MARVEL Instrumentation and Control

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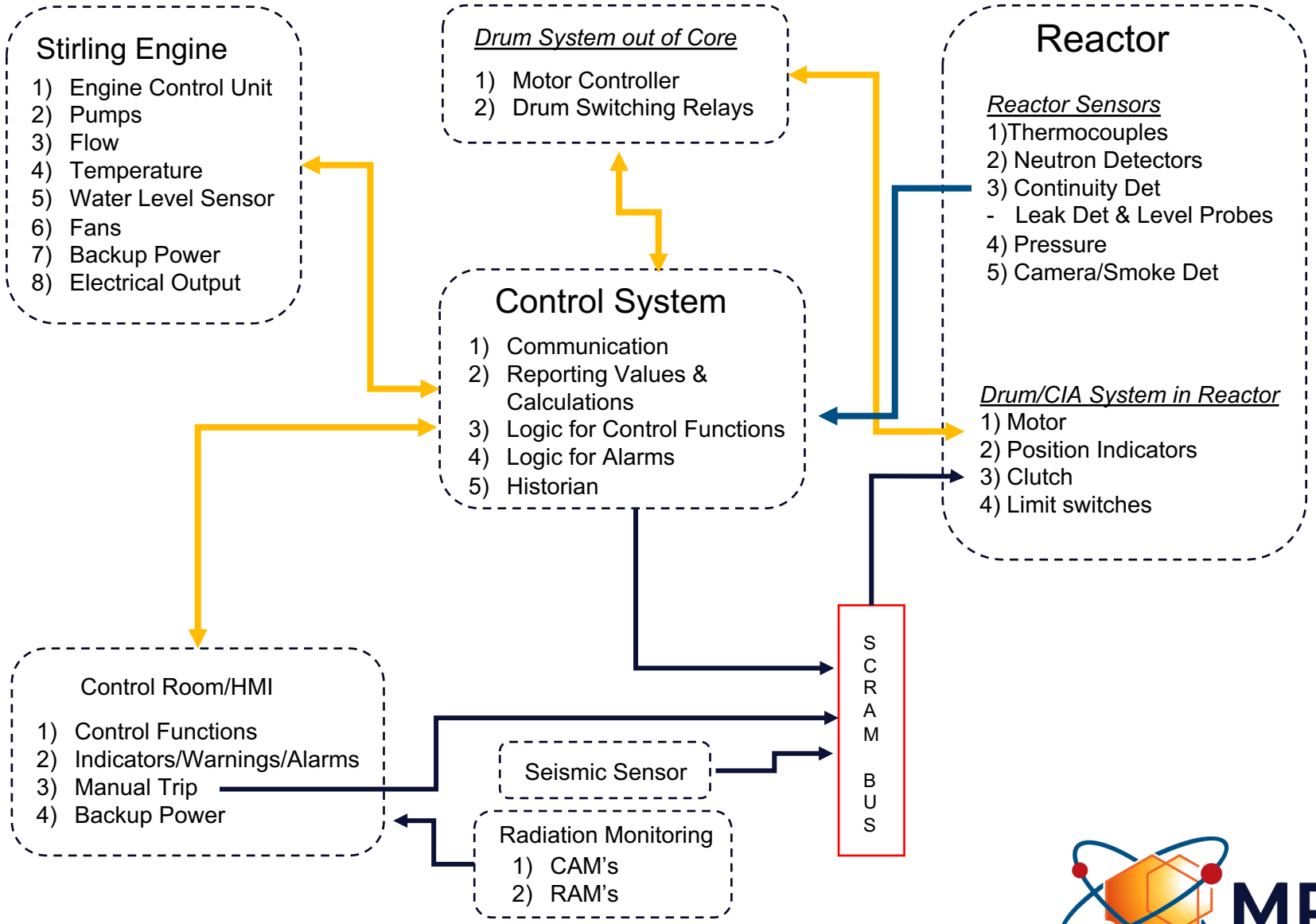
Instrumentation & Control Overview

