



MIRION
TECHNOLOGIES

Radiation. **Safety.**

Designing a Digital Control System for Purdue University

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August 25, 2016

18 Slides

MGP*i***H&B**



Reactor Control System Replacement

Budget

- **DOE - Nuclear Energy University Programs Award of \$1,276,812**
- Purdue University will replace its existing Instrumentation and Control systems with modern technology that will reduce unscheduled maintenance downtime, increase the availability and improve the safety of the reactor for use in its education, training, and research mission.

Basic Criteria

- Fully operational reactor control and reactor safety system capable of operating the reactor from 0% power (shutdown) to 100% power.
- Full control rod insertion from upper limit to lower limit in less than 1 second following a SCRAM signal by the operator or reactor protection system.
- Operational reliability at 99% up time.



proTK™ Neutron Flux Monitoring System



- 60 years of combined experience
- > 26 years of operational experience without any software failure in digital measuring channels
- Supplier of more than 1,000 installed safety system monitoring channels for NPPs and research reactors

✓ **Planning**
✓ **Design**
✓ **Engineering**
✓ **Installation and Set up**

✓ **Production**
✓ **Training**
✓ **Maintenance**
✓ **Onsite support**



proTK™ Neutron Flux Monitoring System

Applications

- Operational process monitoring
- Measurement and monitoring of neutron flux density including Start-up range, intermediate range and power range
- N16 power monitoring



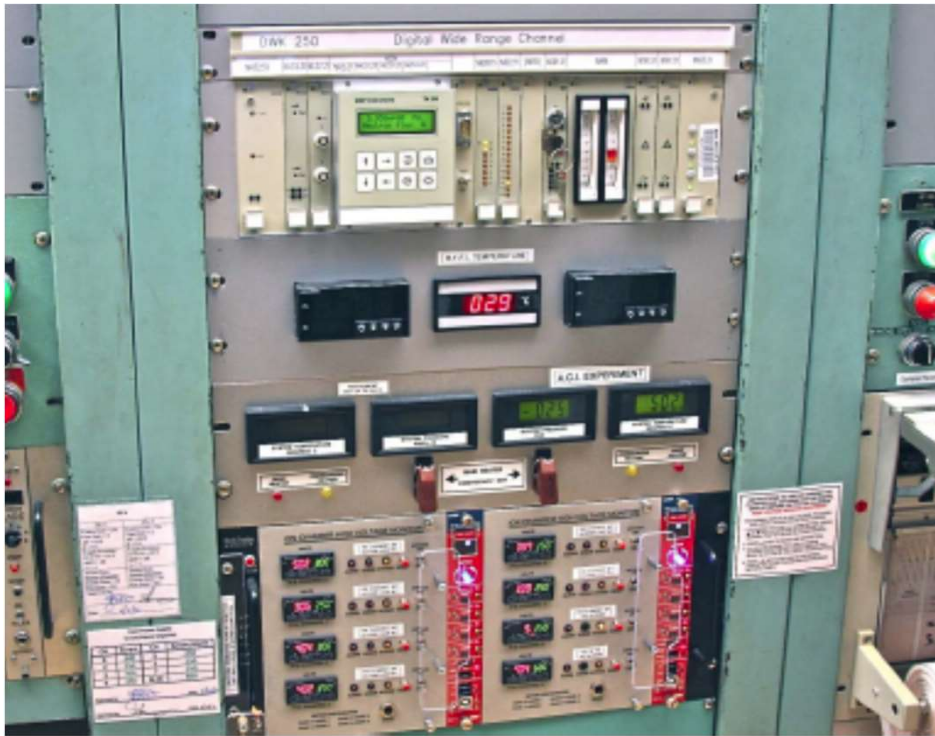
Digital reliability!

