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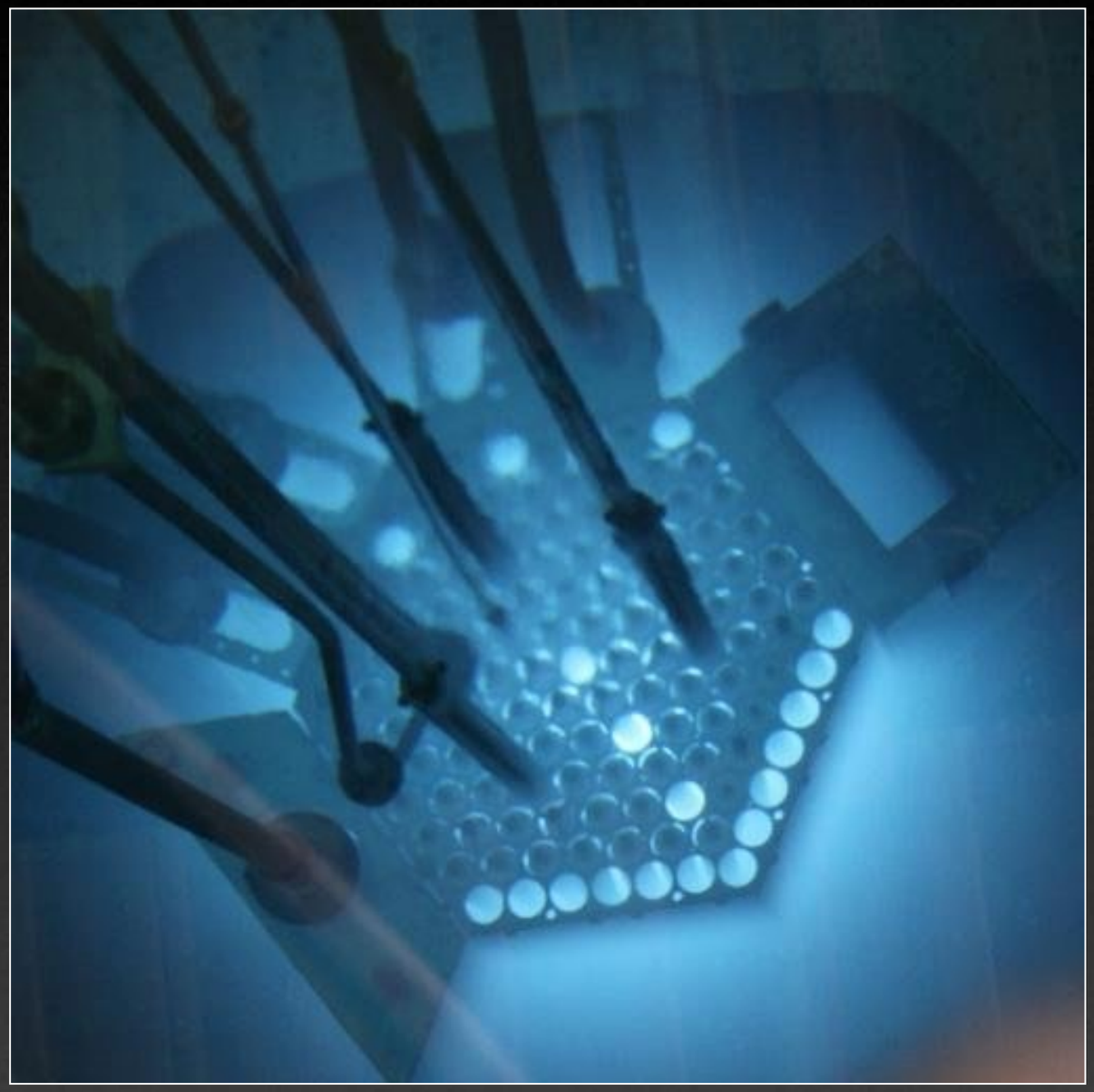

UUTR Modern Reactor Control Console Upgrade

Presented by
Amanda Foley

By Amanda Foley, Glenn Sjoden, Meng-Jen "Vince" Wang, Andrew Allison, Edward "Ted" Goodell

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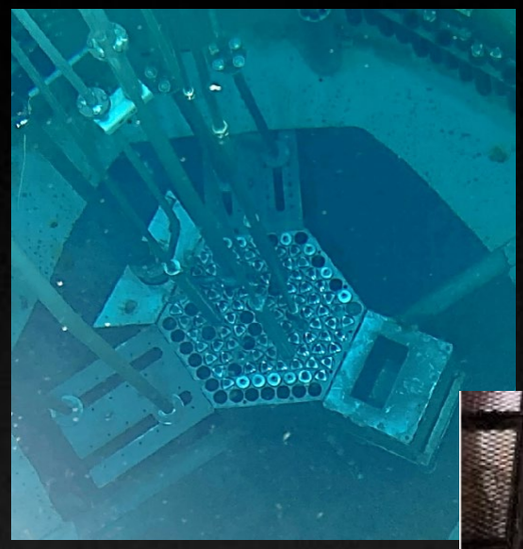
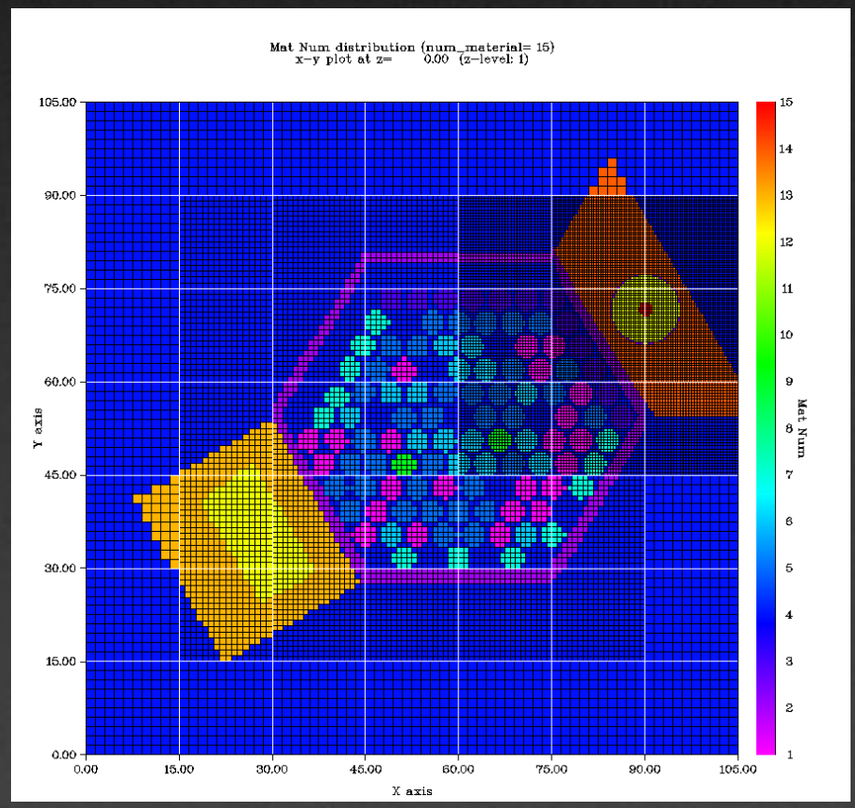
Overview

- Mark I TRIGA
- Introduction
- Old Console Removal
- TF Console Install
- Upgrades, HMI, ARMS
- Control Rod Rebuild
- Issues
- Lessons Learned
- Mission Complete – Fully Operational





