UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

May 27, 1994

Docket No. 52-003

APPLICANT: Westinghouse Electric Corporation

FACILITY: AP600

SUBJECT: SUMMARY OF PIPING AUDIT OF THE WESTINGHOUSE AP600 DESIGN

On April 12 through 14, 1994, representatives of the U.S. Nuclear Regulatory Commission and its consultants from the Brookhaven National Laboratory and the Energy Technology Engineering Center conducted an audit of the AP600 piping design at the Westinghouse offices in Monroeville, Pennsylvania. The audit team discussed and reviewed piping and pipe support design criteria, plant protection against high-energy line breaks, applications of leak-before-break, and some sample analyses of preliminary piping design. The team also discussed the design acceptance criteria (DAC) approach that was previously used for piping systems on the evolutionary plant designs and the types of piping design information that the staff needs in the AP600 SSAR for the approach to be used for design certification of the AP600 plant. Enclosure 1 is a list of attendees.

In general, the audit was successful in resolving many of the staff concerns. Westinghouse is to be commended for a large measure of this success by providing written responses to the 82 questions identified in the staff transmittal less than one week before the audit. However, more than one third of the 82 issues remain open.

To resolve the remaining open issues, the audit team will continue to interact with Westinghouse and will perform a detailed review of the adequacy of the AP600 design procedure and criteria documents. The team will also identify the type of information in these documents that should be included in the SSAR. In addition, the team will meet with Westinghouse from July 19 through 22, 1994 to perform a followup audit of the piping design.

The following information, which was requested during the audit, is needed from Westinghouse for the staff to complete its review:

- Criteria Documents (as listed on "NRC Audit Document Lists" distributed during the piping audit conducted on April 12-14, 1994):

  1. ARC TCG Report: ASME Piping Appendix G
  9. GW-G1-003 Seismic Design Criteria
  27. GW-S2R-002 Nuclear Island Structures Safe Shutdown Earthquake Seismic Response Report (Vols. 1 & 2)

- EPRI Report 3153-02 dated December, 1993 pertaining to thermal stratification.
- Information on the surge line and main steam lines in support of the development of the piping benchmark problems.

Enclosure 2 contains Westinghouse's presentation material. Enclosure 3 contains the questions transmitted to Westinghouse prior to the audit and Westinghouse's response. Enclosure 4 contains the audit report, which summarizes the efforts and findings, as well as the status of each issue.

(Original signed by)

Kristine M. Shembarger, Project Manager
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and License Renewal, NRR

Enclosures:
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DATE	05/23/94	05/24/94	05/24/94	05/ /94

OFFICIAL RECORD COPY DOCUMENT NAME: PIPAUDIT.KMS

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WESTINGHOUSE AP600
AP600 PIPING AUDIT
MEETING ATTENDEES
APRIL 12 THROUGH 14, 1994

Name	Organization
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D. Lingren	Westinghouse
R. Mandava	Westinghouse
D. Bhowmick	Westinghouse
Y. Wong	Westinghouse
P. Strauch	Westinghouse
P. Zanaboni	Ansaldo
D. Terao	NRC
S. Hou	NRC
K. Shembarger	NRC
W. Chen	ETEC
J. Braverman	BNL
P. Bezler	BNL
G. DeGrassi	BNL

Enclosure 1

NRC AUDIT

AP600 PIPING DESIGN CRITERIA AND SAMPLE ANALYSES

SYSTEM DESIGN LOADS

Michael M. Corletti

April 12-14, 1994

Enclosure 2

SYSTEM DESIGN LOADS

- FLUID SYSTEM THERMAL MODES
- DYNAMIC EVENTS
- LOAD COMBINATIONS

SYSTEM DESIGN LOADS

FLUID SYSTEM THERMAL MODES

- Process Flow Diagram & Corresponding Line Index Table
  - PFD - Simplified P&ID Including all Process Lines
  - Prepared in Accordance with AP-3.18

- Line Index Table
  - Included as Appendix in System Specification Document
  - Contents:
    - Line Number - Piping ID - Material / Safety Class
    - Design Pressure / Temperature
    - Insulation Requirements
    - Modes of Operation
    - Operating Temperature / Pressure / Flow / Fluid
    - Identifies Potential Thermal Stratification

SYSTEM DESIGN LOADS

- Fluid System Engineer Defines Thermal Modes for a Particular System
  - Steady-State Modes of Operation
  - Based on Plant Design Basis Initiating Events

- AP600 Plant Design Criteria Document
  - Design Basis Initiating Events
- Classification of Events

Plant Condition	Frequency of Occurrence per Reactor Year	Operating Condition
PC-1	Normal Operation	Normal (I)
PC-2	$F \geq 10^{-1}$	Upset (II)
PC-3	$10^{-1} > F \geq 10^{-2}$	Upset (II)
PC-4	$10^{-2} > F \geq 10^{-4}$	Emergency (III)
PC-5	$10^{-4} > F \geq 10^{-6}$	Faulted (IV)

SYSTEM DESIGN LOADS

Modes of Operation

- Steady State Operation
- Based on Plant Initiating Events
- Considers Failures and Misalignment of Valves
- Maximum Pressure / Temperature for Each Mode Identified

SYSTEM DESIGN LOADS

Design Pressure / Temperature

- Selected in Accordance with ASME Code
  - Design P / T > Conditions during Normal Modes
  - Pressure During Upset Conditions $\leq$ 110% Design Pressure

- AP600 Piping Class Sheets and Standard Details (PL02-Z0-001)

- 3 - Letter Designation
  - First Letter - Design P/T
  - Second Letter - Material
  - Third Letter - Equipment Classification (i.e. Safety Class)

SYSTEM DESIGN LOADS

Insulation Requirements

- Identify Lines Requiring Insulation

- Basis for Insulation:
  - Thermal Efficiency
  - Personnel Protection
  - Freeze Protection
  - Other

SYSTEM DESIGN LOADS

Thermal Stratification

- Potential Thermal Stratification Identified
  - Connecting Line $\Delta T > 50^{\circ}F$
  - Potential Low Flow

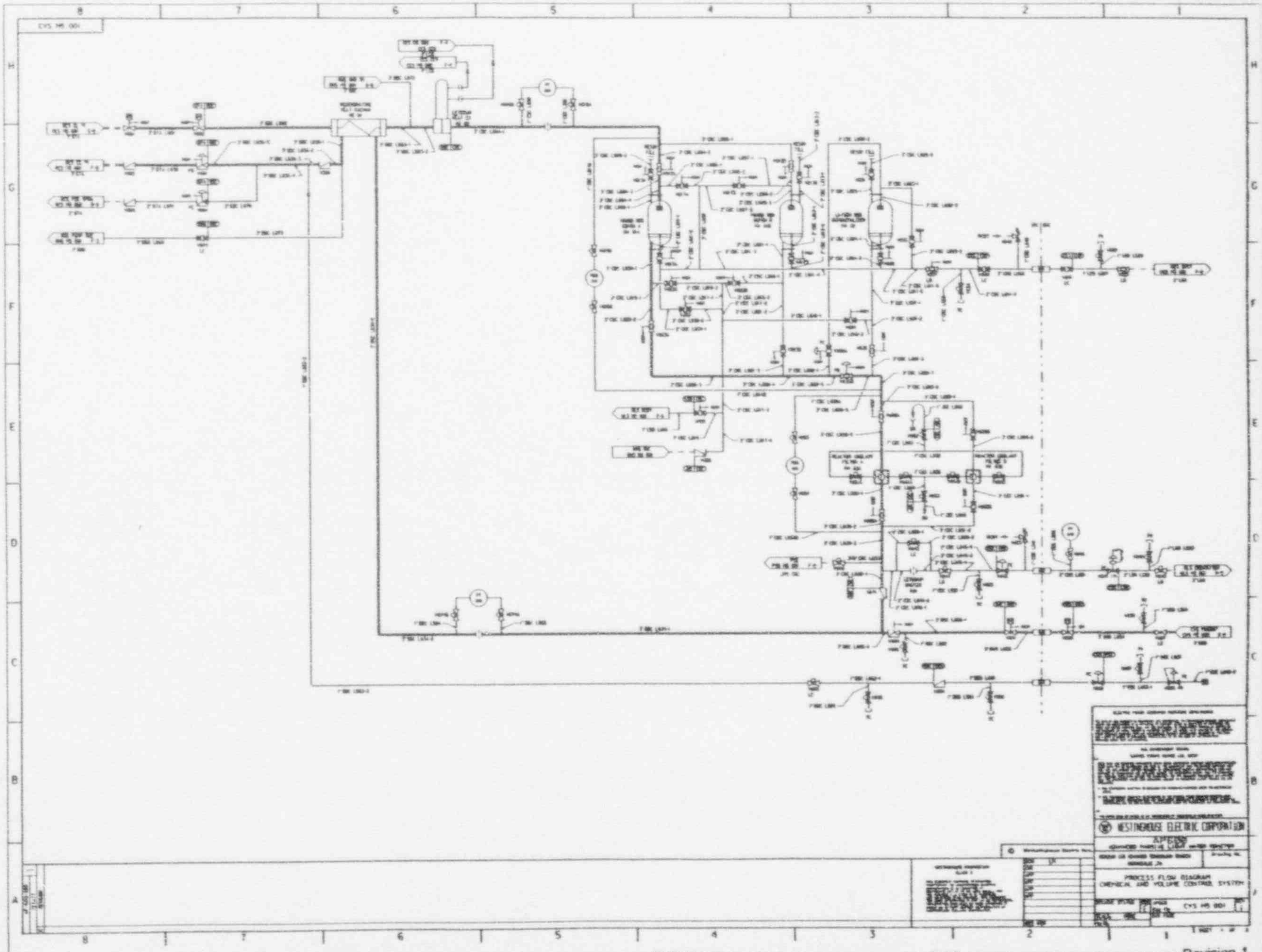
- Piping Design & Analysis Group Evaluates Thermal Stratification
  - TASCS Final Report Methodology (Question 22)

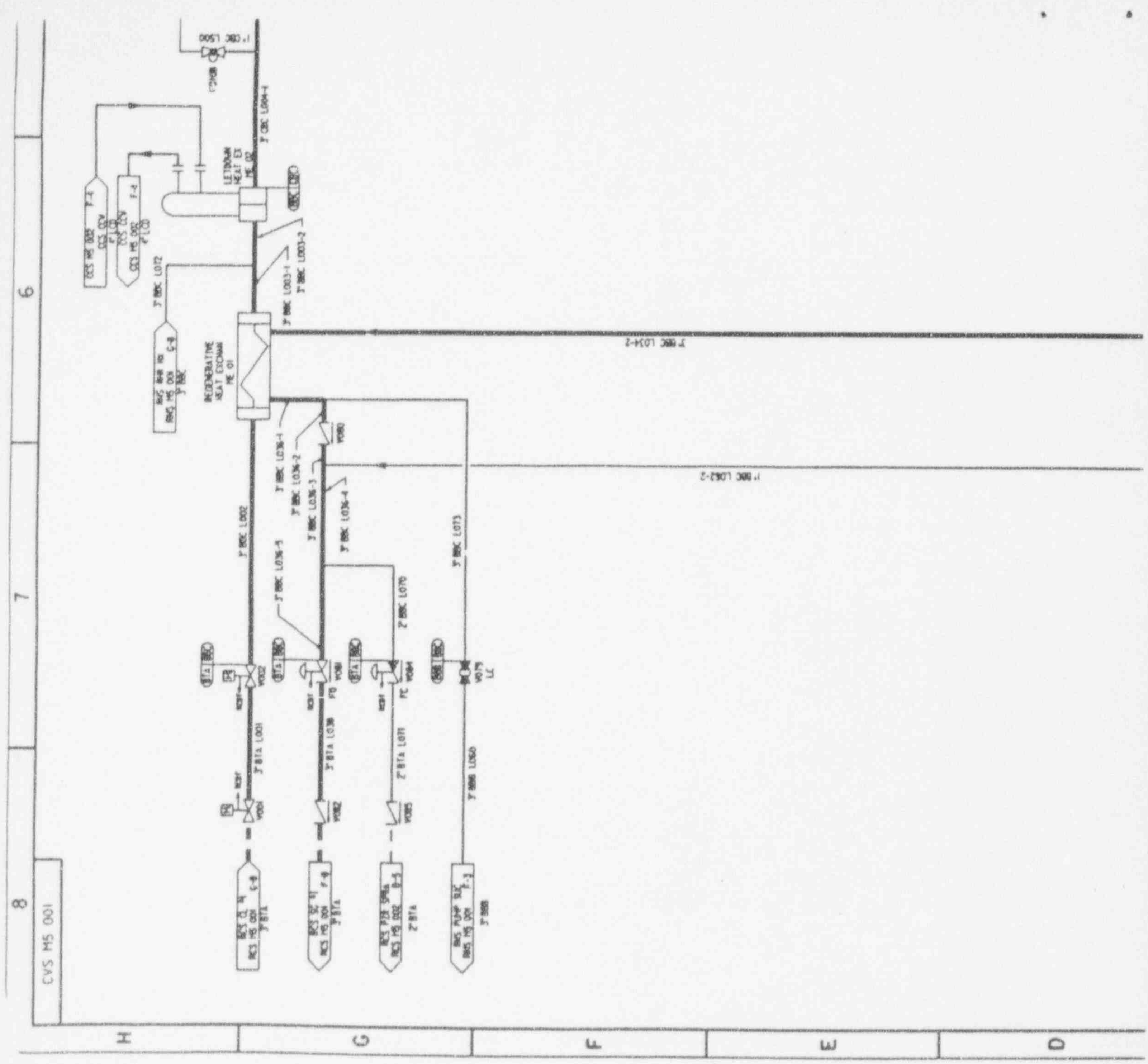
Table E-1

Chemical and Volume Control System Line Index

Normal Makeup Modes

Description	Line Spec	Design Pressure/ Temperature	Normal Operating Modes									Insul Req'd	Comments
			Makeup without WLS Letdown			Makeup with WLS Letdown			WLS Letdown without Makeup				
			Fluid	P/T (psig) (°F)	Flow (gpm)	Fluid	P/T (psig) (°F)	Flow (gpm)	Fluid	P/T (psig) (°F)	Flow (gpm)		
CVS Letdown from RCS to Letdown Isol Vlv V002	3" BTA L001	2485 650	RC	2283 529	70	RC	2283 545	100	RC	2283 545	100	Yes - T,P	
Letdown Isol Vlv V002 to Regenerative Hx	3" BBC L002	2485 650	RC	2283 529	70	RC	2283 545	100	RC	2283 545	100	Yes - T,P	
Outlet Regenerative Hx to RNS Purification Line Connection	3" BBC L003-1	2485 500	RC	2283 245	70	RC	2283 340	100	RC	2283 340	100	Yes - T,P	
RHR Purification Line Connection to Letdown Hx	3" BBC L003-2	2485 500	RC	2283 245	70	RC	2283 340	100	RC	2283 340	100	Yes - T,P	
Outlet Letdown Hx to Mixed Bed Demineralizer Branch Lines	3" CBC L004-1	2485 150	RC	2283 130	70	RC	2283 140	100	RC	2283 140	100	No	
Mixed Bed Demin Branch Line to Demin A (MV 01A) Isol Vlv V012A	3" CBC L004-2	2485 150	RC	2283 130	70	RC	2283 140	100	RC	2283 140	100	No	
Mixed Bed Demin A Isol Vlv V012A to Flush Line Connection	3" CBC L004-3	2485 150	RC	2283 130	70	RC	2283 140	100	RC	2283 140	100	No	
Mixed Bed Demin A Flush Line Connection to Demin A	3" CBC L004-4	2485 150	RC	2283 130	70	RC	2283 140	100	RC	2283 140	100	No	
Mixed Bed Demineralizer Branch Line to Demin B (MV 01B) Isol Vlv V012B	3" CBC L005-1	2485 150	STAG	STAG	STAG	STAG	STAG	STAG	STAG	STAG	STAG	No	
Mixed Bed Demin B Isol Vlv V012B to Flush Line Connection	3" CBC L005-2	2485 150	STAG	STAG	STAG	STAG	STAG	STAG	STAG	STAG	STAG	No	


WESTINGHOUSE ELECTRIC CORPORATION
AP600
PROCESS FLOW DIAGRAM
CHEMICAL AND VOLUME CONTROL SYSTEM
CVS M5 001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LETDOWN HEAT EX ME 02
REGENERATIVE HEAT EXCHAN ME 01

/ision 1

SYSTEM DESIGN LOADS

DYNAMIC EVENTS

- Draft Procedure
- Initiating Events or Consequential Events That Contribute to Mechanical Loads

SYSTEM DESIGN LOADS

DYNAMIC EVENTS:

- Pump Starting or Stopping

- Valve Change in Position
  - Stroke Time < 10 Seconds
  - Spring Relief Valve
  - Check Valves

- Pipe Break
  - High Energy Lines > 1 Inch
  - Exclude Lines Qualified for LBB

- Steam / Water Interaction
  - Lines or Components Where Cold Water and Hot Steam Potentially Interact
    - IRWST
    - Feedwater Line
    - Others

SYSTEM DESIGN LOADS

For Each Dynamic Event

- Identify the Safety Function of the System and/or Component Affected
  - Function (Fluid Flow) and Integrity Required
  - Integrity Required Only
  - Integrity Not Required

- Identify the Active Status of the Component Affected
  - Active During the Event
  - Active After the Event
  - Not Active

SYSTEM DESIGN LOADS

Consequential Dynamic Loads

- Dynamic Loads That Result from an Initiating Event
- In General:
  Loads resulting from dynamic events will only be combined with loads resulting from an initiating event if the loads can mechanistically and realistically occur simultaneously.

Criteria for Piping Systems Identified as Important by the RTNSS Process

- The Westinghouse implementation of the RTNSS process was presented to the NRC Staff in November, 1993
- Implementation is documented in WCAP-13856
- Focused PRA identified no nonsafety-related systems required to meet Commission safety goals
- Nonsafety-related piping systems identified as important (Based on initiating event frequency evaluation)
  - Normal residual heat removal system
  - Component cooling water system
  - Service water system

Proposed Regulatory Oversight

The proposed regulatory oversight for the normal residual heat removal system, component cooling water system, and service water system are short-term availability controls

- Redundant pumps and subsystems should be available prior to entering reduced reactor coolant inventory conditions.

- Maintenance should normally scheduled during Mode 1.

Piping Design Criteria

For the normal residual heat removal system, component cooling water system, and service water system

- The RTNSS process does not impose any piping design requirements.
- Containment penetrations are equipment Class B - ASME Class 2.
- Portions of the normal residual heat removal system are ASME Class 3 to address the ultimate rupture provisions of intersystem LOCA guidelines
- The balance of these systems used for defense-in-depth are Equipment Class D and use ASME B31.1 piping design.

WITH EDITORIAL CORRECTIONS

LEAK BEFORE BREAK (LBB) ANALYSES FOR AP600

D.C. Bhowmick
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WESTINGHOUSE METHODOLOGY FOR LBB ANALYSIS

- Evaluate potential failure mechanisms
- Establish material properties, including fracture tougness values
- Perform stress analysis of the structure
- Select locations for postulating through-wall flaws
- Determine a flaw size giving a detectable leak rate
- Establish stability of selected flaw
- Establish adequate margins in terms of leak rate detection, flaw size, and load

RECOMMENDED MARGINS FOR THE LBB ANALYSIS

- Margin of 10 on leak rate
- Margin of 1.5* on flaw size
- Margin of √2 on loads
- Margin of 1.0 on loads is permitted if absolute load summation is used

* Recent piping integrity programs conducted by the NRC and by many other regulatory agencies indicate that extremely high levels of loads are required to cause a catastrophic failure in piping systems. The prediction methods for establishing this margin are found to be conservative. We suggest that a margin of a factor of 1.5 on flaw size should be adequate.

PRIMARY LOOP LBB FOR AP600

Material:	SA376 TP316LN (Stainless)
Hot Leg Temperature:	600 °F
Cold Leg Temperature:	530 °F
Normal Pressure:	2250 psia

Critical Locations:
Hot Leg Location 1
Cold Leg Location 4

Highest Stress at Location 1 = 23.28 ksi
Highest Stress at Location 4 = 23.80 ksi

Leak Detection Capability: 0.50 GPM

PRIMARY LOOP LBB FOR AP600(Continued)

Leak Rate Results:
Leakage Flaw Size for 5 GPM = 4.30 inches (Location 1)
Leakage Flaw Size for 5 GPM = 5.10 inches (Location 4)

Stability Results:

Location 1:
For a Flaw Size of 8.6 inches (2x Leakage Flaw Size)

$J_{applied}$ = 1749 in-lb/in^2

$T_{applied}$ = 9.2

Location 4:
For a Flaw Size of 10.2 inches (2x Leakage Flaw Size)

$J_{applied}$ = 2946 in-lb/in^2

$T_{applied}$ = 21.3

Margins:
10 for the Leak Detection Capability
2 for the Stability Analysis

MARGIN ON LOAD = 1.0; USING ABSOLUTE SUMMATION METHOD

AP600 PRESSURIZER SURGE LINE SUMMARY FOR LBB EVALUATIONS

OUTER DIAMETER	= 18.00 INCHES
PIPE SCHEDULE	= 160
NOMINAL WALL THICKNESS	= 1.781 INCHES
MINIMUM WALL THICKNESS	= 1.578 INCHES
PIPE MATERIAL	= SA376 TP316LN
NORMAL PRESSURE	= 2250 PSIA
NORMAL TEMPERATURE	= 653°F
WELD	= GTAW TYPE

AT OPERATING TEMPERATURE (653°F)

MINIMUM YIELD STRENGTH	= 17770 PSI
AVERAGE YIELD STRENGTH	= 22210 PSI
ULTIMATE STRENGTH	= 62780 PSI
E	= 25.035×10^6 PSI

AP600 PRESSURIZER SURGE LINE
SUMMARY FOR LBB EVALUATIONS(Continued)

LOADING CONDITIONS :

NORMAL: (algebraic sum method)

- Case A Dead Weight, Pressure, Normal Thermal
- Case B Dead Weight, Pressure, Minimum Stratified Thermal

FAULTED: (absolute sum method)

- Case C Dead Weight, Pressure, Normal Thermal, Seismic
- Case D Dead Weight, Pressure, Maximum Stratified Thermal, Seismic

LOADS AND STRESSES:

CASE A:	Fx = 383181 lbs,	M= 4465000 in-lbs,	STRESS= 19216 PSI
CASE B:	Fx = 383542 lbs,	M= 4370000 in-lbs,	STRESS= 18912 PSI
CASE C:	Fx = 425981 lbs,	M= 6528000 in-lbs,	STRESS = 26444 PSI
CASE D:	Fx = 425620 lbs,	M= 6935000 in-lbs,	STRESS = 27762 PSI

AP600 PRESSURIZER SURGE LINE
SUMMARY FOR LBB EVALUATIONS (Continued)

LBB RESULTS:

CASE A	Leakage Flaw Size for 5 GPM Leak Rate	= 2.52 Inches
CASE B	Leakage Flaw Size for 5 GPM Leak Rate	= 2.55 Inches
CASE C	Critical Flaw Size	= 15.36 inches
CASE D	Critical Flaw Size	= 14.73 Inches

MARGINS:

10 FOR THE LEAK DETECTION CAPABILITY
$>$ 2 FOR THE STABILITY ANALYSES
C/A = 6.1 $>$ 2
D/B = 5.8 $>$ 2

MARGIN ON LOAD = 1.0; USING ABSOLUTE SUMMATION METHOD

MAIN STEAM LINE FOR AP600 LBB

Material	: SA333 Grade 6
Outer Diameter	: 32.00 Inch
Thickness	: 1.23 Inch (min.)
Thickness	: 1.44 Inch (nom.)
Pressure	: 815 psia
Temperature	: 520°F
Yield Strength	: 27820 psi (min.)
Ultimate Strength	: 60000 psi
Flow Stress	: 43910 psi
E Value	: 27.18×10^6 psi

MAIN STEAM LINE FOR AP600 LBB(Continued)

INITIAL LBB RESULTS AT NODE 101 (CRITICAL LOCATION)

Leak Rate Results:
Leakage Flaw Size for 5 GPM = 10.2 inches
Margin = 10

Stability Results:

For a Flaw Size of 20.4 inches (2x Leakage Flaw Size)

$J_{applied}$ = 3025 in-lb/in^2

$T_{applied}$ = 12.0

Margin = 1.85

MARGIN ON LOAD = 1.0; USING ABSOLUTE SUMMATION METHOD

FEEDWATER LINE FOR AP600 LBB

Material	: SA335 P11 (Alloy)
Outer Diameter	: 16.00 Inch
Thickness	: 0.76 Inch (min.)
Thickness	: 0.845 Inch (nom.)
Pressure	: 890 psia
Temperature	: 435°F
Yield Strength	: 24985 psi (min.)
Ultimate Strength	: 60000 psi
Flow Stress	: 42493 psi
E Value	: 27.76×10^6 psi

FEEDWATER LINE FOR AP600 LBB(Continued)

PARAMETRIC ANALYSIS RESULTS

CASE A :

NORMAL	:	20.00 KSI
FAULTED	:	30.00 KSI

CASE B :

NORMAL	:	25.00 KSI
FAULTED	:	32.00 KSI

0.50 GPM LEAK DETECTION CAPABILITY

FEEDWATER LINE FOR AP600 LBB(Continued)

CASE A

LEAK RATE RESULTS

LEAKAGE SIZE FLAW FOR 5 GPM = 2.55 INCHES

MARGIN = 10

STABILITY RESULTS

FOR A FLAW SIZE OF 5.10 INCHES (2 X LEKAGE SIZE FLAW)

$J_{APPLIED}$ = 2044 IN-LB/IN^2

$T_{APPLIED}$ = 21

MARGIN = 2

CASE B

LEAK RATE RESULTS

LEAKAGE SIZE FLAW FOR 5 GPM = 2.00 INCHES

MARGIN = 10

STABILITY RESULTS

FOR A FLAW SIZE OF 4.00 INCHES (2 X LEKAGE SIZE FLAW)

$J_{APPLIED}$ = 1789 IN-LB/IN^2

$T_{APPLIED}$ = 21

MARGIN = 2

MARGIN ON LOAD = 1.0; USING ABSOLUTE SUMMATION METHOD

AP600 MAIN STEAM AND FEEDWATER EVALUATIONS

A) PIPING ANALYSES ACTIONS

Main Steam Line :

- Use multiple input response spectra
- Relocate anchor to shield building

Feedwater Line:

- Use redefined thermal stratification loading
- Relocate 4" Start-Up Feedwater to connect directly to steam generator
- Relocate anchor to shield building
- Revise 16" pipe layout

B) FOR LBB

Material Properties: Actual materials testings are in progress

Table 4.3-1 - Safety-related Piping Inspections, Tests, Analyses and Acceptance Criteria		
Certified Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
1. Design specifications provide a basis for the construction of the safety-related piping and shall include the following: • The functions and boundaries of the safety-related piping • The design and service conditions including cyclic loads for 60 years for the reactor coolant pressure boundary • The environmental conditions • The material requirements • The methods for the dynamic and static analysis of piping systems • The functional capability requirements • The pressure boundary integrity requirements.	Inspection (review) of the design specification shall be conducted for the safety-related portions of the systems listed in Table 4.3-2.	The existence of a design specification is confirmed for the safety-related portions of the systems listed in Table 4.3-2.

