Standardization of ITAAC for SMRs

Application of First Principles

NRC Public Meeting

July 24, 2014

Agenda Topics

- Discussion of first principles
  - See handout of first principles from NEI White Paper
  - Genesis and evolution
- Examples of applying first principles to ITAAC

ITAAC Requirement for DCA

10 CFR 52.47(b)(1):

> The proposed inspections, tests, analyses, and acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a facility that incorporates the design certification has been constructed and will be operated in conformity with the design certification, the provisions of the Act, and the Commission's rules and regulations;

First Principles Overview

- Three sets of first principles
  - Tier 1 scope
  - Tier 1 level of detail
  - ITAAC scope
- Absence or existence of any one criterion is not conclusive to determine if information belongs in Tier 1 or ITAAC, must apply criteria as a whole
- 10 CFR 52.47(b)(1) does not require that an ITAAC be provided for every regulation

First Principles – Tier 1 Scope (1/3)

4. Principles for determining the top-level design and performance characteristics are based on whether the SSC
   a) performs a safety-related function;
   b) performs a risk-significant function as determined by the results of a PRA;
   c) provides a function necessary or important to severe accident mitigation;
   d) is associated with key assumptions or performance characteristics as determined in the various accident analyses specific to the design; or
   e) is otherwise necessary to comply with NRC regulations (e.g. EP)

First Principles – Tier 1 Scope (2/3)

4.a: Performs a safety-related function

- Number of safety-related components without significant safety function that do not need to be in Tier 1, e.g.,
  - Instrument, fill, and drain lines
  - Piping pressure relief valves associated with thermal expansion and anticipated valve leakage
  - Pump run-out protection
  - Interlocks aimed specifically at equipment protection
  - Safety-related valve's passive open/close function
  - Local controls for components
  - Rebar and concrete properties

First Principles – Tier 1 Scope (3/3)

4.e: Is otherwise necessary to comply with NRC regulations

- Examples that meet this criteria: EP, Security, RadWaste
- But, other provisions in regulations should not have ITAAC
  - Administrative and do not pertain to construction (e.g., §52.3)
  - Pertain to operation and cannot be completed before fuel load
  - Pertain to programs rather than as-built plant (e.g., §50.65)
  - Pertain to design methodologies rather than as-built plant (e.g., §50.46)
  - Pertain to portable items or consumables (e.g., fuel design limits)
  - Pertain to plant features that are not significant to function or performance of an SSC, but rather to other purpose (e.g., provisions for inspections or testing)
  - Indirectly related to ITAAC (e.g., single failure criterion)

First Principles – Tier 1 Level of Detail

Safety Significance	Tier 1 Design Description Detail
Safety-related systems that contribute to plant performance during design basis accidents (e.g., emergency core cooling systems).	Major safety-related features and performance characteristics necessary to meet Safety Analysis Acceptance Criteria.
Non-safety-related systems involved in beyond-design-basis events (e.g., combustion turbine generator contribution to station blackout).	Brief discussion of design features and performance characteristics affecting the safety of the plant's response to the event(s).
Non-safety-related systems potentially impacting safety (e.g. potential missiles from the main turbine).	Brief discussion of design features which prevent or mitigate the potential safety concern.
Non-safety-related systems which affect overall plant design (e.g., Drywell Cooling System).	Case-by-case evaluation. A brief discussion of the system if warranted by overall standardization goals.
Non-safety-related systems with no relationship to safety or any influence on overall plant design (e.g., House Boiler System).	No discussion except identification of the system title.
System for which the Tier 1 entry has been included in another system (e.g., the Unit Auxiliary Transformer is addressed in the Electrical Power Distribution System).	No additional discussion except identification of the system title.

*Adapted from ABWR Tier 2 Section 14.3

First Principles – ITAAC Scope (1/2)

3. Not all Tier 1 design descriptions require an ITAAC
   - SECY 91-178 “The staff does not believe that it will be necessary for every design element specified in the certified design rule to have a corresponding Tier 1 verification requirement.”
   - Generally Tier 1 descriptions have corresponding ITAAC, but in some cases ITAAC are not necessary
   - E.g., Fuel, Safety classification, and where ITAAC verify overall system function and need not address individual components which together yield the system functional performance

First Principles – ITAAC Scope (2/2)

6. ITAAC do not need to verify every attribute, nor be a one-to-one check
   - Licensing process as a whole provides reasonable assurance, including NRC program requirements and enforcement authority outside of ITAAC
   - ITAAC functionally duplicate other verification programs, and thus can be limited to the top level characteristics
   - Design details will still be subject to construction verification (e.g., through the QA program)
   - Sources: SECY 90-0241 and SRM 02-0067

Application of First Principles

- Screening of ITAAC against first principles
  - Two examples of ITAAC that do not meet first principles
  - Two examples of ITAAC that do meet first principles
- ITAAC scope for a safety-related valve
  - Scope of ITAAC based on first principles
  - ITAAC scope is necessary and sufficient to provide reasonable assurance

Examples of ITAAC that do not meet first principles

Design Commitment	ITA	Acceptance Criteria
Valves on lines attached to the RPV that require maintenance have maintenance valves installed such that freeze seals will not be required.	Inspections of piping design isometric drawings will be conducted. {{Design Acceptance Criteria}}	A review of piping design isometric drawings confirms that maintenance valves are included such that freeze seals will not be required. {{Design Acceptance Criteria}}
The as-built location of valves on lines attached to the RPV in the TMSS that require maintenance shall be reconciled to design requirements.	A reconciliation evaluation of valves on lines attached to the RPV that require maintenance using as-designed and as-built information will be performed.	A design reconciliation has been completed for the as-built location of valves relative to the design requirements. The report documents the results of the reconciliation evaluation.

