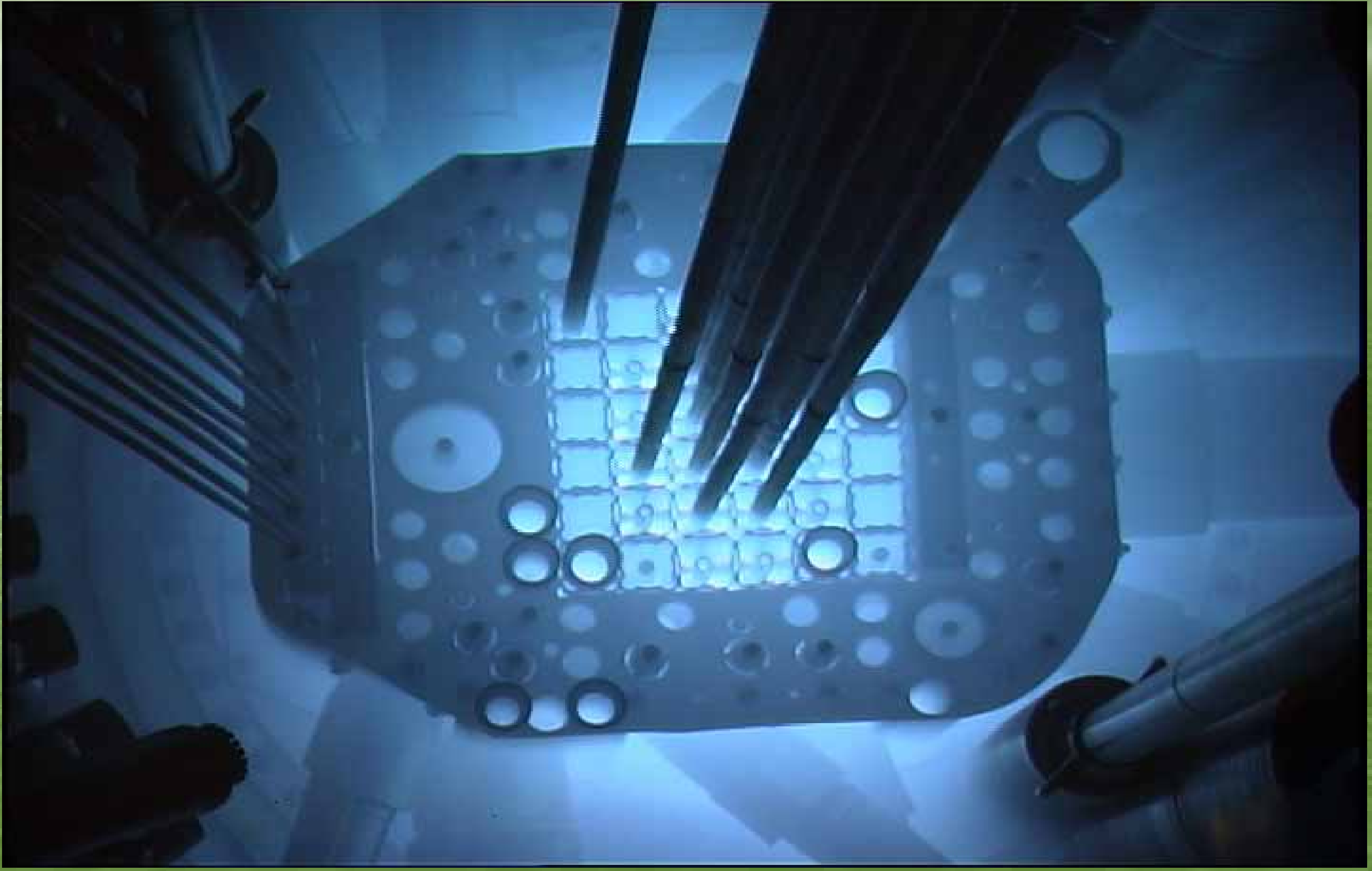
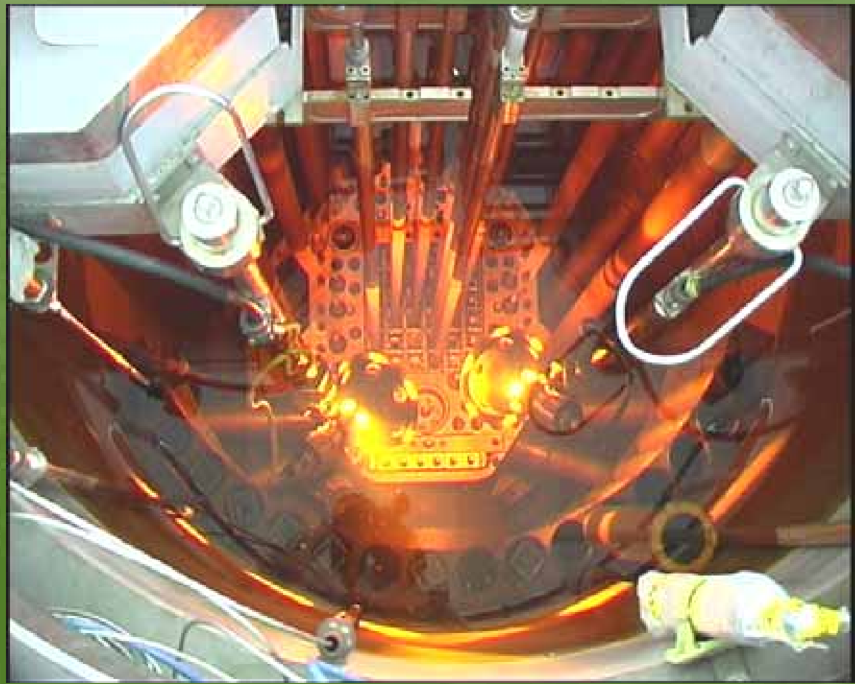
Beam tubes and vertical irradiation channels



