Westinghouse AP1000
Design Certification Review

Discussion Notes / Comments for Meeting With Westinghouse on 07/17/02

(Reference AP1000 Design Control Document, APP-GW-GL-701 Rev.0, dated January 2002)

Meeting Agenda Item: Reactor Internals Dynamic Analysis

1. AP1000 Design Control Document (DCD), Volume 6, Section 3.9.2.3, Dynamic Response Analysis of Reactor Internals under Operational Flow Transients and Steady-State Conditions.

   (a) Pg. 3.9-31, last ¶: Westinghouse (W) proposes that the assessment of RPV internals flow-induced vibrational response is done using a combination of analysis and testing, as specified in Regulatory Guide (R.G.) 1.20. However, W also proposes that the entire vibration assessment program, including the predictive analysis portion, will be performed by the Combined License (COL) applicant. This proposal is repeated in DCD Section 3.9.8.1 (Volume 6, Pg. 3.9-93) citing consistency with R.G. 1.20 as a basis for deferral of the performance of the entire vibration assessment program to the COL applicant.

   The NRC staff is not in complete agreement with this proposal for the following reasons. Title 10 of the Code of Federal Regulations (10 CFR) Part 52.47(a)(2) requires that applications for standard design certification must contain a level of design information sufficient to enable the Commission to reach a final conclusion on all safety questions associated with the design before the certification is granted. Delaying the predictive analysis portion of the vibration assessment program to the COL applicant stage of plant construction does not provide the staff with a level of design information sufficient to reach a final conclusion regarding adequacy of the RPV internals design. Conformance with R.G. 1.20 alone, does not necessarily fulfill the requirements of 10 CFR 52.47(a)(2) for certification of the adequacy of the standard design of the RPV internals, primarily because of the R.G. 1.20 scheduling requirements for the submittal of analytical results to the staff.

   R.G. 1.20, C.2.5, requires that during the construction permit review, preliminary and final reports, which together summarize the results of the vibration analysis, vibration measurement, and RPV internals inspection programs be presented to the staff. However, these reports are not required to be submitted until completion of vibration testing, which occurs too late for the 10 CFR 52.47 standard design certification process.

   Standard Review Plan (SRP) 3.9.2, Rev. 2, provides additional detailed guidance regarding performance of the RPV internals vibration analysis. Review procedures defined in SRP 3.9.2. III.3. indicate that at the construction permit (CP) stage (i.e., PSAR review), the applicant should commit to performing a vibration analysis of the RPV internal structures if they are designated as a prototype design (as are the AP1000 RPV internals), and provide a description of the program. At the operating license (OL) stage

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(i.e., FSAR review), the applicant should provide a detailed dynamic analysis for a prototype design, to be used for vibration prediction prior to the performance of preoperational vibration tests.

The 10 CFR 52.47 standard design certification process does not differentiate between the CP and OL stages. Information provided for review of safety related aspects of a standard design for certification should be equivalent in detail to information provided during the previously defined OL stage of plant construction.

The staff's position on this issue is that the detailed, predictive analysis portion of the RPV internals flow-induced vibration analysis program should be provided for staff review during the design certification process, and not be deferred to the COL applicant stage of actual plant construction. It is recognized that the other phases of the comprehensive R.G. 1.20 vibration assessment program, i.e., vibration measurement and physical inspection, must be done later by the COL applicant to confirm the predictive analysis results. However, the staff considers the results of the predictive analysis phase of this program to be the kind of detailed information necessary for the staff to make a determination of adequacy of the AP1000 RPV internals design for purposes of final design certification.

A precedent for this analytical review during the standard design certification process has been established previously during review of the W AP600 standard design application. In response to the staff's comments on this issue for the AP600 RPV internals design (Ref. NUREG-1512, Section 3.9.2.3), W provided topical report WCAP-14761, "AP600 Reactor Internals Flow-Induced Vibration Assessment Program." Included in this report are specific sections addressing the predictive analysis phase of the vibration assessment program for the AP600 design. Technical details are provided with descriptions of the analytical methods used including computer models, results of the analyses are summarized in tabular format, and comparisons of calculated stresses to ASME Code allowables are included for the major components of the RPV internals design. This type of topical report would also be appropriate for presentation of key details of the AP1000 prototype RPV internals design necessary for staff review at the standard design certification stage.