- Maintenance and freeze sealing functions are not
  - Safety-related functions
  - Risk-significant functions determined by a PRA
  - Important to safety function of structure or system

Examples of ITAAC that do meet first principles

Design Commitment	ITA	Acceptance Criteria
The [XXX system] as-built ASME Code Class [1, 2 and/or 3] components are designed, fabricated, installed, inspected and tested in accordance with ASME Code Section III requirements.	An inspection will be performed of the [XXX system] as-built ASME Code Class [1, 2 and/or 3] component documentation required by ASME Code Section III.	[XXX system] ASME Code Section III Data Report(s) for as-built ASME Code Class [1, 2 and 3] components listed in [Table x.x.x-x] exist(s) that meet the ASME Code Section III requirements.
The [XXX system] safety-related remotely-operated valves perform the required active safety-related function to change position.	A test will be performed of the [XXX system] safety-related remotely-operated valves.	The [XXX system] safety-related remotely-operated valves listed in [Table x.x.x-x] change position as listed in the table upon receipt of a manual or automatic initiating signal, under conditions consistent with preoperational test limitations.

- Perform safety-related functions
  - Maintain integrity of reactor coolant pressure boundary
  - Capability to shutdown and maintain in safe shutdown
  - Capability to prevent or mitigate accidents
- Important to accomplishing the safety function of the system

VALVE ITAAC BASED ON FIRST PRINCIPLES

(EXAMPLE: SAFETY-RELATED, REMOTELY-OPERATED AOV)

Power Sources Necessary to Support Safety-Related SSCs

Electrical ITAAC (DC Power Source)

As-built Inspections

- Physical Independence Between Redundant Class 1E Electrical Circuits (E02)
- Physical Independence Between Class 1E Electrical Equipment and non-Class 1E Circuits (E03)
- Class 1E Inverter Capacity (E06)
- Class 1E Batter Charger Capacity (E07)
- Class 1E Battery Capacity (E08)
- Class 1E AC and DC Circuit Interrupting Devices Coordination (E09)

Preoperational Tests

- Class 1E Electrical Divisional Power Verification (E01)

I&C Systems Necessary to Provide Engineered Safeguards Equipment Actuation

I&C ITAAC

As-built Inspections

- Physical Independence Between Redundant Class 1E I&C Circuits (I02)
- Physical Independence Between Class 1E I&C Circuits and non-Class 1E Circuits (I03)
- Electrical Isolation Between Redundant Class 1E I&C Circuits (I04)
- Electrical Isolation Between Class 1E I&C Circuits and non-Class 1E Circuits (I05)

Preoperational Tests

- Protection System Automatic Control – ESF Equipment Actuation (I12)
- Protection System Manual Control – ESF Equipment Actuation (I14)
- Protection System Completion of Protective Actions (I15)
- Response Time Testing of ESF Equipment Actuation (I16)
- Minimum Inventory of Main Control Room and Remote Shutdown Workstation Displays and Alarms (I20)
- Minimum Inventory of Main Control Room and Remote Shutdown Workstation Manual Controls (I21)

Top Level Safety Function

Under design basis conditions, the valve is capable of retaining the fluid pressure, and achieving its safe position (i.e., open or close) by receipt of control signals and motive force.

DC Power Supply

I&C Controls and Indication

24 Total ITAAC

Equipment Qualification

Mechanical

Post-Accident Core Cooling

Reactor Coolant Pressure Boundary (RCBP) (Fission Product Barrier)

Equipment Qualification ITAAC

- Seismic Category I Equipment Qualification (Q01)*
- Safety-Related Equipment Harsh Environment Qualification (Q02)*
- Class 1E Digital Equipment EMI, RFI, ESD and SWC Qualification (Q04)
- Safety-Related Valve Functional Qualification (Q05)

*ITAAC Q01 and Q02 have two parts: (i) verification of qualification testing and (2) as-built inspection at design location

Post-Accident Core Cooling

Reactor Coolant Pressure Boundary (RCBP) (Fission Product Barrier)

Mechanical ITAAC

As-built Inspection

- ASME Section III Code Class 1, 2 and 3 Component Data Report (A03)

Preoperational Tests

- Safety-Related Remotely Operated Valve Functional Test During Preoperational Test Conditions (M05)
- Safety-Related Air- Operated Valve Fail Position on Loss of Motive Power (M07)