Table 4.3-1 - Safety-related Piping Inspections, Tests, Analyses and Acceptance Criteria		
Certified Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
2. Safety-related piping meets the design specification. The loads, accelerations, and stresses that the piping system imposes on its pipe mounted equipment and on its interfaces with structures and other components and piping is compared to the allowable values. Functional interference is avoided with other piping, structures, and components as the piping moves or deflects due to the thermal, dynamic, and/or static loads which it experiences in service.	The pipe routing; the location, orientation, and size of snubbers and struts; the location and size of hangers; the location and weight of valves, pumps, and heat exchangers; the location and configuration of anchors; the location of guides and pipe whip restraints; and the specified clearances, shall be confirmed by reviewing drawings, and by performing a visual inspection of the installed piping. The as-built information shall be reviewed in conjunction with the as-analyzed piping system. The design report shall be inspected.	The N Symbol Stamp is confirmed for the safety- related portions of the systems listed in Table 4.3-2.

Table 4.3-2 Systems Including Safety-Related Piping

Tier 1 Design Description Section	System
3.1.2	Reactor coolant system
3.2.1	Automatic depressurization system
3.2.2	Containment system (applicable to piping connected to containment piping penetrations, refer to Table 3.2.2-2)
3.2.3	Passive containment cooling system
3.2.4	Passive core cooling system
3.2.5	Steam generator system
3.2.6	Main control room emergency habitability system
3.3.2	Chemical and volume control system
3.3.6	Primary sampling system
3.3.7	Normal residual heat removal system
3.3.8	Spent fuel pit cooling system

Westinghouse Electric Corporation
Advanced Technology Business Area

AP600

Program Operating Procedure

Subject: PIPING AND PIPE SUPPORTS DESIGN, ANALYSIS, AND LAYOUT COORDINATION

Approved: H. J. Bruschi, General Manager
Advanced Technology Business Area

Effective Date:

RESPONSIBLE MANAGER — Contact Manager, Plant Engineering for questions concerning this procedure.

PURPOSE — This procedure establishes the requirements and responsibilities for defining, performing and approving piping and pipe support design and analysis, including resolution of associated layout issues.

SCOPE — This procedure applies to all preliminary and intermediate piping and support analysis and design when these activities are performed by organizations other than the organization having building layout responsibility.

DEFINITIONS — Preliminary Piping Analysis - An analysis conducted after the conceptual piping layout and technical requirements (e.g. functional requirements, design specs, etc.) have been established but before significant engineering effort is invested. Its primary purpose is to ensure the validity, accuracy, and completeness of the requirements, and to validate the feasibility of the piping layout and support configuration in terms of these requirements.

Intermediate Piping Analysis - An analysis conducted after the piping layout and technical requirements have been defined but before the detailed procurement and construction documentation is complete. For ASME Class 1, 2, and 3 piping, the intermediate piping analysis specification and analysis report will be signed-off by registered professional engineers.

Piping Analyst - A qualified AP600 Design Agent with responsibility to perform piping and support analyses and, as necessary, recommend layout changes for resolution of stress issues.

System Designer - The AP600 Design Agent with overall system design responsibility.

Building Structural Designer - The AP600 Design Agent with responsibility for the civil/structural design of the building or area impacted by the piping analysis.

Building Layout Designer - The AP600 Design Agent with responsibility for piping and equipment layout in the building or area impacted by the piping analysis.

Module Designer - The AP600 Design Agent with structural and layout responsibility for modules impacted by the piping analysis.

Equipment Designer - The AP600 Design Agent having design responsibility for the equipment or commodities impacted by the piping analysis.

Pipe Line Number - A uniquely identified segment of piping defined by system components or other physical piping changes. (Pipe Line Numbers are assigned in accordance with Attachment 6 of Component Numbering Procedure, GW GMP 006.)

Piping Analysis Package Number - An identification number assigned to a configuration of pipe line segments that must be analyzed in combination because of interactions among the segments. A Piping Analysis Package is defined from anchor to anchor and consists of one or more piping systems that are connected by fittings or branch connections. (Piping Analysis Package numbers consist of: System Identifier - PLA - assigned sequence number.)

Piping Analysis Input Package - A package of information provided to identify analysis and layout requirements for each piping analysis package. (Piping Analysis Input Packages are provided with a document number which is the same as the associated Piping Analysis Package Number.)

Piping Isometric - An isometric identifying the piping configuration and support locations for the piping to be analyzed. (Piping Isometrics are provided with a document number consisting of: System Identifier - PLK - assigned sequence number.)

Piping Analysis Specification - A package of information defining the specific analysis criteria and methodology. (Piping Analysis Specifications are provided with a document number consisting of: System Identifier - PLS - assigned sequence number. The assigned sequence number must be the same as the Piping Analysis Input Package.)

Piping Analysis Sketch - A sketch that is generated from the piping analysis computer model that shows dimensions and support locations.

Piping Analysis Report - A summary report of the results of the piping analysis and providing backup calculations. (Piping Analysis Reports are provided with a document number consisting of: System Identifier -

PLR - assigned sequence number. The assigned sequence number must be the same as the Piping Analysis Input Package.)

PROCEDURE
General

Preliminary and intermediate piping analysis, which is performed by organizations other than the building layout organization, shall be performed as defined in a Piping Analysis Input Package provided by the building layout design agent. The building layout design agent is to provide a Piping Isometric utilizing PDS and coordinate the inputs of the system designers, equipment designers, building structural and layout designers, and module designers as required to develop the Piping Analysis Input Package.

The piping analyst will prepare a detailed Piping Analysis Specification for review and approval before initiating the detailed analysis. This will be submitted to the building layout design agent for review and approval.

The building layout design agent will coordinate review of other design disciplines and resolve comments as required to provide approval for the Piping Analysis Specification.

The piping analyst will perform stress analyses in strict agreement with the approved Piping Analysis Specification. Results shall be documented in a Piping Analysis Report and forwarded to the layout design agent for review and approval.

RESPONSIBILITY	ACTION
Building Layout Designer	1. Define a piping analysis boundary for each analysis based on Pipe Line Numbers as shown on the P&ID.
	2. Prepare Piping Isometric and 2-D sketches showing conceptual support locations and module supplemental steel.
	3. Prepare a Piping Analysis Input Package defining information to be utilized in each analysis.
	4. Transmit the Piping Analysis Input Package and Isometric to the Piping Analyst.
Piping Analyst	5. Prepare a Piping Analysis Specification and Piping Analysis Sketch based on the piping analysis input package and Piping Isometric. (All dimensions shall be in feet and inches. Any changes from the piping layout configuration provided in the Piping Analysis Input Package and Piping Isometric must be clearly identified.)

Building Layout Designer	6.	Review the Piping Analysis Specification and the Piping Analysis Sketch. Coordinate the reviews by the system, building, layout, module, and equipment designers. Provide comments to piping analyst.
Piping Analyst	7.	If required, the Piping Analyst will revise and resubmit the Piping Analysis Specification and Sketch in accordance with comments.
Building Layout Designer	8.	Approve the Piping Analysis Specification and Piping Analysis Sketch to be utilized for the analysis.
Piping Analyst	9.	Complete analyses in accordance with the approved Piping Analysis Specification.
	10.	Prepare Piping Analysis Report providing the results of the analysis for review and approval.
Building Layout Designer	11.	Review and approve the Piping Analysis Report. Coordinate the reviews by the system, building, layout, module and equipment designer. Comments, if any, will be resolved and documented as above.
Building Layout Designer	12.	The Building Layout Design organization will prepare and issue a monthly summary report identifying all piping analyses in progress, including the status of design input and analysis documentation. This report will, as a minimum, indicate actual dates for the last step completed and forecast dates for the next step to be performed for each analysis package.
REFERENCES	A.	GW GMP 006, AP600 Component Numbering System.
	B.	GW-GOX-001, List of AP600 Systems.
FORMS/EXHIBITS	Exhibit 1 - Piping Design - Layout	
	Exhibit 2 - Piping Design - Analysis	
APPENDICES	Appendix A - Piping Analysis Input Package Format	
	Appendix B - Piping Analysis Specification Format	
	Appendix C - Piping Analysis Report Format	

Exhibit 1

Piping Design - Layout

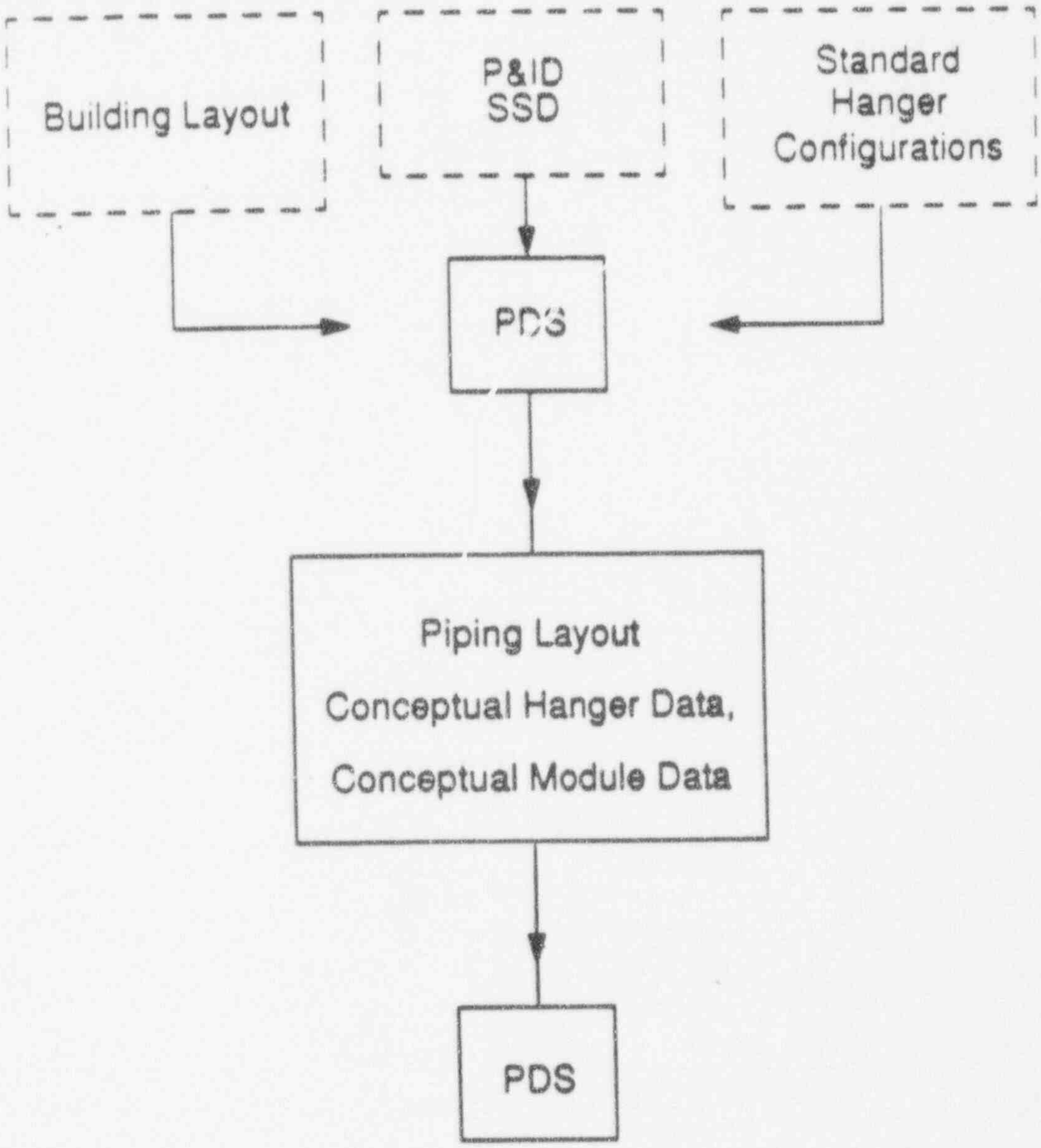
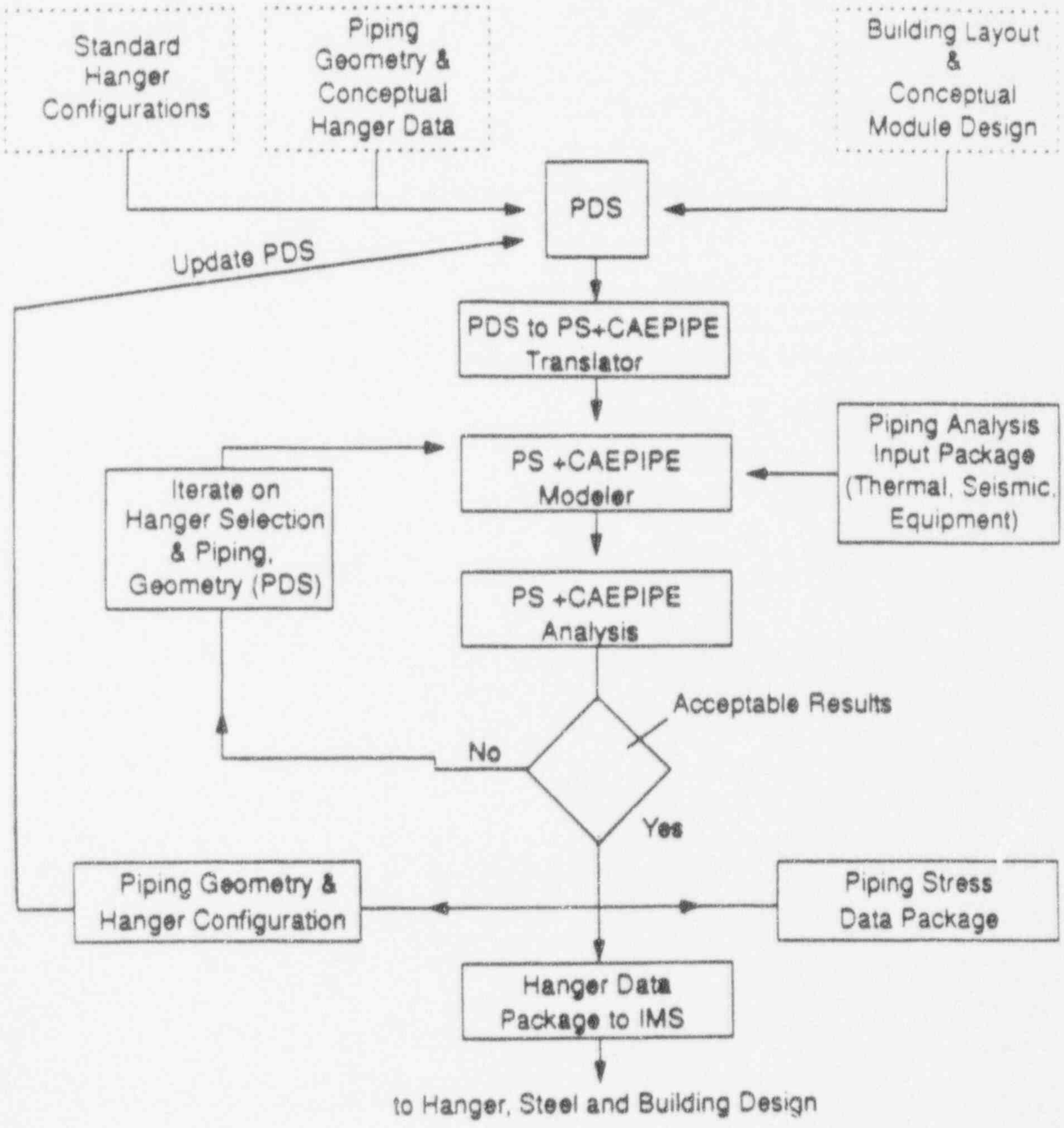


Exhibit 2

Piping Design - Analysis



Appendix A

Piping Analysis Input Package Format

General Comments:

1. The Piping Analysis Input Package must be identified with an AP600 document number assigned by Westinghouse for tracking purposes.

2. The title page must include an author, verifier, and manager's (i.e., supervisor's) approval signature and date.

3. All pages should be numbered as page x of xx.

4. A Table of Contents must be included. This Table of Contents should contain topical headings. The following listing is typical:

5. Revision numbers of the piping analysis specifications should remain as an alphabetical letter until the intermediate piping analysis stage.

Content of Input Package:

Section 1. Introduction

This section provides a brief description of the analysis task.

Section 2. Objectives

This section defines the end products of the analysis and criteria utilized for evaluation.

Section 3. Scope

This section defines the boundaries of the analysis.

Section 4. Requirements

This section identifies the technical and administrative requirements of the analysis.

Section 5. Work Sequence and Approval

This section provides a schedule for receipt of all inputs and for the production of end products and deliverables, including review and approval by other design agents as applicable.

Section 6. Exclusions

This section identifies the pipe and pipe support design, analysis and layout tasks that are specifically excluded from the analysis package.

Section 7. Analysis Technical Input

This section identifies drawings, documents and other criteria to be applied to the analysis.

Section 8. Correspondence and Information Transfer

This section identifies the administrative instructions applicable to the production and distribution of correspondence and documents related to the analysis.

Appendix B

Piping Analysis Specification Format

General Comments:

1. The Piping Analysis Specification must be given an AP600 document number that corresponds to the Piping Analysis Input Package document number.

2. The title page must include an author, verifier, and manager's (i.e., supervisor's) approval signature and date.

3. All pages should be numbered as page x of xx.

4. A Table of Contents must be included. This Table of Contents should contain topical headings similar to the Piping Analysis Input Package. The following listing is typical:

Section	Title	Page
1	Purpose (Objective)	
2	Structural Model	
3	Structural Analysis	
4	Verification	
5	References	

5. Revision numbers of the piping analysis specifications should remain as an alphabetical letter until the intermediate piping analysis stage.

6. The analysis specification should contain all of the information included in the analysis work package with greater descriptions of each task. This should reflect the analyst's understanding of the analysis.

Appendix C

Piping Analysis Report Format

General Comments:

1. The Piping Analysis Report must be given an AP600 document number that corresponds to the Piping Analysis Input Package document number.

2. The title page must include an author, verifier, and manager's (i.e., supervisor's) approval signature and date.

3. All pages should be numbered as page x of xx.

4. A Table of Contents must be included. This Table of Contents should contain topical headings similar to the Piping Analysis Input Package. The following listing is typical:

Section	Title	Page
1	Purpose (Objective)	
2	Analysis Results	
3	References	
4	Criteria Qualification	
5	Input/Output Documentation	

5. Revision numbers of the piping calculations should remain as an alphabetical letter until the intermediate piping analysis stage.

Content of Analysis Report:

Section 1. Purpose (Objectives)

This section must include a description of the piping model and the purpose of the calculation. It would contain a reference to Sections 1, 2, and 3 of the piping analysis specification and indicate the applicable ASME Code and Addenda.

Section 2. Analysis Results

This section must provide specific statements on the analysis results. Each item identified in Section 4 (Verification) of the piping analysis specification should be addressed in a paragraph summary.

Section 3. References

All references included in completing the calculation should be listed in this section. Transmittal letters should be referenced by the "FOK" letters as the primary reference. The reference listing should include subject of the correspondence. Other types of references would include AP600 document numbers. These references should include the revision and the title of the document.

Section 4. Criteria Qualification

This section will contain all calculations required to qualify the piping to the specified criteria. A listing of this section should be included under Section 4 of the Table of Contents. This section as a minimum should include the following:

1. Identification of assumptions and exclusions

2. Qualification documentation for:

   2.1 Stresses

   2.2 Valve Accelerations

   2.3 Valve Nozzle Loads

   2.4 Piping Frequencies

   2.5 A detailed explanation of all loading combinations

   2.6 A discussion on spectra development

   2.7 A discussion on the development of allowable stresses. This should include a reference to the temperature used in the calculation of the stresses.

   2.8 Leak-Before-Break Screening

Section 5. Input/Output Documentation

This section should contain:

1. Piping Stress Isometrics

2. Computer Output

3. Correspondence (if different than previously identified in the reference section)

4. Support sketches reflecting location, orientation, and spatial requirements

Item A-1

Question:

The SSAR should include a list of ASME Code Cases that will be used in AP600 piping and pipe support design.

Response:

Code Cases that would apply to the AP600 piping design are as follows:

- N-71-16 — Februrary 12, 1993
  Additional Materials for Subsection NF, Class 1, 2, 3, and MC Components Supports Fabricated by Welding, Section III, Division 1
- N-122-1 — July 24, 1989
  Stress Indices for Integral Structural Attachments Section III, Division 1, Class 1
- N-247 — January 21, 1982
  Certified Design Report Summary for Component Standard Supports, Section III, Division 1, Class 1, 2, 3, and MC
- N-249-12 — Februrary 12, 1993
  Additional Materials for Subsection NF, Class 1, 2, 3 and MC Supports Fabricated Without Welding Section III, Division 1
- N-318-4 — December 11, 1989
  Procedure for Evaluation of the Design of Rectangular Cross Section Attachments on Class 2 or 3 Piping Section III, Division 1
- N-319-2 — August 14, 1990
  Alternate Procedure for Evaluation of Stresses in Butt Welding Elbows in Class 1 Piping Section III, Division 1
- N-391-1 — July 24, 1989
  Procedure for Evaluation of the Design of Hollow Circular Cross Section Welded Attachments on Class 1 Piping Section III, Division 1
- N-392-2 — December 11, 1992
  Procedure for Evaluation of the Design of Hollow Circular Cross Section Welded Attachments on Classes 2 and 3 Piping Section III, Division 1

In addition to the above, **DRAFT** ASME Code changes related to dynamic stress methods and limits will be invoked in the design of the AP600

The SSAR will be revised to reflect this criteria.