The Critical Facility

- The Critical Facility is a complete mockup of the Tajoura Reactor.
- It was commissioned at the end of 1980.
- It is used in neutronic modeling of the reactor, testing, operators training , and student education.



Organization

f3 The reactor section is part of the basic and applied research dept. The technical dept. provides services to the reactor such as operation and maintenance of the secondary and third cooling circuits, air conditioning, ventilation, and hot water supply

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Laws and Regulations

- When the reactor was commissioned the Law Number 2 /1982 concerning the protection against ionizing radiation was already in force.
- However, a dedicated law for reactor operation and utilization did not exist, and the reactor was operated under the permission of the authority of the Secretariat of Atomic Energy.
- According to this permission the staff of the reactor had to strictly follow the rules and operation procedures set by the reactor provider (these were the rules applicable at the former Soviet Union).

Safety analysis report

- When the reactor was commissioned no separate safety analysis report document, as it is commonly known today, was provided even though all the essential elements of a safety analysis report were included in various know-how and operation manuals of the system.
- In the year 1997 the IAEA in accordance to its standards indicated to the management of the Center the need to establish the safety of the reactor by preparing a safety analysis report. Since that time reactor staff started to prepare the most important part of the safety analysis report, mainly the accident analysis chapter.

- In the year 2004 the Regulatory Authority (RA) started effectively doing its work related to the Tajoura Reactor and the Critical Facility. The RA adapted the recommendations of IAEA concerning the safety and operation of reactors since conversion of the Tajoura Reactor and the Critical Facility was foreseen at that time. During the years 2005 and 2006 the accident analysis chapter for the Tajoura Reactor and the Critical Facility using the two types of fuel (HEU, LEU) was completed.

Reactor Utilization

- The utilization of the reactor suffered the most due to the economic hardship, sanctions and trade embargo which had confronted the country during the years 1985-2004.
- The utilization was limited to the use of the reactor as an educational tool for university students, for training and retraining of reactor operators and for capacity building in the field of radiation safety, radiation chemistry, isotope production and neutron activation analysis.