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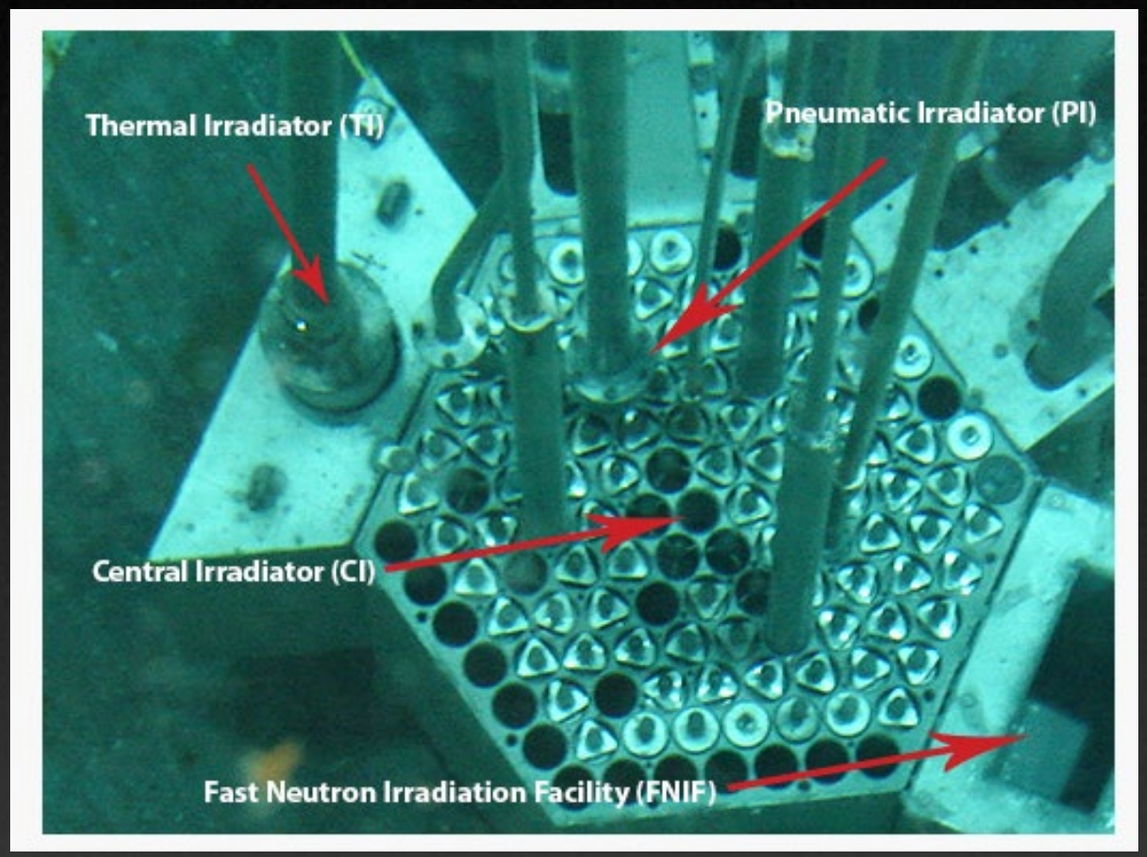
University of Utah's 100 kW Mark I TRIGA Reactor



Preliminary Electronic Dose data in Gray (Gy/s) @90kW:
neutron: 1 Gy(Si)/s (1s=1%)
photon: >30 Gy(Si)/s (f,g) & (n,g)

- U-Zr-H Fuel, <20% U-235
- Pneumatic rabbit system for irradiation of samples
- Central Irradiator
- Thermal Irradiator
- Fast neutron irradiator
- Several additional radiation ports available
- CI Mean Flux (n/cm^2/s) at 90 kW
  - < 0.625 eV: 1.35x10^{12}
  - 0.625 eV to ~1 MeV: 2.06x10^{12}
  - > 1 MeV: 7.56x10^{12}

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Introduction

MARK III Console

ThermoFisher Console

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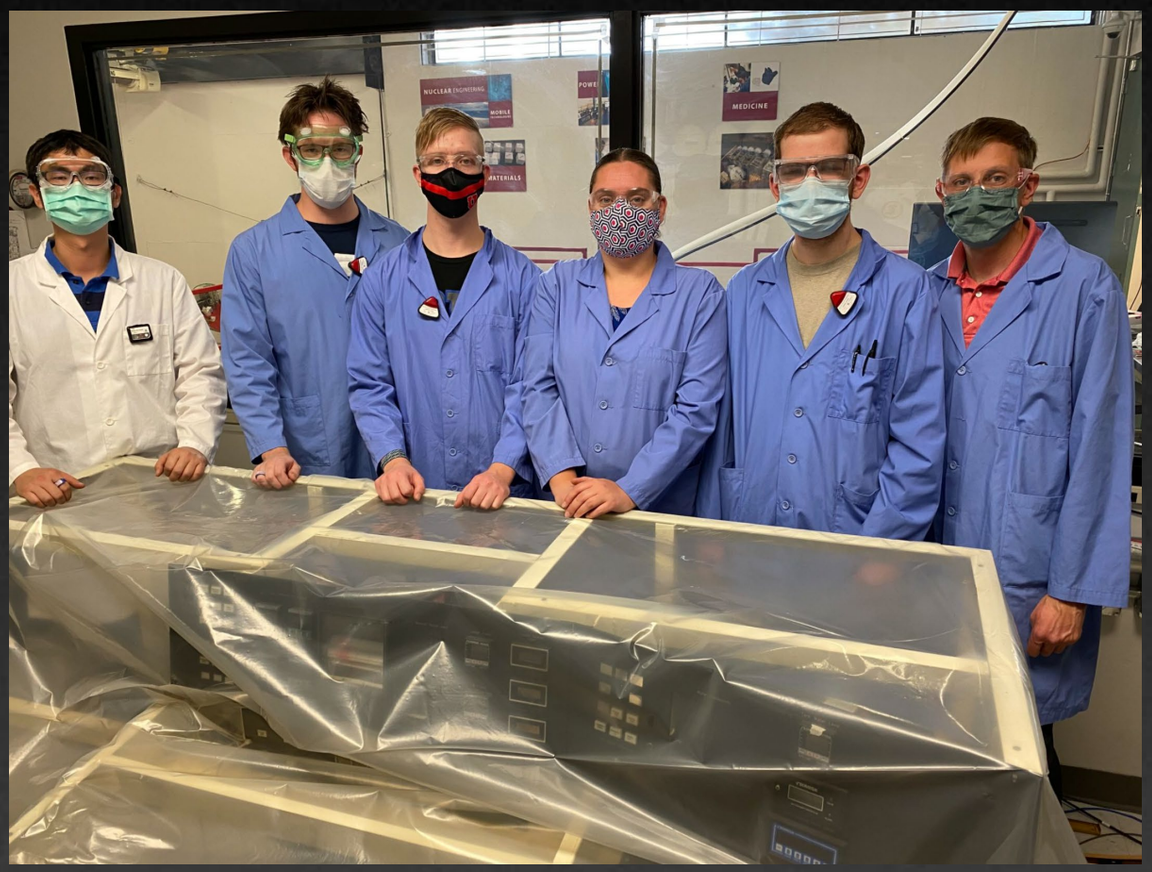
Mark III Console Removal



