Sources of Radiation

Research Reactors
Objective

To discuss the types and uses of Research Reactors
Contents

- Types of Research Reactors
  - Pool Type Reactor
  - TRIGA Reactors
  - Other Reactors/ Critical Assemblies

- Uses of Research Reactors
Research Reactors

- Not used to generate electrical power
- Produce neutrons for various uses
- Use higher enriched $^{235}$U than power reactors

- Approximately 266 in operation worldwide (January 2014)
Types

- Pool type (61 units)*
  - Curved aluminum clad fuel plates
  - Control rods
  - Water for moderation and cooling
  - Beryllium or graphite neutron reflectors common
  - Empty channels for experiments
  - Apertures for neutron beams

- Tank Type (27 units)*

* Research Reactors data is from Jan. 2014
Pool Type Reactor
Test Reactors

The Materials Test Reactor (MTR) completed in 1952 in Idaho was the workhorse of the U.S. Atomic Energy Commission's test reactor program for many years. It was the first reactor to be built solely for testing materials to be used in other reactors.
Types

- TRIGA (37 units)*
  - 60-100 cylindrical fuel elements (36 mm diameter)
  - Uranium fuel and zirconium hydride moderator
  - Water for moderation and cooling
  - Beryllium or graphite neutron reflectors common
  - Operate at thermal power levels from less than 0.1 to 16 megawatts and pulsed to 25,000 MW

* Data from Jan. 2014
### Types

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* Data from Jan. 2014

Some produce radioisotopes
Types

- Some moderated by heavy water (10) or graphite
- Some are fast reactors (no moderator and mixed U - Pu fuel)
Uses

- Analysis and testing of material
- Production of radioisotopes
- Fusion research
- Environmental science
- Advanced material development
- Drug design
- Nuclear medicine
Uses and Benefits of Research Reactors

The United States has participated in cooperative international actions to expand peaceful uses of nuclear energy since the early days of the nuclear era. The foreign research reactors program has produced far-reaching benefits for medicine, science, industry, and the environment.

Advances in Nuclear Medicine
Cancer therapy, medical isotope production, clarification of the biological effects of radiation, development of improved drugs, and blood testing.

Benefits to Industry
Neutron radiography allows diagnosis of defects in metals and engines, research on new and improved materials, and leak detection.

Nonproliferation
Training of international inspectors of nuclear facilities worldwide to prevent diversion of nuclear materials.

Environmental, Agricultural, and Climate Studies
Development of tracer elements for studies of pollution, waste migration, toxic waste management, mine drainage, water chemistry, sediment transport, contamination of freshwater ecosystems, atmospheric dispersion and fallout, product measurements, and soil erosion.

Advancement of Basic Scientific Research
Neutron scattering experiments produce insights into elementary particle physics, clarification of the biostructure of organic substances, and development of new magnetic materials and superconducting materials.

Materials and Advanced Fuels Testing
Testing of materials and fuel forms, including safety experimentation, is being conducted to support advance fuel design and waste management development for use in the power industry.
Uses

- Neutron scattering experiments to study structure of materials at atomic level
- Neutron activation for detecting presence of small amounts of material
Uses

- Radioisotope production
  - $^{90}\text{Y}$ from $^{89}\text{Y}$ for treatment of liver cancer
  - $^{99}\text{Mo}$ from fission of $^{235}\text{U}$ foil to produce $^{99m}\text{Tc}$ for nuclear medicine
Uses

- Industrial processing
- Neutron transmutation doping of silicon crystals
- Study changes resulting from intense neutron bombardment (e.g., embrittlement of steel)
Chicago Pile Reactors

CP-2
Zero Power Reactor

- zero-power full-scale reactor core mockup assemblies used to:
  - gain understanding of a variety of reactor concepts
  - assist in the engineering design of these reactor systems
ZPR-2, a heavy-water reactor, began operation in 1952 and was used in the development of the Savannah power reactors used for plutonium production.
Zero Power Reactor

ZPR-6, designed to advance fast reactor technology for civilian power use, went into operation in July 1963.
Central control rod

Small sample irradiation tube

Large sample irradiation tube

Beryllium annulus

Lower beryllium reflector
prime functions are to perform nondestructive elemental analysis and produce quantities of selected radioactive material for use in industry and medicine

SLOWPOKE laboratories have been utilized in a number of different fields such as:

- Trace element identification
- Radiotracer supply
- Forensic science
- Environmental analysis
- Radioactivity counting
Reactor Specifications

Type: Pool and Tank
Licensed limit: 20 kW
Fuel: Extruded Uranium/aluminum alloy
Moderator: Light water
Cooling: Convection/conduction
Core diameter/height: 22cm/22.1cm
Critical mass $^{235}\text{U}$: 816.664g
Fuel life: $6.4 \times 10^{19}$ nvt (at small inner sites)

Irradiation Parameters

Parameter | Inner Sites | Outer Sites
--- | --- | ---
Thermal flux | $1 \times 10^{12}$ | $0.5 \times 10^{12}$
High Flux Isotope Reactor

Pools and experiment facilities

1. BEAM HOLES
2. DEFECTIVE FUEL ELEMENT TANKS
3. REACTOR CORE
4. BEAM ROOM
5. EXPERIMENT ROOM
6. FUTURE SHIELDING BLOCKS
7. SCUPPER
8. SBHE DUCT
9. POOL COVER
10. REACTOR POOL
11. REACTOR BAY
12. PUMPS
13. HEAT EXCHANGERS
14. BRIDGE
15. FUEL ELEMENT STORAGE RACKS
16. INTER-POOL TRANSFER PLATFORMS
17. CLEAN POOLS
18. SLANT ACCESS EXPERIMENT FACILITIES
19. NEUTRON-CHAMBER THINIBLES
20. TOOL STORAGE PIT
21. PROVISION FOR CRITICAL FACILITY
Where to Get More Information


- IAEA Research Reactor Database
  http://nucleus.iaea.org/RRDB/RR/ReactorSearch.aspx?rf=1

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