Item A-8

Question:

The staff has not endorsed the use of ASME Code, Section III, Appendix N. If any Appendix N analysis methods will be used in the AP600 piping design, they should be identified and submitted for staff approval.

Response:

In general, the analysis methodology described in the SSAR is not based on ASME Appendix N, even though the AP600 method may be the same as the Appendix N method, we do not plan to compare the AP600 methodology with those in Appendix N.

Item A-10

Question:

Provide a set of sample piping analysis that illustrate the application of the proposed piping analysis procedures and criteria to representative AP600 piping systems. The analysis should demonstrate the application of the different dynamic analysis methods that may be used in the AP600 piping design (e.g., enveloped response spectrum, independent support motion methods, modal superposition time history, direct integration time history, etc.).

Response:

The AP600 RCL seismic analysis uses the modal superposition time history method. The preliminary analysis has been completed and is available for NRC review at Westinghouse offices. Presently there is no analysis available which uses the direct integration time history method at this time.

The AP600 Surge line, Mainsteam and Feedwater response spectra piping analysis is in progress. These are based on envelope and independent support motion methods. Preliminary data is available for NRC review at Westinghouse offices.

Item A-25

Question:

The SSAR should include a description of analysis methods and criteria for the design of welded attachments to piping.

Response:

The Code Cases that would be applicable for the analysis of welded attachments on Class 1 and Non-Class 1 piping are defined below:

- N-122-1 — July 24, 1989
  Stress Indices for Integral Structural Attachments Section III, Division 1, Class 1
- N-318-4 — December 11, 1989
  Procedure for Evaluation of the Design of Rectangular Cross Section Attachments on Class 2 or 3 Piping Section III, Division 1
- N-319-2 — August 14, 1990
  Alternate Procedure for Evaluation of Stresses in Butt Welding Elbows in Class 1 Piping Section III, Division 1
- N-391-1 — July 24, 1989
  Procedure for Evaluation of the Design of Hollow Circular Cross Section Welded Attachments on Class 1 Piping Section III, Division 1
- N-392-2 — December 11, 1992
  Procedure for Evaluation of the Design of Hollow Circular Cross Section Welded Attachments on Classes 2 and 3 Piping Section III, Division 1

The SSAR will be revised to reflect this criteria.

A25.

Q.: The SSAR should include a description of analysis methods and criteria for the design of welded attachments to piping.

A.: Welded attachments to piping will be designed in accordance with the requirements of the following code cases: N-122, N-318, N-391, N-392. These items are addressed in the piping design criteria document, GW-P1-001.

The SSAR will be revised to include a list of applicable code cases (see question A1).

A29.

Q.: SSAR Subsection 3.9.3.4 states that the pipe supports satisfy the requirements of ASME code, Section III, Subsection NF. While this is generally acceptable, Subsection NF does not provide adequate weld requirements for ASTM A500 Grade B tube steel members. If these members will be used in AP600 pipe support design the SSAR should be revised to include the supplemental requirements of AWS D1.1, "Structural Welding Code" for tube steel.

A.: The design requirements of AWS D1.1 will be used for the welded ASTM A500 Grade B tube steel connections as detailed in Section 2, Design of Welded Connections, AWS D1.1.

SSAR Revision:

The SSAR Subsection 3.9.3.4 will be revised, as follows.

Add the following sentence to section 3.9.3.4, after the sentence which ends

...pipe supports satisfy the requirements of the ASME Code, Section III, Subsection NF....

"The welded connections for ASTM A500 Grade B tube steel members satisfy the requirements of Section 2, Design of Welded Connections, AWS D1.1."

A32.

Q.: The SSAR should provide a more detailed description of pipe support design and analysis methods. It should include design requirements for baseplates and anchor bolts, consideration of friction forces, requirements for gaps and clearances, support stiffness requirements, and deflection limits for fabricated and standard supports.

A.: The existing level of detail for pipe support design and analysis methods is consistent with existing FSARs. These specific items (baseplates, anchor bolts, etc.) are addressed in the pipe support design criteria document, GW-P1-003, which is available for review. Therefore no additional information detail is planned for inclusion in the SSAR.

The SSAR will not be revised.

A35.

Q.: SSAR Subsection 3.9.3.4 provides stiffness and deflection requirements for pipe support "miscellaneous steel". Is the miscellaneous steel considered part of the pipe support within the Subsection NF boundary or part of the building structure?

A.: Miscellaneous steel which falls outside the NF boundary per NF-1130 is considered part of the building structure. The stiffness and deflection requirements apply to the total displacement of pipe support structure, module or platform steel, and embedment or baseplate. The scope of the deflection calculation, and the pipe support jurisdictional boundaries are both described in the pipe support design criteria document, GW-P1-003, which is available for review. Jurisdictional boundaries had been discussed previously in an NRC RAI (see attached 4 pages).

The SSAR will not be revised.

Question 210.9

Section 3.7.3.8.3 of the SSAR, "Piping Systems on Modules," states that modules are constructed using a structural steel framework to support the equipment, pipe, and pipe supports in the module and that, with one exception, the framework is designed as part of the building structure. If, subsequent to installation of the modules, the framework is relied upon to support any portion of the piping, provide the basis for not complying with the jurisdictional boundary rules in Section NF of Section III of the ASME Code.

Response:

The ASME Code, Section III, Subsection NF, does not clearly address jurisdictional boundaries for the specific case of module structural steel framework. The module framework is considered to be a part of the building structure that is built in the shop for convenience. The module steel frame performs multiple functions (such as supporting maintenance platforms, utilities, lighting, shielding, etc.) and supports the components and piping. Figure 210.09-1 illustrates a large module and shows the NF jurisdictional boundaries. Figure 210.09-2 illustrates a smaller module and similarly shows jurisdictional boundaries. The module framework is detailed on module steel drawings, rather than on individual pipe support or component support drawings.

Modules containing safety-related equipment are classified as seismic Category I. The module steel frames are designed and constructed to ANSI/AISC N690, as described in SSAR Subsection 3.8.4. The module frame structural qualification includes the loads applied to it by the pipe and component supports, in addition to the loads exerted by the maintenance platforms, utilities, etc. Structural steel extending from the module framework to the pipe or component (or standard component support) complies with Subsection NF of the ASME Code.

The jurisdictional boundaries described in this response have been developed based on the 1992 Code. ASME Code committees are currently considering revisions to the Code that would permit the use of AISC N690 for linear support structural steel. If this change is adopted by ASME and endorsed by the NRC, the linear supports would change from NF to AISC N690, thus making them the same as the module structure.

SSAR Revision: NONE

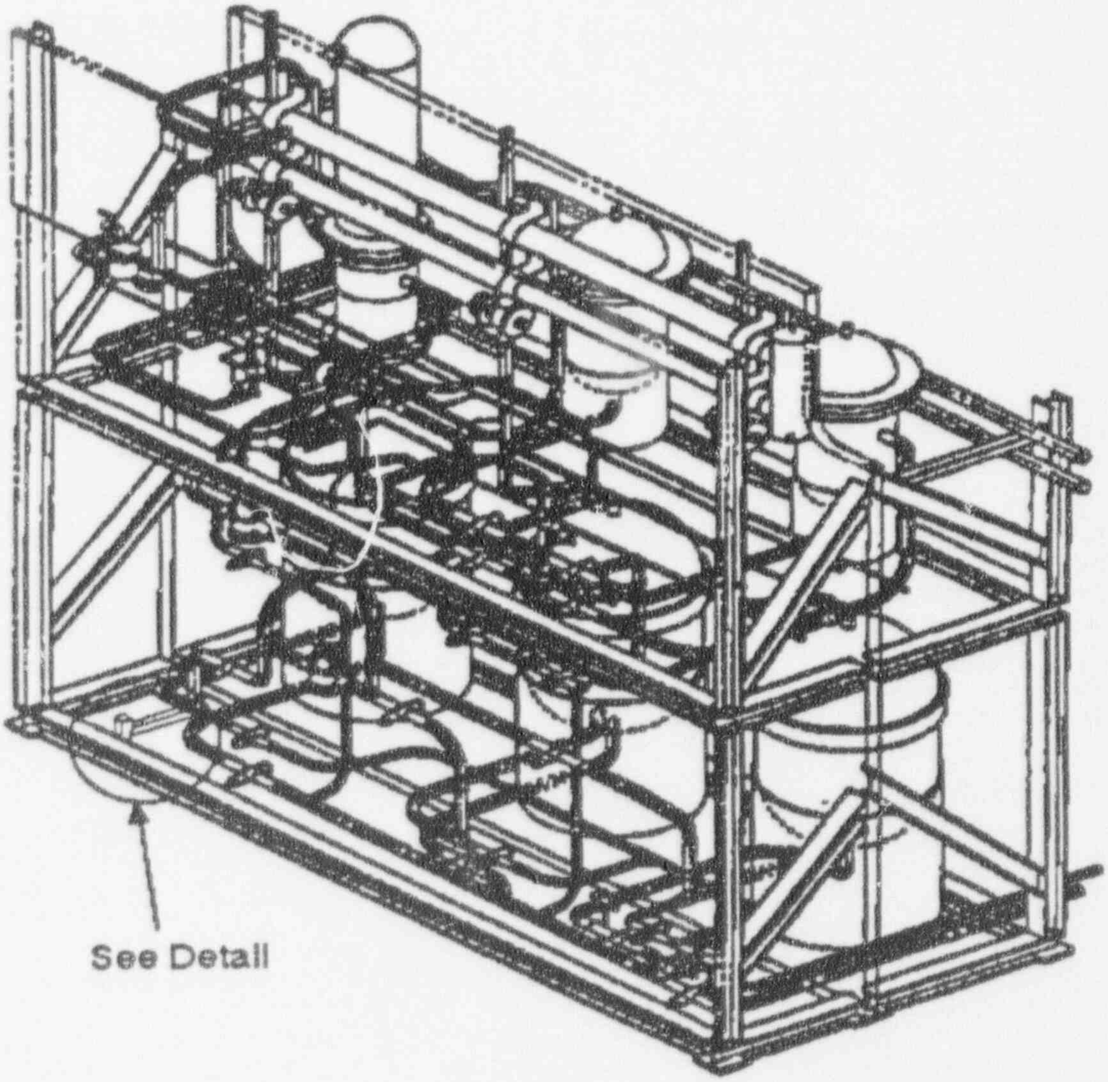


Figure 210.9-1, sheet 1 of 2
Typical Support Jurisdiction on CVS Module

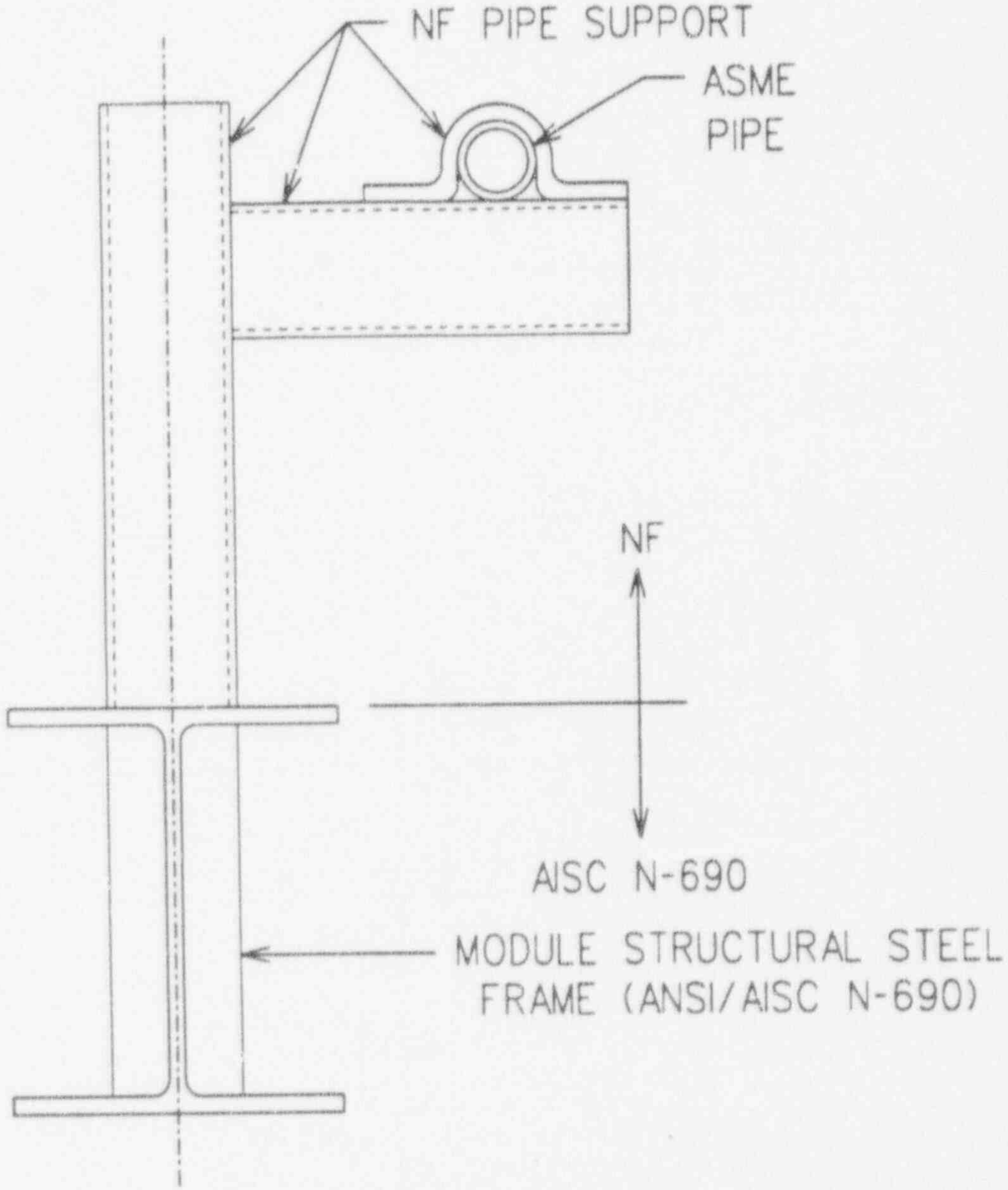


Figure 210.9-1, sheet 2 of 2
Typical Support Jurisdiction on CVS Module

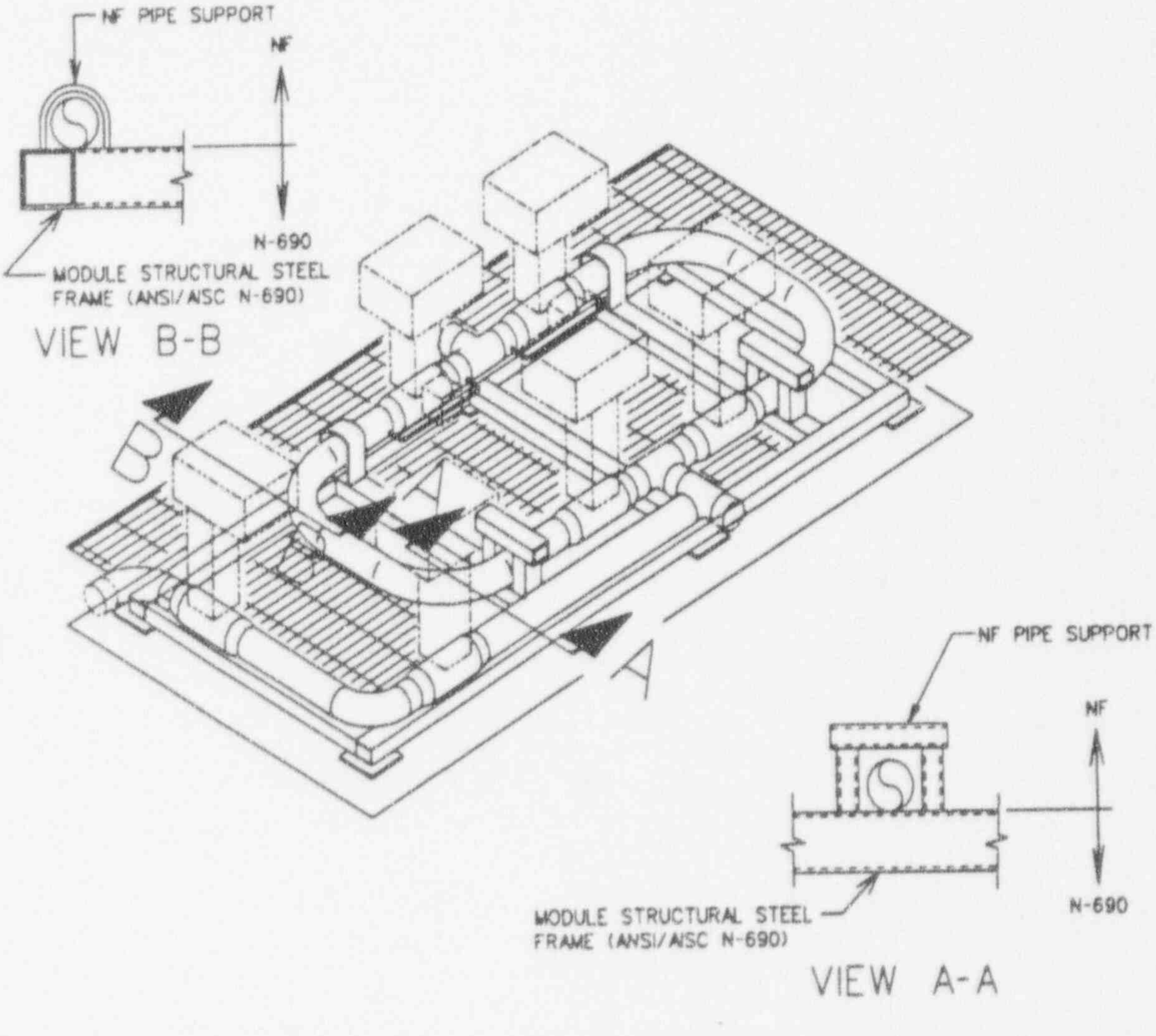


Figure 210.9-2
Typical Support Jurisdiction on Module

A36.

Q.: SSAR Subsection 3.9.3.4 defines a 1/8 inch deflection limit for pipe support dynamic loading. The SSAR should be revised to identify the specific loading combination for which this deflection limit applies.

A.: The loading combination used to calculate deflection is the maximum dynamic portion of pipe support load. Total load (static & dynamic) combinations for pipe supports are defined in Section 3.9 of the SSAR. The dynamic portion of these combinations is as follows.

For supports on safety class A, B, or C piping; the appropriate loading, for the calculation of deflection, is the maximum the combinations defined below:

SRSS(SSE+SSES+SWE), or
SRSS(SSE+SSES+RVC+SWE), or
SRSS(SSE+SSES+RVOT+SWE), or
SRSS(DF+SWE), or
SRSS(SSE+SSES+SRV+SWE), or
SRSS(SSE+SSES+DF).

For supports on safety class D, or E piping; the appropriate loading, for the calculation of deflection, is the maximum the combinations defined below:

SRSS(SSE+$SSES_D$), or
DYN

A36. (continued)

The individual load components are defined below:

SSE = Safe Shutdown Earthquake.
SSES= Seismic Anchor Motion due to SSE, or dynamic transient.
SWE= Self Weight Excitation due to SSE, or dynamic transient.
RVC = Relief valve, closed system (transient).
RVOT = Relief valve open system (transient).
DF = Inertia and displacement due to other transient dynamic event associated with Faulted service conditions, including postulated pipe rupture events.
SRV = Safety relief valve discharge.
DYN = dynamic loads that may occur occasionally, such as loads due to valve operation.

SSAR Revision:

The SSAR Subsection 3.9.3.4 will be revised, as follows.

Add the following paragraphs to section 3.9.3.4,

"The loading combination used to calculate deflection is the maximum dynamic portion of pipe support load.

For supports on safety class A, B, or C piping; the appropriate loading, for the calculation of deflection, is the maximum the combinations defined below:

SRSS(SSE+SSES+SWE), or
SRSS(SSE+SSES+RVC+SWE), or
SRSS(SSE+SSES+RVOT+SWE), or
SRSS(DF+SWE), or
SRSS(SSE+SSES+SRV+SWE), or
SRSS(SSE+SSES+DF).

For supports on safety class D, or E piping; the appropriate loading, for the calculation of deflection, is the maximum the combinations defined below:

SRSS(SSE+SSES+SWE), or

A37.

Q.: SSAR Subsection 3.9.3.4 states that dynamic loads for component supports loaded in the inelastic range are calculated using dynamic load factors, time history analysis, or other methods that account for the inelastic behavior. Will inelastic analysis methods be used in pipe support design? If so, provide a detailed description of the methodology in the SSAR.

A.: Yes, inelastic methods will be used for pipe support design. The methodology for inelastic methods is as described in NF-3340 and Appendix F of ASME Section III, Division I.

The SSAR will not be revised.

B34.

Q.: AP600 SSAR Section 3.6.2.3.4.2 provides that for energy-absorbing materials, the allowable crushable height of the material is 80% of the maximum crushable height at uniform crushable strength. This provision is not totally in agreement with SRP 3.6.2, Section III.2.a.

Modify AP600 SSAR Section 3.6.2.3.4.2 in accordance with the SRP 3.6.2, Section III.2.a provisions.

A.: The SSAR will be revised to state that the allowable capacity of crushable material shall be limited to 80% of its rated energy dissipating capacity as determined by dynamic testing, at loading rates within ± 50% of the specified design loading rate.

SSAR Revision:

The SSAR Subsection 3.6.2.3.4.2 will be revised, as follows.

Add the following paragraph to section 3.6.2.3.4.2,

"The allowable capacity of crushable material shall be limited to 80% of its rated energy dissipating capacity as determined by dynamic testing, at loading rates within ± 50% of the specified design loading rate."

Question:

A-3) Will experimental stress analysis be used in piping or pipe support design? If so, provide a description of the methodology and identify the piping systems and components for which it will be applied.

Response: There are no plans to qualify any specific component or system by the use of experimental stress analysis. If the need arises to use experimental stress analysis for a design, Appendix II of the ASME Section III Code would be followed for the methodology.

Question:
A-41) SSAR Subsection 3.7.3.5 states that the equivalent static load method of analysis can be used for design of small bore piping systems with a factor of 1.5. This is acceptable only for piping systems that can be represented by simple models. The analysis should meet the requirements and acceptance criteria given in SRP 3.9.2.

Response: SRP 3.9.2 is not clear on the definition of a piping system that can be realistically represented by a simple model. The NRC should provide guidelines and clarify the meaning of simple models. Westinghouse believes that the 1.5 factor provides an acceptable design basis for small bore piping.

Question:
A-42) SSAR Subsection 3.7.3.5 states that when the equivalent static load method is applied to piping, a factor of 1.0 may be applied in the axial direction. This is only acceptable if the fundamental frequency equals or exceeds the ZPA frequency.

Response: SRP 3.9.2 does not delineate under what circumstances a factor of less than 1.5 may be used as long as adequate justification is provided for its use. It is the Westinghouse position to use a factor of 1.0 when the piping runs have axial supports. These axial supports will tend to increase the axial fundamental frequency to a value approaching the ZPA.

Question A.22

The SSAR should identify piping systems which may be subjected to thermal cycling due to leaking valves as described in NRC Bulletin 88-08 and thermal stratification as described in NRC Bulletin 88-11. The design provisions for minimizing these effects and the stress and fatigue evaluation methodology for the affected piping components should also be described in the SSAR.

Response

U. S. Nuclear Regulatory Commission Bulletins 79-13 (feedwater line cracking), 88-08 (isolation valve leakage in systems connected to the reactor coolant system) and 88-11 (pressurizer surge line thermal stratification) were issued to address potential safety issues associated with thermal stratification, cycling and striping (TASCS) phenomena in operating nuclear power plants. Westinghouse has recently completed a joint research project with the Electric Power Research Institute from which the technology and practical tools were developed to evaluate TASCS in a realistic manner and mitigate the potential effects of TASCS. This is documented in "Thermal Stratification, Cycling, and Striping (TASCS) Final Report", Research Project 3153-02, December 1993, prepared by Westinghouse Electric Corporation for the Electric Power Research Institute.

The review of the AP600 systems to determine susceptible piping (other than the pressurizer surge line and feedwater line) will follow the requirements of Bulletin 88-08, using the guidelines presented in Section 2.0 of the TASCS Final Report.

Systems which are determined to be susceptible to TASCS loadings must be evaluated for the potential impact on structural integrity. The methodology to evaluate TASCS loadings is provided in the TASCS Final Report. This methodology has been used for several operating plant evaluations, including Comanche Peak, South Texas and most recently, Salem.