(b) Pg. 3.9-32: The DCD continues to define the vibration assessment program in generalized terms, and persists in proposing that the analysis portion of the program will be conducted at some time in the future. Comparisons between the AP1000 and the AP600 designs are made, regarding both similarities and differences. These comparisons suggest that the same process used for certification of the AP600 design should also apply to certification of the AP1000 design, especially regarding the RPV internals predictive analysis for flow-induced vibrations (see comment 1.(a) above).

(c) Pg. 3.9-33, second ¶: The DCD refers to vibration test results of other reactor internals designs (Doel 3, Doel 4, and Paluel 1) that will be utilized to perform the AP1000 vibration assessment program, once again proposing that this will all be done at some future time. Presuming that this data is available now, it could be included in a topical report (similar to WCAP-14761), and be used in comparison to the AP1000 predictive analysis results as another basis for demonstration of the adequacy of the AP1000 prototype design.

(d) Pg. 3.9-33, bullet items: The bulletized list of differences in the AP1000 RPV internals design provide further reason for performing predictive analysis now, during the design certification stage, instead of deferring this analysis to the COL stage. The discussion of differences in design continues into the last paragraph of pg. 3.9-33, including speculation that potentially higher vibratory loads resulting from certain AP1000 design differences is expected to be offset by other design differences. Expectations and speculation about the ultimate affects that these differences may have on design adequacy does not provide a sufficient level of detail to satisfy the requirements of 10 CFR 52.47(a)(2). This type of generalized justification must somehow be quantified for purposes of a safety evaluation review for a standard design certification.

(e) Pgs. 3.9-34 and -35: These pages include discussions which are informative and useful for introductory purposes, but are highly speculative in terms of demonstrating adequacy of the RPV internals design. A technical safety evaluation for purposes of approving / certifying the AP1000 internals design cannot be based solely on these types of general expectations. This further emphasizes the need for a topical report similar to WCAP-14761 (see comment 1.(a) above).

[Is there anything so much different technically about the AP1000 vs. the AP600 that would prevent W from doing a predictive analysis similar to WCAP-14761 at this time?]

(f) Pg. 3.9-35, first ¶: This paragraph is a good example of the kind of general expectations / conclusions that require analytical verification for purposes of design certification. A recognized specific difference in the AP1000 lower internals design produces a lower natural frequency of the internals assembly, resulting in higher estimated amplitudes of vibration. The stated expectation is that these higher displacements of the internals assembly will be acceptable, but no further technical justification for this expectation is provided. The discussion which follows suggests that the internals vibration frequencies and amplitudes will be accurately determined based on the instrumentation measurements during pre-operational testing of the first plant (but this obviously will not occur until the plant has been built). A predictive analysis should be able to conservatively quantify the frequencies and displacements of the internals assembly resulting from enveloping estimates of forcing functions due to operational flow transients. Without analytical data (as opposed to expectations), and subsequent comparison to applicable allowable values, a technical safety evaluation by the staff cannot reach the kind of definitive conclusion which is necessary for a standard design certification.

(g) Pg. 3.9-35, fifth ¶: This paragraph, with respect to reactor coolant pump flow-induced vibration, suggests a comment similar to comment (f) above.

2. AP1000 DCD, Volume 6, Section 3.9.2.4, Pre-operational Flow-Induced Vibration Testing of Reactor Internals.

    (a) Pg. 3.9-35, seventh ¶: The three aspects, or phases, of a R.G. 1.20 pre-operational vibration assessment test program are appropriately identified. However, the first phase, i.e., a prediction of the vibrations of the reactor internals, although specifically identified, is never really presented in detail anywhere in the following discussion of the overall program. Additional description of the vibration analysis phase of the program should be included, or referenced.