Major attributes

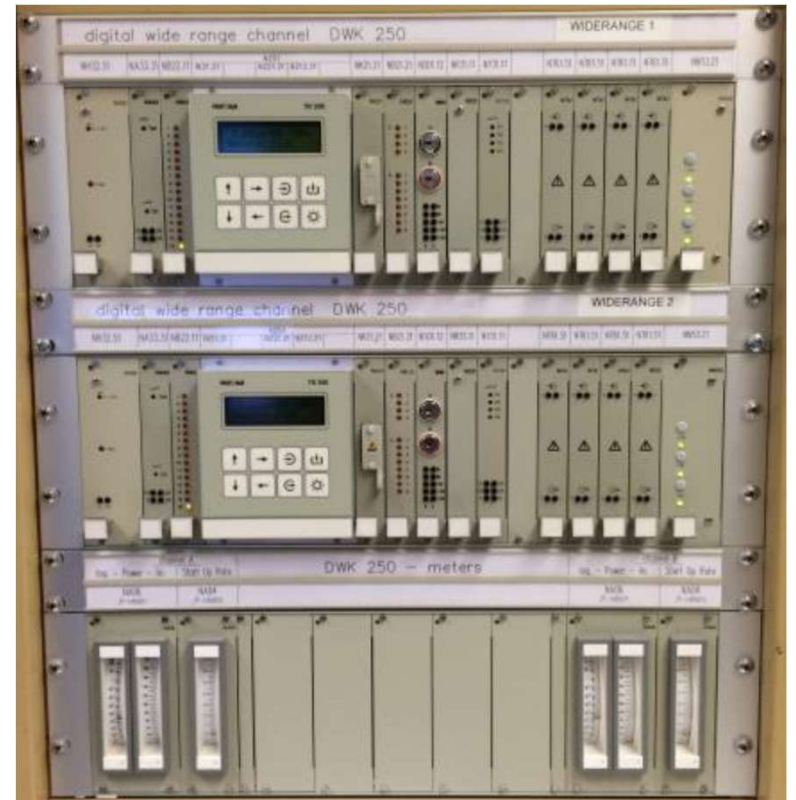
- Modular construction
- Versatile applications
- Robust and reliable
- Proven by operational experience
- Use extensive detector
- Design and manufacturing
- Highest level of safety and reliability
- Type test qualified and proven through excellent operational experience.
- Reactor protection system in accordance with IEC 61225 cat A