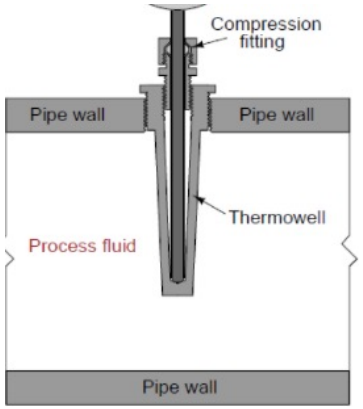


MRP Microreactor Program

Instrumentation Overview

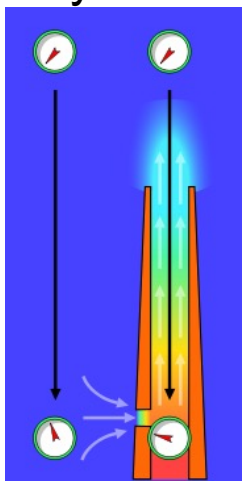
Sensor(s)	Purpose	Locations	Other Info:
Thermocouples	Temperature Reactor Power NaK level	Several on the primary loop, secondary confinement, BeO Reflector, Cooling air on the vessel, temperature on the heater rod.	MI cable

Thermowell

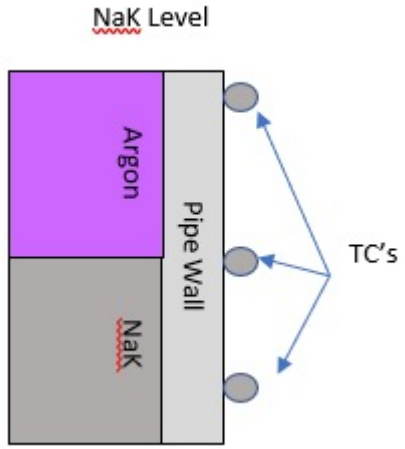


Weld pad – Outer Walls

Temperature should predict power for natural convection at Steady State



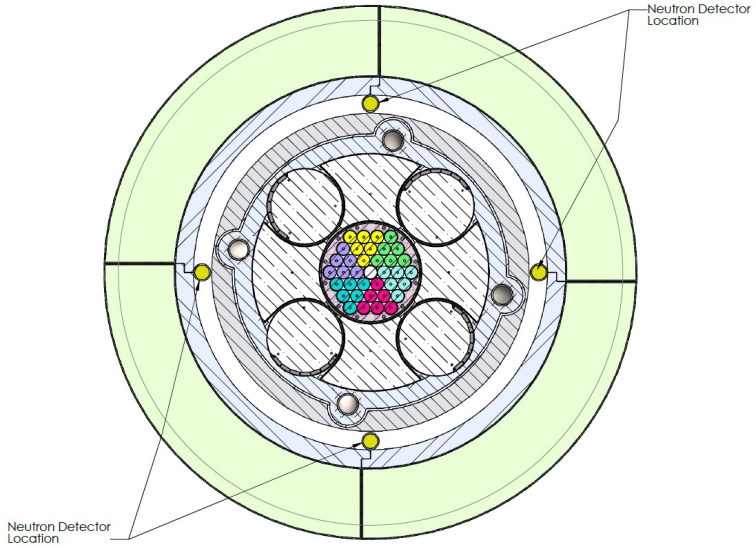
$$Q = m \cdot C_P \cdot dT$$



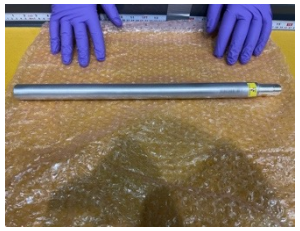
MRP Microreactor Program

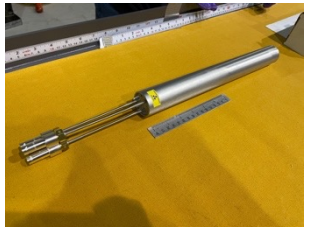
Instrumentation Overview

Sensor(s)	Purpose	Locations	Other Info:
Neutron Detector System	Dynamic Power Response	4 tubes parallel to the NaK downcomers centered near the core centerline.	Inserted from the bottom of the pit. Variable carriages (poly & cadmium) and/or position to adjust readings. Off the shelf signal conditioning equipment and MI cable. Sensitive to vibration & cable properties.



