REGULATORY INFORMATION DISTRIBUTION SYSTEM (RIDS)

ACCESSION NBR: 8604280082 DOC. DATE: 86/04/18 NOTARIZED: NO DOCKET #
FACIL: STN-50-528 Palo Verde Nuclear Station, Unit 1, Arizona Publi 05000528
AUTH. NAME AUTHOR AFFILIATION
VAN BRUNT, E. E. Arizona Nuclear Power Project (formerly Arizona Public Serv
RECIP. NAME RECIPIENT AFFILIATION

KNIGHTON, G. W. PWR Project Directorate 7

SUBJECT: "Palo Verde Nuclear Generating Station Unit 1 Piping Verification Program Test Summary." W/860418 ltr.

DISTRIBUTION CODE: A001D COPIES RECEIVED: LTR 1 ENCL 1 SIZE: 35
TITLE: OR Submittal: General Distribution

NOTES: Standardized plant. 05000528

	RECIPIENT ID CODE/NAME		COPIES LTTR	COPIES ENCL	RECIPIENT ID CODE/NAME		COPIES LTTR	COPIES ENCL
	PWR-B ADTS		1	0	PWR-B EB		1	1
	PWR-B PEICSB		2	2	PWR-B FOB		1	1
	PWR-B PD7 PD	01	5	5	LICITRA, E		1	1
	PWR-B PEICSB		1	1	PWR-B RSB		1	1
INTERNAL:	ACRS	09	6	6	ADM/LFMB		1	0
	ELD/HDS3		1	0	~~NRR/DHFT~~/TSCB		1	1
	NRR/ORAS		1	0	REG FILE	04	1	1
	RGN5		1	1				
EXTERNAL:	24X		1	1	EG&G BRUSKE, S		1	1
	LPDR	03	1	1	NRC PDR	02	1	1
	NSIC	05	1	1				

TOTAL NUMBER OF COPIES REQUIRED: LTTR 30 ENCL 26

Arizona Nuclear Power Project
P.O. BOX 52034 • PHOENIX, ARIZONA 85072-2034

April 18, 1986
ANPP-36295-EEVB/KLM/98.05

Director of Nuclear Reactor Regulation
Attention: Mr. George W. Knighton, Project Director
PWR Project Directorate #7
Division of Pressurized Water Reactor Licensing - B
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Unit 1
Docket No. STN 50-528 (License NPF-41)
PVNGS Unit 1 Piping Verification Test Summary
File: 86-056-026; 86-136-419

Dear Mr. Knighton:

Attached is the PVNGS Unit 1 piping verification test summary. Submittal of this summary is in accordance with License Condition 2.C.(9) of License No. NPF-41. Therefore, ANPP believes this license condition is closed.

If you should have any questions concerning this matter, contact Mr. W. F. Quinn of my staff.

Very truly yours,

E E Van Brunt Jr / KH

E. E. Van Brunt, Jr.
Executive Vice President
Project Director

EEVB/KLM/rw
Attachment

cc: E. A. Licitra (all w/a)
R. P. Zimmerman
A. C. Gehr

A001
1/1

PVNGS UNIT I PIPING VERIFICATION PROGRAM

TEST SUMMARY

A001
1/1

INDEX

LIST OF ABBREVIATIONS

AF -	Auxiliary Feedwater System
AS -	Auxiliary Steam System
ASME -	American Society of Mechanical Engineers
BOP -	Balance of Plant
BPC -	Bechtel Power Corporation
CE -	Combustion Engineering
CESSAR -	Combustion Engineering Standard Safety Analysis Report
CH or CVCS -	Chemical and Volume Control System
CS -	Containment Spray
CT -	Condensate Transfer System
DF -	Diesel Fuel Oil and Transfer System
DG -	Diesel Generator System
EC -	Essential Chilled Water System
EER -	Engineering Evaluation Request
EW -	Essential Cooling Water System
FSAR -	Final Safety Analysis Report
HFT -	Hot Functional Testing
HPSI -	High Pressure Safety Injection System
LPSI -	Low Pressure Safety Injection System
LVDT -	Linear Variable Differential Transformer
MS -	Main Steam System
MSSS -	Main Steam Support Structure
NC -	Nuclear Cooling Water System
PAT -	Power Ascension Testing
PC -	Fuel Pool Cooling and Cleanup System
PVNGS -	Palo Verde Nuclear Generating Station