SSAR Revision

Due to the complexity of the TASCS issue, details regarding the systems review and evaluation of the susceptible piping should not be included in the SSAR. Rather, reference should be made to the TASCS Final Report.

Question B. 5.

AP600 SSAR Section 3.6.1.1, Item A states that piping systems that exceed 200°F or 275 psig for less than one percent of the plant operation time are considered moderate energy systems. Justify this consideration.

Response

The exclusion of piping systems that exceed 200°F or 275 psig for less than one percent of the plant operation time from the requirements for high energy system is provided to address systems that exceed the pressure and temperature criteria for a minimal period of time in the same manner as the exclusion for piping systems that exceed 200°F or 275 psig for less than two percent of the system operation time. This criteria has been included in licensing applications approved since the most recent issue of Standard Review Plan Section 3.6.1 including Vogtle Electric Generating Plant and the Westinghouse Advanced Pressurized Water Reactor (RESAR-SP/90)

Question B. 6.

AP600 SSAR Section 3.6.1.1 Item B states that the thermodynamic state assumed in piping systems and associated reservoirs normally pressurized during operation at power for the calculation of fluid reaction forces is that of normal full power operation. This is contrary to SRP 3.6.2 Section III.2.a which specifies that the initial condition should be the greater of the contained energy at hot standby or at 102% power. Justify the AP600 Section 3.6.1.1 Item B statement or modify the statement in accordance with the SRP 3.6.2, Section III.2.a

Response

The use of the thermodynamic state at 100 percent of normal full power operation is consistent with the recommendations of ANS 58.2, Design Basis for Protection of Light Water Nuclear Power Plants Against the Effects of Postulated Pipe Rupture. This criteria has been included in licensing applications approved since the most recent issue of Standard Review Plan Section 3.6.1 including Vogtle Electric Generating Plant and the Westinghouse Advanced Pressurized Water Reactor (RESAR-SP/90)

Question B. 18

AP600 SSAR Section 3.6.2.1.1.4 provides descriptions of break exclusion zones to the MS, FW and SG blowdown piping. As described these zones terminate outside containment at auxiliary building anchors rather than at outside location isolation valves as *required* by MEB 3-1 Section B.1.b Modify these break exclusion zone descriptions in accordance with MEB 3-1 Section B.1.b.

Response

Stress analyses for piping system must run from anchor to anchor. The break exclusion zone has been defined to match piping system analysis boundaries. This criteria has been included in licensing applications approved since the most recent issue of Standard Review Plan Section 3.6.1 including Vogtle Electric Generating Plant and the Westinghouse Advanced Pressurized Water Reactor (RESAR-SP/90)

Question B. 19

AP600 SSAR Section 3.6.2.1.2.1 specifies the types of breaks to be postulated in ASME Code Class 1, 2, and 3 and "other high-energy piping". Clarify that these other high energy piping are non ASME Code piping.

Response

The term "other high-energy piping" refers to piping designed to requirements other than the ASME Code, Section III. See Subsection 3.6.2.1.1.3. The SSAR will be revised as shown below.

SSAR Revision

Revise the first paragraph of Subsection 3.6.2.1.2.1 as follows:

The following types of breaks are postulated to occur in ASME Code Class 1, 2, and 3 and ~~other~~ high-energy piping **designed to requirements other than the ASME Code, Section III** at the locations determined according to Subsection 3.6.2.1.1, except when the mechanistic pipe break criteria are satisfied.

Question B. 20

AP600 SSAR Section 3.6.2.1.2.1 first bullet first item does not include the MEB 3-1 Section B.3.a.(1) requirement that instrument lines one-inch and less nominal pipe size or tubing size shall be in accordance with RG 1.11. Include this MEB 3-1 Section B.3.a.(1) requirement in Section 3.6.2.1.2.1.

Response

The design requirements for containment isolation for instrumentation lines penetrating ccontainment are found in Subsection 6.2.3.1.1, Item I.

Question C. 1

AP600 SSAR Section 3.6.3 indicates that application of the LBB methodology permits elimination of dynamic effects of pipe breaks in the evaluation of structures, systems and components. These dynamic events include subcompartment pressurization. This description is not in agreement with SSAR Section 3.6.1.1 Item P second paragraph. Clarify this disagreement.

Response

There is no disagreement. Use of leak-before-break methodology to evaluate the mechanistic pipe break criteria supports the elimination of the dynamic effects of pipe breaks. Subsection 3.6.1.1 Item P is addressing the effects of leakage cracks.

Question C. 4

During the May 21, 1993 NRC/W meeting the staff indicated that the W sample analysis approach for justifying LBB applications was not in compliance with the regulations nor SECY-93-087. However, the staff also indicated that performing preliminary stress analysis and establishing bounding parameters subject to ITAAC verification was an alternative approach to satisfy GDC4 of 10CFR50 as proposed by the staff in SECY-93-087. Describe how W intends to comply with GDC4 of 10CFR50.

Response

Westinghouse has completed the leak-before-break analysis of the AP600 reactor coolant loops and the pressurizer surge line. Westinghouse has also completed the initial analysis of the steam lines and feedwater lines. Westinghouse intends to complete the leak-before-break analysis of designated lines to which mechanistic pipe break criteria will apply on a schedule that will support the preparation of the Final Safety Evaluation Report for the Final Design approval. The information now available will support approval in the draft Safety Evaluation Report of the methods and criteria used for the AP600 as well as the approval of the specific analysis for the reactor coolant loops and the pressurizer surge line.

B.1 AP600 SSAR Section 3.6 indicates that the evaluation of the dynamic effects of postulated breaks in the RCL, RCL branch lines, MS & FW lines out to anchors adjacent to the isolation values and other primary and secondary system piping inside containment equal to or greater than four inch NPS (LBB piping) is to be eliminated for AP600 based on LBB applications. High energy piping systems qualifying for LBB applications are to be evaluated only for the effects of leakage cracks.

The scope of the AP600 LBB piping appears to be more extensive than in previous Westinghouse plant designs. Provide a comparison of the scope of AP600 LBB piping systems and previous Westinghouse plants LBB piping systems including a comparison of pipe sizes. Indicate how the increased scope of AP600 LBB piping can be justified including consideration of susceptibility to water hammer and leakage detection.

RESPONSE:

Comparison of scope of AP600 LBB piping systems and previous Westinghouse plants LBB piping systems including a comparison of pipe sizes.

LBB Piping	AP600	Previous W Plants
Primary Loop	Hot Leg OD = 37.50" Cold Leg OD = 27.12"	Hot Leg OD = 33.6" to 34" Cold Leg OD = 32.0" to 32.3"
Pressurizer Surge Line	Pipe Size = 18"	Pipe Size = 14" to 16"
Main Steam Line	Pipe Size = 32"	Pipe Size = 30"
Feed Water Line	Pipe Size = 16"	
Pressurizer Spray Line	Pipe Size = 4" & 6"	Pipe Size = 4"
ADS	Pipe Size = 4", 8", 12" & 14"	
Direct Vessel Injection	Pipe Size = 8"	Pipe Size = 6", 10", etc.
Normal RHR	Pipe Size = 10", 12" & 20"	Pipe Size = 10" to 12" Pipe Size = 6" & 8" (Branch)
Passive RHR	Pipe Size = 10"	
CMT Line	Pipe Size = 8"	
Pressurizer Safety	Pipe Size = 6"	

B.1 Continued

Water Hammer:

The water hammer susceptibility justification for the feedwater line is enclosed. During the detailed LBB analyses specific water hammer susceptibility issues are addressed.

Leakage Detection:

The leakage detection system for AP600 is addressed in the SSAR Section 5.2.5 and is in compliance with Regulatory Guide 1.45.

Section B question 1. Susceptability to waterhammer in the feedwater line.

Design provisions to reduce the potential for feedwater waterhammer

Steam generator design

Steam generator bubble collapse water hammer has occurred in certain early pressurized water reactor steam generator designs having feedrings equipped with bottom discharge holes. The AP600 steam generators feature a top feed ring design: This feature introduces feedwater into the steam generator at an elevation above the top of the tube bundle and below the normal water level by a top discharge feedring limiting the potential for void formation. The feedring design incorportates top mounted spray tubes to preclude formation of voids due to draining when the bulk water falls temporarily below the distribution system.

Feedwater dearator heating of startup and main feedwater

The AP600 design incorporates a dearator feedwater heater and storage tank which provides a source of heated (approximately 250°F) main or startup feedwater for refilling the feedline and steam generator as required. During the feedwater waterhammer evaluation program it was determined that heated feedwater in the range of 250°F virtually eliminated water hammer events in the steam generator designs tested.

Feedwater piping

The feedwater line layout is established to minimize the potential of draining the feedwater line and permitting steam to enter the line at low feedwater flow rates. The layout is such that a short section of horizontal pipe is welded directly to the SG feed nozzle followed with a downward tunring pipe section minimizing the horizontal volume. Further, the SG feedwater nozzle is the highest elevation within the feedwater piping layout.

Each main feedwater line includes a check valve to prevent reverse flow from the steam generator in the event of a feedwater pump trip or other system malfunction. The check valves will thus limit the potental for steam introduction into the feedwater lines and subsequent steam collapse. Additionally, the check valves are slow closing (approximately 1 second) to limit the waterhammer loads resulting from a rapid closing valve.

Main Feedwater Control

Main feedwater control positioning of the feedwater control valve during normal operation is the function of an automatic feedwater level control system using a refinement of a standard three element control scheme. The three-element control system maintains feedwater flow equal to the steam flow, and steam generator water level is used as an input to trim feedwater flow and maintain programmed water level. Refinements on the standard control are made by varying the flow demand of the valve based on the actual stem position. Refined feedwater control provides greater steam generator level stability and thus reduces potential for feedwater transients. The main feedwater control valve is a globe design employing a stacked disc trim to provide the required range of feed control.

Startup Feedwater Control

Automatic startup feedwater control logic is provided on the AP600 to minimize the potential for feedwater line transients and to enhance stable SG level control. During startup operations from no-load to about 2.4 percent load, respective steam generator startup feedwater control valves automatically maintain the water level in each steam generator. The SFCVs are air-operated, modulating control devices with a globe design employing a stacked disk trim to provide the required range of startup feed control.

In summary, the AP600 steam generator and feedwater system have incorporated features designed to eliminate the conditions linked to the occurrence of steam generator water hammer.

C.2 AP600 SSAR Section 3.6.3 indicates that in LBB applications an appropriate margin on leak detection is demonstrated.

Modify AP600 SSAR Section 3.6.3 to also indicate that appropriate margins on flaw size and on loading are also demonstrated.

RESPONSE:

Add at the end of AP600 SSAR Section 3.6.3;
"The appropriate margins on flaw size and on loading are also demonstrated."

Question C. 3

AP600 SSAR Section 3.6.3.1 provides a general discussion of compliance with regulatory requirements for LBB applications.

Provide detailed descriptions of the piping systems to which LBB procedures are to be applied. Include in these descriptions: Identification of the terminal ends or anchors, pipe size and wall thickness, and pipe material and welding process.

Response

AP600 LBB Scope

Lines Qualified to LBB	P&ID #	Analysis Input Package #
32" Main steam	SGS M6 001 & 002	SGS PLA 030 & 040
31" Hot leg	RCS M6 001	RCS PLA 050
22" Cold leg	RCS M6 001	RCS PLA 050
20" NRHR	RCS M6 001	RNS PLA 010
18" Surge line	RCS M6 001 & 002	RCS PLA 040
16" Feed water	SGS M6 001 & 002	SGS PLA 010 & 020
14" ADS	RCS M6 002	RCS PLA 010
12" Fourth stage ADS	RCS M6 001	RCS PLA 030 & PXS PLA 030
12" Normal RHR	RCS M6 001	RNS PLA 010
10" Normal RHR	RNS M6 001	RNS PLA 010
10" Passive RHR	RCS M6 001 & PXS M6 002	PXS PLA 030 & 040
8" Cold Leg to CMT	PXS M6 001 & RCS M6 001	PXS PLA 050 & 060
8" Direct vessel injection	PXS M6 001	PXS PLA 010 & 020
8" Second & Third ADS	RCS M6 002	RCS PLA 010
6" Pressurizer spray	RCS M6 002	RCS PLA 020
6" Pressurizer safety	RCS M6 002	RCS PLA 010
4" Pressurizer spray	RCS M6 001 & 002	RCS PLA 020
4" First stage ADS	RCS M6 001	RCS PLA 010

The welding process used in the AP600 LBB applicable piping systems is gas tungsten arc weld (GTAW). The pipe size, and material are identified in the piping classification on the P&IDs. The wall thickness is specified in the AP600 document "Specification Piping Class Sheets", PL02-Z0-001, Rev. 1. Terminal ends or anchors are shown in drawings from the analysis inputs packages.

C.3 Continued

Also demonstrate how the regulatory requirements for LBB applications are satisfied for each of the piping systems.

RESPONSE:

- For the primary loop LBB analyses are completed. Regulatory requirements are met. Results are presented in AP600 SSAR Appendix 3B.

- For the pressurizer surge line LBB analyses are performed and regulatory requirements are satisfied.

- Feedwater Line and Main Steam Line

  Initial analyses are performed using the lower bound material properties. Material testings are in progress. Piping analyses to qualify the piping system including LBB are in progress.

C.3 Continued

Provide a more detailed description of the LBB analysis method of analysis for each of the piping systems, including the bases for the material and fracture toughness properties, leak rate evaluations and stability evaluations.

RESPONSE:

- Westinghouse Methodology for LBB Analyses

  - Evaluate potential failure mechanisms
  - Establish material properties, including fracture toughness values
  - Perform stress analyses of the structure
  - Select locations for postulating through-wall flaws
  - Determine a flaw size giving a detectable leak rate
  - Establish stability of the selected flaw
  - Establish adequate margins in terms of leak rate detection, flaw size and load

- Material properties:
  Actual certified material test reports are used for the yield and ultimate strengths. Whenever certified material test reports are not available ASME Code minimum values are used.

- Toughness properties:
  For the stainless steel fracture toughness properties have been established from the tests and the lower bound toughness properties are used for stability analyses. These fracture toughness properties (WCAP-10456) and criteria (WCAP-10931, Revision 1) for the Westinghouse LBB applications on operating plants have been accepted by the NRC. For the AP600 steels which are not stainless, actual material tests are in progress.

- Leak rate calculation. Calculate leak rate crack opening area due to normal operating loads. Calculate the leak rate using two-phase flow formulation and accounting for crack surface roughness. Calculate the leakage flaw size for 10 times the leak detection capability. Show that the calculated leak rate is detectable.

- Stability Analyses:
  Using maximum faulted loads, demonstrate that there is appropriate margin between the leakage flaw size and the critical flaw size.

C.3 Continued

- Westinghouse LBB methodology and analyses for the operating plants were accepted and approved by the NRC.

Recommended margins for the LBB analyses:

- Margin of 10 on leak rate
- Margin of 1.5 on flaw size
- Margin of $\sqrt{2}$ on loads
- Margin of 1.0 on loads is permitted if absolute load summation is used.

Question A.22

The SSAR should identify piping systems which may be subjected to thermal cycling due to leaking valves as described in NRC Bulletin 88-08 and thermal stratification as described in NRC Bulletin 88-11. The design provisions for minimizing these effects and the stress and fatigue evaluation methodology for the affected piping components should also be described in the SSAR.

Response

U. S. Nuclear Regulatory Commission Bulletins 79-13 (feedwater line cracking), 88-08 (isolation valve leakage in systems connected to the reactor coolant system) and 88-11 (pressurizer surge line thermal stratification) were issued to address potential safety issues associated with thermal stratification, cycling and striping (TASCS) phenomena in operating nuclear power plants. Westinghouse has recently completed a joint research project with the Electric Power Research Institute from which the technology and practical tools were developed to evaluate TASCS in a realistic manner and mitigate the potential effects of TASCS. This is documented in "Thermal Stratification, Cycling, and Striping (TASCS) Final Report", Research Project 3153-02, December 1993, prepared by Westinghouse Electric Corporation for the Electric Power Research Institute.

The review of the AP600 systems to determine susceptible piping (other than the pressurizer surge line and feedwater line) will follow the requirements of Bulletin 88-08, using the guidelines presented in Section 2.0 of the TASCS Final Report.

Systems which are determined to be susceptible to TASCS loadings must be evaluated for the potential impact on structural integrity. The methodology to evaluate TASCS loadings is provided in the TASCS Final Report. This methodology has been used for several operating plant evaluations, including Comanche Peak, South Texas and most recently, Salem.

SSAR Revision

Due to the complexity of the TASCS issue, details regarding the systems review and evaluation of the susceptible piping should not be included in the SSAR.

Question A. 28

The SSAR should discuss the resolution of the intersystem LOCA issue described in SECY-90-016. Design pressure ratings and minimum wall thicknesses of low pressure piping systems that interface with the reactor coolant pressure boundary should be provided.

Response:

The issue of intersystem LOCA as described in SECY-90-016 is addressed in the SSAR subsections 1.9.5.1 and 5.4.7.2.2. As described in these subsections, the only AP600 low-pressure interfacing system whose rupture could cause an intersystem LOCA is the Normal Residual Heat Removal System. The design pressure of the RNS system requires the use of Schedule 80 pipe. The ultimate rupture strength of the RNS piping is sufficient so that the RNS is capable of withstanding full operating system (RCS) pressure without rupture.

SSAR Revision:

None

Question A. 38

SSAR Subsection 3.9.3.4 states that for certain Service Level D conditions, such as pipe rupture, the system integrity and operability may be demonstrated by allowing the supports to fail. Identify all other Service Level D conditions in which pipe supports are allowed to fail.

Response

At this time, no other Service Level D conditions meet this criteria.

Question B. 3

AP600 SSAR Sections 3.6.1 and elsewhere state that the IRWST and RV annulus, which do not contain any pipes less than three-inch diameter subject to failure, are evaluated for pressurization with "different criteria" (presumably criteria are different from those in A2). These criteria are provided in Section 3.6.1.2.1, "pressurization Response".

Clarify these criteria.

Response

NRC should clarify question.

Question B. 4

AP600 SSAR Section 3.6.1 states that pressurization loads for pipe failures i the break exclusion zone for high-energy lines in the vicinity of containment-penetrations are evaluated for a 1.0 square foot break. AP600 SSAR Sections 3.6.1.1, Item E and 3.6.2.1.1.4 also specify a 1.0 square foot break for the break exclusion zones for the MS and FW lines.

Clarity this 1.0 square foot break area.

Response

The 1.0 square foot break is based on BTP SPLB 3-1, October 1980.

Question B. 7

AP600 SSAR Section 3.6.1.1 Item D states that high and moderate-energy pipe through wall cracks are evaluated for spray wetting and flooding effects. No time period for flooding effects is specified. BTP MEB 3-1 Section B.3.c.(4) provides that the time period should be conservatively estimated on the period required to effect corrective actions.

Response

The flooding levels provided in the SSAR Section 3.4.1 are based on a preliminary calculation which assumes that the break is isolated 30 minutes after control room indication (except where the leak is not readily isolable or where leakage is otherwise limited). This "30 minute" criteria is also stated in the AP600 Design Criteria for Protection from Flooding, GW-N1-007, Rev. B.

SSAR Revision

SSAR Section 3.6.1.1 Item D will be modified to add:

Flooding effects are determined based on a conserative estimate for the time period required to effect corrective actions.

Question B. 15

AP600 SSAR Section 3.6.2.1.1 does not include the requirements of MEB 3-1 Sections B.1.c.(4) and (5) for structures separating a high energy line from an essential component and the environmental qualification of safety-related equipment, respectively.

Include these MEB 3-1 Section B.1.c requirements in AP600 SSAR Section 3.6.2.1.1.

Response

All structures are designed for specific break location, not for worst case break location.

B. 17

AP600 SSAR Section 3.6.2.1.1.4 does not include the requirements of MEB 3-1 Section B.1.b.(6).(d) for inspection ports in guard pipe assemblies.

Include these MEB 3-1 Section B.1.b.(6).(d) requirements in AP600 SSAR Section 3.6.2.1.1.4.

Response

AP600 does not require inspection ports since design is configured so that all welds are inspectable without access ports.

B. 26

AP600 SSAR Section 3.6.2.1.2.2. Item D is not totally in agreement with MEB 3-1 Section B.2.a requirements for moderate-energy fluid systems separated from essential systems and components.

Modify AP600 SSAR Section 3.6.2.1.2.2. Item D in accordance with these MEB 3-1 requirements.

Response

AP600 position is consistent with ANS-58.2-1988 and NRC should clarify their concern.

Question A-2 — ASME Section III requires a design specification for Class 1, 2, and 3 piping systems. Provide a sample ASME Code piping design specification or a procedure for preparing an ASME Code piping design specification.

Response — The NRC should explain what they are looking for in more detail. ASME Piping Design Specs are not available for AP600 at this time.

Question A-4 — The SSAR should provide detailed descriptions of all dynamic analysis methods that may be used in piping design (e.g., enveloped response spectrum method, independent support motion method, modal superposition time history method, direct integration time history method). The descriptions should include the criteria for selection of significant parameters for each method (e.g., cutoff frequency, integration time step, number of modes, etc.). Guidelines for selection of analysis method should also be included.

Response — Westinghouse agrees that the descriptions of dynamic analysis methods will be provided in a project procedure document. The required parameters in each method will be discussed in the document. Westinghouse believes to have as many methods as it requires to deal with analysis need. Specific application guidelines will be included.

Question A-5

Will inelastic analysis methods be used in piping design? If so, describe the methodology and identify the piping systems and components for which it will be applied.

Response

Inelastic analysis method may be used on a limited case basis. Whenever the structure integrity evaluation is the only requirement in design, and the strain limit is more appropriate than the code stress limit, the in-elastic analysis method will be most likely applied. With respect to the in-elastic analysis method, common procedures appearing in WECAN - plus, ANSYS, ABAQUS will be used. These procedures are usually based on incremental theory of plasticity. Selection of isotropic or kinametic hardening rules or the combination of the two will be made when judged appropriate. AP-600 piping is at an earlier design stage. It is yet to identify any systems that may require in-elastic analysis.

Question A-7

SSAR Subsection 3.7.3.13.3 states that the interaction of seismic Category I piping and non-seismic piping connected to it is achieved by incorporating into the seismic analysis a length of non-seismic pipe that represents the dynamic behavior of the complete run of the non-seismic system. Provide justification that a length of non-seismic pipe extending to two seismic restraints in each direction (instead of an anchor) is sufficient to represent the dynamic behavior of the complete run.

Response

It is important to understand that by extending a length of two seismic restraints in each direction into non-seismic portion of the piping is to include the dynamic effects of the model beyond seismic portion of the piping. Experiences from piping analysis found that the stiffness and mass effects from portions further than two seismic restraints can be considered negligible in design. Since piping system deformation is mainly based on the beam analysis mode, design can provide a simple realization of such approximation.

Question A-11

When a branch pipe is decoupled from a larger run pipe in accordance with the criteria given in SSAR Subsection 3.7.3.8.1, how is the mass of the branch pipe considered in the analysis of the run pipe?

Response

Based on the pipe size ratio used in the decoupling criteria in section 3.7.3.8.1, the mass ratio is 7.45/45.3 = 0.164 for the same length of pipe 2"/6" (Schedule 160). Neglecting such as small ratio in mass will have no effect only any dynamic responses of the run pipe since the effect on local mode is negligible.

Question A-12

SSAR Subsection 3.7.3.8.2.1 states that in the analysis of a decoupled branch line, the run pipe connection point is considered an anchor for seismic inertia analysis and the response spectrum at that point is the floor response spectrum at the supports near the connection. This is only accurate if the run pipe is rigid and does not amplify the floor response spectrum. Similar criteria are provided for piping connected to equipment. Equipment must also be rigid in order to use the floor spectrum as seismic input. The SSAR should be revised to address this concern.

Response

The AP600 design basis for decoupling of branch and run piping for seismic analyses of the branch piping has been used on existing plants and is endorsed by the ARC Technical Core Group report on piping design (Appendix G). Seismic experience indicates that branch pipe failure from the inertial effects of the run pipe motion is very unlikely and that the main concern is the static effects of run pipe motion. The AP600 design basis ensures that there will be no pipe failures for the SSE loading.

The AP600 design basis for decoupling equipment from the SSE analysis of the supported piping is similar to the design basis for decoupling the run pipe as described in SSAR Subsection 3.7.3.8.2.1.

Based on the above, the SSAR will not be revised.

