Design and Characteristics of the Jordan Research and Training Reactor

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Jordan Overview

- Population ~ 6 million
- Area ~ 89212 km²
- Capital – Amman (~ 40% of population)
- GDP ~ $18 billion
  - Growth ~ 3-4% per year
- Energy imports > 20% of GDP
Electricity and Water
Motivation

The Human Development Index is a comparative measure of life expectancy, literacy, education, and standards of living. Countries fall into four broad categories based on their HDI: very high, high, medium, and low human development.

4,000 kWh per person per year is the dividing line between developed and developing countries.
Nuclear Energy in Jordan

- Commitment to nuclear energy was officially made in early 2007

- Basic elements of the program
  - Initiating a project for building a nuclear power plant
  - Exploration of potential uranium resources
  - Science and education
    - Jordan Research and Training Reactor (JRTR)
    - Human resource development
      - University level nuclear science and engineering programs
JRTR Background

- RFP issued in early 2009
- Evaluation process lasted nearly a year
- KAERI-DAEWOO consortium (KDC) was selected to execute the project
- Contract signed and project started in March 2010
JRTR Design Guidelines

- Multi-purpose reactor for performing research and education in science and engineering
  - Open pool and LEU fueled
- Achieve optimal thermal neutron flux levels per unit power to support the intended applications
- Maintain negative feedback behavior under all conditions
- Maintain radiation exposure to personnel and public within internationally set limits under all operating and accident conditions
JRTR General Characteristics

- 5-MWth (upgradable to 10-MWth)
- Light water moderated and cooled
- MTR (U₃Si₂ in Al matrix)
  - 19.75% U-235 enrichment
  - 7 kg loading
- D₂O and Be reflectors
- Four Hf CARs, two B₄C SSR
- Four Beam tubes
- Irradiation ports for various applications (e.g., NAA)
- Thermal column
JRTR Core Characteristics

- Core design satisfies general safety and performance requirements
  - Thermal neutron flux reaching $10^{14}$ n/cm$^2$·s
  - Power distribution with overall peaking of 2.5
  - Power coefficient of reactivity of nearly -13 pcm/MW
JRTR Safety Considerations

- Reactor design satisfies general safety objectives
  - Shutting down the reactor and maintaining it in a safe shutdown condition for all operational states or accident conditions
  - Providing for adequate heat removal from the core after shutdown, including accident conditions
  - Containing radioactive material in order to minimize its release to the environment

- Equipped with systems and components to meet the above objectives

- Safety analysis showed that the above objectives are met under all conditions
JRTR Safety Analysis

- Safety analysis addressed
  - Normal operating conditions
  - Anticipated operational occurrences (AOO)
  - Accident conditions

- Initiating events selected based on international guidance and experience

- Example events
  - Loss of electric power (AOO)
    - Peak clad temperature < 150 °C
    - CHFR > 2
  - Rupture of primary coolant system pipe (accident)
    - Peak clad temperature < 150 °C
    - CHFR > 2
JRTR Utilization

- Intense source of neutrons for various applications
  - Neutron Activation Analysis infrastructure
  - Isotope production infrastructure
    - Hot cells
  - Beam tubes for neutron science
  - In-pool and thermal column irradiation locations

- Education and Training
  - Support Jordan’s education programs in science and engineering
JRTR Utilization Characteristics

- Optimized performance
  - Thermal neutron flux in all locations reaching $10^{13}-10^{14} \text{n/cm}^2\cdot\text{s}$

- Science program is under development
Overall Progress
Training

- Training program has been initiated with KDC – 25 trainees
  - Engineering personnel
  - Prepare the first batch of JRTR operators

- Training to support utilization will be soon underway
Summary

- JRTR represents a successful collaboration between JAEC and KDC

- The JRTR is a high performance research reactor that is expected to serve as a regional science and education hub

- The JRTR has reached advanced stages in its construction and licensing

- Commissioning activities are scheduled to begin during 2015

- The JRTR is a key component in Jordan’s nuclear program, which is viewed as essential to the country’s future progress
THANK YOU