    (b) Pg. 3.9-36, third ¶: Once again the DCD approach defers comparison of technical data which is pertinent to the design certification process. The "predicted vibrational responses" should be made available now. Then comparison to the actual measurement data available from the Doel 3 and 4 vibration assessment programs could provide a quantified basis for acceptability of the AP1000 prototype design necessary for the 10 CFR 50.47 design certification process.

    (c) Pg. 3.9-36, last ¶: Request clarification of the following statement regarding visual inspection of RPV internals before and after hot functional testing:

        "This inspection is performed on AP1000 plants subsequent to the first."

        Does this imply that the first plant built is excluded from these inspections? If so, why would the prototype plant be excluded from inspection?

    (d) Pg. 3.9-38, second ¶: This is a continuation of the DCD approach that verification of acceptability of expected RPV internals vibration levels can be deferred to the pre-operational / hot functional test phase of plant construction. While the final verification of acceptability may, in fact, be most specifically demonstrated at that time by use of actual instrumented test data, the deferral of predictive analysis is not compatible with the need for this type of technical data for the design certification process. 'Expected' vibration levels have to be quantified at some point in the process. It would seem that the final design of the AP1000 RPV internals has been developed sufficiently to provide that quantification for the design certification review process. The discussion in DCD Section 3.9.2.5.1.2 indicates that the AP1000 RPV internals are represented in detailed analytical models which can be used to analyze the dynamic characteristics of the internals response to various hydraulic forcing functions. The staff considers the analytical results of this type of predictive analysis to be the kind of detailed information necessary for the staff to make a determination of adequacy of the AP1000 RPV internals design for purposes of final design certification.

3. AP1000 DCD, Volume 6, Section 3.9.2.5, Dynamic System Analysis of the Reactor Internals Under Faulted Conditions.

(a) Pg. 3.9-41, last sentence of Section 3.9.2.5.2: This section describes the analytical methods used to calculate stresses and deflections in the RPV internals due to the combined loads from postulated pipe rupture and the safe shutdown earthquake. The last sentence in this section states the final conclusion that the reactor internals components are within acceptable stress and deflection limits. This significant conclusion is stated without providing, or referencing, any supporting stress and deflection data from the actual analyses (which presumably have been done in order to reach this conclusion).

A results summary of analytical data, including comparison to appropriate allowable values, should be provided which demonstrates that stress, deflection, and stability criteria for the RPV internals design have been met.

4. AP1000 DCD, Volume 6, Section 3.9.2.6, Correlation of Reactors Internals Vibration Tests with the Analytical Results.

(a) Pg. 3.9-41, first ¶ under 3.9.2.6:

(i) Results of dynamic analysis of reactor internals vibration (used for comparison to test results) are generally mentioned, but it is not clearly defined which reactor design was used to generate the analytical results. Are results of predictive analyses of the AP1000 RPV internals vibration used here to make this comparison? If so, this seems contradictory to the W proposal that predictive analysis be deferred to the COL stage of plant construction. Clarification is needed.

(ii) A conclusion of adequacy is stated without providing, or referencing, any analytical results to demonstrate adequacy (similar to comment 3.(a) above). A summary of results is needed to justify conclusions which would establish an analytical model as a benchmark for future analyses.

Piping Design Acceptance Criteria Comparison

	Piping/Support	HELB	LBB	Benchmark Problem
ABWR	DAC	DAC	N/A	NUREG/CR-6049
System 80+	DAC	DAC	DAC (bounding curves) NRC reviewed 4 LBB calcs	NUREG/CR-6128
AP600	essentially complete (except support details)	essentially complete (except PW restraint details)	DAC (bounding curves) NRC reviewed 5 LBB cals LBB confirmatory analysis	NUREG/CR-6414
AP1000	DAC	DAC	DAC (bounding curves) no LBB calcs	to be determined