Question A-13	Will the floor response spectra used in piping analyses always be based on an envelope of all design soil profiles? Will peak shifting methods be applied in any piping analyses instead of peak broadening? If so, a description of the methodology should be included in the SSAR.
Response	The preferred SSE analysis method is to use an envelope response spectra that represents all the soil conditions. The peaks are broadened and peak shifting method is not used is these analyses. (SSAR Subsection 3.7.2.5). The SSE analysis of piping system may be done with several sets of response spectra where each set represents a selected soil condition. The peak shifting method in ASME III, Appendix N may be used in these analyses. SSAR subsection 3.7.2.5 will be revised.

Question A-14 When time history analysis is performed, how will modeling uncertainties and parameter variations (normally accounted for by floor response spectrum peak broadening) be considered?

Response For a time-history analysis of a decoupled piping system, the input time-history must be generated as a spectra consistent time-history at the structure boundary. Such spectra at the structure boundary may be a broadened floor response spectra, that envelopes all of the soil conditions or a series of selected soil conditions. In each case, the spectra is broadened so that parametric variations are accounted for in the spectra consistent time-history. This method is used with enveloping uniform input.

For multi-point time-history input the phasing of the various input motions is maintained as calculated from the time-history analysis of the supporting systems and structures. In this case the time scale of the input is expanded and contracted by 15% and three separate time history analyses are used for each soil condition

For the primary loop piping, the piping is coupled to the interior concrete building. The input motion are at the top of the basemat and are obtained from the building time-history analysis. The response spectra for the limiting soil case is sufficiently flat such that parametric variations are accounted.

Question A-15 SSAR Subsection 3.9.3.1.5 and the referenced Tables should be revised to properly reflect the requirements of the NRC staff position on single earthquake design. The definitions of "ES" and "E" in Tables 3.9-3 and 3.9-4 require a clearer definition (1/3 SSE?). Tables 3.9-9 and 3.9-10 should include notes that reference the additional stress criteria given in Table 3.9-11. The equations in Tables 3.9-11 that impose limits on SSE SAM stresses are not consistent with the NRC staff position equations. The Class 2/3 equation is not equivalent to NRC equation 10b. The Class 1 NRC equation 12a must always be satisfied.

Response SSAR Tables 3.9.3 and 3.9.4 will be revised to show that smaller earthquake is one-third of the SSE (SSAR Subsection 3.7.3.2).

SSAR Tables 3.9.9 and 3.9.10 will be revised to refer to Table 3.9-11.

The equation for seismic anchor motion stress for ASME Class 2 and 3 piping in Table 3.9-11 is a logical extension of the NRC equation. This is based on the additive stress approach that is used in Equation 11 of NC3653.

The NRC should clarity their last sentence on Equation 12a.

Question A-16 The use of ASME Code Case N-411 damping in response spectrum analysis is acceptable subject to the conditions given in Regulatory Guide 1.84. This should be noted in the SSAR.

Response The AP600 piping design basis SSE damping value will be revised to 5% damping for all system frequencies. (SSAR Subsection 3.7.3.15 and Table 3.7.1-1 will be revised). This is consistent with the recent changes to the ASME Code. SSAR Tables 3.9-9 and 3.9-10 will also be revised to incorporate these ASME Code changes. The 5% SSE damping is applicable to both types of response spectra analysis: envelope and multiple-input.

Question A-17	The SSAR should specify the damping values that will be used when time history analysis (by modal superposition or direct integration) of piping systems is performed.
Response	SSAR Subsection 3.7.3.15 will be revised to state that 2% and 3% SSE damping is used for time history analysis of auxiliary piping, and 4% SSE damping is used for time history analysis of the primary loop and pressurizer surgeline piping.

Question A-18

The mathematical representation for the modal combination methods described in SSAR Subsection 3.7.3.7.2 are different from those methods given in R.G. 1.92. Provide an explanation and justification of the differences.

Response

The methods specified by R.G. 1.92 are included in SSAR and will be used in conjunction with program PS+CAEPIPE. The other method described in 3.7.3.7.2 Combination of Low-Frequency Modes is the method used by Westinghouse (TSS 5 Method) in program WESTDYN. It is a combination method developed by Westinghouse from the same data used by the NRC in development of R.G. 1.92. It has been approved for use by USNRC on domestic plants since the mid 1980's. (See Section 3.7.N.2.7 of Vogtle FSAR).

Question A-19

The first three methods for combining high frequency modes described in SSAR Subsection 3.7.3.7.1 are different from the method given in Appendix A to SSRP 3.7.2. Provide additional justification for these methods or demonstrate that these methods would provide equivalent or more conservative results that the NRC-accepted method.

Response

An additional method, the "Left Out Force" method as used in program PS+CAEPIPE is to be added to the SSAR Subsection 3.7.3.7.1. The equations of the "Left Out Force" similar to the NRC method except that they maintain all equations in matrix form rather than convert mass effects to scaler form as in the NRC method.

The Residual Load Method (RLM) equations [Method A] and the Full Zero Period Acceleration Method (FZPA) method [Method B] are also similar to the NRC method except that they also maintain all equations in matrix form rather than convert mass effects to scaler form. Methods A and B were incorporated into Westinghouse's program WESTDYN in the mid 1980's and have been used for US and foreign nuclear plants since that time. Method C in the RLM adapted to for use with multi-level response spectra solutions.

The SSAR will be revised to add the "left out force method".

F. Left Out Force method for Response Spectra Analysis:
(Based on Clough and Penzien method)

$$\text{Left Out Force} = \left(1 - \sum_{w_j < w_R} M\, e_j e_j^T\right) M K^{-1} K_B x_B(t)$$

(with respect to lower modes).

Where M = mass matrix

e_j = eigenvector of mode j

e_j^T = transposed eigenvector of mode j

$\sum_{W_j < W_R}$ = sum from lowest frequency to rigid mode frequency w_R

K_B = the N x M boundary coupling matrix

x_B (t) = vector (M) of support movements

Question A-20	Recent test data indicates that the effects of the reactor environment could reduce the fatigue resistance of certain materials. The SSAR should describe how these environmental effects will be accounted for in the fatigue analysis of AP600 piping systems.
Response	The conclusion of the environmental effect on fatigue life is premature. Appropriate action will be taken if the environment is determined to be significant by the industry.

Question A-21 The current ASME Code Class 2 and 3 rules for fatigue may be inadequate for piping components designed for a 60 year design life. The SSAR should identify these components and describe the analysis that will be performed to verify their fatigue adequacy.

Response Recent studies from industries have demonstrated that the current ASME Code Class 2 and 3 rules for fatigue are adequate. It is Westinghouse's position that the AP600 Class 2 and 3 piping design will continue to use ASME rules.

References:

1. EPRI Report #TR-102901, "Comparison of Piping Designed to ANSI B31.1 and ASME Section III, Class 1," Prepared for EPRI by SIA, Inc., August 1993.

2. Saudia National Lab Report SAND94-0187, "Evaluation of Conservatism and Environmental Effects in ASME Code, Section III, Class 1 Fatigue Analysis," Prepared by SNL, draft, April 1994.

Question A-23	From SSAR Subsection 3.9.3.3, it is not apparent that the design and analysis requirements of pressure relieving devices are in compliance with ASME, Section III, Appendix O and the additional criteria given in SRP 3.9.3. This section should be revised to confirm the consistency with the NRC acceptance criteria.
Response	The design and analysis will comply with ASME III, Appendix O. The loading combinations are identified in SSAR Tables 3.9-7 and 3.9-8 and the stress limits are listed in SSAR Tables 3.9-9 and 3.9-10. The system operating transients are described in AP600 system specification documents or each system. Where more than one value is installed on the same run pipe, the sequence of valve openings is based on the value setpoints. Stresses are evaluated in the run piping, the connecting piping, and the associated supports. The SSAR Subsections 3.9.3 and 10.3.2 will be revised.

Question A-24	The SSAR should include functional capability requirements for piping systems which meet the criteria of NUREG-1367.
Response	The NRC should clarity requirements of NUREG-1367. SSAR Tables 3.9-9 and 3.9-10 will be revised to refer to NUREG-1367.

Question A-26 If composite modal damping will be used in piping system analysis, a detailed description and justification for the methodology must be provided.

Response Composite modal damping is calculated using the strain energy method. (SSAR Subsection 3.7.1.3). The method has been used on operating plants.

Question A-27

The SSAR should provide a more detailed description of piping thermal expansion methods and assumptions including the minimum temperature for which explicit thermal analysis is required.

Response

This level of detail is not normally put into SSAR. The information is usually found in plant procedures or piping design criteria. The minimum temperature for which explicit thermal expansion analysis is required is 150°F. The SSAR will not be revised.

Question A-30 SSAR Table 3.9-8 includes self weight excitation (SWE) under several Level B and C load combinations for pipe supports. Is this SWE associated with the SSE or with some other dynamic load?

Response Notes will be added to SSAR Table 3.9-8 to indicate that SWE corresponds to the indicated dynamic load (RVC, RVOT, DU, SRV, DE, DF or SSE).

Question A-31

SSAR Table 3.9-8 defines several load combinations in which SSE inertia, anchor motion, and self weight excitation is combined by SRSS. Provide justification for SRSS (versus absolute) summation.

Response

The SRSS combination method for SSE inertial, anchor motion and SWE loads is based on the low probability of different system modes peaking at the same time. The different modes are:

Loading	System Mode
inertial	piping
anchor motion	building
SWE	pipe support

Comparison to test results show that inertial and anchor motion loads may be combined by SRSS

Reference:

EPRI No. 6153 March 1989, Seismic Analysis of Multiple Supported Piping Systems

Question A-33

If special engineered supports such as energy absorbers or limit stops will be used in AP600, the SSAR should include a detailed description of the design and analysis methods and modeling assumptions that would be applied in designing a piping system with such supports. A sample piping analysis problem should also be provided for review.

Response

Limit stops supports are described in SSAR Subsection 3.7.3.8.4. A sample piping problem is not available at this time.

Energy absorbing supports are not planned for AP600 piping systems at this time. SSAR 3.9.3.4 will be revised or additional information will be provided on energy absorbing supports.

Question A-34 — The SSAR should identify and tabulate all safety-related piping systems which utilize snubbers. The tabulation should include the snubber information required by SRP 3.9.3. Gapped support devices or other special engineered supports used in place of snubbers should also be included.

Response — A table of snubbers and limit stops will not be included in the SSAR. This is consistent with operating plant practice.

Question A-39 — The SSAR should provide detailed design requirements for safety-related instrumentation line tubing and supports. It should include considerations, analysis methods, and acceptance criteria.

Response — Safety-related instrument line tubing (and its supports) is ASME small bore piping. See SSAR subsection 3.7.3.8.2.2 for requirements.

Question A-43 SSAR Subsection 3.7.3.8.3 provides decoupling criteria for piping supported by the structural steel framework of modules. Provide the justification for decoupling when the deflection of the frame is less than 1/8 inch.

Answer 43 The deflection criteria to decouple the module steel from the SSE analysis of the supported piping is a logical extension of decoupling the pipe support steel from the piping analysis. This approach is applied to simple module steel configurations for which the module steel provides support for only piping. It is not applied to complex module configurations for which the module steel provides support for other components such as equipment or HVAC ductwork. (See Question 36)

This deflection criteria is based on the ARC Technical Core Group report on piping, Appendix G.

This approach is similar to decoupling the run pipe (See Question 12).

Question B-2

AP600 SSAR Section 3.6.1 and elsewhere indicate that structures inside containment are evaluated for the pressurization loads due to a break area equivalent to three-inch (nominal) diameter primary system pipe.

It appears that the preceding is based on the successful application of LBB to the scope of the AP600 LBB piping described in A1.

Changes in scope of the AP600 LBB piping will require revisions to this indication in Section 3.6.1 and elsewhere.

Response

SSAR revisions for pressurization loads on structures will be made, if required, based on the results of the leak-before-break analysis.

Question B-8

AP600 SSAR Section 3.6.2.1.1.1 provides criteria for break postulation at intermediate locations in high-energy piping systems. These criteria are in accordance with BTP MEB 3-1, Rev. 2, Section B.1.c.(1).(b) criteria.

The staff is recommending that these MEB 3-1 Rev. 2 criteria be replaced with the previous MEB 3-1 Rev. 1 criteria.

Revise these criteria in accordance with the MEB 3-1 Rev. 1 criteria.

Response

The criteria in Revision 1 of MEB 3-1 includes one or two arbitrary intermediate break locations based on Equation (10) of NB 3653.

The AP600 position is based on ANS 58.2-1988 and requires no arbitrary intermediate break locations. This position has also been applied to operating plants.

The SSAR will not be revised.

Question B-9, B-11, and B-13	AP600 SSAR Section 3.6.2.1.1.2 does not contain the MEB 3-1 Section B.1.c.(2) (NRC to clarify) criteria for the effects of piping reanalysis due to the difference between design and as-built configurations on initially determined intermediate break location in ASME Code, Section III, Class 1 high-energy piping systems.
	Include these MEB 3-1 criteria in AP600 SSAR Section 3.6.2.1.1.1.
	AP600 SSAR Section 3.6.2.1.1.2 does not contain the MEB 3-1 Section B.1.c.(2) criteria for the effects of piping reanalyses due to differences between design and as-built configurations on initially determined break locations in ASME Code, Section III, Class 2 and 3 high-energy piping systems.
	Include these MEB 3-1 criteria in AP600 SSAR Section 3.6.2.1.1.2.
	AP600 SSAR Section 3.6.2.1.1.3 does not provide criteria for the effects of piping reanalyses due to differences between design and as-built configurations on initially determined break locations in non-ASME Code high-energy piping systems. MEB 3-1 Section B.1.c.(3) provides that breaks in non-ASME high energy piping systems are postulated on the same requirements for ASME Code Class 2 and 3 piping systems.
	Accordingly include the piping reanalysis MEB 3-1 Section 3.1.c.(2) criteria in AP600 SSAR Section 3.6.2.1.1.3.
Response	The AP600 position (SSAR Subsection 3.6.2.5) is equivalent to the SRP position.

Question B-10 & B-12 AP600 SSAR Section 3.6.2.1.1.2 provides that breaks are postulated at intermediate locations in ASME Code Section III, Class 2 and 3 high-energy piping systems where the maximum stress value due to sustained, occasional and thermal expansion loads exceeds 0.8 (1.8 S_h and S_A) or 0.8 (1.5 S_y and S_A).

The Sy-based criteria is not in accordance with MEB 3-1 Section B.1.c.(2).(b).(ii) criteria.

Justify the S_y-based criteria or modify AP600 SSAR Section 3.6.2.1.1.2 in accordance with MEB 3-1 Section B.1.c.(2).(b).(ii).

Similar to A10, AP600 SSAR Section 3.6.2.1.1.3 provides that breaks are postulated at intermediate locations in non-ASME Code high-energy piping systems where the maximum stress calculated by the sum of equation (9) and (10) in sub-article NC-3600 of the ASME Code, Section III considering normal and upset conditions exceeds 0.8 (1.8 S_h and S_A) or 0.8 (1.5 S_y and S_A).

The S_y-based criterion is not in accordance with MEB 3-1 Section B.1.c.(3) criteria.

Justify the S_y-based criterion or modify AP600 SSAR Section 3.6.2.1.1.2 in accordance with MEB 3-1 Section B.1.c.(3).

Response The use of 1.5 S_y and 1.8S_h is based on Equation 9 of NC 3653. The SSAR will be revised to remove the 1.5 S_y term.

Question B-14

AP600 SSAR Section 3.6.2.1.1.3 provides criteria for break postulation at intermediate fittings in non-analyzed, non-ASME Code high-energy piping systems.

These criteria are not in total agreement with the requirements of MEB 3-1 Section B.1.c.(2).(b).(i).

Modify these criteria in accordance with the requirements of MEB 3-1 Section B.1.c.(2).(b).(i).

Response

The NRC should clarify the SRP requirement concerning "protective structures".

Question B-16	AP600 SSAR Section 3.6.2.2.1.4 provides that guard pipe assemblies are pressure tested at the maximum operating pressure of the enclosed process pipe. MEB 3-1 Section B.1.b.(6).(c) provide that the guard pipe be tested at a pressure not less than its design pressure.
	Justify this AP600 SSAR Section 3.6.2.1.1.4 provision or modify the section in accordance with MEB 3-1 Section B.1.b.(6).(c).
Response	The guard pipe design pressure is the same as the design pressure for the enclosed process pipe.

Question B-21	Contrary to MEB 3-1 Section B.3.a.(i), the criteria of AP600 SSAR Section 3.6.2.1.2.1 first bullet, second item also applies to pipe size less than four-inch NPS and not only to pipe size four-inch and greater NPS as represented. Justify this AP600 SSAR Section 3.6.2.1.2.1 item or modify the item in accordance with MEB 3-1 Section B.3.a.(1).
Response	Since only circumferential breaks are postulated in piping smaller than 4 inches, there is no need to evaluate the ratio of axial stress to circumferential stress. The SSAR will not be revised.

Question B-22	AP600 SSAR Section 3.6.2.1.2.1 does not include the MEB 3-1 Section B.3.a.(2) criterion for the selection of break locations without the benefit of stress calculations. Include this MEB 3-1 Section B.3.a.(2) criterion in AP600 SSAR Section 3.6.2.1.2.1.
Response	The break location position is given in SSAR Subsection 3.6.2.1.1.3, second bullet. The SSAR will not be revised.

Question B-23

AP600 SSAR Section 3.6.2.1.2.2 Item C first bullet provides that for ASME Code Class 1 high and moderate-energy piping, through wall cracks are postulated at locations where the maximum stress range is greater than 1.2 S_m.

In accordance with MEB 3-1 Sections B.1.e.(1) and B.2.c.(1).(b), clarify that the maximum stress range is to be calculated by equation (10) of NB-3653 of the code.

Response

SSAR Subsection 3.6.2.1.2.2 will be revised to indicate that 1.2 Sm limit applies to Equation 10 of NB-3653.

Question B-24

AP600 SSAR Section 3.6.2.1.2.2 Item C second bullet provides that for ASME Code, Class 2 and 3 high and moderate energy piping, through wall cracks are postulated where the maximum stress range is greater than 0.4 (1.8 S_h and S_A) or 0.4 (1.5 S_y and S_A).

In accordance with MEB 3-1 Sections B.1.e.(2) and B.2.c.(1).(c), clarify that the maximum stress range is the sum of equation (9) and (10) of the NC/ND-3653 of the code.

Also, the S_y-based criterion is not in accordance with these same MEB 3-1 sections.

Justify the S_y-based criterion or modify AP600 SSAR Section 3.6.2.1.2.2 Item C second bullet in accordance with these same MEB 3-1 sections.

Response

SSAR Subsection 3.6.2.1.2.2 will be revised to indicate that stress limit applies to the sum of equations (9) and (10) of NC/ND 3653.

The use of 1.5 S_y and 1.8 S_h is based on equation 9 of NC/ND 3653. The SSAR will be revised to remove the 1.5 S_y term.

Question B-25 & B-27 AP600 SSAR Section 3.6.2.1.2.2 does not include the MEB 3-1 Section B.1.e.(3) requirement for leakage cracks in non-analyzed, non-safety class piping.

Include this MEB 3-1 requirement in AP600 SSAR Section 3.6.2.1.2.2.

AP600 SSAR Section 3.6.2.1.2.2 does not include the MEB 3-1 Section B.2.c.(3) requirement for leakage cracks in moderate-energy fluid systems designed to non-seismic standards.

Include this MEB 3-1 requirement in AP600 SSAR Section 3.6.2.1.2.2.

Response

In the SSAR "through-wall cracks" are the same as the "leakage cracks" in the SRP.

In the SSAR "leakage cracks" refers to crack associated with leak-before-break.

The SSAR Subsection 3.6.2.1.2.2.c will be revised to include the following

In the absence of stress analysis, through-wall cracks in high and moderate energy non-nuclear piping are postulated at locations which give the worst effects for flooding and spraying.

Question B-28, B-29 and B-30

AP600 SSAR Section 3.6.2.1.3.1 contains requirements for circumferential breaks in high-energy fluid systems. These requirements are not in total agreement with corresponding MEB 3-1 Section B.3.a.(3) through B.3.a.(5) requirements.

Modify AP600 SSAR Section 3.6.2.1.3.1 in accordance with these MEB 3-1 requirements.

AP600 SSAR Section 3.6.2.1.3.1 contain requirements for longitudinal breaks in high-energy fluid systems. These requirements are not in total agreement with corresponding MEB 3-1 Section B.3.b.(3) through B.3.b.(5) requirements.

Modify AP600 SSAR Section 3.6.2.1.3.1 in accordance with these MEB 3-1 requirements.

AP600 SSAR Section 3.6.2.1.3.1 describes four exceptions for break locations specified in Section 3.6.2.1.2.1. These exceptions are not totally in agreement with the provisions of MEB 3-1 Section B.3.a.(2).

Clarify these exceptions.

Response

The AP600 position is based on ANS 58.2-1988.

The SSAR will not be revised.

Question B-31

AP600 SSAR Section 3.6.2.1.3.2 does not include the requirements of MEB 3-1 Section B.3.c.(4) for leakage cracks. (wets, flooding)

Include these MEB 3-1 requirements in AP600 SSAR Section 3.6.2.1.3.2.

Response

The AP600 position is based on ANS 58.21-1988. Flooding is evaluated based on the time required for operator action. Flooding occurs in the affected and communicating compartments.

Wetting is evaluated for targets in the vicinity of the through-wall crack.

SSAR Subsection 3.6.1.1.D describes the AP600 position.

The SSAR will not be revised.

Question B-32	AP600 SSAR Section 3.6.2.3.1 provides that for the static method of analysis of jet impingement loads, a dynamic load factor (DLF) of 1.2 to 2.0 is used. DLFs of less than 2.0 are not in accordance with ANSI/ANS 58.2-1988. Revise AP600 SSAR Section 3.6.2.3.1 in accordance with ANSI/ANS 58.2-1988.
Response	The use of a DLF less than 2.0 is based on ANS-58.2-1988, Section 7.3. The DLF value is based on a dynamic response analysis of the system. The SSAR will not be revised.

Question B-33

AP600 SSAR Section 3.6.2.3.2 provides that during the transient motions at terminal ends a limited number of pipe supports may be permitted to fail.

Clarify these permitted pipe support failures.

Response

Pipe support failures occur when the resisting stiffness or force provided by the support onto the piping is nonlinear. The support failure may occur in several ways:

a) prior to (or after) plastic strain in the support, support failure causes the support load to suddenly decrease to zero

b) At the plastic load limit, support failure causes the support stiffness to suddenly decrease to zero

The piping system will be analyzed using nonlinear force-deflection curves to represent the failure mode of the support. As with the case without support failure, the piping components are represented by elastic material properties.

Question B-35	AP600 SSAR Sections 3.6.2.2 and 3.6.2.3 for the analytical method to define jet thrust forcing functions and response models, and dynamic analysis methods to verify the integrity and operability of mechanical components, component supports and piping systems, respectively, are not totally in accordance with SRP 3.6.2, Section III.2.a through III.2.c and Sections III.3 through III.4. In addition, for piping ITAAC purposes an appendix to AP600 SSAR Section 3.6 which describes procedures for the implementation of these sections of SRP 3.6.2 will be required.
Response	The NRC should clarify the question on analytical methods and procedures.

AUDIT TRIP REPORT

PURPOSE: NRC Audit of Westinghouse Piping Design Criteria and Sample Analyses for AP600 Standard Plant

LOCATION: Westinghouse Energy Center, Monroeville, PA

DATES: April 12-14, 1994

THE NRC
AUDIT TEAM: NRC Staff - D. Terao, S. Hou
NRC Consultants -
BNL: G. DeGrassi, P. Bezler, J. Braverman
ETEC: P. Chen

WESTINGHOUSE
PARTICIPANTS: D. Lindgren, E. Johnson, R. Mandava and others

1.0 INTRODUCTION

On April 12-14, 1994, the staff of the Nuclear Regulatory Commission (NRC) and its consultants from the Brookhaven National Laboratory (BNL) and Energy Technology Engineering Center (ETEC) met with Westinghouse (W) representatives at W office in Monroeville, Pennsylvania. The purpose was to conduct an audit of W design procedures and criteria for AP600 piping and pipe support design, plant protection against high energy line break, applications of leak-before-break (LBB) technology, and sample piping analysis. This report presents a summary of the audit discussions and findings in these areas.