LIST OF ABBREVIATIONS

RCP -	Reactor Coolant Pump
RCS -	Reactor Coolant System
SFR -	Startup Field Report
S/G or SG -	Steam Generator System
SI -	Safety Injection System
SP -	Essential Spray Pond System
TC -	Thermocouple
TER -	Test Exception Report
WR -	Work Request

PVNGS UNIT I PIPING VERIFICATION PROGRAM
TEST SUMMARY

1. INTRODUCTION:

The Piping Verification Program at PVNGS was established to meet various Code and Regulatory Guidelines and was conducted over a period of several years which included Initial Prerequisite Testing, Pre Core Hot Functional Testing, and the Hot Pump Demonstration Test and Post Core Testing. The Program complied with the following guides and standards.

A. PVNGS Design Criteria Part II, Section 5.10 of the Plant Design General Design Criteria Section.

B. U.S. NRC Regulatory Guide 1.26, 1.58 and 1.68

C. U.S. NRC Standard Review Plan 3.9.2

D. PVNGS FSAR Section 3.9.2 Appendix 14.B.11 and Section 14.2

E. ASME Code Section III Subsections NA, NB, NC and ND

F. Requirements for Pre-Operational and Initial Startup Vibration Testing of Nuclear Plant Piping Systems, ANSI/ASME-OM-3; Draft 1, Revision 3.

G. NUREG/CR-1606, "An Evaluation of Condensation Induced Water Hammer in Preheat Steam Generators".

H. CESSAR Section 14.2.12.2.3, "Pre Core Reactor Coolant System Expansion Measurements".

I. CESSAR Section 14.2.12.2.4, "Downcomer Feedwater System Waterhammer Test".

J. CESSAR Section 14.2.12.5.17, "Main and Emergency Feedwater Systems Test".

2. DISCUSSION:

2.1 TEST OBJECTIVES:

The piping verification program was conducted in three separate test steps: thermal expansion, steady-state vibration, and dynamic effects testing. These steps were to ensure the structural and functional integrity of the piping system.

The piping verification program included selected portions of the following systems:

1. ASME Code Class 1, 2 and 3 systems

2. Other high energy systems inside Seismic Category I structures

3. High energy portions of systems whose failure could reduce the functioning of any Seismic Category I plant feature to an unacceptable safety level.

4. Seismic Category I portions of moderate energy systems located outside containment.

System selection was based upon a determination that there shall be a reasonable expectation of occurrence for the tested events, and that the system is in a normal plant operating mode.

High energy piping is defined as piping with operating temperature greater than 200°F or operating pressure greater than 275 psig. Moderate energy piping is defined as piping with operating temperature less than 200°F and operating pressure less than 275 psig. Additionally, the testing program verified the operability of snubbers on the above identified systems with an expected thermal travel greater than 0.25 inches.

Thermal expansion testing was performed to verify that during the process of heating up and cooling down the plant, piping and major components subjected to various steady-state temperature conditions were free to expand and contract, with no stress in excess of ASME Code allowables generated from piping supports, hangers, stops, pipe whip restraints, or the piping itself, and to assure operability of snubbers.

Steady-state vibration testing was performed to verify that vibrations in the piping systems, induced by flow in the pipe and equipment motion, did not produce unacceptable vibration levels of the piping.

Dynamic effects testing was performed to verify the adequacy of piping systems and piping restraints during transient conditions such as pump starts, stops, and valve closures, and during normal plant operations.

2.2 <u>INITIAL TEST CONDITIONS</u>:

A. All Quality Class Mechanical Snubbers have been tested per PVNGS Station Procedure 73TI-9ZZ03, "Snubber Pre Service Inspection".