Commitment	ADM Reference
ASME Code and Code Cases for AP1000 piping and pipe support design	Table 1-1, Table 3.9-10, 5.2.1.1, 5.2.1.2, Table 5.2-3
Analysis Methods; experimental stress analysis, independent support motion, inelastic analysis, small-bore piping, non-seismic / seismic interaction, buried piping	3.7.3.2, 3.7.3, 3.7.3.12, 3.7.3.13, 3.9.1.3, 3.9.3.1.5, Table 3.9-10, 5.2.1.1
Piping Modeling; piping benchmark program, decoupling criteria	3.6.2.1, 3.7.3.8.2.1, 3.9.1.2,
Pipe stress analysis criteria; loading and load combinations, damping values, combination of modal responses, high frequency modes, thermal oscillations in piping connected to the reactor coolant system, thermal stratification, safety-related valve design, installation and testing, functional capability, combination of inertial and seismic motion effects, welded attachments, modal damping for composite structures, minimum temperature for thermal analysis	3.6.2.2, 3.6.3, 3.7.2.15, 3.7.3.7, 3.7.3.8.2.1, Table 3.7.1-1, 3.9.3.1, 3.9.3.1.2, 3.9.3.1.5, 3.9.3.3, Table 3.9-5, Table 3.9-6, Table 3.9-7, Table 3.9-11, Table 5.2-3
Pipe support criteria; applicable codes, jurisdictional boundaries, pipe support baseplate and anchor bolt design, use of energy absorbers and limit stops, pipe support stiffnesses, seismic self-weight excitation, design of supplementary steel, considerations of friction forces, pipe support gaps and clearances, instrument line support criteria	3.9.3.4, 3.9.1.2, 3.9.3.5, 3.9.3.4

Piping Design Acceptance Criteria (DAC) – SYSTEM 80+ vs. AP1000

SYSTEM 80+	Approved Design Material (ADM) Reference	Corresponding AP1000 DCD
ASME Code and Code Cases for System 80+ piping and pipe support design	**Table 1.8-6** **System 80+ Industrial Codes and Standards** *ASME Section III, 1989* **3.9A (1.1)** **Piping Design, General** *Seismic Category I small and large bore piping is designed to meet the analysis requirements of the ASME BP&V Code, Section III, NB-3650, NC-3650, or ND 3650.*	**Table 1-1** **Index of AP100 Tier 2 Information Requiring NRC Approval for Change** *ASME Code Section III* **Table 3.9-10** **Stress Criteria for ASME Code Section II Class 2 and 3 Components and Supports** *ASME Code Section III Requirements (applicable NB-3600 sub-sections)* **Section 5.2.1.1** **Compliance with 10 CFR 50.55a** *1989 Edition, 1989 Addenda for Articles NB-3200, NB-3600, NC-3600, ND-3600* **Section 5.2.1.2** **Applicable Code Cases** *See Table 5.2-3*
Analysis Methods; experimental stress analysis, independent support motion, inelastic analysis, small-bore piping, non-seismic / seismic interaction, buried piping	**3.7.3.2** **Determination of Number of Earthquake Cycles** *Seismic Category I subsystems, designed for 2 SSE events w/ 10 cycles per event. Alternately, an equivalent number of fractional cycles not less than 1/3 of maximum SSE amplitude.* **3.7.3.8** **Analytical Procedures for Piping** *If inelastic methods are used, details of methods ad acceptance criteria to be provided with site specific information.*	**Section 3.7.3.2** **Determination of Number of Earthquake Cycles** *2 SSE events w/ 10 cycles per event. For fatigue evaluation purposes, 5 events w/ 63 cycles per event where each cycle is 1/3 of maximum SSE amplitude.* **3.9.3.1.5** **ASME Classes 1,2, and 3** *Inelastic analysis methods are not used.*