- Labeled and unplugged all support equipment from console
- Expected to be a simple “pick it up and move it process”
  - Door frames where too small to move console through in one piece
  - Console table section was removed to fit through the doors
- Sent to recycle

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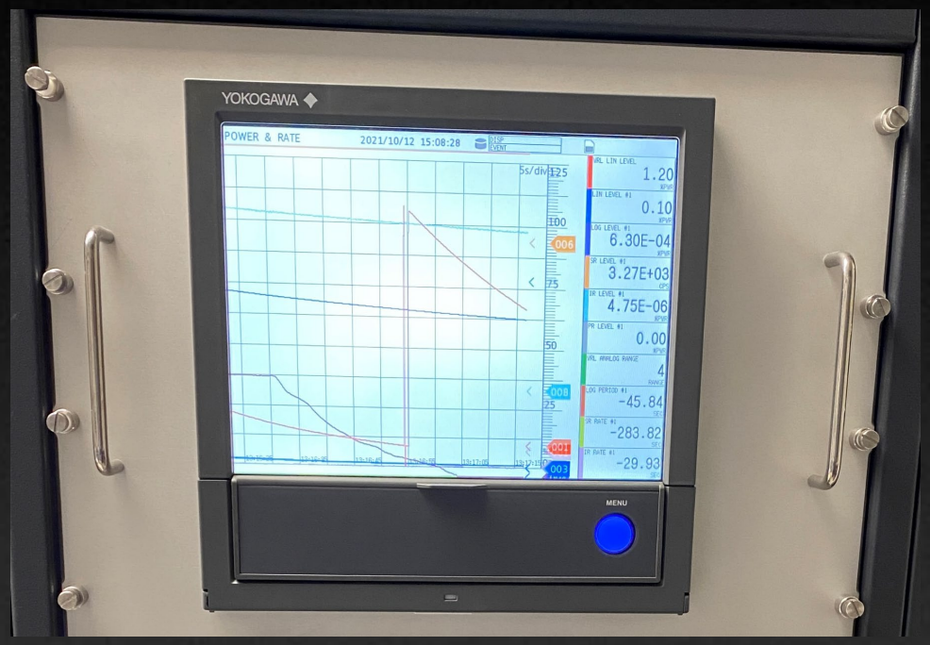
2020 Console Equipment Upgrades



Digital Chart Recorder

- Better Data Logging

Scram Logic & Magnet Power

- Digital convenience without changing safety systems

Auto Reg Rod Control

- Off the shelf replacement parts

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2020 Console Equipment Upgrades

← Console PLC

ARMs PLC →

- Easy integration of new support equipment with Groove Epic PLC – reprogrammable and expandable
- Ability to redesign HMI and connect additional sensor hardware if desired

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Human Machine Interface

Nuclear Engineering
COLLEGE OF ENGINEERING | THE UNIVERSITY OF UTAH

ROD CAL: RUN # 0 — START

RUN: RUN # 2,110 — 221.496 kWh — START — 3.929 HR

TOTAL: 238,358.4 kWh — 4,051.49 HR — Open Log Location

SCRAMS

LIN PWR HIGH | %PWR HIGH | HIGH FUEL TEMP | POOL LOW | MANUAL | NON-OP

DAMPER

ENABLED | DAMPER OPEN

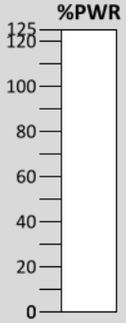
MAGNET POWER

OPERATE | RESET | OFF

NEUTRON FLUX

POWER RANGE

0.14 %PWR

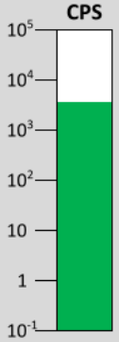


BISTABLES

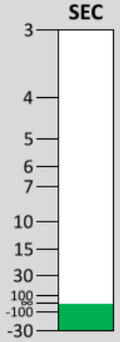
LIN PWR HIGH | LOW SOURCE COUNTS | NON-OP | CHANNEL IN TEST

SOURCE RANGE

3.392e+03 CPS

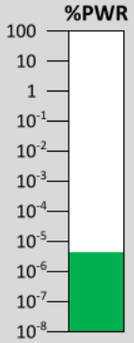


INF SEC



WIDE RANGE

4.74e-06 %PWR



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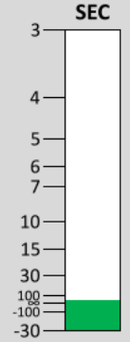
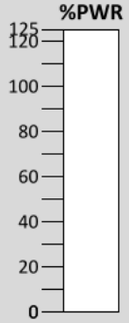


LOG AND LINEAR

POWER RANGE

-0.52 %PWR

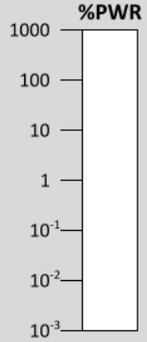


BISTABLES

LIN PWR HIGH | %PWR HIGH | NON-OP | CHANNEL IN TEST

WIDE RANGE

1.00e-03 %PWR



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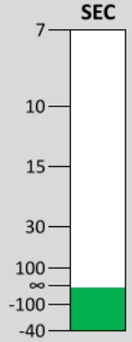
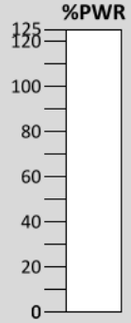


WIDE RANGE LIN.

POWER RANGE

0.42 %PWR



BISTABLES

LIN PWR HIGH | NON-OP | CHANNEL IN TEST

RANGE

10 mW | 100 mW | 1 W

10 W | 100 W | 1 KW

10 KW | 100 KW | 1 MW

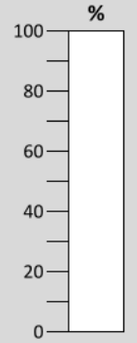
AUTO | MANUAL

FUEL TEMPERATURE

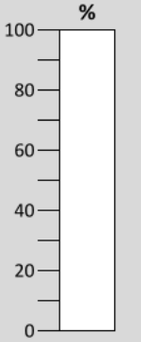
	SENSOR #1	SENSOR #2
TOP	29.8	25.2
MIDDLE	24.8	26.9
BOTTOM	25.5	25.0