The audit agenda is in Attachment 1. The attendance list is in Attachment 2. A list of W procedure and criteria documents available for audit is in Attechmant 3. In Attachment 4, a summary of Audit results and status were listed for every concerned issue. The Attachment 5 consists of W presentation handout (Non-proprietary portion only).

This audit was performed in support of the W application for design certification of the AP600 standard plant in accordance with the 10CFR52 process. In the area of piping design, W will provide design acceptance criteria (DAC) in lieu of final piping designs. This approach has been accepted by the staff in previous design certification submittals by others because piping and pipe support designs cannot be finalized until as-built or as-procured information is obtained. The DAC approach enables the staff to make a final safety determination, subject only to satisfactory implementation and verification during the combined license (COL) review through appropriate inspections, tests, analyses, and acceptance criteria (ITAAC).

Enclosure 4

In preparation for audit, the audit team reviewed the information in Sections 3.6, 3.7 and 3.9 of the AP600 Standard Safety Analysis Report (SSAR) Revision 1 and prepared a list of issues, which was transmitted to W by the staff prior to the audit. Written response to the issues by W was received and discussed during the audit. See Attachment 4 for issue description, audit results and status of each issue.

2.0 AUDIT SUMMARY

At the opening, the staff discussed the DAC approach that was previously used for piping systems on the evolutionary plant designs and the type of information that the staff needs in the AP600 SSAR for the approach to be used for its design certification.

As indicated in the agenda (Attachment 1), the audit was divided into three major areas. The first area was a review of design criteria in which W gave presentations on several topics (see Agenda Section I and W handout in Attachment 5). The second area was a review and discussion of W responses to issues that were raised by the audit team prior to the audit (Agenda Section II). The final area was an audit of design procedures and sample analysis (Agenda Section III). A summary of the discussions is presented below.

2.1 Design Criteria

In the area of design criteria, Westinghouse gave presentations on the following topics: applicable Codes and Standards, design loads, criteria for piping systems identified as important by the RTNSS process, LBB analyses for AP600, generic piping design ITAAC, and design specifications and procedure documents. Agenda items I(c), I(e) and I(f) on design methods and criteria were covered under the NRC discussion items or the audit of procedures. Copies of the non-proprietary portions of W presentation handouts are included in Attachment 5. Highlights of the discussions are presented below.

W provided a list of Codes to be used in the AP600 piping design. The piping will be designed to the requirements of the ASME Boiler and Pressure Vessel Code Sections II, III and XI 1989 Edition including the 1989 Addenda. The audit team noted that the NRC has endorsed the 1989 Code Edition but has not yet endorsed the 1989 Addenda. In addition, W provided a list of Code Cases to be used in the AP600 piping design. The audit team questioned why Code Case N-411 was not included in the list since the SSAR had referenced the use of N-411 damping. W stated that they would like to use 5% damping instead of N-411 damping based on recent changes in ASME Code seismic criteria. The audit team indicated that the NRC staff has not endorsed the new Code criteria. W indicated that they will request NRC to review these new Code rules for specific application to the AP600 design certification.

W gave a presentation on the development of system design loads for AP600 piping design. In the area of thermal stratification evaluation, the audit team expressed a concern over in-plant tests to verify the adequacy of thermal stratification analysis assumptions. This area will need further review.

Another concern was the mechanistic combination of consequential dynamic loads. W provided a draft procedure on identifying dynamic and consequential event combinations for AP600 fluid systems. According to the procedure, loads resulting from dynamic events will only be combined with loads resulting from an initiating event if the loads can mechanistically and realistically occur simultaneously. The audit team expressed a concern that this approach is not consistent with the current staff position described in NUREG-0484. The combination requirements for dynamic loads given in the footnotes of several SSAR Subsection 3.9 tables did not clearly explain the proposed criteria. This topic will need further review.

W gave a presentation summarizing their position on criteria for piping systems identified as important by the RTNSS process. W identified three nonsafety-related systems as important based on initiating event frequency evaluation. They are the normal residual heat removal system, the component cooling water system, and the service water system. The W proposed regulatory oversight for these systems are short-term availability controls. They do not propose any additional piping design requirements for these systems such as seismic evaluation. The staff needs to further review the acceptability of the proposed W requirements.

In the area of LBB applications, W is requesting approval of LBB analysis for many high-energy lines in the AP600 plant. However, in order to achieve acceptable results for piping as small as four inches nominal pipe size, W is proposing to deviate from established acceptance criteria in NUREG-1061, Volume 3. W is proposing to lower the margin on flaw size from 2.0 to 1.5. Furthermore, W is proposing to use a leakage rate of 0.5 gpm instead of 1.0 gpm for RCS inventory. Lastly, W is proposing to apply LBB to the feedwater line inside containment. The staff expressed its concerns on the application of LBB to the feedwater line and the difficulties in approving deviations from NUREG-1061, Volume 3 acceptance criteria.

In the area of piping ITAACS, W stated that no work has been done recently. They provided copies of their proposed piping ITAACs which were prepared on 12/15/92 (see Attachment 5). The staff indicated that separate meetings will be scheduled on ITAACs and there was no need to discuss this subject further at this time.

W provided a list of design procedure documents that are available for audit. ASME Code design specifications were not available because only preliminary piping analyses have been performed. The audit team asked W to provide a procedure for the preparation of design specifications for final piping designs.

Currently, W has piping design criteria documents that provide detailed design guidelines for piping and pipe support design as well as high-energy line break and LBB criteria. However, these documents are considered proprietary by W. The audit team will identify the specific proprietary information it needs to reach a safety finding.

2.2 NRC Discussion Items

The audit team had prepared a list of 82 issues based on a review of the latest SSAR: 43 in piping and pipe support design area, 35 in high-energy line break area, and 4 in LBB area. W provided written responses to 79 of the 82 issues. The audit team reviewed each response and discussed each issue with the cognizant W engineer. After the discussions, each item was assigned a status of either closed, technically resolved, or open. Closed means that the issue was adequately resolved and no further SSAR revision is necessary; technically resolved means that technical agreement for resolution of the issue was reached but a SSAR revision will be required; and open means that further work is needed to resolve the issue.

Attachment 4 provides issue description, audit results, and status of each issue discussed during the audit. By the end of the audit, status of all issues was summarized as follows:

	Open	Technically Resolved	Closed	Total
Design Criteria issues	25	12	6	43
Pipe break issues	4	20	11	35
LBB issues	1	2	1	4
Total	30	34	18	82

Although there are a fairly large number of open items, many of them involved requests to provide more detailed information on design and analysis methods and criteria in the SSAR. W had provided information consistent with the level of detail included in existing FSARs. The NRC staff explained that more detailed descriptions of the design and analysis methods are needed in the SSAR because the design certification will be based on the approval of design procedures rather than on the approval of final piping designs. W agreed to provide more detailed descriptions in the SSAR. The audit team will review the design procedures to identify the type of information that should be included in the SSAR. This is expected to resolve a significant number of open items.

Some of the potentially significant open issues which need to be resolved are the following:

A. Issues in design criteria

A1, A16 - W wants to adopt the draft ASME Code changes on seismic criteria which provide increase stress allowables and 5% damping. The NRC staff has not endorsed these changes.

A6, A39 - W wants to use "experience methods" to qualify small bore piping systems. The NRC staff has not approved these methods.

A7 - The W position on restraining non-seismic piping connected to seismic piping is not consistent with the requirements of S.R.P. 3.9.2. W agreed to reevaluate their position.

A12 - The W procedures do not adequately account for amplification of the floor response spectrum at decoupled branch pipe connections or at equipment nozzles. W agreed to try to develop a deflection criteria to establish significance of response spectrum amplification.

A22 - W plans to identify and evaluate piping systems susceptible to thermal stratification and cycling in accordance with the EPRI TASCS program methodology. This methodology has not yet been approved by the NRC staff. The staff is also concerned that there are no plans to perform in-plant tests to verify the thermal stratification load assumptions.

A31 - W has proposed SRSS combination of SSE inertia, anchor motion and self weight excitation for pipe support design. Further justification is required.

A36 - W has proposed a 1/8 inch deflection criteria for pipe supports based on the maximum dynamic portion of the pipe support load. The adequacy of this deflection limit needs to be further reviewed.

A40 - W has not yet provided a description of the "design by rule" methodolgy included in SSAR Subsection 3.7.3.1.

A43 - W proposed a 1/8 inch deflection criteria for decoupling piping supported by simple structural modules. The audit team believes that the coupling criteria should consider mass and frequency ratios. W agreed to give this further consideration.

B. Issues in High-energy line break

In the HELB area, the majority of the issues, issues relating to compliance with the requirements of MEB 3-1 and ANSI/ANS-58.2-1988, were closed or technically resolved. However, the extent of high-energy piping systems requiring the postulation of breaks can not be fully defined pending the results of LBB evaluations. Open issues included:

B15 - As clarified during the audit, the structural capacity of walls separating redundant trains in general, and in particular to the wall between the main steam line and the control room need further review.

B18 - The extent of piping and equipment in the break exclusion zones for the main steam, feedwater, and steam generator blowdown systems need further review.

B33 - The assumption of "failures" of a limited number of supports in transient analyses of pipe whip needs further review.

C. Issues in LBB

C3 - W intends to apply the LBB methodology to the feedwater system. Susceptibility of the system to water hammer events could preclude application of LBB to this system. W intends to use a leak detection capability of 0.5 gpm vs. the 1.0 gpm as in the RG 1.45, and to use a 1.5 margin on flaw size vs. the 2.0 margin of NUREG-1061. Further staff review is needed.

2.3 Audit of Piping Procedures and Sample Problems

W provided the audit team with a list AP600 criteria documents that were available for audit (see Attachment 3). Most of these criteria documents were included in the "blue book" which was made available for review. Due to time constraints, the audit team performed a cursory review of the blue book to identify the documents that are applicable to piping and pipe support design. The selected items are checked off in the criteria document list in Attachment 3. The audit team requested copies of the selected documents for detailed review. W provided copies of all selected documents with the exception of the ARC TCG Report Appendix G on ASME Piping (Item 1) and the EPRI TASCS Program Final Report (Item 32). W needs EPRI approval to release these reports but expects to be able to provide them at a later date. The audit team needs to review and evaluate the criteria documents and identify any information in these documents that should also be included in the SSAR.

W provided some preliminary piping analysis data for review. W explained that there are several different organizations working on the analyses. The preliminary Reactor Coolant Loop seismic analysis was performed by W and had been completed. The analysis used the WECAN program and applied the modal superposition time history analysis method. The Pressurizer Surge Line, Main Steam Line, and Feedwater Line analyses were still in progress. The Surge Line and Feedwater Line are being analyzed by Ansaldo in Italy. The seismic analyses are being performed by the enveloped response spectrum analysis method using the PS+CAEPIPE program. The Main Steam Line seismic analysis is being performed in Spain by

Initec. The independent support motion (ISM) response spectrum method of analysis is being applied using the PS+CAEPIPE program. The audit team tentatively selected two piping systems and three analysis methods for benchmarking. They are the Pressurizer Surge Line using the enveloped response spectrum analysis method for seismic loads, the Main Steam Line using the ISM response spectrum method of analysis for seismic loads, and the Main Steam Line using the modal superposition time history analysis method with fluid transient loading (which W agreed to provide). The audit team identified the type of information which is needed to perform the benchmark analyses. Consistent with the evolutionary plants, the BNL will develop a piping benchmark program for checking piping computer programs to be used by the COL licensee to complete the AP600 piping design and analysis.

3.0 CONCLUSIONS

In general, the audit was successful in resolving many of the staff concerned issues. W is to be congratulated in contributing a large part to this success by providing impressive written response to the issues identified in the staff transmittal less than one week before the audit.

At the exit meeting, the staff presented the status of the discussion items (see Attachment 4) and summarized the open issues. The issue of using the new (draft) ASME Code rules was again raised by W. These Code rules, which are expected to be approved by the ASME Code shortly, provide a significant increase in the piping stress allowable limits. The staff indicated that the NRC representatives on the Code Committees Who have reviewed these new rules believe that the justification for these incresed stress limits is not adequate. W indicated that they will request for NRC staff review of the new Code rules for specific application to the AP600 design certification.

The audit team will interact with W to resolve open issues and continue to perform a detailed review of the adequacy of the AP600 design procedure and criteria documents that were provided by W. The team will also identify the type of information in these documents that should also be included in the SSAR. W needs to provide the team with the EPRI and ARC reports that were requested as well as the detailed information on the preliminary piping analysis needed to develop the piping benchmark problems.

Attachment 1

NRC AUDIT
AP600 PIPING DESIGN CRITERIA AND SAMPLE ANALYSES

April 12-14, 1994

Agenda

I. Review Design Criteria

A. Applicable Codes and Standards
B. Design Loads
C. Methods to be used for completing the piping design analysis
D. Criteria for piping systems identified as important by the RTNSS process
E. Piping stress analysis criteria
F. Pipe support design criteria
G. Criteria for postulating high-energy line breaks
H. LBB approach applicable to AP600 piping systems
I. Generic piping design ITAAC
J. Design specifications and procedure documents

II. NRC Discussion Items

III. Audit of Piping Design, High-Energy Line Breaks, and LBB Applications

Attachment 2

ATTENDANCE SHEET

AP600 PIPING AUDIT

NRC/WESTINGHOUSE

Tuesday, April 12, 1994

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ATTENDANCE SHEET

AP600 PIPING AUDIT

NRC/WESTINGHOUSE

Wednesday, April 13, 1994

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Attachment 3

NRC Audit Document Lists

1. Criteria Documents

* * 1. ARC TCG Report: ASME Piping Appendix G
* * ✓ 2. GA-G1-001 General Module Design Criteria
* * ✓ 3. GA-M1-001 Mechanical Equipment Module Design Criteria
* * ✓ 4. GA-P1-001 Piping Module Design Criteria
* * ✓ 5. GA-S1-001 Structural Module Design Criteria
* ✓ 6. GW-C1-001 Civil/Structural Design Criteria
* 7. GW-GOX-001 List of Plant Systems
* ✓ 8. GW-G1-001 Plant Design Criteria
* ✓ 9. GW-G1-003 Seismic Design Criteria
* ✓ 10. GW-G1-010 Safety Classification and Seismic Requirements Methodology
* 11 GW-G1R-001 Compliance Evaluation Report VS Utility/EPRI
* ✓ 12. GW-G1X-001 Governing Codes and Standards
* 13. GW-GL-001 Compliance with SRP Acceptance Criteria
* 14. GW-GL-003 Conformance with US NRC Regulatory Guides
* ✓ 15. GW-M1-001 Mechanical Design Criteria
* * ✓ 16. GW-N1-001 Pipe Rupture Design Criteria
* * ✓ 17. GW-N1-005 Design Criteria Guidelines for Protection from Seismic Interaction
* * ✓ 18. GW-P1-001 Piping Design Criteria
* * ✓ 19. GW-P1-002 AP600 General Layout Criteria
* * 20. GW-P1-005 Thermal Stratification Criteria
* * 21. GW-PLA-001 Piping Analysis Description Document
* 22. GW-PVR-001 Report On Valve Envelope Information
* 23. GW-S1-001 Module Embedments and Insert Plates
* * 24. GW-S1-002 Anchor Bolt Design Guide
* * 25. GW-S1-003 Concrete Expansion Anchors
* * ✓ 26. GW-S1-006 Pipe Support Design Criteria
* 27. GW-S2R-002 Nuclear Island Structures Safe Shutdown Earthquake Seismic Response Report (Volume 1 & 2)
* 28. GW-SUP-001 Design Methodology of Structural Modules
* 29. GW-VW-001 Design for Inspectability Program Class I Components
* 30. PL02-Z0-001 Piping Class Sheets
* 31. SS01-Z0-001 Standard Steel Shapes
* * 32. "Thermal Stratification, Cycling and Striping (TASCS) Final Report", Research Project 3153-02, Dec 1993, EPRI

"✓": In W "Design Criteria Document" (The Blue Book).

"*": Items requested by NRC audit team for further review.

NRC Audit Document Lists

2. Codes

    1. ASME B and PV Code, Section II, III, XI, and NF 1989 Edition including the 1989 Addenda
    2. ASME Code Cases: N-71-16, N122-1, N247, N249-12, N318-4, N319-2, N391-1, N392-2
    3. ASME/ANSI-OM3 and OM7
    4. ASME B31.1 Power Piping Code 1989 Edition including 1989 Addenda
    5. ANSI/ANS-58.2-1988 "Design Basis for Protection of Light Water Nuclear Power Plants Against Effects of Postulated Pipe Rupture"
    6. Regulatory Guide 1.29 September 1978
    7. Regulatory Guide 1.60 December 1973
    8. Regulatory Guide 1.61 October 1973

3. General Reference

    1. Ladish Catalog No. 55
    2. G&W Bonney Forge Catalog W-8
    3. WFI Branch Connection Catalogs
    4. EPRI ALWR Utility Requirements Document
    5. NCIG-05, EPRI Report NP 5639, "Guidelines for Piping System Reconciliation" May 1988
    6. PE-2 AP600 Dept. Procedure "Piping and Pipe Supports Design, Analysis, and Layout Coordination"
    7. AISC "Manual of Steel Construction" Ninth Edition
    8. AISC "Nuclear Facilities - Steel Safety-Related Structures for Design Fabrication and Erection" 1984
    9. AISC/ANSI N690-84
    10. PS+CAEPIPE Piping Analysis Code Version 3.4.05W Theory Manual and User Manual
    11. WECAN User Manual "Westinghouse Electric Company Computer Analysis"
    12. WECAN/Plus User Manual
    13. System Specification Documents
        1. SGS-M3-001
        2. PXS-M3-001
        3. RNS-M3-001
        4. RCS-M3-001
    14. Piping and Instrumentation Diagrams
        1. SGS-M6-001 & 002
        2. PXS-M6-001, 002, 003 & 004
        3. RNS-M6-001
        4. RCS-M6-001, 002 & 003

Attachment 4

NRC AUDIT OF AP600 PIPING DESIGN & SAMPLE ANALYSIS
April 12-14, 1994

STATUS OF DISCUSSION ITEMS

A. PIPING DESIGN CRITERIA ISSUES

A1. ISSUE:

The SSAR should include a list of ASME Code Cases that will be used in AP600 piping and pipe support design.

RESULTS OF AUDIT:

W provided a list of of ASME Code Cases that will be used in AP600 piping and pipe support design. NRC will review the list for acceptability. In addition, W stated that Draft ASME Code changes related to dynamic stress analysis methods and limits will be used in the design. These Code changes have not been endorsed by the NRC. W was informed that the NRC staff review of the draft Code changes will be performed in accordance with the normal Code review and endorsement procedures and is expected to take some time.

STATUS:

Open. If W requests specific approval of the Code changes in support of AP600 design certification, the request will require NRC review on case-by-case basis.

A2. ISSUE:

ASME Section III requires a design specification for Class 1, 2, and 3 piping systems. Provide a sample ASME Code piping design specification or a procedure for preparing an ASME Code piping design specification.

RESULTS OF AUDIT:

A design specification for ASME Code piping systems is not available since W is only performing preliminary analysis at this time.

STATUS:

Open. The audit team asked W to provide a procedure for preparing an ASME Code design specification.

A3. ISSUE:

Will experimental stress analysis be used in piping or pipe support design? If so, provide a description of the methodology and identify the piping systems and components for which it will be applied.

RESULTS OF AUDIT:

W stated that there are no plans to qualify any specific component or system by the use of experimental stress analysis. If the need arises, Appendix II of the ASME Section III Code would be followed for the methodology. The audit team found this acceptable.

STATUS:

Closed.

A4. ISSUE:

The SSAR should provide detailed descriptions of all dynamic analysis methods that may be used in piping design (e.g., enveloped response spectrum method, independent support motion method, modal superposition time history method, direct integration time history method). The descriptions should include the criteria for selection of significant parameters for each method (e.g., cutoff frequency, integration time step, number of modes, etc.). Guidelines for selection of analysis method should also be included.

RESULTS OF AUDIT:

W stated that descriptions of dynamic analysis methods will be provided in a project procedure document. The staff, however, informed W that more detailed descriptions of the analysis methods must be provided in the SSAR because in the area of piping design, the design certification will be based on the approval of design procedures rather than on the approval of final piping designs.

STATUS:

Open. It was agreed that NRC will review the W design procedure documents and identify the information that should be included in the SSAR.

A5. ISSUE:

Will inelastic analysis methods be used in piping design? If so, describe the methodology and identify the piping systems and components for which it will be applied.

RESULTS OF AUDIT:

W stated that inelastic analysis may be used on a limited case basis although they are not planning to use these methods for normal ASME Code qualification at this time. Systems that may require inelastic analysis have not yet been identified.

STATUS:

Open. The audit team asked W to provide more detailed information on inelastic analysis methods in the SSAR.

A6. ISSUE:

SSAR Subsection 3.7.3.8.2.2 states that small bore piping may be qualified by experience based on EPRI report NP6628. This methodology has not been accepted by the staff and should not be applied.

RESULTS OF AUDIT:

W did not provide a written response to the question on the use of "experience" methods to qualify small bore piping systems.

STATUS:

Open. The audit team advised W that the methodology given in EPRI report NP6628 has not been approved by the NRC staff.

A7. ISSUE:

SSAR Subsection 3.7.3.13.3 states that interaction of seismic Category I piping and non-seismic piping connected to it is achieved by incorporating into the seismic analysis a length of non-seismic pipe that represents the dynamic behavior of the complete run of the non-seismic system. Provide justification that a length of non-seismic pipe extending to two seismic restraints in each direction (instead of an anchor) is sufficient to represent the dynamic behavior of the complete run.

RESULTS OF AUDIT:

W stated that from their experience, incorporating a length of non-seismic piping up to two seismic restraints in each direction is adequate for approximating the dynamic effects of the non-seismic piping on the response of the seismic piping. The audit team noted that S.R.P. 3.9.2 requires that the non-seismic piping up to the first anchor beyond the seismic/non-seismic interface be designed in such a manner that it will not cause a failure of the seismic piping during an SSE. W was asked how it will assure that potential failure of non-seismic piping or pipe supports will not cause failure of the seismic piping.

STATUS:

Open. W agreed that they need to do more work on this issue. They will either provide additional justification to demonstrate that their methodology is acceptable or they will adopt the NRC criteria and design the non-seismic piping and pipe supports to seismic requirements.

A8. ISSUE:

The staff has not endorsed the use of ASME Code, Section III, Appendix N. If any Appendix N analysis methods will be used in the AP600 piping design, they should be identified and submitted for staff approval.

RESULTS OF AUDIT:

W stated that they do not plan to compare the AP600 methodology to the methodology in ASME Code, Section III, Appendix N. This was acceptable to the audit team.

STATUS:

Closed.

A9. ISSUE:

The SSAR should provide more detailed piping system dynamic analysis modeling criteria and guidelines. In addition to the type of information given in SSAR Subsection 3.7.3.3 on subsystem modeling procedures, it should include specific guidelines for piping systems (e.g., representation of mass and stiffness properties for various piping components, maximum mass point spacing criteria, mass and stiffness representation of different types of pipe supports, etc.).

RESULTS OF AUDIT:

W did not provide a written response to the request that the SSAR include more detailed piping system dynamic analysis modeling criteria and guidelines.

STATUS:

Open. NRC will review the design procedure documents and identify the information that should be included in the SSAR.

A10. ISSUE:

Provide a set of sample piping analyses that illustrate the application of the proposed piping analysis procedures and criteria to representative AP600 piping systems. The analyses should demonstrate the application of the different dynamic analysis methods that may be used in the AP600 piping design (e.g., enveloped response spectrum, independent support motion methods, modal superposition time history, direct integration time history, etc.).

RESULTS OF AUDIT:

W identified four preliminary piping analysis problems that are either completed or in progress. The audit team tentatively selected two problems for benchmarking: the Pressurizer Surge Line using the enveloped response spectrum method and the Main Steam Line using the independent support motion response spectrum method and the modal superposition time history method.

STATUS:

Open. W agreed to provide the data required for developing the benchmark problems.

A11. ISSUE:

When a branch pipe is decoupled from a larger run pipe in accordance with the criteria given in SSAR Subsection 3.7.3.8.1, how is the mass of the branch pipe considered in the analysis of the run pipe?

RESULTS OF AUDIT:

W stated that the effect of branch line mass on the analysis of the run pipe is not considered because it is always negligible when the pipe size ratio meets the decoupling criteria (diameter ration greater than three to one). However, after further discussion and review of sample problems, W agreed to revise the SSAR to indicate that mass effects will be considered when significant.

STATUS:

Technically resolved. W will revise the SSAR.