Pu-LI (at ZPPR)
~1E6 n/sec
SS 1”OD x 2” OL





MRP Microreactor Program

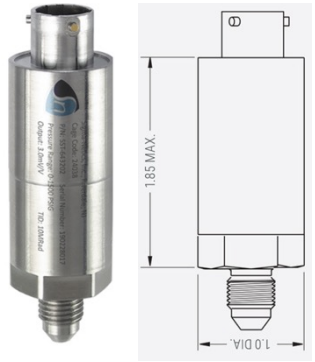
Instrumentation Overview

Instrumentation needing to be integrated with manufacturing

Sensors On or Near the Reactor			
Sensor(s)	**Purpose**	**Locations**	**Other Info:**
Continuity Principle	NaK level	Upper Plenum on the top head	MI Cable with sheath over probes to prevent continuity with other metals.
	Leak Detector	Bottom of Secondary Confinement	
Pressure	Pressure	Tap on primary for two sensors. Tap on secondary.	Must be angled and temperature kept between (100 to 250°C). Low Pressures 0 to 70psig (operation).
	Fill Gas Inlet at manifold		
Heater Rod	Melt LBE loop	Central Tube	Able to be replaced if broken, load is in the range ~1.5 to 3kW
Smoke Detector and/or Camera	Leak Detector	On the chimney above the upper flange.	Must be <70°C
	Visual		

Continuity

Pressure 0 – 100 psig



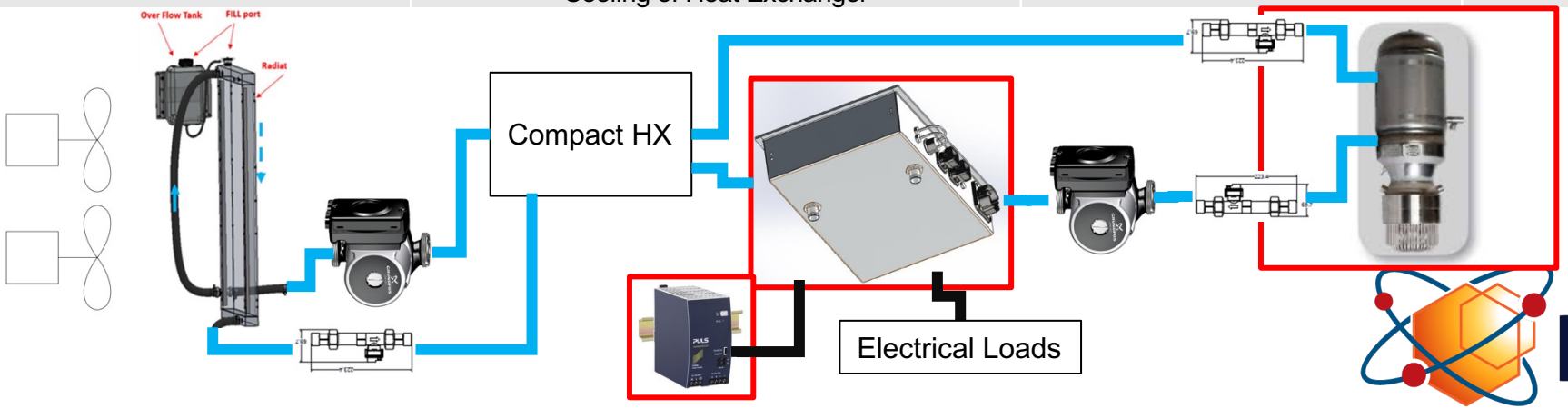
2.5 kW Heater Rod (PCAT spare)