Recent Installations



MIT Nuclear Reactor
Laboratory



SANDIA Laboratory

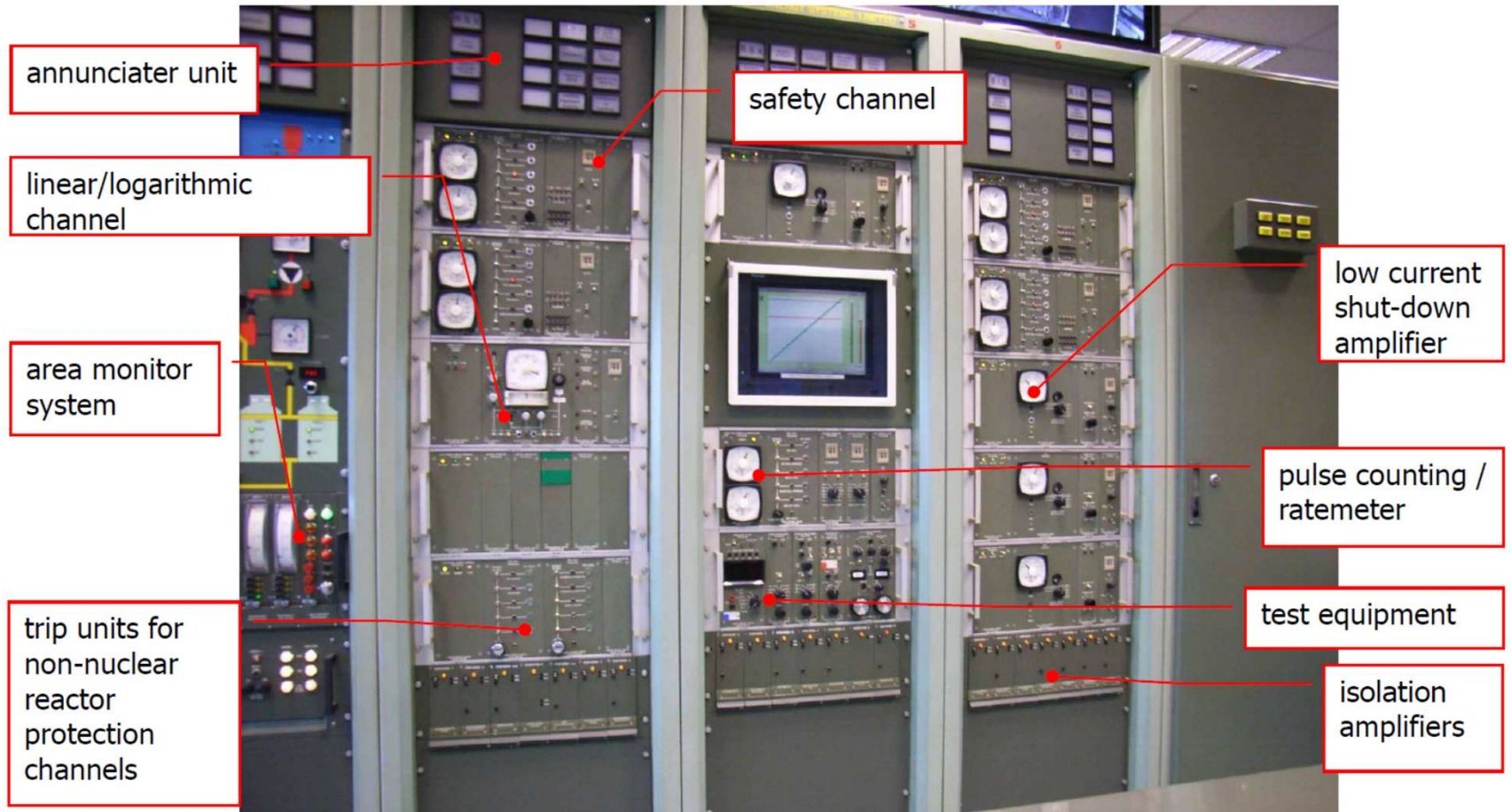


Control Room Prior to Upgrade at University of Delft, Netherlands



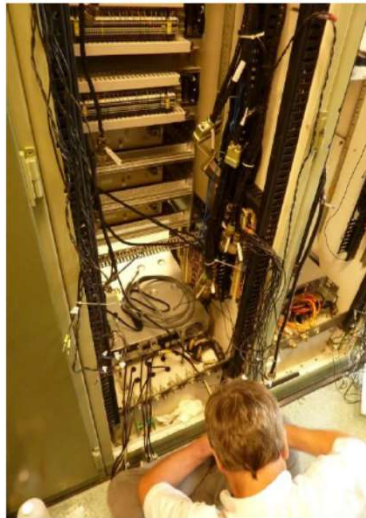