A12. ISSUE:

SSAR Subsection 3.7.3.8.2.1 states that in the analysis of a decoupled branch line, the run pipe connection point is considered an anchor for seismic inertia analysis and the response spectrum at that point is the floor response spectrum at the supports near the connection. This is only accurate if the run pipe is rigid and does not amplify the floor response spectrum. Similar criteria are provided for piping connected to equipment. Equipment must also be rigid in order to use the floor spectrum as seismic input. The SSAR should be revised to address this concern.

RESULTS OF AUDIT:

The W response stated that seismic experience indicates that branch line failure from the inertial effects of the run pipe motion is very unlikely and therefore amplification of the floor response spectrum is not necessary. After further discussion, W agreed that amplification should be considered when significant.

STATUS:

Open. W will try to develop and propose a deflection limit for establishing when response spectrum amplification is significant. A similar criteria will be developed for equipment.

A13. ISSUE:

Will the floor response spectra used in piping analyses always be based on an envelope of all design soil profiles? Will peak shifting methods be applied in any piping analyses instead of peak broadening? If so, a description of the methodology should be included in the SSAR.

RESULTS OF AUDIT:

W stated that they want to have the option of using the peak shifting method in response spectrum analysis. They agreed to revise SSAR Subsection 3.7.2.5 to address this.

STATUS:

Technically resolved. W will revise the SSAR.

A14. ISSUE:

When time history analysis is performed, how will modeling uncertainties and parameter variations (normally accounted for by floor response spectrum peak broadening) be considered?

RESULTS OF AUDIT:

The W response provided different options for accounting for modeling uncertainties and parameter variations in a time history analysis. The audit team found the response acceptable but asked W to include the descriptions in the SSAR.

STATUS:

Technically resolved. W will revise the SSAR.

A15. ISSUE:

SSAR Subsection 3.9.3.1.5 and the referenced Tables should be revised to properly reflect the requirements of the NRC staff position on single earthquake design. The definitions of "E" and "ES" in Tables 3.9-3 and 3.9-4 require a clearer definition (1/3 SSE?). Tables 3.9-9 and 3.9-10 should include notes that reference the additional stress criteria given in Table 3.9-11. The equations in Tables 3.9-11 that impose limits on SSE SAM stresses are not consistent with the NRC staff position equations. The Class 2/3 equation is not equivalent to NRC equation 10b. The Class 1 NRC equation 12a must always be satisfied.

RESULTS OF AUDIT:

W agreed to revise SSAR Tables 3.9-3, 3.9-4, 3.9-9 and 3.9-10 as requested. However, they stated that the seismic anchor motion stress for Class 2/3 piping is a logical extension of NRC equation 10b and asked for clarification of the statement that Equation 12a for Class 1 piping must always be met. In the discussion, the audit team showed W that the proposed Class 2/3 equation is not equivalent to NRC equation 10b and explained that the Equation 12a stress limit on seismic anchor motions for Class 1 piping must always be met (not only when Equation 10 is exceeded). W agreed to revise the SSAR accordingly.

STATUS:

Technically resolved. W will revise the SSAR.

A16. ISSUE:

The use of ASME Code Case N-411 damping in response spectrum analysis is acceptable subject to the conditions given in Regulatory Guide 1.84. This should be noted in the SSAR.

RESOLTS OF ANALYSIS:

In their response, W stated that the piping design basis damping be revised from N-411 damping to 5% damping for both envelope and multiple input response spectrum analysis. This is consistent with the draft ASME Code changes. The audit team pointed out that the Code changes have not been endorsed by the NRC (see Item A-1).

STATUS:

Open. W stated that they may need to reconsider their position on damping.

A17. ISSUE:

The SSAR should specify the damping values that will be used when time history analysis (by modal superposition or direct integration) of piping systems is performed.

RESULTS OF AUDIT:

The W response indicated that 2% and 3% damping will be used for SSE time history analysis of auxiliary piping, and 4% damping will be used for the primary loop and the pressurizer surge line piping. The audit team found this acceptable but asked that this information be included in the SSAR. In addition, the SSAR should include a description of α and β damping if it will be used for direct integration time history analysis.

STATUS:

Technically resolved. W will revise the SSAR.

A18. ISSUE:

The mathematical representations for the modal combination methods described in SSAR Subsection 3.7.3.7.2 are different from those given in R.G. 1.92. Provide an explanation and justification for the differences.

RESULTS OF AUDIT:

The W response stated that the modal combination method described in the SSAR is the method used in the Westinghouse program WESTDYN (TSS 5 Method). They stated that the method was developed by Westinghouse from the same data used by NRC in the development of R.G. 1.92, and that the method was approved for use by NRC on domestic plants since the mid 1980's (including Vogtle).

STATUS:

Open. The audit team needs to further review this combination method for basis of acceptance.

A19. ISSUE:

The first three methods for combining high frequency modes described in SSAR Subsection 3.7.3.7.1 are different from the method given in Appendix A to SRP 3.7.2. Provide additional justification for these methods or demonstrate that these methods would provide equivalent or more conservative results than the NRC-accepted method.

RESULTS OF AUDIT:

W stated that the three methods for combining high frequency modes are similar to the NRC method given in Appendix A to SRP 3.7.2. In addition, W will revise the SSAR to include one additional method, the "Left Out Force" method as used in the program PS+CAEPIPE. This method is based on the Clough and Penzien method.

STATUS:

Open. The audit team needs to further review all of the proposed methods for adequacy.

A20. ISSUE:

Recent test data indicates that the effects of the reactor environment could reduce the fatigue resistance of certain materials. The SSAR should describe how these environmental effects will be accounted for in the fatigue analysis of AP600 piping systems.

RESULTS OF AUDIT:

W stated that their position on the environment effects on fatigue issue is that it is not significant and that the current ASME Code fatigue curves provide adequate margins.

STATUS:

Open. The audit team asked W to include in the SSAR the reasons why they believe that this issue is not significant for a PWR environment.

A21. ISSUE:

The current ASME Code Class 2 and 3 rules for fatigue may be inadequate for piping components designed for a 60 year design life. The SSAR should identify these components and describe the analysis that will be performed to verify their fatigue adequacy.

RESULTS OF AUDIT:

The W response stated that current Class 2/3 rules for fatigue are adequate. However after further discussion, W agreed to try to develop a screening criteria for piping systems that may need additional fatigue evaluation beyond the Class 2/3 Code requirements.

STATUS:

Open. W will try to develop screening criteria.

A22. ISSUE:

The SSAR should identify piping systems which may be subjected to thermal cycling due to leaking valves as described in NRC Bulletin 88-08 and thermal stratification as described in NRC Bulletin 88-11. The design provisions for minimizing these effects and the stress and fatigue evaluation methodology for the affected piping components should also be described in the SSAR.

RESULTS OF AUDIT:

The W response stated that the identification and evaluation of piping systems susceptible to thermal statification and thermal cycling will be performed in accordance with the methodology developed by EPRI and Westinghouse under the Thermal Stratification, Cycling and Striping (TASCS) program. The methodology is provided in the TASCS Final Report. The audit team pointed out that the NRC has not yet approved the methodology and that the EPRI TASCS report has not yet been released. In addition, W should provide a more detailed description of the methology in the SSAR. W stated that they will try to have EPRI release the TASCS report to NRC for the AP600 review.

STATUS:

Open. W should provide the EPRI report or a description of the EPRI methodology for NRC review.

A23. ISSUE:

From SSAR Subsection 3.9.3.3, it is not apparent that the design and analysis requirements of pressure relieving devices are in compliance with ASME, Section III, Appendix O and the additional criteria given in SRP 3.9.3. This section should be revised to confirm consistency with the NRC acceptance criteria.

RESULTS OF AUDIT:

The W response stated that the design and analysis of pressure relieving devices will comply with ASME III, Appendix O. The only exception to SRP 3.9.3 requirements is that where more than one valve is installed on the same run pipe, the sequence of valve openings is based on valve setpoints. The SSAR will be revised to incorporate this information. The audit team found this acceptable.

STATUS:

Technically resolved. W will revise the SSAR.

A24. ISSUE:

The SSAR should include functional capability requirements for piping systems which meet the criteria of NUREG-1367.

RESULTS OF AUDIT:

The W response requested clarification of the NUREG-1367 requirements. The audit team explained that the stress limits and other limitations given in the NUREG should be specified in the SSAR. W agreed to include this information in the SSAR.

STATUS:

Technically resolved. W will revise the SSAR.

A25. ISSUE:

The SSAR should include a description of analysis methods and criteria for the design of welded attachments to piping.

RESULTS OF AUDIT:

W provided a list of Code Cases that would be applicable for the analysis of welded attachments on piping and committed to revise the SSAR to incorporate these criteria. The audit team found this acceptable.

STATUS:

Technically resolved. W will revise the SSAR.

A26. ISSUE:

If composite modal damping will be used in piping system analysis, a detailed description and justification for the methodology must be provided.

RESULTS OF AUDIT:

The W response stated that composite modal damping is calculated using the strain energy method described in SSAR Subsection 3.7.1.3. The audit team asked W to identify specific piping applications for which modal composite damping would be used (e.g., in piping systems with large and small diameter pipes to combine 2% and 3% damping). This information should be included in the SSAR.

STATUS:

Open. W should identify specific applications of composite damping to piping design.

A27. ISSUE:

The SSAR should provide a more detailed description of piping thermal expansion analysis methods and assumptions including the minimum temperature for which an explicit thermal analysis is required.

RESULTS OF AUDIT:

The W response stated that the description of thermal expansion methods is found in plant procedures or piping design criteria and is not normally put into the SSAR. The minimum temperature for which explicit thermal analysis is performed is 150°F. The audit team informed W that this level of detail in the SSAR is required for design certification (see Item A4).

STATUS:

Open. The audit team will review the design procedure documents and identify the information that should be included in the SSAR.

A28. ISSUE:

The SSAR should discuss the resolution of the intersystem LOCA issue described in SECY-90-016. Design pressure ratings and minimum wall thicknesses of low pressure piping systems that interface with the reactor coolant pressure boundary should be provided.

RESULTS OF AUDIT:

The W response stated that the only AP600 low pressure interfacing system whose rupture could cause an intersystem LOCA is the normal RHR system. This system uses Schedule 80 pipe and its ultimate rupture strength is sufficient to withstand full RCS pressure without rupture. The staff found this acceptable but questioned whether the RHR system is the only potentially affected system. It appeared that the NRC Reactor Systems branch has not yet reviewed this information. Final resolution will require verification by the Reactor Systems Branch.

STATUS:

Open. Acceptance is pending verification by the Reactor System Branch review.

A29. ISSUE:

SSAR Subsection 3.9.3.4 states that pipe supports satisfy the requirements of ASME Code, Section III, Subsection NF. While this is generally acceptable, Subsection NF does not provide adequate weld requirements for ASTM A500 Grade B tube steel members. If these members will be used in AP600 pipe support design, the SSAR should be revised to include the supplemental requirements of AWS D1.1, "Structural Welding Code" for tube steel.

RESULTS OF AUDIT:

The W response stated that the SSAR will be revised to incorporate the design requirements of AWS D1.1 for welded ASTM A500 Grade B tube steel connections in pipe supports. The audit team found this acceptable.

STATUS:

Technically resolved. W will revise the SSAR.

A30. ISSUE:

SSAR Table 3.9-8 includes self weight excitation (SWE) under several Level B and C load combinations for pipe supports. Is this SWE associated with the SSE or with some other dynamic load?

RESULTS OF AUDIT:

The W response indicated that notes will be added to SSAR Table 3.9-8 to indicate that self weight excitation (SWE) corresponds to the indicated dynamic load. In the discussion, W clarified that self weight excitation will apply to dynamic loads with building motions only. The audit team found this acceptable.

STATUS:

Technically resolved. W will revise the SSAR.

A31. ISSUE:

SSAR Table 3.9-8 defines several load combinations in which SSE inertia, anchor motion, and self weight excitation is combined by SRSS. Provide justification for SRSS (versus absolute) summation.

RESULTS OF AUDIT:

W stated that the SRSS combination method for SSE inertial, anchor motion and SWE loads is based on the low probability of different system modes peaking at the same time. W referenced an EPRI report in which comparison to test results showed that inertial and anchor motion loads may be combined by SRSS. However. the audit team questioned the acceptability of combining SWE loads with piping loads by SRSS because of coupling between piping modes and pipe support modes. W will try to provide an example to demonstrate the acceptability of this combination method.

STATUS:

Open. W will provide justification for combining SEW loads with piping dynamic loads using SRSS.

A32. ISSUE:

The SSAR should provide a more detailed description of pipe support design and analysis methods. It should include design requirements for baseplates and anchor bolts, consideration of friction forces, requirements for gaps and clearances, support stiffness requirements, and deflection limits for fabricated and standard supports.

RESULTS OF AUDIT:

The W response indicated that the existing level of detail for pipe support design and analysis methods is consistent with existing FSARs. The audit team informed W that this level of detail in the SSAR is required for design certification (see Item A-4).

STATUS:

Open. The audit team will review the W design procedure documents and identify the information that should be included in the SSAR.

A33. ISSUE:

If special engineered supports such as energy absorbers or limit stops will be used in AP600, the SSAR should include a detailed description of the design and analysis methods and modeling assumptions that would be applied in designing a piping system with such supports. A sample piping analysis problem should also be provided for review.

RESULTS OF AUDIT:

The W response indicated that limit stops are described in the SSAR but a sample problem is not available at this time. Energy absorbing supports are not planned for AP600 at this time but may be considered in the future. The SSAR will be revised to include additional information on these types of supports.

STATUS:

Open. SSAR should adequately describe design and analysis methods and modeling assumptions for special supports to be used with separate sample analysis problems.

A34. ISSUE:

The SSAR should identify and tabulate all safety-related piping systems which utilize snubbers. The tabulation should include the snubber information required by SRP 3.9.3. Gapped support devices or other special engineered supports used in place of snubbers should also be included.

RESULTS OF AUDIT:

W indicated that a table of snubbers and limit stops will not be included in the SSAR because the NRC staff no longer requires that information in the SAR. The staff agreed.

STATUS:

Closed.

A35. ISSUE:

SSAR Subsection 3.9.3.4 provides stiffness and deflection requirements for pipe support "miscellaneous steel". Is the miscellaneous steel considered part of the pipe support within the Subsection NF boundary or part of the building structure?

RESULTS OF AUDIT:

The W response stated that the stiffness and deflection requirements apply to the total displacement of the pipe support structure, module or platform steel, and embedment or baseplate. The audit team found this acceptable.

STATUS:

Closed.

A36. ISSUE

SSAR Subsection 3.9.3.4 defines a 1/8 inch deflection limit for pipe support dynamic loading. The SSAR should be revised to identify the specific loading combination for which this deflection limit applies.

RESULTS OF AUDIT:

The W response stated that the loading combination used to calculate deflection is the maximum dynamic portion of pipe support load. The SSAR would be revised to provide the dynamic load combinations that would be considered. BNL needs to further review the adequacy of the 1/8 inch deflection limit for this load combination.

STATUS:

Open. W should revise the SSAR to identify the dynamic load combinations, and the audit team will further review the adequacy of the 1/8 inch deflection limit for this load combination.

A37. ISSUE:

SSAR Subsection 3.9.3.4 states that dynamic loads for component supports loaded in the inelastic range are calculated using dynamic load factors, time history analysis, or other methods that account for the inelastic behavior.

Will inelastic analysis methods be used in pipe support design? If so, provide a detailed description of the methodology in the SSAR.

RESULTS OF AUDIT:

W stated that inelastic analysis methods will be used for pipe support design in accordance with the methodology described in NF-3340 of ASME, Section III, Appendix F. The audit team asked for a more detailed description in the SSAR and an example to illustrate the methodology.

STATUS:

Open. W should provide a more detailed description of the inelastic analysis methods in the SSAR and a separate example to illustrate the methodology.

A38. ISSUE:

SSAR Subsection 3.9.3.4 states that for certain Service Level D conditions, such as pipe rupture, the system integrity and operability may be demonstrated by allowing the supports to fail. Identify all other Service Level D conditions in which pipe supports are allowed to fail.

RESULTS OF AUDIT:

W stated that pipe supports will be allowed to fail for pipe rupture loads only. They agreed to revise the SSAR accordingly.

STATUS:

Technically resolved. W will revise the SSAR.

A39. ISSUE:

The SSAR should provide detailed design requirements for safety-related instrumentation line tubing and supports. It should include loading considerations, analysis methods, and acceptance criteria.

RESULTS OF AUDIT:

The W response indicated that safety-related instrument line tubing is considered small bore piping. The design requirements are given in SSAR Subsection 3.7.3.8.2.2. The audit team asked W to revise the SSAR to specify that these requirements are applicable to instrument line tubing. In addition, seismic qualification by experience should be deleted as an option (See Item A-6).

STATUS:

Technically resolved. W will revise the SSAR.

A40. ISSUE:

SSAR Subsection 3.7.3.1 includes "design by rule" as an acceptable seismic analysis method for any subsystem. If this method can be applied to piping, the SSAR should provide a detailed description of the methodology. If not, Subsection 3.7.3.1 should be revised to indicate that it is not applicable to piping analysis.

RESULTS OF AUDIT:

W did not provide a written response to describe the "design by rule" methodology.

STATUD:

Open. W should either provide a detailed description of the methodology for review or revise the SSAR to delete it as an acceptable method.

A41. ISSUE:

SSAR Subsection 3.7.3.5 states that the equivalent static load method of analysis can be used for design of small bore piping systems with a factor of 1.5. This is acceptable only for piping systems that can be represented by simple models. The analysis should meet the requirements and acceptance criteria given in SRP 3.9.2.

RESULTS OF AUDIT:

W stated that SRP 3.9.2 is not clear on the definition of a piping system that can be realistically represented by a simple model. The staff explained that a simple model means a pipe rum without line-mount equipment such as valves. W believes that the 1.5 factor provides an acceptable design basis for small bore piping. The staff agreed that a 1.5 factor is acceptable.

STATUS:

Closed.

A42. ISSUE:

SSAR Subsection 3.7.3.5 states that when the equivalent static load method is applied to piping, a factor of 1.0 may be applied in the axial direction. This is only acceptable if the fundamental frequency equals or exceeds the ZPA frequency.

RESULTS OF AUDIT:

W indicated that axial supports will tend to increase the axial fundamental frequency of a piping run to a value approaching the ZPA. Thus a factor of 1.0 is appropriate. The audit team agreed that a factor of 1.0 is acceptable for determining axial response of piping with axial supports.

STATUS:

Closed.

A43. ISSUE

SSAR Subsection 3.7.3.8.3 provides decoupling criteria for piping supported by the structural steel framework of modules. Provide the justification for decoupling when the deflection of the frame is less than 1/8 inch.

RESULTS OF AUDIT:

The W response indicated that the 1/8 inch deflection criteria for decoupling the module steel is a logical extension of decoupling the pipe support steel from the piping analysis. The approach will only be applied to simple modules and not to complex modules. The audit team felt that this criteria is not adequate. Decoupling of the supported piping from the module structure should consider the mass and frequency ratios as described in SSAR Subsection 3.7.3.8.3. W agreed to give this further consideration and will also try to provide a better definition of a "simple" module.

STATUS

Open. W will provide more information to justify the decoupling criteria.

B. HIGH ENERGY DESIGN CRITERIA ISSUES

B1. ISSUE:

AP600 SSAR Section 3.6 indicates that the evaluation of the dynamic effects of postulated breaks in the RCL, RCL branch lines, MS & FW lines out to anchors adjacent to the isolation values and other primary and secondary system piping inside containment equal to or greater than four-inch NPS (LBB piping) is to be eliminated for AP600 based on LBB applications. High-energy piping systems qualifying for LBB applications are to be evaluated only for the effects of leakage cracks.

The scope of the AP600 LBB piping appears to be more extensive than in previous W plant designs. Provide a comparison of the scope of AP600 LBB piping systems and previous W plant LBB piping systems including a comparison of pipe sizes. Indicate how the increased scope of AP600 LBB piping can be justified including consideration of susceptibility to water hammer and leakage detection.

RESULTS OF AUDIT:

W provided a comparison between the scope of the AP600 piping systems to which LBB evaluations are to be performed and the scope of piping systems in previous W plants to which LBB evaluations have been performed. As expected, the scope of the AP600 piping systems is more extensive than in previous W plant designs.

W also provided a description of their approach for considering water hammer in the candidate LBB FW piping system. During discussions of the W approach, the staff observed that specific items in the W approach would mitigate but not assure elimination of water hammer effects in the FW system. In addition it was also observed that since there was no operating history for the AP600 FW system, staff approval of application of the LBB methodology to the FW system would be difficult.

W also described the AP600 leak detection systems and their capabilities (0.5gpm). The staff raised a concern regarding the 0.5 gpm capability and discussed the need for local leak detection devices to achieve the 0.5 gpm leak detection capability vs the 1.0 gpm RG 1.45 capability. The issue is to be addressed by Plant System Branch.

STATUS:

Technically resolved. Descriptions of the scope of the AP600 LBB piping systems may require modifications pending resolution of issues on a system by system basis.

B2. <u>ISSUE</u>:

AP600 SSAR Section 3.6.1 and elsewhere indicate that structures inside containment are evaluated for the pressurization loads due to a break area equivalent to three-inch (nominal) diameter primary system pipe.

It appears that the preceding is based on the successful application of LBB to the scope of the AP600 LBB piping described in B1.

Changes in scope of the AP600 LBB piping will require revisions to this indication in Section 3.6.1 and elsewhere.

<u>RESULTS OF AUDIT</u>:

<u>W</u> committed to revise the SSAR provisions for pressurization loads on structures, if required, based on the results of LBB analyses.

<u>STATUS</u>:

Technically resolved. <u>W</u> will revise the SSAR.

B3. <u>ISSUE</u>:

AP600 SSAR Sections 3.6.1 and elsewhere state that the IRWST and RV annulus, which do not contain any pipes less than three-inch diameter subject to failure, are evaluated for pressurization with "different criteria" (presumably criteria are different from those in B2). These criteria are provided in Section 3.6.1.2.1, "Pressurization Response".

Clarify these criteria.

<u>RESULTS OF AUDIT</u>:

<u>W</u> committed to identify the "different criteria" as those provided in SSAR Section 3.6.1.2.1, "Pressurization Response."

<u>STATUS</u>:

Technically resolved on the basis of the <u>W</u> commitment.

B4. <u>ISSUE</u>:

AP600 SSAR Section 3.6.1 states that pressurization loads for pipe failures in the break exclusion zone for high-energy lines in the vicinity of containment-penetrations are evaluated for a 1.0 square foot break. AP600 SSAR Sections

3.6.1.1, Item E and 3.6.2.1.1.4 also specify a 1.0 square foot break for the break exclusion zones for the MS and FW lines.

Clarify this 1.0 square foot break area.

RESULTS OF AUDIT:

W explained that the break area is based on BTP SPLB 3-1. This is acceptable.

STATUS:

Closed.

B5. ISSUE:

AP600 SSAR Section 3.6.1.1 Item A states that piping systems that exceed 200°F or 275 psig for less than one percent of the plant operation time are considered moderate-energy systems. Justify this consideration.

RESULTS OF AUDIT:

W explained that the one percent of plant operation time criterion was approved for the Vogtle Electric Generating Plant.

W also explained that although, based on this criterion, the CVCS system was a borderline moderate-energy system, the system was classified as a high-energy system.

STATUS:

Open. W was requested to identify other borderline system for staff consideration of approval of this criterion.

B6. ISSUE:

AP600 SSAR Section 3.6.1.1 Item B states that the thermodynamic state assumed in piping systems and associated reservoirs normally pressurized during operation at power for the calculation of fluid reaction forces is that of normal full-power operation. This is contrary to SRP 3.6.2 Section III.2.a which specifies that the initial condition should be the greater of the contained energy at hot standby or at 102% power.

Justify this AP600 Section 3.6.1.1 Item B statement or modify the statement in accordance with SRP 3.6.2 Section III.2.a.

RESULTS OF AUDIT:

W explained that this SSAR requirement was in accordance with ANSI/ANS-58.2-1988 and also approved by the staff for the Vogtle Electric Generating Plant. This is acceptable on the basis of staff endorsement of ANSI/ANS-58.2-1988.

STATUS:

Closed.

B7. ISSUE:

AP600 SSAR Section 3.6.1.1 Item D states that high and moderate-energy pipe through wall cracks are evaluated for spray wetting and flooding effects. No time period for flooding effects is specified. BTP MEB 3-1 Section B.3.c.(4) provides that the time period should be conservatively estimated on the period required to effect corrective actions.