ROD POSITION

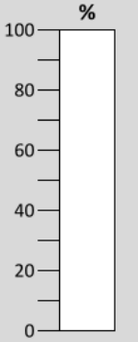
SAFETY 0.6 %



SHIM 1.0 %



REG 0.3 %



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10/12/2021

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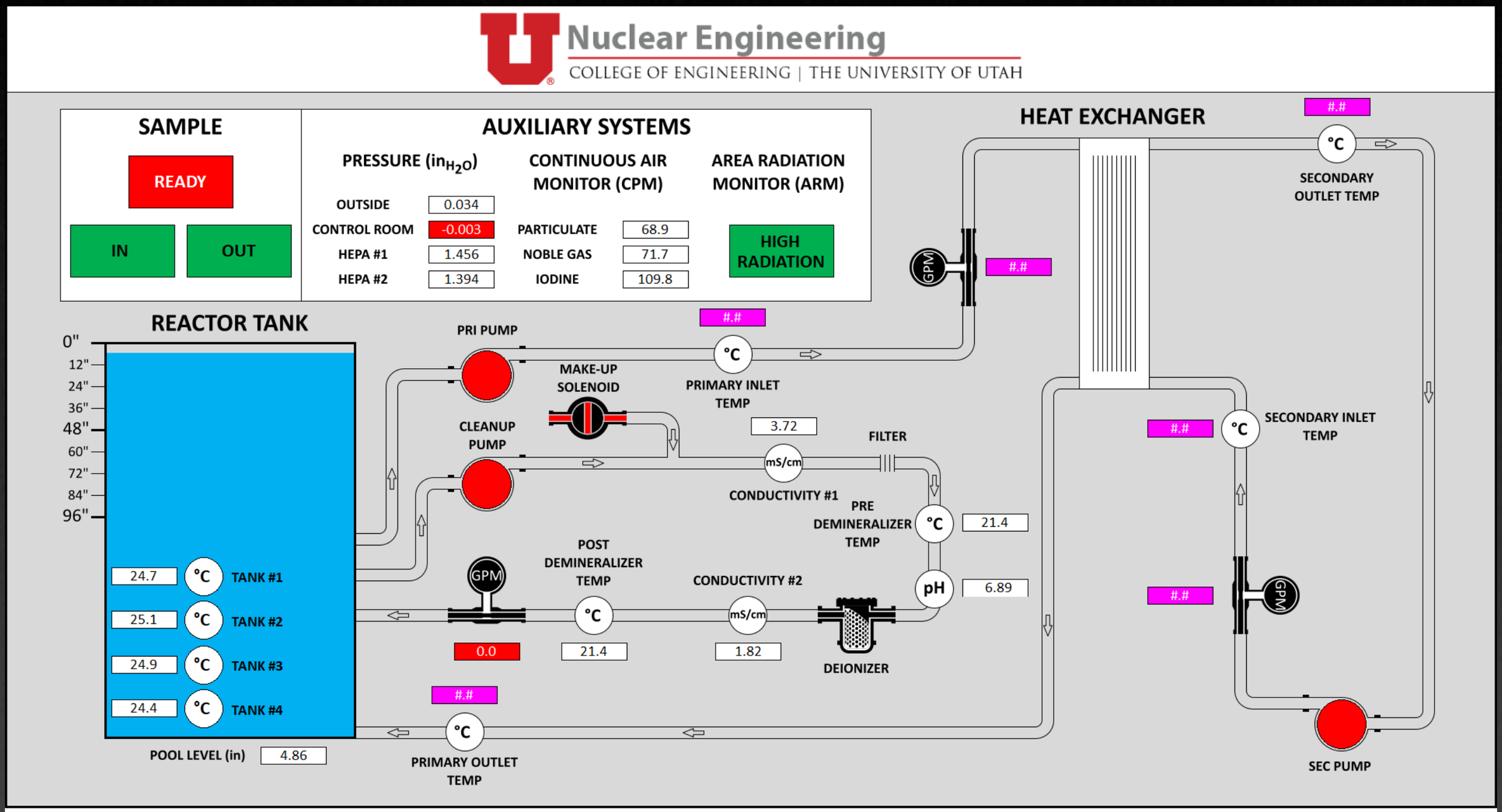
Human Machine Interface



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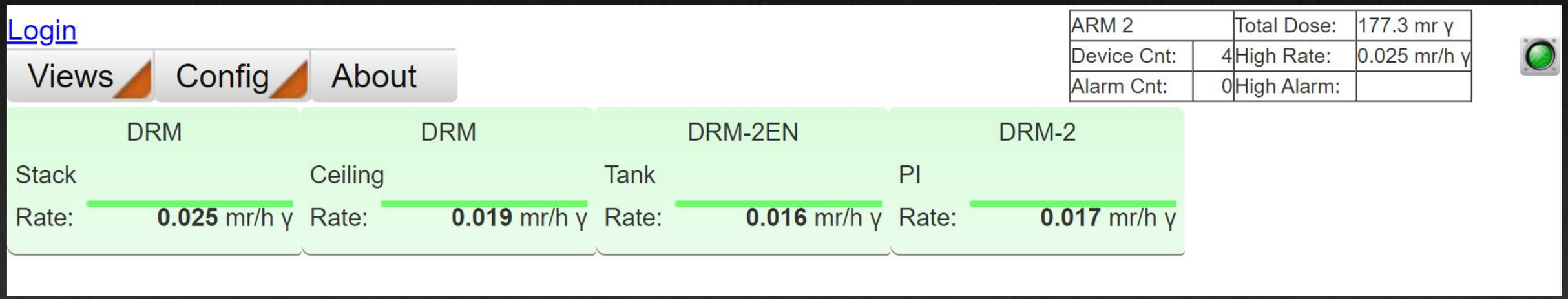
ARMs Teleview 3000 Display



- Ability to display ARMs readings outside of control room

Console Replacements/Upgrades

- SCRAM relay logic (still completely analog)
- Controller for control rods, magnet power, and interlocks
- Digital chart recorder
- Digital displays
- Ultra-sonic water sensor
- pH sensor
- Water float level alarms
- Damper wiring
- High radiation bell
- Air pressure gauges
- Conductivity sensors
- Water flow rate sensors
- Console lights are LED

Control Rod Drives

- Wiring diagrams did not match in service wiring.
- Attempting to integrate the Regulating Rod into the ThermoFisher console resulted in damage to the Auto Rod Control Board due to wiring fault.