Existing Equipment to be Replaced

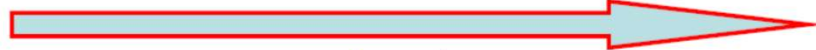




Schedule of Installation



Start
Removing
Old equipment



4 weeks

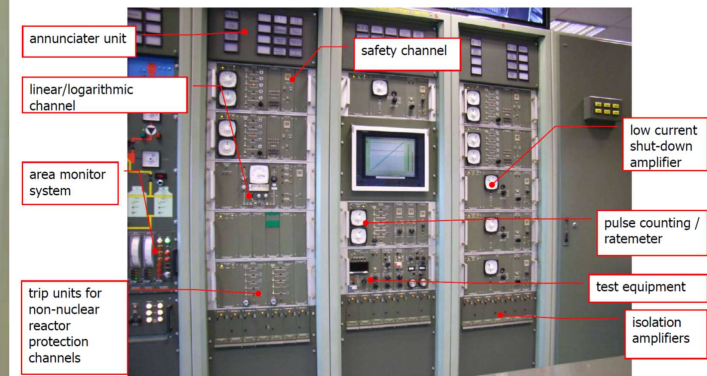
Site Acceptance
Test



Functioning System at University of Delft, Netherlands



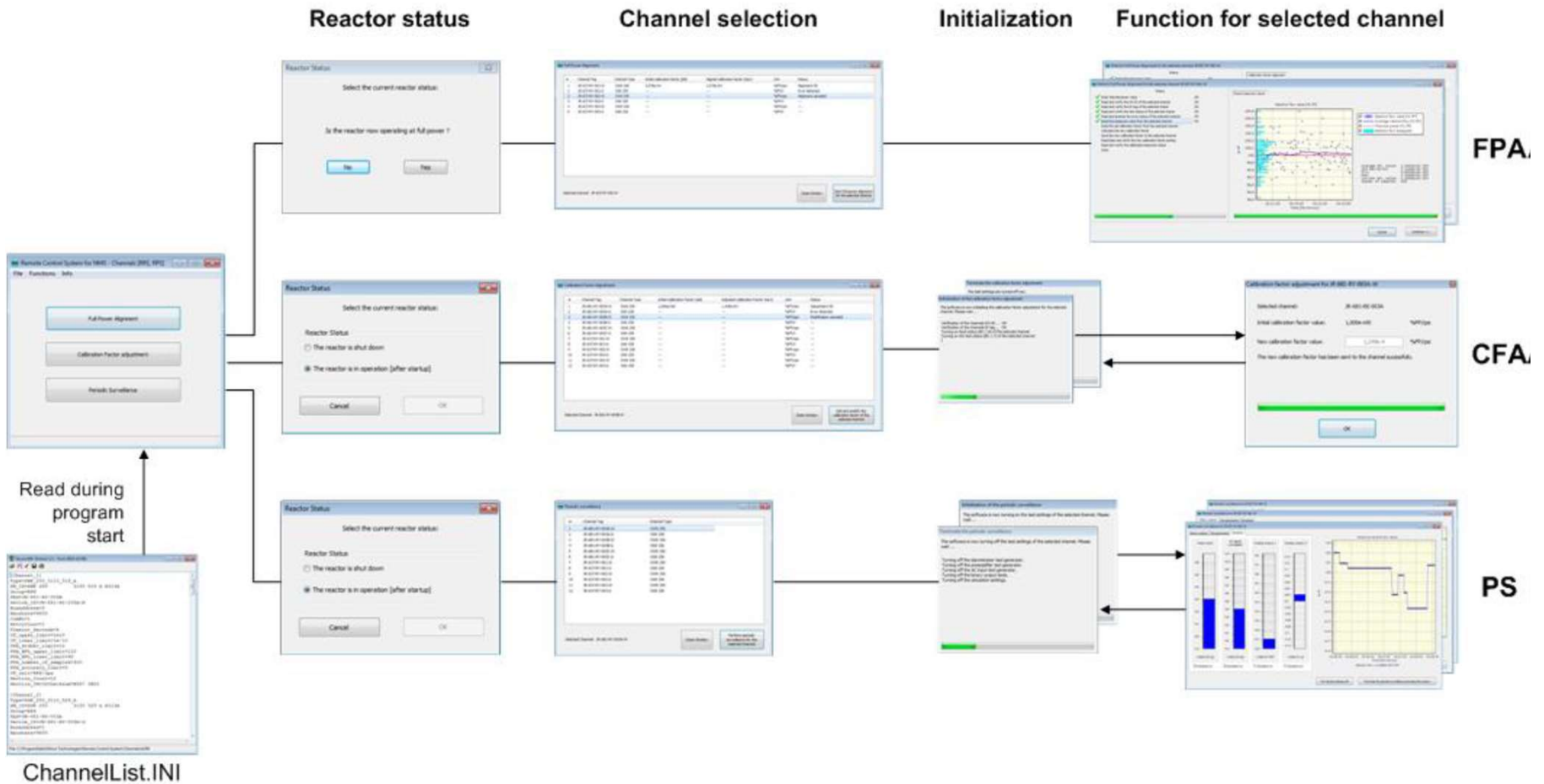
Final Installation



Replaced
Equipment

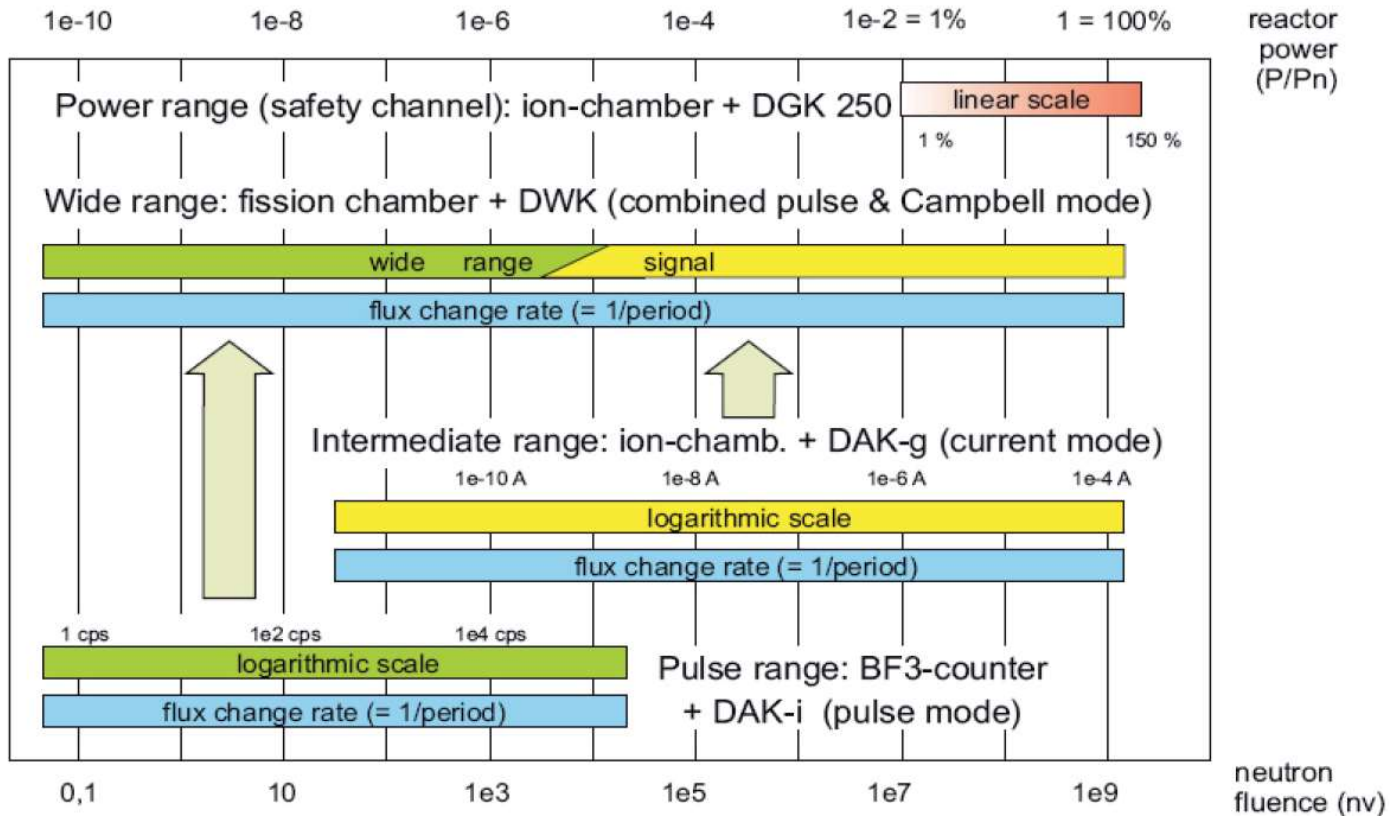


Software Structure - HMI



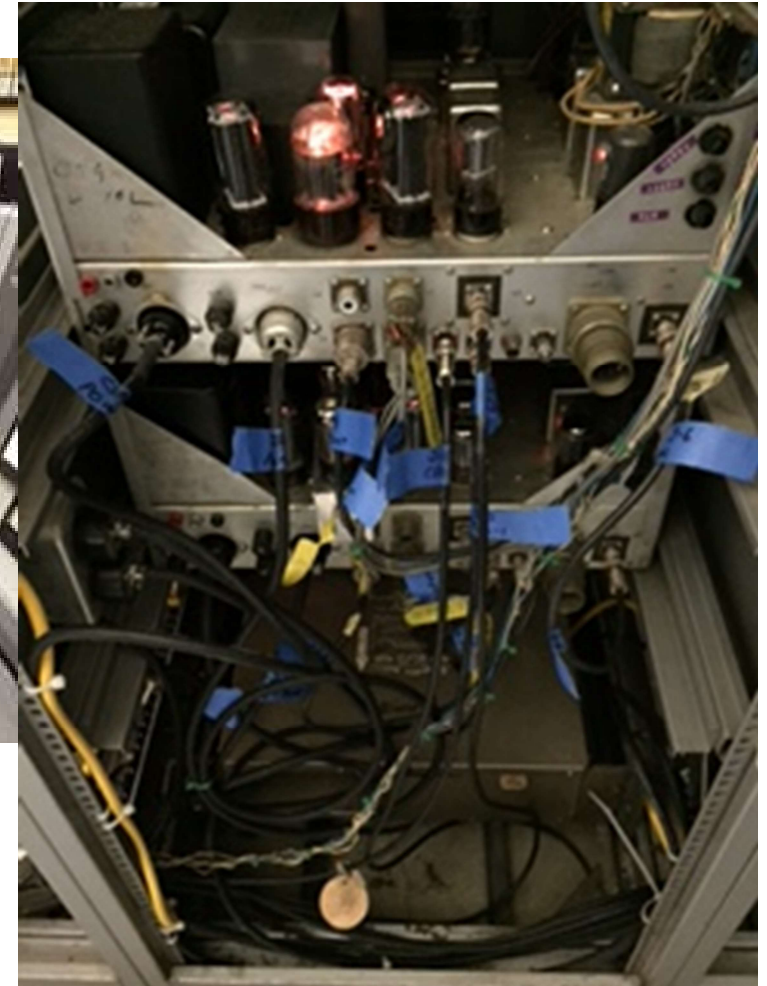
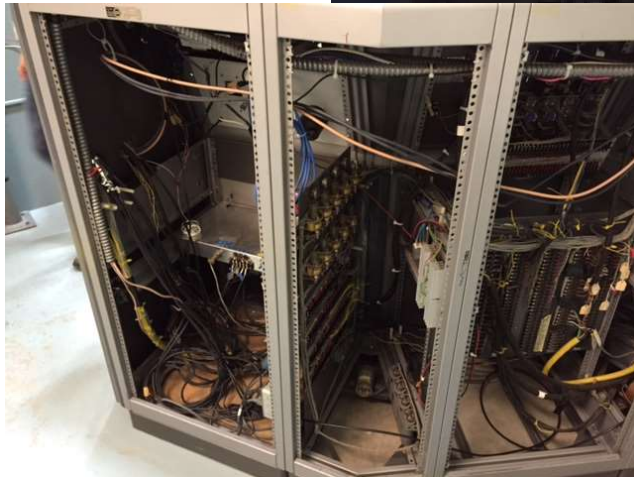