Modify AP600 Section 3.6.1.1 Item D in accordance with MEB 3-1 Section B.3.c.(4).

RESULTS OF AUDIT:

W committed to modify SSAR Section 3.6.1.1 Item D to add:

"Flooding effects are determined based on a conservative estimate for the time period required to effect corrective actions."

STATUS:

Technically resolved. W will revise the SSAR.

B8. ISSUE:

AP600 SSAR Section 3.6.2.1.1.1 provides criteria for break postulation at intermediate locations in high-energy piping systems. These criteria are in accordance with BTP MEB 3-1, Rev 2, Section B.1.c.(1).(b) criteria.

The staff is recommending that these MEB 3-1 Rev. 2 criteria be replaced with the previous MEB 3-1 Rev. 1 criteria.

Revise these criteria in accordance with the MEB 3-1 Rev. 1 criteria.

RESULTS OF AUDIT:

W committed to modify SSAR Section 3.6.2.1.1.1 in accordance with BTP MEB 3-1, Rev. 1, Section B.1.c.(1).(b) criteria.

STATUS:

Technically resolved. W will revise the SSAR.

B9. ISSUE:

AP600 SSAR Section 3.6.2.1.1.1. does not contain the MEB 3-1 Section B.1.c.(1) criteria for the effects of piping reanalysis due to the difference between design and as-built configurations on initially determined intermediate break location in ASME Code, Section III, Class 1 high-energy piping systems.

Include these MEB 3-1 criteria in AP600 SSAR Section 3.6.2.1.1.1.

RESULTS OF AUDIT:

W explained that SSAR Subsection 3.6.2.5 was intended to be equivalent to the SRP position. However, W committed to modify SSAR Subsection 3.6.2.5 to explicitly include break locations in as-built considerations.

STATUS:

Technically resolved. W will revise the SSAR.

B10. ISSUE:

AP600 SSAR Section 3.6.2.1.1.2 provides that breaks are postulated at intermediate locations in ASME Code Section III, Class 2 and 3 high-energy piping systems where the maximum stress value due to sustained, occasional and thermal expansion loads exceeds 0.8 (1.8 S_h and S_A) or 0.8 (1.5 S_y and S_A).

The S_y-based criterion is not in accordance with MEB 3-1 Section B.1.c.(2).(b).(ii) criteria.

Justify the S_y-based criterion or modify AP600 SSAR Section 3.6.2.1.1.2 in accordance with MEB 3-1 Section B.1.c.(2).(b).(ii).

RESULTS OF AUDIT:

W agreed that the S_y-based criterion was not in accordance with the SRP requirement but was in accordance with the ASME Code 1989 Edition. this is acceptable on the basis of the staff endorsement of the ASME Code, 1989 Edition.

STATUS:

Closed.

B11. ISSUE:

AP600 SSAR Section 3.6.2.1.1.2 does not contain the MEB 3-1 Section B.1.c.(2) criteria for the effects of piping reanalyses due to differences between design and as-built configurations on initially determined break locations in ASME Code, Section III, Class 2 and 3 high-energy piping systems.

Include these MEB 3-1 criteria in AP600 SSAR Section 3.6.2.1.1.2.

RESULTS OF AUDIT:

W explained that SSAR Subsection 3.6.2.5 was intended to be equivalent to the SRP position. However, W committed to modify SSAR Subsection 3.6.2.5 to explicitly include break locations in as-built considerations.

STATUS:

Technically resolved. W will revise the SSAR.

B12. ISSUE:

Similar to B10, AP600 SSAR Section 3.6.2.1.1.3 provides that breaks are postulated at intermediate locations in non-ASME Code high-energy piping systems where the maximum stress calculated by the sum of equation (9) and (10) in sub-article NC-3600 of the ASME Code, Section III considering normal and upset conditions exceeds 0.8 (1.8 S_h and S_A) or 0.8 (1.5 S_y and S_A).

The S_y-based criterion is not in accordance with MEB 3-1 Section B.1.c.(3) criteria.

Justify the S_y-based criterion or modify AP600 SSAR Section 3.6.2.1.1.2 in accordance with MEB 3-1 Section B.1.c.(3).

RESULTS OF AUDIT:

W agreed that the S_y-based criterion was not in accordance with the SRP requirement but was in accordance with the ASME Code 1989 Edition. This is acceptable on the basis of the staff endorsement of the ASME Code, 1989 Edition.

STATUS:

Closed.

B13. ISSUE:

AP600 SSAR Section 3.6.2.1.1.3 does not provide criteria for the effects of piping reanalyses due to differences between design and as-built configurations on initially determined break locations in non-ASME Code high-energy piping systems. MEB 3-1 Section B.1.c.(3) provides that breaks in non-ASME high energy piping systems are postulated on the same requirements for ASME Code Class 2 and 3 piping systems.

Accordingly include the piping reanalysis MEB 3-1 Section 3.1.c.(2) criteria in AP600 SSAR Section 3.6.2.1.1.3

RESULTS OF AUDIT:

W explained that SSAR Subsection 3.6.2.5 was intended to be equivalent to the SRP position. However, W committed to modify SSAR Subsection 3.6.2.5 to explicitly include break locations in as-built considerations.

STATUS:

Technically resolved. W will revise the SSAR.

B14. ISSUE:

AP600 SSAR Section 3.6.2.1.1.3 provides criteria for break postulation at is intermediate fittings in non-analyzed, non-ASME Code high-energy piping systems.

These criteria are not in total agreement with the requirements of MEB 3-1 Section B.1.c.(2).(b).(i).

Modify these criteria in accordance with the requirements of MEB 3-1 Section B.1.c.(2).(b).(i).

RESULTS OF AUDIT:

W committed to modify SSAR Section 3.6.2.1.1.3 second bullet, second item to add "cross, flange, and nonstandard fitting" to the list of examples of intermediate fittings.

STATUS:

Technically resolved. W will revise the SSAR.

B15. ISSUE:

AP600 SSAR Section 3.6.2.1.1 does not include the requirements of MEB 3-1 Sections B.1.c.(4) and (5) for structures separating a high energy line from an essential component and the environmental qualification of safety-related equipment, respectively.

Include these MEB 3-1 Section B.1.c requirements in AP600 SSAR Section 3.6.2.1.1.

RESULTS OF AUDIT:

Based on clarification of the issue during the audit, W committed to: 1) design walls between redundant trains for the worst case line break irrespective of the fact that the break postulation criteria of MEB 3-1 might not require such a break be postulated, and 2) design the approximately 3 ft. thick concrete wall between the MS line and the control room for the worst case MS line break. Pressurization requirements as a result of this MS line break are being reviewed by the staff.

STATUS:

Open. W will provide additional information.

B16. ISSUE:

AP600 SSAR Section 3.6.2.2.1.4 provides that guard pipe assemblies are pressure tested at the maximum operating pressure of the enclosed process pipe. MEB 3-1 Section B.1.b.(6).(c) provide that the guard pipe be tested at a pressure not less than its design pressure.

Justify this AP600 SSAR Section 3.6.2.1.1.4 provision or modify the section in accordance with MEB 3-1 Section B.1.b.(6).(c).

RESULTS OF AUDIT:

W indicated that: 1) the maximum operating pressures of process piping enclosed by the guard pipe assemblies were between 1003 and 1100 psi and 2) the design pressure of the assemblies was 1100 psi. W committed to include these operating and design pressure in the SSAR. This is acceptable on the basis of the small difference between the operating and design pressures and the W commitment.

STATUS:

Technically resolved. W will revise the SSAR.

B17. ISSUES:

AP600 SSAR Section 3.6.2.1.1.4 does not include the requirements of MEB 3-1 Section B.1.b.(6).(d) for inspection ports in guard pipe assemblies.

Include these MEB 3-1 Section B.1.b.(6).(d) requirements in AP600 SSAR Section 3.6.2.1.1.4.

RESULTS OF AUDIT:

W committed to modify SSAR Section 3.6.2.1.1.4 to include the MEB 3-1 Section B.1.b.(b).(d) requirement for inspection posts. This is acceptable.

STATUS:

Technically resolved. W will revise the SSAR.

B18. ISSUE:

AP600 SSAR Section 3.6.2.1.1.4 provides descriptions of break exclusion zones for the MS, FW, and SG blowdown piping. As described these zones terminate outside containment at auxiliary building anchors rather than at outside isolation valves as required by MEB-3-1 Section B.1.b.

Modify these break exclusion zone descriptions in accordance with MEB 3-1 Section B.1.b.

RESULTS OF AUDIT:

The break exclusion zones for the AP600 MS, FW and SG blowdown piping were found to be much more extensive than anticipated: some 50 ft. to the outside isolation valve plus approximately 6 ft. of piping beyond the outside isolation valve to the auxiliary building anchors. The zones also included a number of relief valves, branch lines, and other equipment.

STATUS:

Open. The staff is to further evaluate the configuration of the piping in the break exclusion zones.

B19. ISSUE:

AP600 SSAR Section 3.6.2.1.2.1 specifies the types of breaks to be postulated in ASME Code Class 1, 2, and 3 and "other high-energy piping".

Clarify that these other high-energy piping are non-ASME Code piping.

RESULTS OF AUDIT:

W committed to modify SSAR Section 3.6.2.1.2.1 to identify the "other" high-energy piping as piping designed to other than the ASME Code, Section III. This is acceptable.

STATUS:

Technically resolved. W will revise the SSAR.

B20. <u>ISSUE</u>:

AP600 SSAR Section 3.6.2.1.2.1 first bullet first item does not include the MEB 3-1 Section B.3.a.(1) requirement that instrument lines one-inch and less nominal pipe or tubing size shall be in accordance with RG 1.11.

Include this MEB 3-1 Section B.3.a.(1) requirement in AP600 SSAR Section 3.6.2.1.2.1.

<u>RESULTS OF STATUS</u>:

<u>W</u> indicated that the design requirements for instrumentation lines penetrating containment are provided in SSAR Section 6.2.3.1.1, Item I.

However, other staff reviews found that SSAR Appendix A commits to RG 1.11 except for containment pressure monitoring lines, and to RG 1.151 with no exception. This is acceptable on the basis of the SSAR Appendix 1A commitment. However, <u>W</u> should also reference the Appendix 1A commitment in SSAR Section 3.6.2.1.2.1.

<u>STATUS:</u>

Technically resolved. <u>W</u> should revise the SSAR.

B21. <u>ISSUE</u>:

Contrary to MEB 3-1 Section B.3.a.(i), the criteria of AP600 SSAR Section 3.6.2.1.2.1 first bullet, second item also applies to pipe size less than four-inch NPS and not only to pipe size four-inch and greater NPS as represented.

Justify this AP600 SSAR Section 3.6.2.1.2.1 item or modify the item in accordance with MEB 3-1 Section B.3.a.(1).

<u>RESULTS OF AUDIT</u>:

<u>W</u> explained that since only circumferential breaks are postulated in piping of diameter less than 4 inches, there was no need to evaluate the ratio of the axial to circumferential stress as described in MEB 3-1 Section B.3.A.(i) for the elimination of the type of break to be postulated. This is acceptable.

<u>STATUS:</u>

Closed.

B22. <u>ISSUE</u>:

AP600 SSAR Section 3.6.2.1.2.1 does not include the MEB 3-1 Section B.3.a.(2) criterion for the selection of break locations without the benefit of stress calculations.

Include this MEB 3-1 Section B.3.a.(2) criterion in AP600 SSAR Section 3.6.2.1.2.1.

RESULTS OF AUDIT:

W indicated that criteria for the selection of break locations without the benefit of stress analysis were provided in SSAR Subsections 3.6.2.1.1.3, "Piping Not Designed to ASME Code." This is acceptable on the basis of the clarification provided by W.

STATUS:

Closed.

B23. ISSUE:

AP600 SSAR Section 3.6.2.1.2.2 Item C first bullet provides that for ASME Code Class 1 high and moderate-energy piping, through wall cracks are postulated at locations where the maximum stress range is greater than 1.2 S_m.

In accordance with MEB 3-1 Sections B.1.e.(1) and B.2.c.(1).(b), clarify that the maximum stress range is to be calculated by equation (10) of NB-3653 of the code.

RESULTS OF AUDIT:

W committed to revise SSAR Section 3.6.2.1.2.2 to indicate that the 1.2 S_m limit applies to Equation (10) of NB-3653.

STATUS:

Technically resolved. W will revise the SSAR.

B24. ISSUE:

AP600 SSAR Section 3.6.2.1.2.2 Item C second bullet provides that for ASME Code, Class 2 and 3 high and moderate energy piping, through wall cracks are postulated where the maximum stress range is greater than 0.4 (1.8 S_h and S_A) or 0.4 (1.5 S_y and S_A).

In accordance with MEB 3-1 Sections B.1.e.(2) and B.2.c.(1).(c), clarify that the maximum stress range is the sum of equation (9) and (10) of the NC/ND-3653 of the code.

Also, the S_y-based criterion is not in accordance with these same MEB 3-1 sections.
Justify the S_y-based criterion or modify AP600 SSAR Section 3.6.2.1.2.2 Item C second bullet in accordance with these same MEB 3-1 sections.

RESULTS OF AUDIT:

W committed to modify SSAR Section 3.6.2.1.2.2 to indicate that the stress limits are applicable to the sum of Equations (9) and (10) of NC/ND-3653. Also W explained that the S_y-based criterion was in accordance with the ASME Code, 1989 Edition. This is acceptable on the basis of: 1) the W commitment and 2) staff endorsement of ASME Code 1989 Edition.

STATUS:

Technically resolved. W will revise the SSAR.

B25. ISSUE:

AP600 SSAR Section 3.6.2.1.2.2 does not include the MEB 3-1 Section B.1.e.(3) requirement for leakage cracks in non-analyzed, non-safety class piping.

Include this MEB 3-1 requirement in AP600 SSAR Section 3.6.2.1.2.2.

RESULTS OF AUDIT:

W explained that "through-wall cracks" in the SSAR are the same as "leakage cracks" in SRP 3.6.2. With this explanation, the MEB 3-1 Section B.1.e.(3) requirement is provided for by SSAR Section 3.6.2.1.2.2 Item E. This is acceptable on the basis of the W explanation and the provisions of SSAR Section 3.6.2.1.2.2 Item E.

STATUS:

Closed.

B26. ISSUE:

AP600 SSAR Section 3.6.2.1.2.2, Item D is not totally in agreement with MEB 3-1 Section B.2.a requirements for moderate-energy fluid systems separated from essential systems and components.

Modify AP600 SSAR Section 3.6.2.1.2.2, Item D in accordance with these MEB 3-1 requirements.

RESULTS OF AUDIT:

W explained that SSAR Section 3.6.2.1.2.2 Item D was in accordance with ANSI/ANS-58.2-1988 which is not in total agreement with MEB 3-1. The issue is resolved on the basis of staff endorsement of ANSI/ANS-58.2-1988.

STATUS:

Closed.

B27. ISSUE:

AP600 SSAR Section 3.6.2.1.2.2 does not include the MEB 3-1 Section B.2.c.(3) requirement for leakage cracks in moderate-energy fluid systems designed to non-seismic standards.

Include this MEB 3-1 requirement in AP600 SSAR Section 3.6.2.1.2.2.

RESULTS OF AUDIT:

W committed to modify SSAR Section 3.6.2.1.2.2 to provide that in the absence of stress analysis, through-wall cracks (the same as leakage cracks in SRP 3.6.2) in high-and moderate-energy non-nuclear piping are postulated at locations which give the worst effects for flooding and spraying. This is acceptable on the basis of the W commitment, except that W should change "non-nuclear piping" to "piping designed to non-seismic standards."

STATUS:

Technically resolved. W will revise the SSAR.

B28. ISSUE:

AP600 SSAR Section 3.6.2.1.3.1 contains requirements for circumferential breaks in high-energy fluid systems. These requirements are not in total agreement with corresponding MEB 3-1 Section B.3.a.(3) through B.3.a.(5) requirements.

Modify AP600 SSAR Section 3.6.2.1.3.1 in accordance with these MEB 3-1 requirements.

RESULTS OF AUDIT:

W explained that these SSAR 3.6.2.1.3.1 requirements are in accordance with ANSI/ANS-58.2-1988 which is not in total agreement with MEB 3-1. This issue is resolved on the basis of the staff endorsement of ANSI/ANS-58.2-1988.

STATUS:

Closed.

B29. ISSUE:

AP600 SSAR Section 3.6.2.1.3.1 contain requirements for longitudinal breaks in high-energy fluid systems. These requirements are not in total agreement with corresponding MEB 3-1 Section B.3.b.(3) through B.3.b.(5) requirements.

Modify AP600 SSAR Section 3.6.2.1.3.1 in accordance with these MEB 3-1 requirements.

RESULTS OF AUDIT:

W explained that these SSAR 3.6.2.1.3.1 requirements are in accordance with ANSI/ANS-58.2-1988 which is not in total agreement with MEB 3-1. This issue is resolved on the basis of the staff endorsement of ANSI/ANS-58.2-1988.

STATUS:

Closed.

B30. ISSUE:

AP600 SSAR Section 3.6.2.1.3.1 describes four exceptions for break locations specified in Section 3.6.2.1.2.1. These exceptions are not totally in agreement with the provisions of MEB 3-1 Section B.3.a.(2).

Clarify these exceptions.

RESULTS OF AUDIT:

W explained that these SSAR 3.6.2.1.3.1 requirements are in accordance with ANSI/ANS-58.2-1988 which is not in total agreement with MEB 3-1. This issue is resolved on the basis of the staff endorsement of ANSI/ANS-58.2-1988.

STATUS:

Closed.

B31. ISSUE:

AP600 SSAR Section 3.6.2.1.3.2 does not include the requirements of MEB 3-1 Section B.3.c.(4) for leakage cracks.

Include these MEB 3-1 requirements in AP600 SSAR Section 3.6.2.1.3.2.

RESULTS OF AUDIT:

As previously indicated W explained in response to issue B25 that "through-wall cracks" in the SSAR are the same as "leakage crack" in SRP 3.6.2. Also as indicated in response to issue B7, W has committed to modify SSAR Subsection 3.6.1.1 Item D in accordance with MEB 3-1, Section B.3.c.(4). This is acceptable on the basis of the explanation provided by W in response to issue B25 and the commitment provided by W in response to issue B7.

STATUS:

Technically resolved. W will revise the SSAR.

B32. ISSUE:

AP600 SSAR Section 3.6.2.3.1 provides that for the static method of analysis of jet impingement loads, a dynamic load factor (DLF) of 1.2 to 2.0 is used. DLFs of less than 2.0 are not in accordance with ANSI/ANS-58.2-1988.

Revise AP600 SSAR Section 3.6.2.3.1 in accordance with ANSI/ANS-58.2-1988.

RESULTS OF AUDIT:

W committed to modify the DLF provisions of SSAR Section 3.6.2.3.1 in accordance with ANSI/ANS-58.2-1988. This is acceptable on the basis of the W commitment.

STATUS:

Technically resolved. W will revise the SSAR.

B33. ISSUE:

AP600 SSAR Section 3.6.2.3.2 provides that during transient motions at terminal ends a limited number of pipe supports may be permitted to fail.

Clarify these permitted pipe support failures.

RESULTS OF AUDIT:

W explained that pipe supports are assumed to have "failed" in analyses performed to verify the acceptability of the response of the unbroken portions of piping systems subsequent to postulation of line breaks. The support failure assumption is an analytical artifice for considering the non-linear response of support in the pipe whip analysis.

STATUS:

Open. W is to provide a sample analyses demonstrating the support failure assumption technique for staff evaluation of the technique.

B34. ISSUE:

AP600 SSAR Section 3.6.2.3.4.2 provides that for energy-absorbing materials, the allowable crushable height of the material is 80% of the maximum crushable height at uniform crushable strength. This provision is not totally in agreement with SRP 3.6.2, Section III.2.a.

Modify AP600 SSAR Section 3.6.2.3.4.2 in accordance with this SRP 3.6.2, Section III.2.a provisions.

RESULTS OF AUDIT:

W committed to modify SSAR Subsection 3.6.2.3.4.2 to specify the SRP 3.6.2 Section II.2.a criteria for energy-absorbing materials. This is acceptable on the basis of the W commitment.

STATUS:

Technically resolved. W will revise the SSAR.

B35. ISSUE:

AP600 SSAR Sections 3.6.2.2 and 3.6.2.3 for the analytical method to define jet thrust forcing functions and response models, and dynamic analysis methods to verify the integrity and operability of mechanical components, component supports and piping systems, respectively, are not totally in accordance with SRP 3.6.2, Section III.2.a through III.2.c and Sections III.3 through III.4.

In addition, for piping ITAAC purposes an appendix to AP600 SSAR Section 3.6 which describes procedures for the implementation of these sections of SRP 3.6.2 will be required.

RESULTS OF AUDIT:

The staff explained how the issue was related to the 10CFR52 process and requested that W provide descriptions of how the high energy line break and pipe whip analyses were to be performed. The staff identified sections of other plants' SSARs which contained information which was illustrative of descriptions previously accepted by the staff.

STATUS:

Technically resolved. W indicated that the other plants' SSARs identified by the staff were to be evaluated and material similar to that identified in the other plants' SSARs prepared for inclusion in the AP600 SSAR and staff review.

C. LEAK BEFORE BREAK DESIGN CRITERIA ISSUES

C1. ISSUE:

AP600 SSAR Section 3.6.3 indicates that application of the LBB methodology permits the elimination of dynamic effects of pipe breaks in the evaluation of structures, systems and components. These dynamic effects include subcompartment pressurization. This description is not in agreement with AP600 SSAR Section 3.6.1.1 Item P second paragraph.

Clarify this disagreement.

RESULTS OF THE AUDIT:

W explained that the SSAR "through-wall cracks" are the same as SRP "leakage cracks" and thus that SSAR Section 3.6.1.1 Item P relates to SRP leakage cracks and therefore acceptable.

STATUS:

Closed.

C2. ISSUE:

AP600 SSAR Section 3.6.3 indicates that in LBB applications an appropriate margin on leak detection is demonstrated.

Modify AP600 SSAR Section 3.6.3 to also indicate that appropriate margins on flaw size and on loading are also demonstrated.

RESULTS OF AUDIT:

W committed to modify SSAR Section 3.6.3 to specify that appropriate margins on flaw size and on loading are also demonstrated. This is acceptable on the basis of the W commitment.

STATUS:

Technically resolved. W will revise the SSAR.

C3. ISSUE:

AP600 SSAR Section 3.6.3.1 provides a general discussion of compliance with regulatory requirements for LBB applications.

Provide detailed descriptions of the piping systems to which LBB procedures are to be applied. Include in these descriptions: Identification of the terminal ends or anchors, pipe size and wall thickness, and pipe material and welding process.

Also demonstrate how the regulatory requirements for LBB applications are satisfied for each of the piping systems.

Provide a more detailed description of the LBB analysis method of analysis for each of the piping systems, including the bases for the material and fracture toughness properties, leak rate evaluations and stability evaluations.

RESULTS OF AUDIT:

W provided the requested information in a general fashion which indicated that the AP600 LBB evaluations would be similar to prior W evaluations and hence acceptable. W also committed to provide more detailed discussions and descriptions as originally requested.

W intends to apply LBB to the FW system. However, it was observed that the susceptibility of the FW system to water hammer loadings could preclude such application.

W is also proposing a margin of 1.5 (vs the NUREG margin of 2.0 on flaw size) and a leak detection capability of 0.5gpm (vs. the RG 1.45 1.0 gpm capability) both of which were observed to be problematic.

STATUS:

Open. The issues of 1.5 margin on flaw size , 0.5 gpm on leak detection capability, and applying LBB to the FW system need further W/staff discussions.

C4. ISSUE:

During the May 1993 NRC/W meeting the staff indicated that the W sample analysis approach for justifying LBB applications was not in compliance with the regulations nor SECY-93-087. However, the staff also indicated that performing preliminary stress analyses and establishing bounding parameters subject to ITAAC verification was an alternative approach to satisfy GDC4 of 10CFR50 as proposed by the staff in SECY-93-087.

Describe how W intends to comply with GDC4 of 10CFR50.

RESULTS OF AUDIT:

W committed to the LBB acceptance criteria of NUREG-1061 and will require that the COL applicant demonstrate compliance with these criteria, which is acceptable.

STATUS:

Technically resolved. W should revise the SSAR to include the commitment and the COL applicant requirement. Details are to be resolved in further W/staff discussions.

ATTACHMENT 5

W PRESENTATION HANDOUT