Piping Level of Detail for Design Certification (March 4, 2014)

I. Background

Title 10 of the *Code of Federal Regulations* (10 CFR), Section 52.47, "Contents of applications; technical information," for design certification applications requires in part that the application "include performance requirements and design information sufficiently detailed to permit the preparation of acceptance and inspection requirements by the NRC, and procurement specifications and construction and installation specifications by an applicant." Section 52.47(c) provides further information on the scope of an "essentially complete" design.

Relevant Commission direction on implementing this regulation is included in the Staff Requirements Memorandum (SRM) dated February 15, 1991, on SECY-90-377, "Requirements for Design Certification under 10 CFR Part 52," dated November 8, 1990. Section III of this SRM addresses level of detail in design certifications. The Commission expected that the design be complete (except for adjustment within established design envelopes during the procurement and installation process), but did not require information of the type found in actual procurement and construction specifications in all instances because some flexibility was needed to accommodate as-procured characteristics. Therefore, the Commission approved the staff's proposal to take a graded approach to the level of detail according to the relationship to safety of the structure, system, or component. The threshold established was the depth of detail in the final safety analysis report at the operating stage for a recently licensed plant (except for site-specific, as-procured, and as-built information).

In SECY-92-053, "Use of Design Acceptance Criteria During 10 CFR Part 52 Design Certification Reviews," the NRC staff described topics for which the design could not be completed to the level of detail originally envisioned, either because technologies were changing rapidly or because (as in the case of piping analyses) as-built or as-procured information was needed to complete this level of detail. Instead, design acceptance criteria (DAC)—including methodologies, design processes, and acceptance criteria—would be included in the design certification. In combination with inspections, tests, analyses, and acceptance criteria (ITAAC) to verify the completion of the design in accordance with the DAC, the staff would be able to make a final safety determination on piping issues at the design certification stage.

II. Differences for Future Design Certifications

For the design certification applications envisioned in the near term (namely, small modular light-water reactors and the APR1400 large light-water reactor design), the original arguments in favor of establishing DAC may no longer be valid. Small modular reactors generally have simplified piping systems, often with passive components, for which it may be practical to complete the initial piping design at a level sufficient to prepare procurement specifications at the design certification stage. The APR1400 reactor is currently being constructed in South Korea and the United Arab Emirates, so the progress of construction at those sites may provide examples of as-built information adequate to complete initial piping analyses for a U.S. design certification. Therefore, the staff has re-examined the level of detail that should be provided for piping analyses to support these types of design certifications.

III. Graded Approach to Level of Detail in Piping Design

Consistent with Commission direction and the more detailed information in SECY-90-377, the staff proposes a graded approach to the level of piping analysis detail needed to make a safety determination at the design certification stage without the need for DAC.

This approach consists of four main concepts:

1. The design certification would continue to present essentially complete designs for the overall systems, consistent with past design certifications regardless of the use of DAC.

2. The proposed ITAAC for the design certification would continue to include verification of design (including reconciliation), fabrication, installation, inspection, and testing for all ASME *Boiler and Pressure Vessel Code* (BPV Code) Class 1, 2, and 3 components and piping.

3. The design certification application would document the overall methodology to be employed in completing the detailed piping design for all systems.

4. The NRC review of the piping design in the design certification application would employ a graded approach, with the highest level of detail being expected for Class 1 reactor coolant pressure boundary piping, as these piping systems have the most significant effect on plant safety. A similar level of detail would also be expected for the Class 2 steam and feedwater lines from the reactor vessel to the first 6-way rigid restraint beyond the isolation valves, since breaks in these lines could directly affect the reactor. Less detail would be needed for other portions of Class 2 and 3 piping, for which breaks have lower safety significance, as well as for small-bore piping (nominal pipe size of 2" or less[1]), for which the final design relies heavily on as-built information and for which breaks also have lower safety significance.