	3.7.3.9 **Multiple supported Equipment Components with Distinct Inputs** *If independent support motion (ISM) response spectrum methods are used, a detailed description of methods, including sample problem and computer code verification to be provided.*	**Section 3.7.3.** **Independent Support Response Spectrum Methods** **Details** *Provides details for alternate methods for piping analysis using ISM. (Note that this option is included in Program PIPESTRESS)*
	3.7.3.12 **Piping Outside Containment Structure** **3.7.3.12.1** **Buried Piping** *Defines the analysis for Seismic Category I buried piping systems.*	**3.7.3.12** **Seismic Category I Buried Piping Systems and Tunnels** *There is no seismic Category I buried piping in AP1000*
	3.7.3.13 **Interaction of Other Piping with Category I Piping** *Non-Category I piping adjacent to or attached to Category I is analyzed to Category I criteria.*	**3.7.3.13** **Interaction of Other Systems with Seismic Category I Systems.** *Provides details for the evaluation of Seismic Category II and Non-Seismic piping adjacent to or attached to Category I piping.*
	3.9.1.3 **Experimental Stress Analysis** *When experimental analysis is used, it is performed in accordance with Appendix ii of ASME B&PV Code, Section III, Division I.*	**3.9.1.3** **Experimental Stress Analysis** *No experimental stress analysis is used for AP1000 piping.*
	3.9A (1.1) **Piping Design, General** *Seismic Category I small and large bore piping is designed to meet the analysis requirements of the ASME BP&V Code, Section III, NB-3650, NC-3650, or ND 3650.*	**Table 3.9-10** **Stress Criteria for ASME Code Section II Class 2 and 3 Components and Supports** *ASME Code Section III Requirements (applicable NB-3600 sub-sections*

		Section 5.2.1.1 **Compliance with 10 CFR 50.55a** *1989 Edition, 1989 Addenda for Articles NB-3200, NB-3600, NC-3600, ND-3600*
Piping Modeling; piping benchmark program, decoupling criteria	**3.6.2.1.4.1** **Postulated Rupture Locations** *Provides details as to the postulation of pipe rupture locations in Class 1, Class 2, Class 3, and Seismically analyzed B31.1 Piping.* **3.9.1.2.1** **Code Class Systems, Components, and Supports** *Computer codes used for piping dynamic analysis will be benchmarked in accordance with NUREG/CR-6128.* **3.9A(1.5.2.2)** **Branch Decoupling Criteria** *Details of Decoupling criteria defined for piping analyses*	**3.6.2.1** **Criteria Used to Define High- and Moderate-Energy Break and Crack Locations and Configurations** *Provides details as to the postulation of pipe rupture locations in Class 1, Class 2, Class 3, and Seismically analyzed B31.1 Piping, High Energy Pipe breaks, High or Moderate Energy Through-Wall cracks.* **3.9.1.2** **Computer Codes Used in Analysis** *The combined License applicant will implement NRC benchmarking program using AP1000 specific problems if a piping analysis computer program other than those used for design certification (PIPESTRESS, GAPPIPE, WECAN, and ANSYS) is used.* **3.7.3.8.2.1** **Large Diameter Auxiliary Piping** *Defines the decoupling criteria applicable for AP1000 piping analyses.*

Pipe stress analysis criteria, loading and load combinations, damping values, combination of modal responses, high frequency modes, thermal oscillations in piping connected to the reactor coolant system, thermal stratification, safety-related valve design, installation and testing, functional capability, combination of inertial and seismic motion effects, welded attachments, modal damping for composite structures, minimum temperature for thermal analysis	**3.6.2.2.2** **Analytical Methods to Define Forcing Functions and Response Models for Piping Excluding that Approved for Leak-Before-Break** *Circumferential breaks result in pipe severance / separation of at least one pipe diameter.* *Dynamic force of fluid jet dischanrge based on circular break area, fluid pressure, and analytically determined thrust coefficient.* *Fluid thrust forces are calculated using simple one-step forcing function or detailed computer solution.* **3.6.3.8** **Results** *Defines criteria for application of leak-before-break according to NUREG 1061, Volume 3.* **3.7.2.15** **Analysis Procedure for Damping** *If composite modal damping is used, applicable piping damping is defined in Table 3.7-1.* **Table 3.7-1** **Damping Values** *Piping diameter ≤ 12 inches, % of critical damping = 2.0* *Piping diameter > 12 inches, % of critical damping = 3.0* *Uniform envelope response spectrum analysis, % critical damping = 5.0*	**3.6.2.2** **Analytical Methods to Define Jet Thrust Forcing Functions and Response Models** *Provides details as to the development and evaluation of Jet Thrust loads for applicable branch lines.* **3.6.3** **Leak-Before-Break Evaluation Procedures** *Provides detailed criteria for the evaluatoin of Leak-Before-Break, including Application of Mechanistic Pipe Break Criteria (NUREG/CR-6519), Design Criteria for Leak-Before Break (NURGE-1061), Analysis Methods and Criteria, including postulation of leakage flaws, stability and crack flaw size, acceptance standards, and bounding analyses.* **3.7.2.15** **Analysis procedure for Damping** *Refers to sub-section 3.7.1.3 for the definition of critical damping values and Table 3.7-1.* **Table 3.7.1-1** **Safe Shutdown Earthquake Damping Values** *Piping diameter ≤ 12 inches, % of critical damping = 2.0* *Piping diameter > 12 inches, % of critical damping = 3.0* *Primary Coolant Loop, % critical damping = 4.0* *Uniform envelope response spectrum analysis, %*

