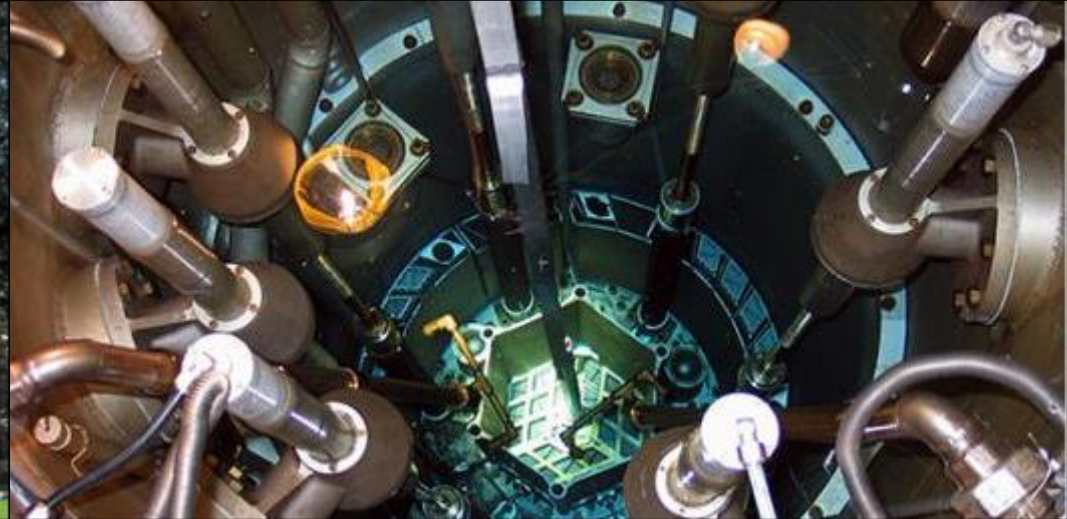




# MIT NUCLEAR REACTOR LABORATORY

*an MIT Interdepartmental Center*



## Application of the MITR Simulator for Licensed Operator Requalification and Training

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# MIT Research Reactor (MITR-II)

- MITR-I constructed 1956-1958
- Core and process systems redesigned for MITR-II
  - Light water cooled and moderated, heavy water reflected
  - First criticality on August 14<sup>th</sup>, 1975
- Primary/Secondary systems rebuilt in 2010 for relicensing and power uprate up to 6.0 MW
- Operates 24/7 except during scheduled outages
- 26 total licensed operators
  - 15 current/former students

[3]

# Overview of MITR Simulator

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- Developed with WSC, Inc
  - May 2021 - First unit
  - June 2022 - Second unit + 7 MW LEU MITR model to support fuel conversion
  - December 2022 - Hardware upgrade for touchscreens
- Benchmarked primary/secondary system RELAP5 input deck
- Validated point kinetic core model
- Empirical reactivity data
  - Calibration curves for control blades
  - fission product poison worth
- I&C circuitry and interlock logic

[1,4,5,6]

# Overview of MITR Simulator







# Previous Use

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- Public outreach and education
- Professional training courses
- MIT Nuclear Science and Engineering Department classes (UG/Grad)
- Independent Activity Period Course
  - Registration from students in 5 different departments
  - UG, Grad, Affiliate
  - Specific interest from AeroAstro for space propulsion and cyber security applications



# Operator Training

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- NRL initial training program and requalification program both meet the requirements of 10 CFR 55
  - Minimum required time performing shift duties
  - Specific reactor control evolutions
  - Demonstration of reactor physics, operating characteristics, transient behavior, alarm response
  
- MITR Maintains 20-25 licensed staff (RO/SRO)
  - Up to 5 student operators and 1-2 full time staff in training each yearly cycle

# Effects of Extended Outages



- MITR Operating cycle is typically ~10 weeks, followed by a 2-3 week outage
  - Quarterly requirements for calibration/surveillance that can be required for qualification
  - Quarterly OJT requirements for license maintenance
  - Limited opportunities for training startups and power manipulations
- Unanticipated extended outages lasting >3 months

<u>Year</u>	<u>Reason for Shutdown</u>	<u>Reactor Downtime</u>
<b>2010</b>	<b>Main HX replacement, power uprate</b>	<b>5 months</b>
<b>2020</b>	<b>COVID-19 closure, NSS upgrade</b>	<b>6 months</b>
<b>2023</b>	<b>Leak repair</b>	<b>&gt;6 months</b>



# Initial Training

- Areas identified as appropriate for simulator use, supplementation, or substitution
- Reduce burden on operations schedule
- Provide additional practice opportunities to trainees

## H. Shim Blade Calibration

1. Discuss the method used to calibrate the regulating rod and shim blades. \_\_\_\_\_
2. Demonstrate familiarity with the calculations used to convert “doubling time” data into integral and differential rod worths. \_\_\_\_\_
3. Draw, and indicate the scale of, the shim bank and regulating rod differential and integral worth curves. \_\_\_\_\_

PM 1.16.4  
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## J. Operational Training

On at least four separate occasions, participate in the scheduled “Operator Training”. This training should include raising and lowering reactor power in both automatic and manual modes, calculating thermal power settings and picoammeter readings for irregular power levels, determining reactor period by various methods, and changing reactor power on a given period.

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_

## H. Reactor Startup

In conjunction with the Startup Checklist, conduct the reactor startup four times, from all rods in to full power.

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_

## I. 1/M Startup

Perform a 1/M startup from full shutdown to critical without the knowledge of the ECP.

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[2,7]





# Requalification/OJT

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- Two year training cycle
  - Minimum of 10 reactivity control manipulations
  - Reactor startup
- Majority of technical and management staff maintain RO/SRO licenses but infrequently perform shift work duties
  - Opportunity to refamiliarize themselves with startup procedure
  - Perform startup as Operator on Console instead of Supervisor
- Monthly training lectures to ensure knowledge does not atrophy after initial training
  - Review changes to equipment/procedures
  - Training on systems with significant updates (ex: NSS upgrade, plume catcher)

[2,7]

# Licensed Operator Training



- First university research reactor to use a digital simulator for operator training
- Review of feedback mechanisms
- Interaction between reactor systems and core physics
- Demonstration of transient scenarios we would not practice on physical reactor



*Annual Reactor Physics Requalification training for licensed personnel, March 2023*

- Procedural prevention but not engineered controls (reliability concern, NOT reactor safety)
  - Cold slug accident by restarting a stopped secondary pump
    - Overcools primary, inserts positive reactivity, trips reactor off auto control
  - Xenon decay/burnout as reactivity insertion from precluded state
    - Startup procedure calls for “critical” at 50 kW on a +50sec period
    - Sitting with all absorbers full out leads to power increase, scram at 6.5 MW, shortest period 165 sec

[9, 10]



# Advantages

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- Accessibility
  - Outside restricted area, no dosimetry required
- Realism of interface
  - Outward resemblance of graphics, console layout
  - Instrument behavior matching closely with expected response
- Demonstration of hypothetical scenarios, expanded scope of training
- Quick reset, time control, initial condition change
- Generated interest → more engagement with routine retraining



# Next Steps

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- Official incorporation into training program
  - MIT Reactor Safeguards Committee review and approval
- Instructor training for new Training Supervisor
- Additional features added for specific training purposes
  - Neutron counters, facsimile logbook

# Acknowledgements

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Thank you, Questions?



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