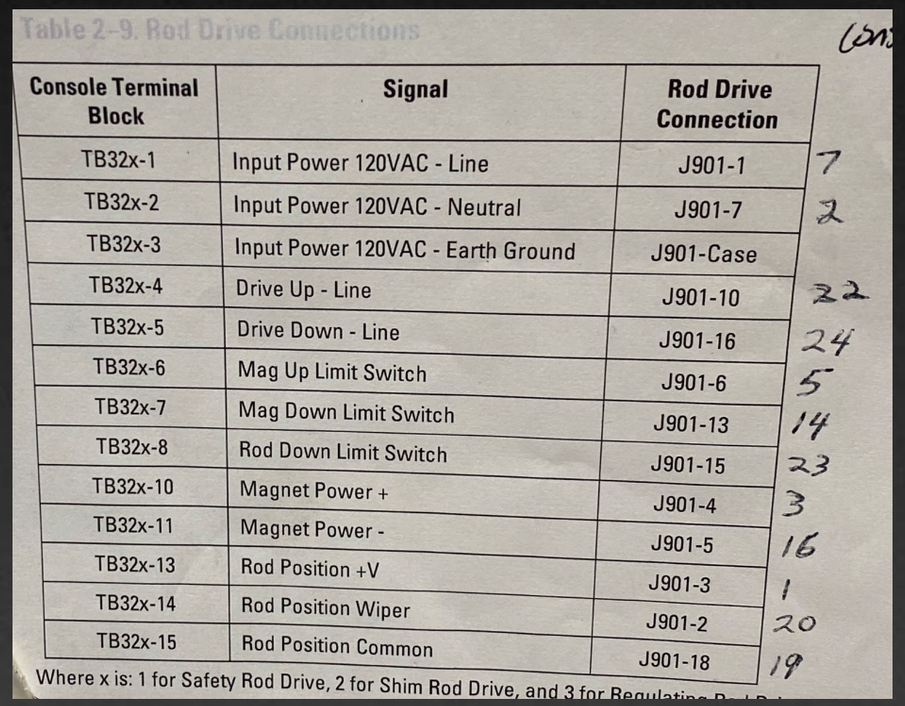


Table 2-9. Rod Drive Connections (Con

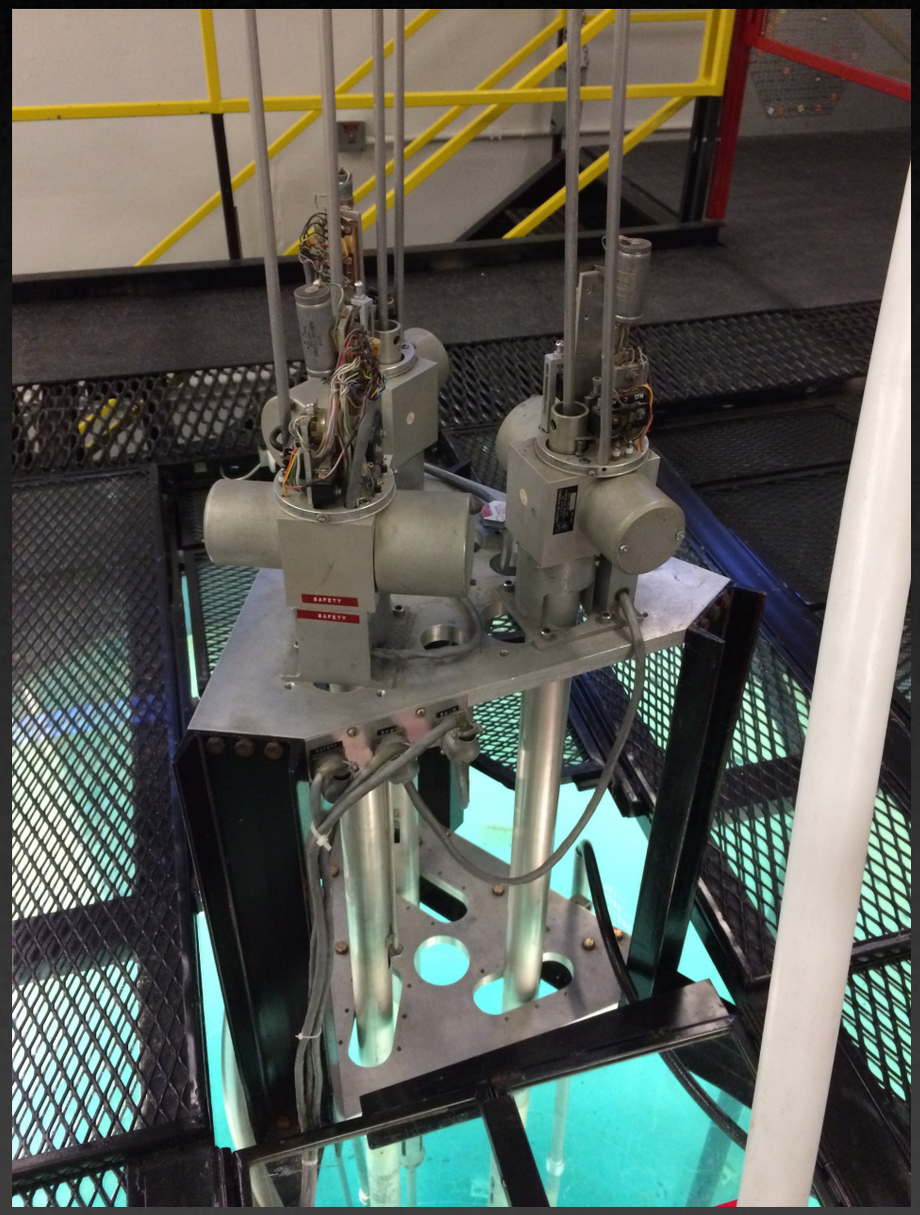
Console Terminal Block	Signal	Rod Drive Connection	
TB32x-1	Input Power 120VAC - Line	J901-1	7
TB32x-2	Input Power 120VAC - Neutral	J901-7	2
TB32x-3	Input Power 120VAC - Earth Ground	J901-Case	
TB32x-4	Drive Up - Line	J901-10	22
TB32x-5	Drive Down - Line	J901-16	24
TB32x-6	Mag Up Limit Switch	J901-6	5
TB32x-7	Mag Down Limit Switch	J901-13	14
TB32x-8	Rod Down Limit Switch	J901-15	23
TB32x-10	Magnet Power +	J901-4	3
TB32x-11	Magnet Power -	J901-5	16
TB32x-13	Rod Position +V	J901-3	1
TB32x-14	Rod Position Wiper	J901-2	20
TB32x-15	Rod Position Common	J901-18	19

Where x is: 1 for Safety Rod Drive, 2 for Shim Rod Drive, and 3 for Regulating

Control Rod Drives

- High voltage and low voltage were together on the same Amphenol connection
- Wire tracing was nearly impossible due to undocumented rewire

  - e.g... ten-turn potentiometer wiper wire was either moved or completely removed



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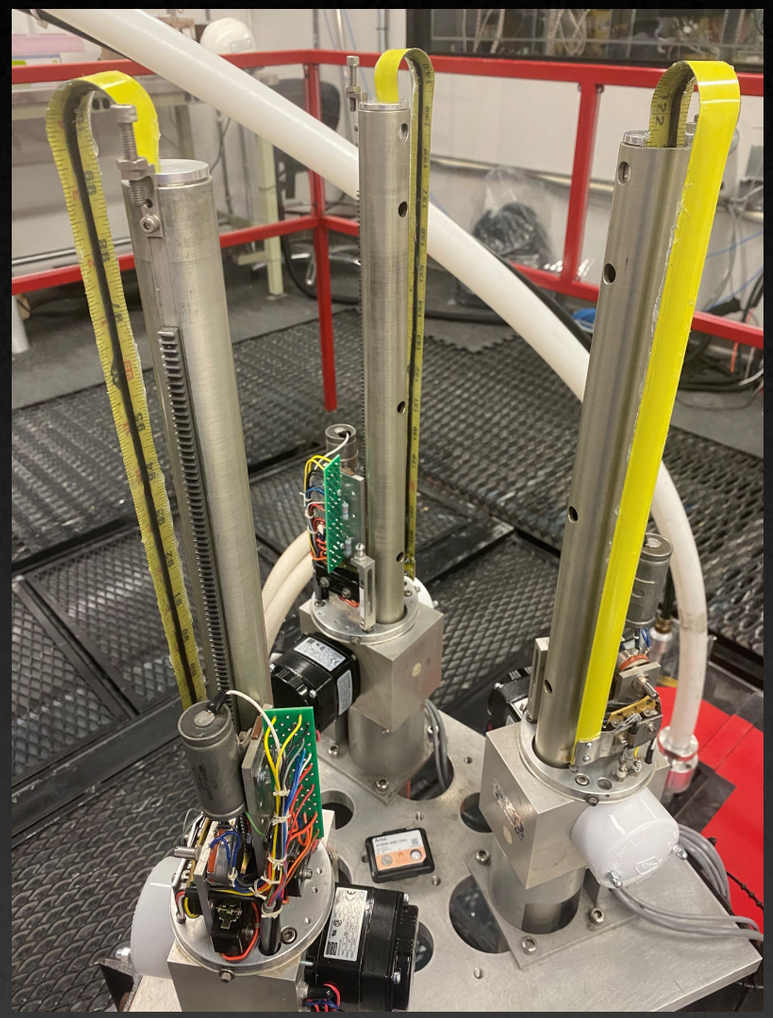
Control Rod Drive Rebuild



Replaced

- Draw tube sleeve bearings
- Pinion shaft outrigger bearing
- Resistors, Switches, Connectors
- Bodine motors in shim & safety rods
- A flexible guide and wire system