MRP Microreactor Program

Instrumentation Overview

Instrumentation Outside of Reactor System

Engine System			
Component	**Purpose**	**Locations**	**Other Info:**
Engine Control Unit	Sets Engine Parameters Reports System Parameters CANBus connection to User Electrical Connections to Load Break Resistor	Side Wall	Off the Shelf/Supplied by Vendor
Flow/Temperature	Flow Temperature Reactor Power	Primary Engine Cooling Loop and Secondary Engine Cooling Loop	Off the Shelf/Supplied by Vendor. Secondary method for power determination.
Pumps	Produce Flow	Primary Engine Cooling Loop and Secondary Engine Cooling Loop	Off the Shelf/Supplied by Vendor
Heat Exchanger	Transfer heat	Compact heat exchangers on Primary Engine Cooling Loop, Larger heat exchangers to outside air	Off the Shelf/Supplied by Vendor
Level probe	Water level	Secondary coolant loop	Off the Shelf/Supplied by Vendor
Fans	Cooling of Heat Exchanger	Secondary coolant loop	Off the Shelf/Supplied by Vendor



MRP Microreactor Program

Instrumentation Overview

Instrumentation Outside of Reactor System (continue)

Control System			
Component	**Purpose**	**Locations**	**Other Info:**
Data Acquisition Chassis, Controller & I/O Cards	Robust, real-time data acquisition and control using signal I/O, and communication protocols	TREAT I&C Room or Room next to the Pit	Off the Shelf Equiptment
User Interface	Interface between the user and the Controller	Local display by the DAQ and TREAT Control Room	Off the Shelf Equipment
KVM	Remote Control of User Interface	Local I&C Cabinet and TREAT Control Room	Off the Shelf Equipment
Diesel Generator Connections	Backup Power for Long Term	Near the I&C Cabinet	Cannot be attached to the SCRAM components
Battery Backup (UPS)	Backup Power for Short Term	In the I&C Cabinet	Cannot be attached to the SCRAM components
Radiation Sensors	Report radiation levels near the reactor	Outside the Pit on the walls	Off the Shelf Equipment
Seismic Sensor	Scram Reactor if there is a seismic event	I&C Cabinet	(Safety Related)
Manual Scram Buttons	Manual Scram Buttons	Local Reactor Scram & Control Room	(Safety Related)
Monitors/cables etc.	All other parts to make it work	Varies	Off the Shelf Equipment

MRP Microreactor Program

Technological Gaps & Development Focus

- Power Measurement
  - PCAT to validate methods
- LBE Freezing
  - PCAT to validate
- Neutron Detection
  - Vibration from Engines
    - Decouple neutron detectors from the rest of the structure
  - Suitability of COTS signal conditioning equipment and custom MI Cables
    - On paper should work fine
    - Simple tests in TREAT to prove operation
  - Neutron Source
    - Requires iterating after core design changes
- QCANbus protocol (Depends on the path)
  - Driver development for integral control with operator's interface and control system logic.
- Specifics on vendors and manufacturing processes
  - Investigate Possible Non-Metallic material for contact with NaK (Dielectric in level probes or leak detectors)
  - Requires time to determine specifics

MRP Microreactor Program

Development Timeline

- **Sensors design document** by (April 2022)
- **90% Final design** related to the reactor structure for procurement and construction (July 2022)
  - All other systems are independent of structure manufacturing
  - I&C Interim Design Review (March 2022)
  - Purchases for on reactor components (~Aug 2022)
- **Software Development and Qualification** of all systems before fuel arrives (July 2023)
- **Purchases for off reactor components** (~Aug 2022)

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