British Nuclear Group

Intelligent nuclear clean-up

Control and Instrumentation Nuclear Safety Research

- Participation by Management Services, Reactor Sites
- Essential Research Capability

NuSAC SCR

16 September 2004

Presented by: Steve Johnson

Reactor Sites Participation in C&I Nuclear Research

Reactor Sites contributes to collaborative research projects in the following areas:

- Safety Related Applications of Computer Systems:
  - Many of the software projects previously mentioned are part funded by Reactor Sites (Magnox):
    - Software Diversity (City University and Bristol University)
    - Reliability Quantification by Testing (Bristol University)
    - Software test coverage and formal proof (LDRA)
    - Use of PCs in low safety integrity level systems (Adelard)
    - Assurance of SMART sensor software (Adelard)
    - Generic documentation to support SMART sensors (Moore Industries)
    - CEMSIS

CONTINUED….

Reactor Sites Participation in C&I Nuclear Research

- Non-Computer Based Safety Systems:
  - Essential Research Capability in:
    - Reactor Neutron Flux Instrumentation (Nucleonics)
    - Reactor Protection Equipment

I will talk further about the Essential Research Capability

Essential Research Capability - Overview

Two ‘Key Teams’ are being supported:

- Nucleonics Key Team - covers specialist instrumentation (detectors) used for reactor neutron flux measurement. These are unique UK designs developed historically within UKAEA
- Reactor Protection Equipment Key Team - covers bespoke UK designs of equipment used for reactor trip and shutdown including failsafe ‘Laddic’ logic systems and trip units

The above instrumentation has a central role in nuclear safety.

The capability is highly specialised and in each case is held uniquely by a single company.

Essential Research Capability

Essential Research Capability is needed to:

- Ensure that a sufficient technical capability is retained in these specialist areas
- Investigate and support operational problems
- Provide specialist input and advice to safety cases

Work programmes of the Key Teams are reviewed and agreed annually based on agreed priorities.

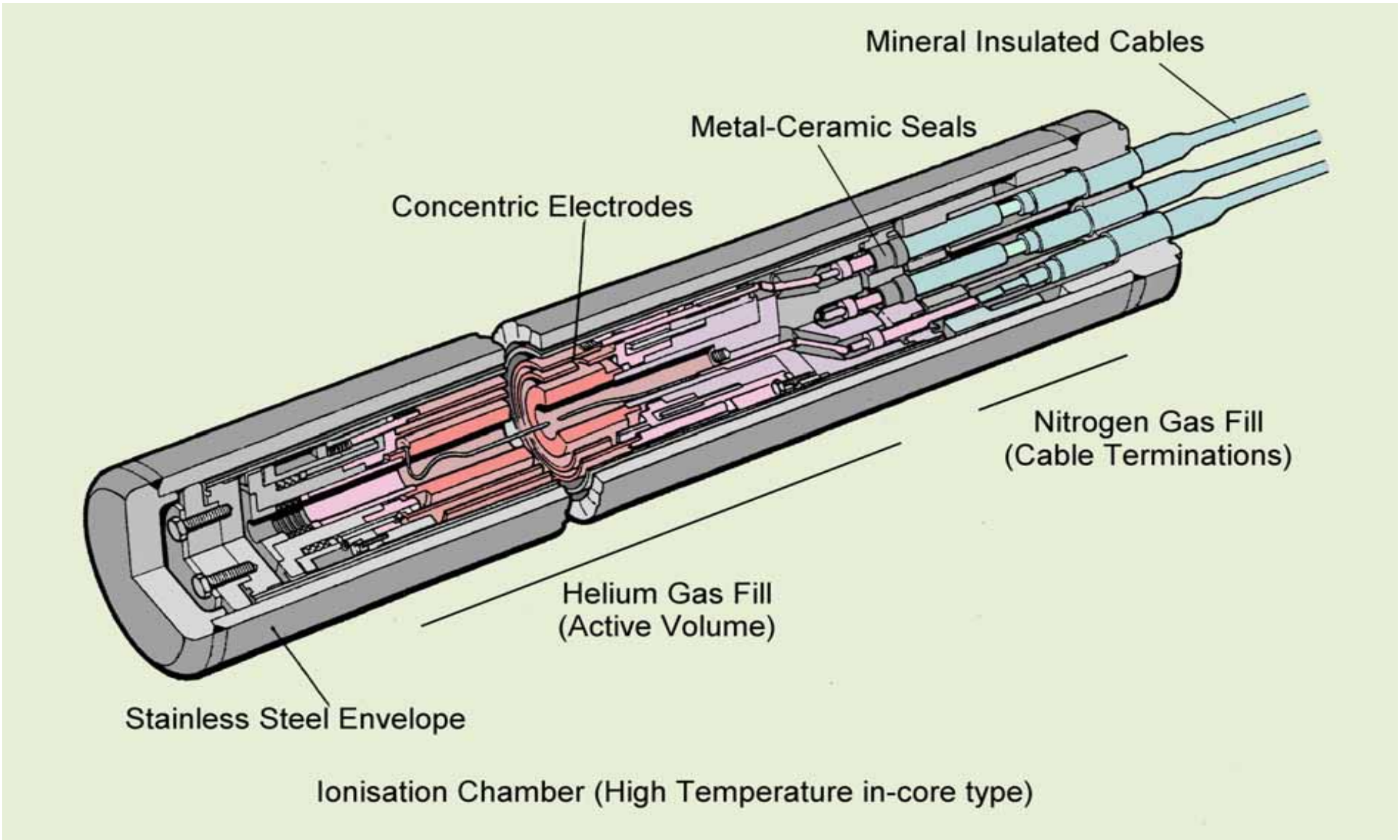
Essential Research Capability - Work Areas

- Nucleonics
  - Detector faults investigations
  - Review and update detector specifications
  - Detector MI cables - remanufacture options, review specifications
  - Detector on-load testing -techniques, and analysis of results
- Reactor Protection Equipment
  - Protection Equipment obsolescence issues
  - Use of circuit simulation/modelling techniques to support the design process
  - Investigation of component issues -ageing issues, potentiometer faults
  - Expert review of the design process (Prof. Jim Woodcock)

Detector faults Investigation -Background

- Neutron flux is a key measurement used for control and protection of Reactors
- Neutron flux detector operation is simple in principle but there are many difficult design and manufacturing issues
- Most detectors operate in a mild environment outside the reactor core but some AGR reactors have detectors in the reactor core
- In-core detectors were developed by UKAEA in the 1970s but are still ‘state of the art’ in terms of performance and operating environment (ie. wide range of measurement maintained in many years operation at temperatures up to 550°C)
- Some detector types have not been manufactured since the 1980s

Detector Faults Investigation -Background



Ionisation Chamber (High Temperature in-core type)

Detector Faults Investigation

Substantial numbers of spare detectors exhibited calibration changes during storage. This raised issues of suitability for use, spares availability, safety.

Investigations:

- Investigation revealed this was due to contamination of the fill gas with nitrogen due to minute leaks across metal-ceramic seals
- A theoretical explanation for the sensitivity changes was established (Penning effect) and the possible range of calibration changes established
- The susceptibility of each detector type to seal leakage was then assessed
- Investigation of brazing techniques for the seals led to development of

Conclusion

- Essential Research Capability needs to be retained in specialist areas of Nuclear Safety Instrumentation
- This is being maintained by funding programmes of work by the Key Teams in Nucleonics and Reactor Protection Equipment.