- In the years 1984-1986 nine different isotopes were produced in the reactor. The radiochemical laboratory at the REWDRC did the required chemical treatment of these isotopes. These isotopes were produced to gain experience and for training the personnel.
- However, Na^{24} was supplied to a local industry, for purposes of evaluating the homogeneity of the production process, while I^{131} was ordered by local hospitals for the diagnosis and treatment of thyroids.

- Tc^{99m} was produced as a part of capacity building, but its use in hospitals was not possible due to the lack of a clean room, which is necessary for producing Tc^{99m} suitable for medical applications.
- In the years 1987-1999 the production of I^{131} was continued to supply the local hospitals
- Br^{82} was also produced as part of an IAEA project to improve reactor utilization in industrial applications.

Radioactive isotopes produced in Tajoura Reactor

No.	Isotope	Half life	Target
1	P^{32}	14.2 d	P_2O_5
2	Na^{24}	15 hrs	Na_2Co_3
3	Au^{198}	2.7 d	Pure gold 99.99%
4	K^{42}	12.36 hrs	K_2CO_3
5	Cr^{51}	27.7 d	**Enriched chromium metal with Cr^{50}**
6	Fe^{59}	44.6 d	Enriched ferric oxide
7	I^{131}	8.1 d	TeO_2
8	Tc^{99m}	6 hrs	MoO_3
9	Br^{82}	35 hrs	KBr

Reactor refurbishment

- The replacement of the cooling tower and parts of the third circuit pipes in the year 1998 which have deteriorated due to corrosion problems and lack of spare parts.
- The reactor control system included a computer monitoring system which provided the monitoring of around 100 reactor parameters. The computer was also used to detect failures and provide to the operator an event log. Many of the parameters which were not measured were calculated by the computer using suitable formula. After three years the computer started to have problems due to difficulties in securing spare parts for the maintenance and

the rapidly changing computer technologies. It was decided to introduce a new system based on desktop computers to replace the old monitoring system. The work was done by the reactor staff. The new monitoring system is capable of monitoring more than 8o reactor parameters and can calculate some parameters which are important for safety

- The Instrumentation and Control system, provided by the supplier of the reactor, was designed and constructed in the seventies. The circuits of the I&C system are of low scale integration. Its maintenance is very costly and time consuming because of its size which is huge and over dimensioned. Also no longer are spare parts available for the maintenance. It was decided to replace the system by a new system incorporating new technologies, which will reduce its size and thus the burden of its maintenance. The work is expected to start on refurbishment of the control and safety systems for the reactor and for the critical facility in the near future.

Maintenance strategies

- Since the year 1984 when the facility was completely handed over to the Libyan side, the management has been investing all its efforts to keep both the reactor and the critical facility in an excellent technical state. This was accomplished with low inventory of spare parts and decreasing resources during the time of economic hardship in late eighties and the sanctions during the nineties. Thanks are due to the maintenance program which concentrated on:
  - Appling a strict control of water quality in all closed circuits to keep the conductivity in the primary circuit of the reactor below the recommended limits (<1 μs/cm) and the pH between 5.5 and 6.0

- The conductivity in the secondary circuit was kept below 10 μs/cm and pH between 6.0 and 8.0.
- In the critical facility potassium bi-chromate was added to its pool water as a corrosion inhibitor
- The continues maintenance of the mechanical filters responsible for air quality Control to insure the removal of fine sand particles which are a characteristic of the area.
- The operation of the primary circuit, the secondary circuit and the purification system at least twice a week when the reactor is not operated to reduce corrosion risk, and keep the circuits in working condition.
- The adoption of predictive maintenance instead of periodical maintenance without jeopardizing the safety to reduce the need for spare parts, proved its effectiveness in situations through which our reactor was subjected.

Thank you for your attention