		critical damping = 5.0
	3.9.3.1 **Load Combinations, Design Transients and Stress Limits** *SSE and pipe rupture loads are combined by the SRSS method in accordance to NURGE-0484 Rev 1 guidelines.*	**3.9.3.1** **Loading Combinations, Design Transients, and Stress Limits** *Defines applicable loading conditions and combinations for piping and supports. Refers to Tables 3.9-3, 3.9-5, 3.9-6, and 3.9-7 for specifics.*
	3.9.3.1.4.3 **Functional Capability, ASME Code Class 1, 2, and 3** *Piping is designed to meet NUREG-1367 requirements and allowable stress of 3.0 SM (Class 1), or 3.0 Sh (Class 2 and 3), but not greater than 2.0 Sy.*	**3.9.3.1.5** **ASME Classes 1, 2, and 3 Piping** *Functional capability requirements are defined in Table 3.9-11 based on NUREG-1367*
	3.9.3.3 **Design and installation Details for Mounting of Pressure Relief Devices** *Analysis of safety and relief valves is performed using application of time history forcing functions in dynamic analyses, or equivalent static analyses based on ASME Section III Appendix O as supplemented by SRP3.9.3, Section II.2.*	**3.9.3.3** **Design and Installation Criteria of Class 1, 2, and 3 Pressure Relieving Devices** *The design of pressure relieving valves complies with the requirements of ASME Code, Section III, Appendix O.*
	Table 3.9-10 **Loading Combinations for ASME Section III Class 1 Piping** *Defines loading combinations for Class 1 piping*	**Table 3.9-5** **Minimum Design Loading Combinations for ASME Class 1,2,3 and CS Systems and Components** *Defines loading combinations*

		Table 3.9-6 **Additional Load Combinations and Stress Limits for ASME Class 1 Piping** *Defines loading combinations and applicable allowables.*
	Table 3.9-11 **Loading Combinations for ASME Section III Classes 2 and 3 Piping** *Defines loading combinations for Class 2 and 3 piping*	**Table 3.9-7** **Additional Load Combinations and Stress Limits for ASME Class 2, 3, Piping** *Defines loading combinations and applicable allowables.*
		Table 3.9-11 **Piping Functional Capability – ASME Class 1, 2, and 3** *Defines loading combinations and allowables for functional capability evaluations.*
	3.9A (1.4.2) **Thermal Analysis** *Lines with T max < 150 °F and anchor motions < 1/16 inch are not analyzed for thermal expansion.*	**Section 3.9.3.1.5** **ASME Classes 1, 2, and 3 Piping** *Piping operating at 150 °F or less does not require thermal expansion analysis. Thermal anchor movements , 1/16 inch are considered as negligible.*
	3.9A (1.4.3.2.1) **Response Spectrum Analysis** *Defines response spectrum, Damping values, modal cutoff and rigid modes, modal combinations, and inclusion of seismic anchor motions.*	**3.7.3.7** **Combination of Modal Response** *Defines modal combinations for response spectrum analysis, including high-frequency modes, left-out-force methods,SRP3.7.2 Methods, and combination of low-frequency modes considering the effects of closely spaced modes.*