Comprehensive Detection





Purdue University – Current System





Determining Potential Scope of Supply

Budget

Digital Front End – Neutron Flux Monitoring

Analog vs Digital for Reactor Control & RPS – Back End

Hybrid System

Partner



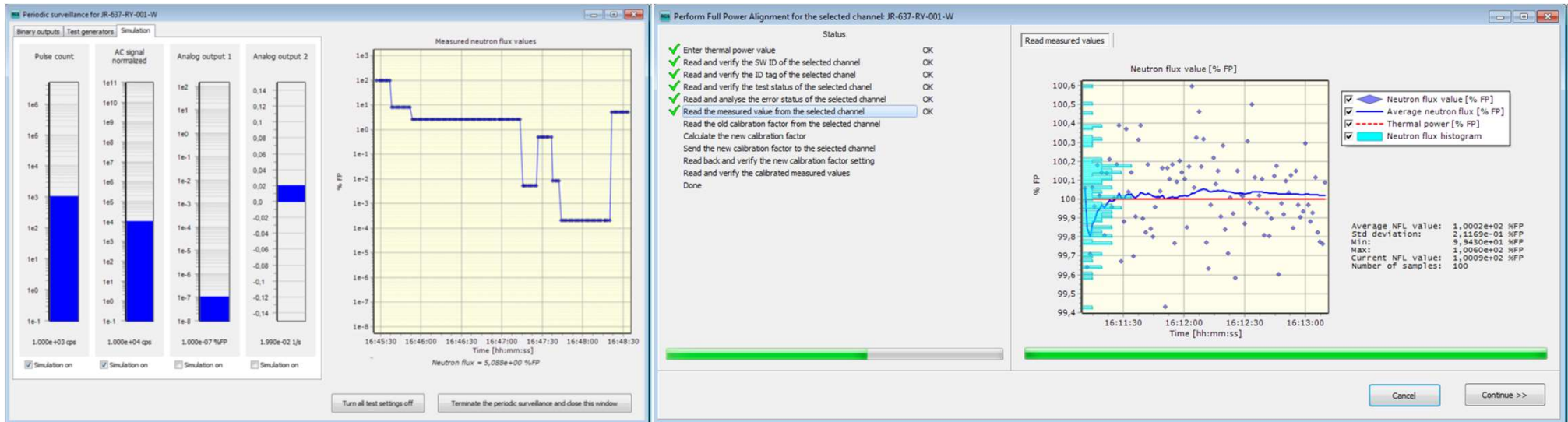
System Design and Development Processes

- Existing System Reengineering
- System Functional Requirements Definition
 - Technical Specifications
 - Safety Analysis Report
- Detailed Hardware Design
 - Qualification safety or non-safety related
- Detailed Software Design
 - Qualification safety or non-safety related
- System Implementation
- System Testing
- Installation
- Site Acceptance Testing