B. Inspection for possible obstructions for pending piping and RCS components thermal movement has been performed.

C. Inspection for damage to piping supports and restraints (rigid and snubber) and insulation has been performed.

D. Initial position of RCS components, pipe, snubbers, or spring hangers before thermal heatup for anticipated measurement of pipe snubbers movement has been established and proper cold set verified and recorded.

E. All temporary hangers and spring hanger travel stops have been removed.

F. Testing personnel have been familiarized with the piping system to be tested and are familiar with the communication procedure to stop the test.

2.3 <u>DEFINITION OF TEST MODES</u>:

2.3.1 Thermal Expansion

The thermal expansion testing was performed in incremental temperature steps. The step increment for heatup was governed by the reactor coolant system temperature during Hot Functional Testing, and by power testing plateaus during Power Ascension Testing, for piping systems connected to the RCS.

2.3.2 Steady-State Vibration

The steady-state vibration testing was performed at the normal operating mode of the piping systems.

2.3.3 Dynamic Effects Program

The dynamic effects program was performed at the system conditions specified below. Operating modes were as follows:

A. Preoperational (Pre-Core Hot Functional) Testing

1. Charging System - starting and stopping of the charging pumps during conditions of both low and high pressure within the reactor coolant system.

2. Letdown System - opening and closing of valves with the reactor at operating temperature and pressure.

3. Pressurizer Spray System - opening and closing of the control valves under maximum flow conditions.

4. Shutdown Cooling System - opening of the isolation valves and operation of the LPSI pumps with the system aligned for shutdown cooling. Operation of containment spray (placed on recirculation) and LPSI pumps simultaneously.

5. Steam Generator Blowdown - closing of the isolation valve with the steam generator at high rate flow condition.

6. Safety Injection - starting, full operation, and shutdown of the HPSI pumps.

7. Actuation of a main steam relief valve at set pressure at its (approximate) rated flow capacity.

8. Starting and stopping:

   a. Essential Cooling Water Pumps

   b. Essential Chilled Water Pumps

   c. Auxiliary Feedwater Pumps

   d. Fuel Pool Cooling Pumps

9. Auxiliary Feedwater Waterhammer Test - lowering S/G Water Level below the Feedsparger and restoring Auxiliary Feedwater Flow.

B. Power Ascension Testing

1. Main Steam

   a. Rapid closure of turbine stop valves at approximately 50, 80 and 100 percent power level.

   b. Actuation of main steam dump valves.

2. Main Feedwater

   a. Starting and stopping of feedwater pumps.

   b. Starting of second main feedwater pump at approximately 75 percent power.

   c. Operating main feedwater pump using the S/G downcomer inlet up to approximately 15 percent power, then switching flow to steam generator economizer inlet. Observing feedwater piping response within containment building.

2.4 <u>METHOD OF TEST VERIFICATION</u>:

A. Thermal Expansion

1. The thermal expansion test involved monitoring all identified systems for piping expansion due to temperature changes of the metal itself. The monitoring was performed by measuring the RCS components and the piping thermal movement and/or by visual inspection. Specified RCS temperature plateaus were attained for plant heatup and cooldown. The piping expansion and contraction was monitored by measuring the movement of snubbers and spring hangers complimented with remote position indicating instrumentation. All necessary data was then obtained and recorded.

B. Steady-State Vibration

1. The piping was checked by visual means for steady-state vibration during normal systems operation, supplemented with quantitative measurement obtained with vibration-monitoring instruments.

2. Velocity measurements with portable instrumentation were made at intervals along the pipe on exposed portions of the pipe or on the pipe clamp. Measurements were taken perpendicular to the pipe and at right angles to each other at a section of the pipe.

   Personnel utilized for the vibration inspection were trained in the usage of equipment and the vibration monitoring technique.

C. Dynamic Effects

1. For the dynamic effects test, the monitoring of specified lines and points was accomplished with instrumentation temporarily installed on the piping or piping restraints and through visual inspection.

