IAEA & GIF-RSWG

Functional Containment

Jim Kinsey
Idaho National Laboratory
Office of Nuclear Energy
U.S. Department of Energy

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Functional Containment - Definition

The term “functional containment” is applicable to advanced non-LWRs without a pressure retaining containment structure.

A functional containment can be defined as “a barrier, or set of barriers taken together, that effectively limit the physical transport and release of radionuclides to the environment across a full range of normal operating conditions, AOOs, and accident conditions.”
Additional Functions

Beyond a physical enclosure’s role in limiting the release of radioactive materials for one or more event categories, the staff and developers have recognized that structures may serve other purposes and be used to meet specific NRC regulations. Those functions may include:

- Structural support to primary cooling systems
- Support for the decay heat removal fundamental safety function via structural support for and housing of backup or emergency cooling such as reactor cavity cooling systems
- Prevention barrier against external events such as flooding and wind loadings
- Design feature credited in aircraft impact assessments
- Physical security design feature credited in preventing or delaying adversaries
- Design feature credited during environmental assessments of severe accident mitigation design alternatives
Fundamental Safety Functions

- Reactivity Control
- Decay Heat Removal
- Radionuclide Retention

“Functional Containment”
- Normal Operation
- Anticipated Events
- Design Basis Events
- Design Basis Accidents
- Beyond Design Basis Events

Performance Criteria
- Part 20
- F/C and/or Fuel Design Limits
- F/C and/or Barrier Limits
- 50.34 (safety related SSCs)
- F/C, Safety Goal, EPA PAGs

Other Functions
- Decay Heat Removal
- External Event Barrier
- Security
- Environmental Protection
- Asset Protection

Physical Building

“Functional Containment” (as needed for specific events)

Note: F/C refers to frequency/consequence targets
Commission Policy in US

• Functional Containment Performance Criteria for Non-Light-Water Reactors

• Commission policy issued October 2018

• NRC Accession # ML18010A516
Major Design Impact of Safety Philosophy

Emphasis on retention of radionuclides at source (within fuel particles) means:

• Manufacturing process must lead to high quality fuel

• Normal operation fuel performance must limit potential for immediate radionuclide release during off-normal conditions – coolant is continuously monitored during operation

• Off-normal fuel performance must limit potential for delayed radionuclide release to a small fraction of non-intact fuel particles from manufacturing and normal operation conditions
Safety Design Focus

• High fuel manufacturing quality and normal operation fuel performance aim at ensuring Modular HTGR could release activity within the HPB (e.g., activity circulating in the coolant) and stay within offsite accident dose limits without consideration of retention in the reactor building

• Thus, safety design focus is on avoiding incremental releases from fuel during off-normal events
Functions for Control of Radionuclide Release

Maintain Control of Radionuclide Release

Control Radiation

Control Radiation from Core

Control Radiation from Processes

Control Radiation from Storage

Control Personnel Access

Control Radiation from Core

Control Radiation from Processes

Control Radiation from Storage

Control Direct Radiation

Control Radiation Transport

Control Transport from Core

Control Transport from HPB

Control Transport from Reactor Building

Control Transport from Site

Denotes Required Functions to Meet 10CFR50.34

Control Radionuclides in Fuel Particles

Retain Radionuclides in Fuel Elements

Remove Core Heat

Control Core Heat Generation

Control Chemical Attack
Multiple Barriers to Radionuclide Release that Provide the “Functional Containment” for Modular HTGRs

- Fuel Kernel
- Fuel Particle Coatings
- Matrix/Graphite
- Helium Pressure Boundary
- Reactor Building