Mirion - Scope of Supply – Digital Front End

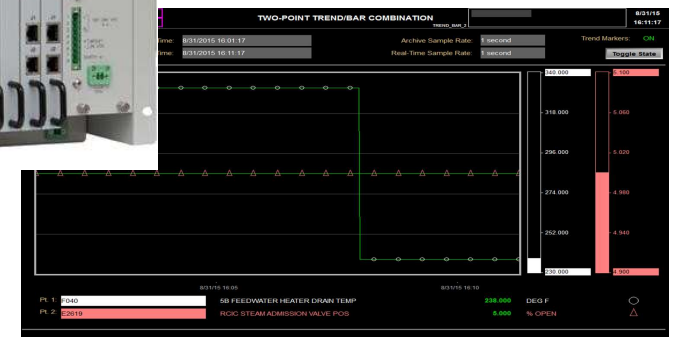
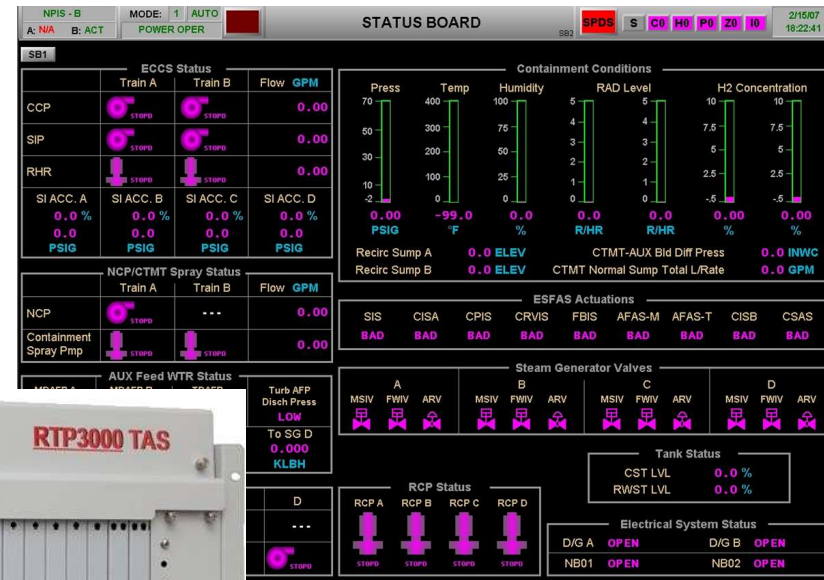
- DWK 250 Startup Range Monitoring using FC, also used as wide range monitor
- DAK 250 Intermediate Range Monitoring using CIC
- DAK 250 Intermediate Range Monitoring using UIC with linear range switching
- DGK 250 Power Range Monitoring using UIC





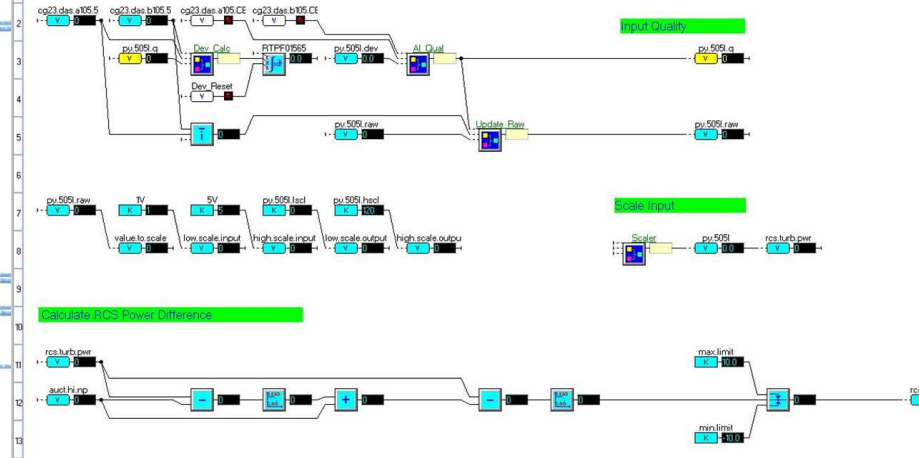
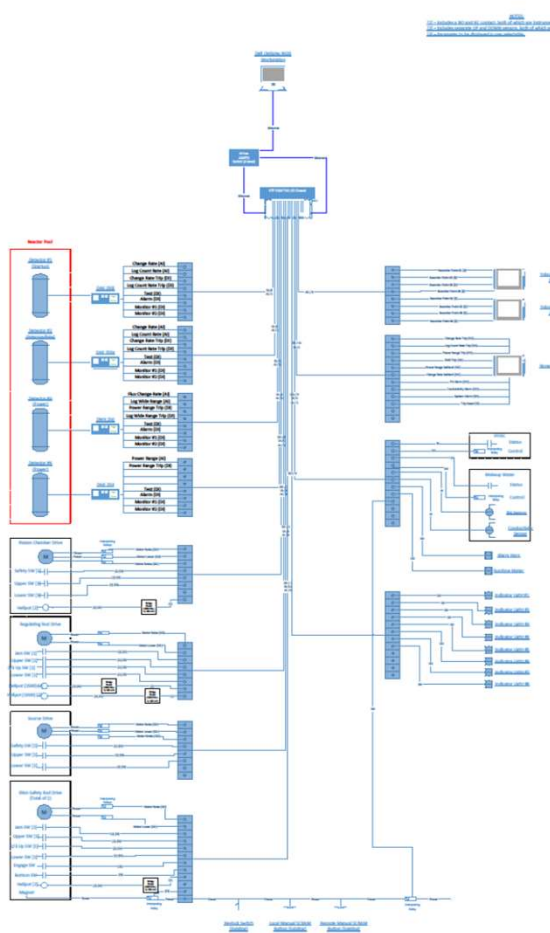
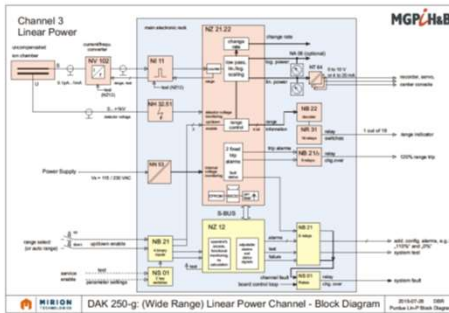
Curtiss-Wright/Scientech Scope of Supply – Back End