2. Visual inspections were performed prior to and after the system had undergone a transient to determine if there was any indication of damage to the piping, pipe whip restraints, pipe supports, penetration sleeves (where piping passes through walls and floors), or other components in the system.

2.5 ACCEPTANCE CRITERIA:

A. Thermal Expansion

1. Measured thermal deflection was consistent with calculated deflection that had been corrected to test condition temperature.

2. Piping movement was not obstructed.

3. Movement of supports was not to exceed the working travel range.

4. The resulting stress values, from thermal expansion, shall be in compliance with the applicable ASME Boiler and Pressure Vessel Code.

B. Steady-State Vibration

1. Measured steady-state values: less than 2.5 in/sec velocity.

2. Visual inspection: No noticable vibration.

3. The resulting stress values, from vibration, shall not be greater than one-half the alternating stress intensity at 10^6 stress cycles, as defined in Section III of the ASME Boiler and Pressure Vessel Code.

C. Dynamic Effects

1. Measured dynamic values for specific locations were consistent with predetermined maximum allowable loads.

2. Acceptance of visually examined systems was that no visual detectable permanent deformations occurred in the piping supporting system that would negate the support's intended function.

2.6 EVALUATION AND APPROVAL OF TEST RESULTS:

All obtained data was forwarded to the respective BPC or CE Engineering organizations for evaluation and reconciliation with existing engineering documents and calculations. Approval of the test results by these organizations was made part of the permanent test package. All test packages were reviewed and approved in accordance with the appropriate PVNGS Station Manual Procedures.

2.7 INDIVIDUAL TEST DESCRIPTIONS:

The individual tests as well as the obtained test results will be discussed in this section. Section 2.7.1 will discuss tests conducted during the Pre Core Hot Functional Test Phase, Section 2.7.2 will discuss tests conducted during the Post Core HFT and Section 2.7.3 will address the tests performed during Power Ascension Testing.

2.7.1 PRE CORE HOT FUNCTIONAL TEST PHASE

a. 91HF-1ZZ06 - B.O.P. Piping Steady State Vibration Test
b. 91HF-1ZZ07 - B.O.P. Piping Dynamic Transient Test
c. 91HF-1ZZ08 - B.O.P. Piping Thermal Expansion Measurements
d. 91HF-1ZZ12 - Reactor Coolant System Vents Dynamic Transient Test
e. 91HF-1ZZ13 - B.O.P. Piping Thermal Expansion Test (Pre Core Pump Demonstration Test)
f. 91HF-1ZZ14 - B.O.P. Piping Thermal Expansion Test Supplement
g. 91HF-1FW02 - Auxiliary Feedwater Waterhammer Test
h. 91HF-1RC01 - RCS Expansion Measurements
i. 91HF-1RC16 - NSSS Pipe Stop Installation and Gap Measurement Test
j. 91HF-1RC20 - Pre-Core Pump Demonstration Test RCS Thermal Expansion Measurements

2.7.1.1 91HF-1ZZ06 - B.O.P. PIPING STEADY STATE VIBRATION TEST

A. Test Objective:

The purpose of this procedure was to demonstrate that the flow induced vibration experienced by the ASME Section III Code Class 1, 2, and 3 Systems piping and other selected high and moderate energy piping is acceptable. Acceptable vibrations are those which could not be visually observed, or when measured did not exceed a screening velocity of 2.5 in/sec. If vibration was to exceed 2.5 in/sec. the particular piping vibration would have to be analyzed for acceptablity.

The following systems were tested:

AF - Auxiliary Feedwater
SI - Safety Injection and Shutdown Cooling
RC - Reactor Coolant
CH - Chemical and Volume Control
PC - Fuel Pool Cooling and Cleanup
NC - Nuclear Cooling Water
EW - Essential Cooling Water
EC - Essential Chilled Water
DF - Diesel Fuel Oil and Transfer
AS - Auxiliary Steam
SS - Nuclear Sampling System
SP - Essential Spray Pond System
DG - Diesel Generator System
MS - Main Steam System
CT - Condensate Storage System

B. Test Description:

Systems to be tested were operated in their normal operational mode, as required by their applicable station operating procedures. While in this mode the system piping, applicable branch piping and components were observed for vibration. The acceptablility of the vibrations experienced was determined by visual inspection and supplemented by portable vibrometer readings at preselected points.