Steve Smith from **OSU** rebuilt all 3 control rod drives Nov/Dec 2020 and help install them Jan 2021; **Dave Leestma** from **WSU** also traveled to U. Utah and assisted in the re-wire/installation in Jan 2021– ***We are grateful for the dedicated assistance from OSU and WSU personnel for their valuable help!***

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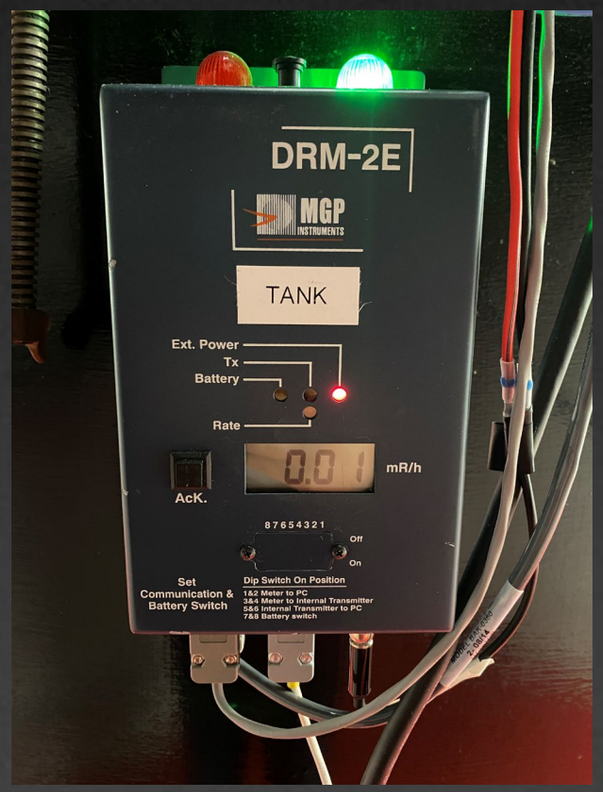
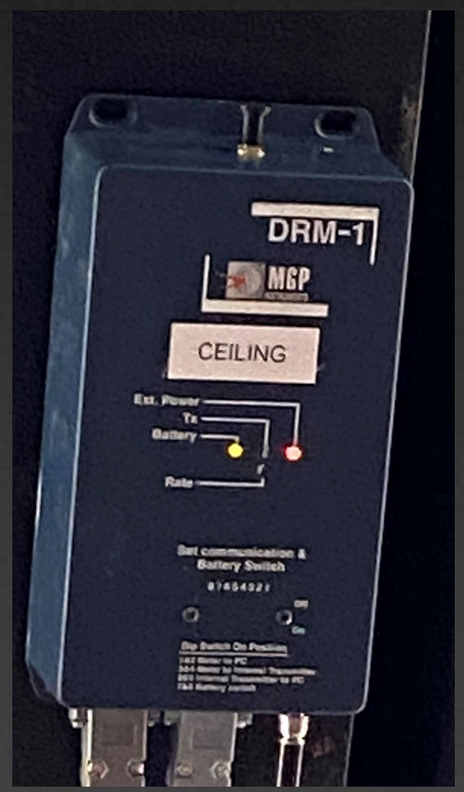
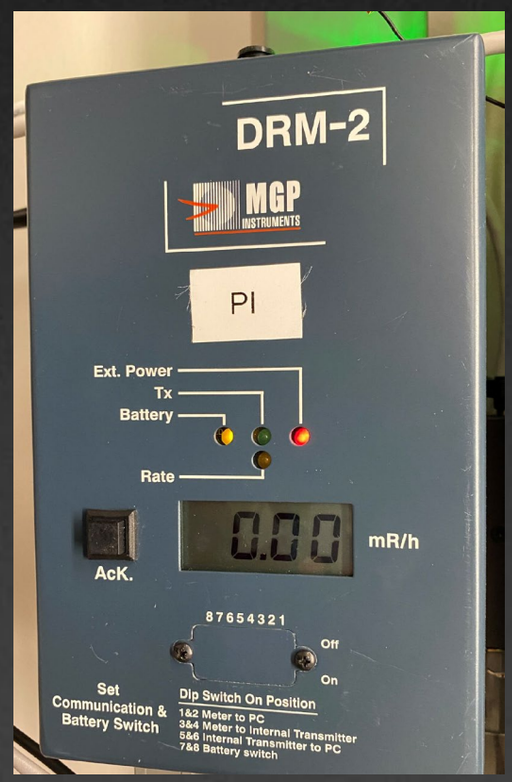
Area Radiation Monitor Update

- Replaced old ARMs with Mirion DRM-1/2/2E
- Integrated into the new console using Teleview 3000 and a Direct Logic 205 PLC for alarm state

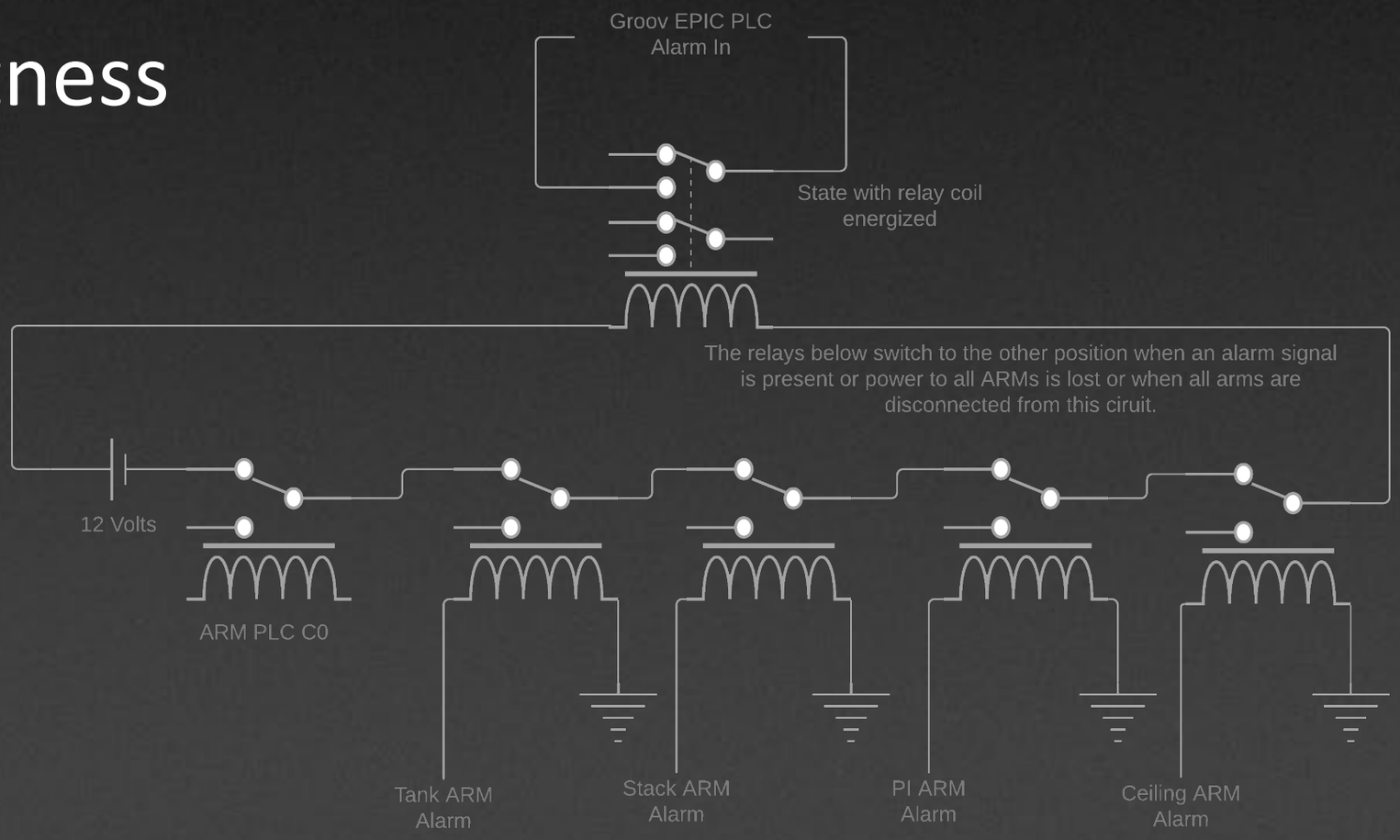






Area Radiation Monitor Issues

- Teleview and the Direct Logic 205 PLC would not always communicate the signal that switches the alarm relay state
- High rad alarm from detectors added to alarm loop for robustness