- RTP 3000 TAS System, Reactor Protection
- Drive Assembly Interface Electronics
- RMS System Interface
- HVAC System Interface
- Makeup Water System Interface
- Equipment Rack Electronics
- Operator Console HMI
- Trend Recorders
- Annunciator
- Elapsed Time Meter
- Indicator Lights
- Display Workstations
- Networking Hardware





Configuration & Logic Diagrams

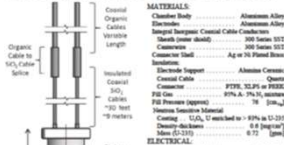


110 10913 WR Fission Chamber Rev. 04
(Prior to installation into water pit housing)
Page 1 of 2

WIDE RANGE FISSION CHAMBER

The 110-10913 Wide Range Fission Chamber is designed to measure thermal neutron radiation over multiple decades within the range of 2×10^{-4} to 2×10^{-10} [neut/cm²-sec]. The chamber has a nominal sensitive volume of 9.7 [cm³] in a cylinder with a nominal diameter of 3×10^1 [cm] as an ion chamber. It may be operated in any orientation at temperatures up to 700° [F].

The chamber is a β -particle counter with an aluminum alloy case and a beryllium oxide window. The chamber is constructed of high purity materials and has two integral hermetic stainless steel end caps. The High Voltage (HV) and Signal (SIG) cables are terminated with SO connectors (when used without housing) or other certified options.)



MATERIALS

Chamber Body	Aluminum Alloy
Window	Aluminum Alloy
Gas	300 Screen 517
Electrode	Ag or 30 Filled Glass
Window Support	Aluminum Ceramic
Central Cable	Organic
Coaxial Cable	FR95, 32 PI or FR95
Coaxial Cable	FR95 or 76% moisture
Coaxial Cable	FR95 (approx)
Coaxial Cable	FR95 (approx)
Coaxial Cable	FR95 (approx)
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Coaxial Cable	FR95 (approx)

ELECTRICAL

Characteristic Impedance	70 [ohms]
Resistance @ Room Temperature	10 [ohms]
Signal Electrode to Case	$\pm 10^7$ [ohms]
Signal Electrode to Case	$\pm 10^7$ [ohms]
Coaxial Cable to Case (max)	4.983 [ohms]
Coaxial Cable to Case (min)	4.334 [ohms]

MAXIMUM RATINGS

Operating Temperature (max)	175 [ohms]
Temperature	300 [ohms]
Operating Temperature (min)	100 [ohms]
Temperature	150 [ohms]

TYPICAL OPERATING (Data 1)

Operating Voltage (max)	1500 [ohms]
Operating Voltage (min)	100 [ohms]
Sensitive Area Range	2×10^{-4} to 2×10^{-10} [neut/cm ² -sec]
Sensitive Area	9.7 ± 0.2 [cm ³]
Sensitive Area	$3 \times 10^1 \pm 0.2$ [cm]
Counting Rate (max)	2×10^4 [cps]

MECHANICAL

Window Length (max)	100 [ohms]
Window Length (min)	100 [ohms]
Window Length	100 [ohms]
Window Length	100 [ohms]
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MIRION TECHNOLOGIES



Current Status

- **Digital Front End – Mirion equipment shipped to Idaho Falls, Scientech**
- **Integration of Digital Front End & Hybrid – Back End, July 25, 2016**
- **Factory Acceptance Testing (FAT) August 27, 2016**
- **Project tracking within budget and on schedule**



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