Review of the detailed information for the most significant piping systems, combined with the overall methodology and ITAAC applicable to all systems, would provide the staff a sufficient basis for the staff to make a safety conclusion.

There is precedent for such a graded approach to piping design detail in the AP1000 design certification document (DCD). DCD Section 3.9.8.7 includes a COL information item stating that COL applicants will complete the as-designed piping analysis for the piping lines chosen to demonstrate all aspects of the piping design. These piping packages are any package containing Class 1 piping larger than 1 inch in diameter, plus additional packages identified in Table 3.9-20. The packages listed in this table are generally Class 2 and 3 lines, plus a package that includes the 1-inch Class 1 reactor head vent piping. Appendix 14A to the DCD clarifies that the DAC may also be closed via an amendment to the design certification, without any COL applicant action. This process represents a graded approach, since the DAC may be demonstrated (and the associated ITAAC closed) based on a review of packages selected for their safety significance.

IV. Specific Information in Design Certification Applications

The following table provides additional information on the information that would be expected to support the staff's safety determination, following the graded approach described above. The individual items in the table are similar to those presented in SECY-90-377 and are consistent with the level of detail found in operating plants' final safety analysis reports (which include, for example, some summary stress information, piping isometric drawings, and pipe rupture locations, but not detailed piping stress analyses for all systems and components).

If, for a specific design, the completion of this level of detail relies so heavily on as-built, as-procured information that the initial rationale for piping DAC can be justified, an applicant can propose, and the staff may determine it is appropriate to accept, piping DAC for that design.

[1] Nominal pipe sizes are set at 2" and 2.5"; no piping is expected at a size in between.

		ASME Class 1	ASME Class 2/3[2] ≤ 2" dia.	ASME Class 2/3[2] ≥ 2.5" dia.
Functional design criteria for mechanical systems and components	Expectations for performance, redundancy, and reliability	X	X	X
	Separation criteria			
	Modules with common systems			
	Interface requirements			
	Systems interactions			
Preliminary system design description	Incorporation of design criteria	X	X	X
	System performance			
	Common and interfacing systems			
	Differences among modular configurations			
Piping design methodology	Methodology for piping, pipe rupture analysis, and leak-before-break analysis,[3] including codes, phenomena, etc.	X	X	X
Simplified piping & instrumentation diagrams	System equipment	X		X
	Major flow paths			
	Pipe sizes			
	Protective devices			
	Safety/seismic class breaks			
Process flow diagrams or descriptions	Pressure, temperature, and flow	X		X
Key piping parameters	Design pressure	X		X
	Design temperature			
	Wall thickness			
	Material			
Plant layout and arrangement information	Major equipment locations	X		X
	Piping layout drawings (isometrics) including support locations and attachment points to structures			
Design specifications for major components connected to piping systems[4]	Valves	X		
	Pumps			
Preliminary piping stress analyses[5]	Piping stress analyses including seismic, thermal, deadweight, dynamic, and fatigue[6]	X		Notes 2, 5
Preliminary pipe rupture hazards analyses	Postulated pipe break locations	X		Notes 2, 5
	Pipe break analyses			
	Leak-before-break analyses (see Note 3)			
	Location of pipe whip/jet devices			

[2] For piping inside containment including non-Code class, high-energy piping systems.
[3] mPower is not expected to apply leak-before-break criteria to its piping.
[4] As inputs to piping stress analysis and plant layouts (e.g., weights, sizes). For small modular reactors, no pumps are expected for large-bore Class 1 lines, only valves.
[5] DCD should summarize results of analyses (methodology already described above), with full analyses available for audit. Stress, fatigue, and pipe break analyses for Class 1 piping should extend to the first 6-way rigid restraint on the Class 2 side of an isolation valve that separates Class 1 from Class 2 piping. This will enable a decoupling of the analysis (e.g., effects of Class 2 breaks on Class 1 piping).
[6] See ASME Boiler and Pressure Vessel Code, Section III requirements for design reports in NCA-3550. These would not be the certified <u>final</u> design reports.