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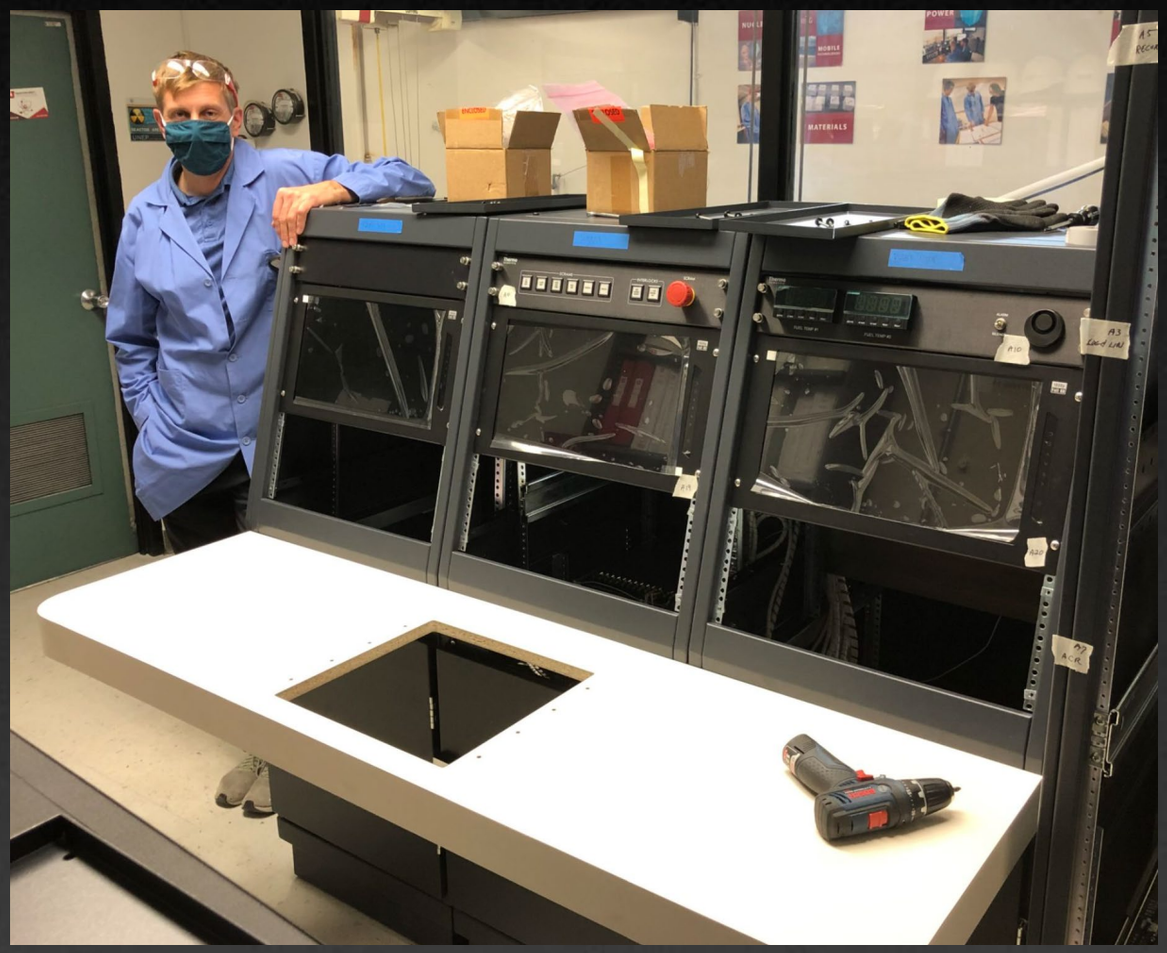
ThermoFisher Console Install

The Plan

- 2 weeks with ThermoFisher installation specialists

  -Includes training on new console

- Support equipment installed by facility staff



Console Install Timeline

- 1 month to defuel the reactor, and then disassemble/remove the old console
- 2 weeks with Thermo Fisher techs
- 2 months for all three UUTR control rod drives to be rebuilt
- An additional 3.5 months of troubleshooting, software modification, and calibration of sensors and monitoring systems, as well as completion of 10 CFR 50.59 documentation and approvals
- Control rod and thermal power calibrations performed through June and July of 2021
- The project timeline from disassembly of the old console to success with the first criticality in 2021 required a total of 8 months

Console Installation Challenges

- Control Rods improperly wired and needed to be rebuilt
- Auto Control Board damaged during install
- Connecting University security system to appropriate alarms
- Wiring the damper
- Incorrect understanding of legacy systems that still needed to be integrated into the new system
  - CAM – Lin interpolation was programed into human machine interface but needed log interpolation
- ThermoFisher wiring changeup in console—required correction

Lessons Learned

- 5 SCRAM indications is burdensome
  - Scram logic drawer
  - Power monitoring drawers
  - Console panel
  - HMI x2
- Make sure the drawers and the HMI are labeled the same
- Updated SOPs needs to be consistent with HMI and Drawer terminology

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Lessons Learned

- When integrating legacy systems, “quadruple check” the wiring!
- Label everything
- Know who the subcontractors are – PLC/HMI programmer—and obtain logic unit logins/passwords before human memories fade
- Make sure information is well documented and passed down through personnel changes.
- Purchase a fast computer for HMI so it updates faster than every 2 seconds when an input is made – e.g. raising control rods!
  …(cheaper is not always better!)
- Test equipment as soon as they arrive so that they can be replaced under warranty.

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Thank You to Everyone Involved

- Amanda Foley
- Steven Pappas
- Matthew Lund
- Glenn Sjoden
- Meng-Jen (Vince) Wang
- Codey Olson
- Ted Goodell
- Logan Forster
- Steve Smith (OSU)
- Dave Leestma (WSU)
- Dan Miller (TF)
- John King (TF)

Amanda.Foley@utah.edu

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Extra Slides

Timeline

1975 – Reactor went critical for the first time.

1995 – Mark III Console installed from UC Davis.

2010 – Ordered two uncompensated ion-chambers and one compensated ion-chamber with a $249,000 DOE Reactor Infrastructure grant.

Timeline

2015/2016

- Equipment failure caused a shutdown for almost one year due to failed fission chamber.
- Installed two new uncompensated ion chamber and temporary fission chamber.
  - Fission chamber cabling no longer compatible with console; therefore temporary NIMs rack used to monitor source counts.