C. Test Results:

All of the data collected and test results obtained were within the acceptance criteria, with the exception of the motor driven (AFB-P01) and turbine driven (AFA-P01) Auxiliary Feedwater Pumps recirculating thru their respective mini-flow lines. Design modifications performed to respective miniflow lines resulted in acceptable vibration readings during reperformance of this test.

Additionally, portions of the Auxiliary Steam, Safety Injection (LPSI, HPSI, & CS), Spray Chemical Addition and Shutdown Cooling Systems could not be tested due to the unavailability of equipment prior to and during HFT. These systems were tested as they became available either prior to or during Post Core HFT. These systems were tested per procedure 73HF-1ZZ11, Piping Verification Pre-Core Carryover Tests.

D. Conclusions:

All systems tested operated normally and the vibrations observed or manually measured fell within the acceptance criteria except as noted above. All systems, as supported and operated, performed as designed.

2.7.1.2 91HF-1ZZ07 - B.O.P. PIPING DYNAMIC TRANSIENT TEST

A. Test Objective:

The purpose of this procedure was to verify, visually and through installed instrumentation, the adequacy of piping systems and their supports during transient conditions such as pump starts, stops and valve closures during normal plant operations. The following systems were tested:

EW - Essential Cooling Water System
PC - Fuel Pool Cooling System
EC - Essential Chilled Water System
SI - Safety Injection Systems
CVCS- Chemical and Volume Control System
RC - Pressurizer Spray System
SC - Steam Generator Blowdown System
SG - Steam Generator Safety Valve lift
AF - Auxiliary Feedwater System

B. Test Description:

For this test, each system was inspected prior to the transient for damaged insulation, pipe and hangers. After this inspection the transient was initiated either by starting and stopping pumps or by opening and closing valves. After the transient, the piping system was inspected again to verify that no damage was apparent other than that noted during the pre-test inspection.

Additionally, S/G "1" blowdown piping was instrumented with load cells to determine the induced loads on the snubber pins during closing of the containment isolation valves.

C. Test Results:

Each system that was tested met the acceptance criteria in that no damage was noted during the post-test walkdown, thus proving that the system supports, as installed, are adequate to handle normal operational transients. Observed loads were below the calculated maximum allowable loads.

D. Conclusions:

The procedure met its objective by subjecting selected systems and components to normally expected operational transients. The systems responded without causing any damage to components, piping or supports.

2.7.1.3 91HF-1ZZ08 - B.O.P. PIPING THERMAL EXPANSION MEASUREMENTS

A. Test Objective:

The purpose of this procedure was to verify that selected ASME III Class 1, 2, & 3 piping was capable of expanding and contracting during system heat up and cooldown. Additionally, it was demonstrated that selected hangers and snubbers on these systems worked as designed without exceeding the design limits.

The following systems were tested:

DG - Diesel Generator System
AS - Auxiliary Steam System
CH - Chemical and Volume Control System
SI - Safety Injection System
RC - Reactor Coolant System
SD - Steam Generator System
SS - Nuclear Sampling System

Additionally, the purpose of the test was to observe and document the thermal movement of the SI, SG, and RC piping systems relative to their respective whip restraints during plant heatup and cooldown so that shims and energy absorbing material blocks could be sized/fabricated to provide for the unobstructed freedom of the pipe within a prescribed clearance tolerance band relative to the whip restraint when the plant is in operation and to observe and verify, by measurement, the unobstructed freedom of the Main Steam Supply System Header lines, located within the MSSS Building between Containment and the Turbine Building, to expand and contract during plant heatup and cooldown.