	3.9A (1.4.7) **Thermal Stratification** *Identifies NRC Bulletins 88-08 and 88-11. Piping systems subjected to stratified flow are evaluated for additional stresses due to thermal stratification.* **3.9A(1.5.2.2)** **Branch Decoupling Criteria** *Details of Decoupling criteria defined for piping analyses and impact on seismic analysis.* **3.9A (1.6.5)** **Welded Attachments** *Local stresses due to all support loads acting on a welded attachment are evaluated and added to the nominal pipe stresses. Methods for evaluating local stresses are provided in ASME Code Cases N-318 and N-392.*	**3.9.3.1.2** **Loads for Class 1 components, Core Support, and Component Supports** *Identifies NRC Bulletins 79-13, 88-08, and 88-11 Identifies specific AP1000 piping systems that are susceptible to thermal stratification, cycling, and / or striping.* **3.7.3.8.2.1** **Large Diameter Auxiliary Piping** *Defines the decoupling criteria applicable for AP1000 piping analyses.* **Table 5.2-3** **ASME Code Cases** *Defines the following Code Cases applicable to welded attachment evaluations* *N-122, N-318, N-392*
Pipe support criteria; applicable codes, jurisdictional boundaries, pipe support baseplate and anchor bolt design, use of energy absorbers and limit stops, pipe support stiffnesses, seismic self-weight excitation, design of supplementary steel, considerations of friction forces, pipe support gaps and clearances, instrument line support criteria	**3.9.3.4** **Component Supports** *Energy absorbing and/or non-linear piping restraints may be used. If used, description of methodology to analyze and design piping systems incorporating these items will be provided on a site-specific basis*	**3.9.3.4** **Component Supports** AP1000 uses gapped support devices to minimize the use of snubbers. **3.9.1.2** **Computer Codes Used in Analysis** *The combined License applicant will implement NRC benchmarking program using AP1000 specific problems if a piping analysis computer program other than those used for design certification (PIPESTRESS, GAPPIPE, WECAN, and ANSYS) is used.*

	1.10 **Tubing** **1.10.1** **General** *Design analysis and loading considerations that are used for piping and supports are used for tubing.*	**3.9.3.5** **Instrumentation Line Supports** *The design and acceptance criteria for safety-related instrumentation supports are similar to those for pipe supports, ASME subsection NF.*
	1.10.2 **Support and Mounting Requirements** *Defines support and mounting considerations*	
	1.7.2.3 **Seismic Loads** *The response of the support itself due to seismic acceleration is also evaluated (i.e. self-weight excitation)*	**3.9.3.4** **Component Supports** *The mass of the pipe support miscellaneous steel is evaluated as a self-weight excitation*
	1.7.2.8 **Support Stiffness** *Actual support stiffnesses consider the flexibility of all support components as well as the effects of building structure.*	**3.9.3.4** **Component Supports**
	1.7.2.9 **Friction** *Frictional forces are considered in the support design. Typical frictional coefficients are defined.*	**3.9.3.4** **Component Supports** *Friction loads induced by the pipe must be considered in the evaluation of supports. Friction coefficients are identified.*
	1.7.2.10 **Support Gaps** *Total gaps < 1/8 inch in the restrained direction for frame type supports are considered to be zero.*	**3.9.3.4** **Component Supports** *Maximum gap = diametral expansion of pipe due to thermal expansion and pressure plus 1/8 inch.*

	1.7.4 **Acceptance Criteria** *Seismic Category I supports are designed to meet the requirements of ASME Code, Section III, Subsection NF.* **1.7.5** **Jurisdictional Boundaries** *Jurisdictional boundaries are defined in ASME Section III, Subsection NF.*	3.9.3.4 Component Supports ASME Code, Section III, Subsection NF **3.9.3.4** **Component Supports** The boundary between the supports and the building is based on Subsection NF