Timeline

2015/2016

- Cleaned up reactor console wiring that was originally installed –needed overhaul due to noise/leakage currents.
- Received DOE Reactor Infrastructure grant for $433,563 to replace the neutron flux monitoring channels.

Timeline

2018 – Received DOE Reactor Infrastructure grant for $995,600 to replace reactor Control.

2018 – Received RIF grant for core facilities from Utah VP for Research -- $34,940 for Lynx multichannel analyzer, software updates, and radiation monitoring equipment.

2019 – Installed new compensated ion-chamber, new fission chamber, and new neutron power monitoring channels (power monitor drawers).

Timeline

Oct 2020 –Began install of new ThermoFisher console and replacement of air pressure gauges, ultra-sonic water sensor, water float sensor, pH meter, conductivity sensors, flow meters, area radiation monitors (ARMs), rewire damper and PI.

……

June 2021 –ThermoFisher console install completed.

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TR-40 Wide Range Linear Monitor

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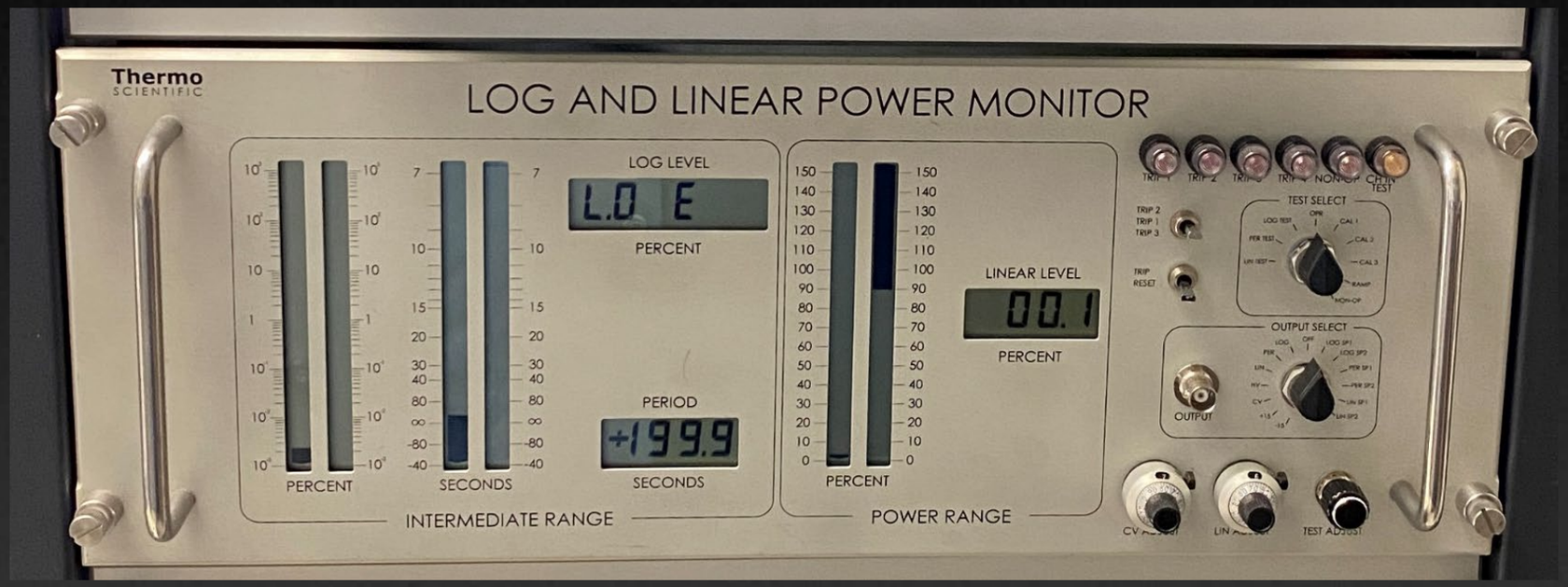
TR-20 Log and Linear



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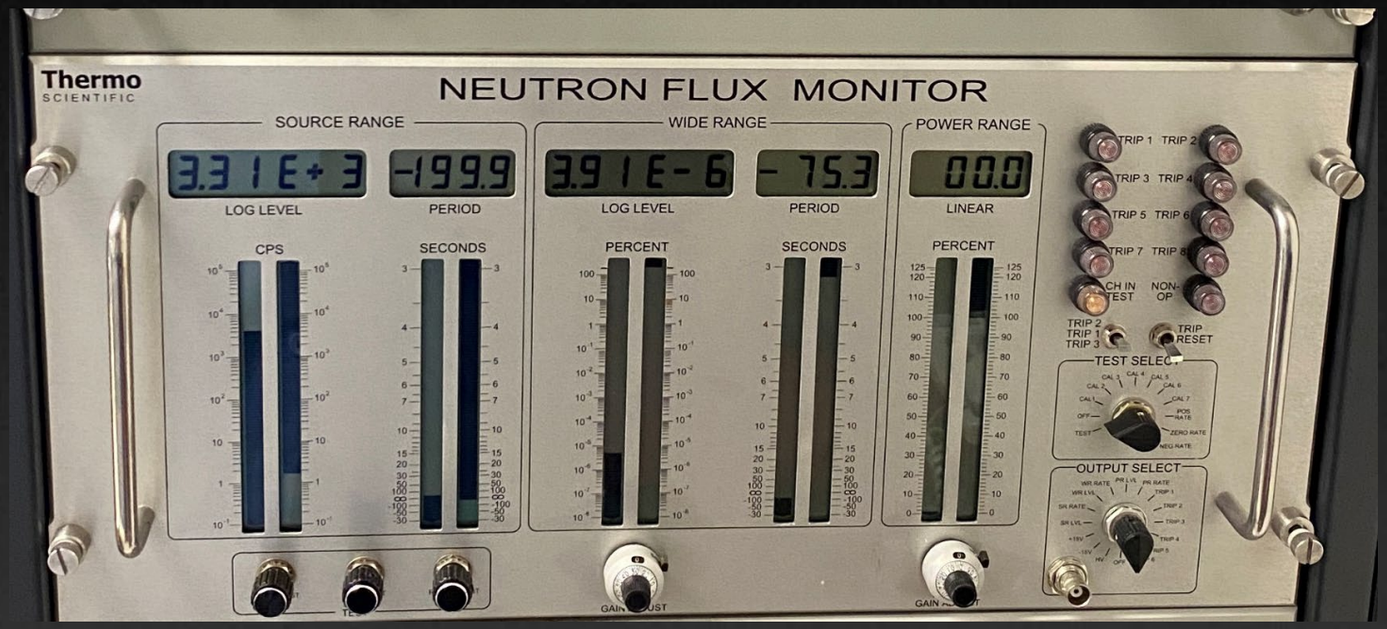
TR-10 Neutron Flux Monitor



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Personnel Changes

Reactor Supervisor

Andrew Allison (2021 – Present)

Amanda Foley (2021 – Present)

Steven Pappas (2021 – 2021)

Matt Lund (2017 – 2020)

Ryan Schow (2014 – 2017)

Director

Dr. Glenn Sjoden (2020 – Present)

Matt Lund (2017 – 2020) Interim

Ryan Schow (2016 – 2017) Interim

Dr. Tatjana Jevremovic (2009 – 2016)

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CAM Blower Replacement

Old Blower

New Blower

- CAM Blower was leaking / not serviceable
- The CAM blower Universal RAI blower model 22U-RAI was replaced with a Howder Roots blower model 22U-RAI.