B. Test Description:

At the various test plateaus the piping systems were observed and measurements taken at predetermined locations to determine the migration of the pipe due to thermal movement of the piping system relative to the whip restraint. These observations and measurements were compared to the data obtained at cold plant ambient conditions, and was utilized to forecast total piping movement relative to the whip restraint so that the unobstructed freedom of the system could be assured as well as providing information to size the shims and energy absorbing material blocks.

At the various test plateaus, the main steam lines were observed and clearances determined either by feeler guage measurements or go-no go guage checks at the Five Way restraints located in the MSSS Building. These clearance checks were necessary to ensure the system is free to expand and contract during plant operation.

During heatup and cooldown, the system piping and supports were checked by visual observation, by measurements taken with instruments and by hand rulers at selected points. All the data taken was compared to the cold ambient data for assurance of proper movements and stress acceptability.

C. Test Results:

The data obtained during the performance of this procedure proved the acceptability of the systems tested to expand and contract without binding from ambient (70°F - 130°F) conditions to normal operating conditions at 565°F and back to ambient. Portions of several systems did however exhibit some minor movement inconsistencies and were remonitored during the performance of procedure 91HF-1ZZ14 during the Hot Pump Demonstration Test.

D. Conclusions:

The B.O.P. piping, as installed, expanded and returned to normal, as was expected, with the exception of some minor discrepancies described above.

As installed, the SI, SC, and RC piping systems involving whip restraints and/or Five Way restraints performed as predicted with no abnormalities noted. Comparison of ambient base line data before and after plant heatup/cooldown revealed a small amount of thermal relaxation, which was expected. The tested piping systems, as installed, exhibited acceptable thermal movements throughout the heatup and cooldown cycles. Questionable portions of systems were retested during the Hot Pump Demonstration Test per procedure 91HF-1ZZ14.

2.7.1.4 91HF-1ZZ12 - REACTOR COOLANT SYSTEM VENTS DYNAMIC TRANSIENT TEST

A. Test Objective:

The purpose of this procedure was to verify the adequacy of the piping systems and pipe restraints during transient conditions, such as valve openings and closures, during normal plant conditions. This was done as a requirement of FSAR Section 14.2, Appendix 14B.11 and Safety Evaluation Review 3.9.2 Dynamic Testing and Analysis of Systems, Components and Equipment. This requirement ensures that ASME Code, Section III, Class 1, 2 and 3 piping is designed to maintain dynamic effects within acceptable limits. The systems tested were the RCS Reactor Vessel Vent and the Pressurizer Vent lines and associated piping.

B. Test Description:

The Vent system was tested in its normal operational mode as required by the applicable station operating procedures. The acceptability of the transients experienced was determined by visual inspection. Prior to initiating flow through a particular configuration, the system was walked down and visually inspected to verify that the piping system had no damaged hangers, crushed insulation or any other indications of damage. Flow was then initiated and the valves were closed causing a transient. The system was then walked through again to visually inspect for damage.

C. Test Results:

The results were acceptable. There was no movement in the system and no damage to piping, insulation or hangers.

D. Conclusions:

The system operated normally and no signs of damage due to the induced transients were observed. All piping and components, as supported and operated, performed as designed.

2.7.1.5 91HF-1ZZ13 - B.O.P. PIPING THERMAL EXPANSION TEST (PRE CORE PUMP DEMONSTRATION TEST)

A. Test Objective:

The purpose of this procedure was to observe and document the thermal movement of the SI, SG and RC piping systems relative to their respective whip restraints during the heat-up and cooldown during the Hot Pump Test. Also, to verify the unobstructed movement of the piping system while maintaining prescribed maximum/minimum clearances for those systems operating at design temperatures.

B. Test Description:

The referenced piping systems were observed at the various test plateaus during plant heatup and cooldown [ambient (70 - 130°F), 260°F, 360°F, 460°F, 565°F, 565°F, 350°F, 280°F, ambient]. Measurements were taken at preselected locations to determine the movement of the pipe relative to the whip restraints due to thermal movement of the piping system. These observations and measurements were compared to the data obtained during hot functional testing and the data obtained at plant ambient conditions.

C. Test Results:

The measured gaps were within the acceptance criteria except for piping systems that did not reach their full operating temperature. Two whip restraints needed to be reworked based on the data obtained during the conduct of this procedure.

D. Conclusions:

The restraints that did not meet the acceptance criteria of this procedure were monitored during Post-Core HFT in accordance with procedure 73HF-1ZZ09, "B.O.P. Piping Thermal Expansion Test (Post Core Hot Functional)". All other restraints were acceptable and thus this procedure was closed out and the test results accepted.

2.7.1.6 91HF-1ZZ14 - B.O.P. PIPING THERMAL EXPANSION TEST SUPPLEMENT

A. Test Objective:

The purpose of this procedure was to resolve outstanding Test Exceptions for procedure 91HF-1ZZ08, "B.O.P. Piping Thermal Expansion Measurements". The entire procedure was to complete the requirement of selected ASME III, Class 1, 2 and 3 piping as to their freedom to expand and contract during system heatup and cooldown. Additionally, it was demonstrated that selected hangers and snubbers on these systems worked as designed without exceeding the design limits. The following systems are included in the procedure:

CH - Letdown
SI - Shutdown Cooling
RC - Pressurizer Surge
SG - Main Feedwater to First Anchor Upstream of Steam Generator
SG - Main Steam to Main Turbine
SG - Generator Blow Down to Containment Isolation Valve

B. Test Description:

During heatup and cooldown the system piping and supports were either examined by visual observation, or by measurements taken with instruments and by hand rulers at selected points. All the data was compared to the ambient data for assurance of proper movements and stress acceptability.

C. Test Results:

Most of the data obtained certified the acceptability of the systems to expand and contract from ambient up to 565°F heatup and back to ambient. Again, there were several test exceptions as identified in the Pre-Core HFT procedure 91HF-1ZZ08, "B.O.P. Piping Thermal Expansion Measurements". Particularly the S/G blowdown piping and the pressurizer spray piping exhibited inconsistencies in their movements, however all the stresses imposed on the piping or supports by these questionable pipe movements were within the code allowables. The systems in question have been retested per 73HF-1ZZ11, "Piping Verification Precore Carry Over Tests" during Post-Core HFT.

D. <u>Conclusion</u>:

The procedure was successful in testing all outstanding items of the Pre-Core HFT procedure 91HF-1ZZ08, "B.O.P. Piping Thermal Expansion Measurements" even though several additional trouble spots were identified. These questionable portions of systems were retested per 73HF-1ZZ11, "Piping Verification Precore Carry Over Tests" and the test results of this procedure were acceptable.

To meet the requirements of CESSAR Section 14.2.12.2.14, "Downcomer Feedwater System Waterhammer Test", the following test was performed:

2.7.1.7 91HF-1FW02 - AUXILIARY FEEDWATER WATERHAMMER TEST

A. Test Objective:

This test was performed to satisfy CESSAR Section 14.2.12.2.14 requirements. The test consisted of lowering the S/G feedwater level below the feedring, securing feed for at least thirty minutes and initiating auxiliary feedwater flow with both essential auxiliary feedwater pumps at the same time. The test boundaries included both essential auxiliary feedwater pumps, auxiliary feedwater piping to S/G #1 and S/G #1.

B. Test Description:

A pretest walkdown of the piping to be tested was conducted to verify pipe integrity. The S/G feedring had been previously inspected and verified to be properly installed and undamaged. For the test, the S/G #1 water level was lowered below the feedring (66% on wide range instrumentation). After 30 minutes without feed flow, full flow from both essential auxiliary feedwater pumps was directed to S/G #1, potentially causing a waterhammer. After the transient the auxiliary feedwater piping was walked down again to check for any damage. At the completion of hot functional testing the auxiliary feedwater ring was also inspected for any signs of damaging waterhammer.

C. Test Results:

Even though portions of the piping had been instrumented for a portion of this test the only acceptance criteria required by CESSAR is that no damage has been caused to auxiliary feedpiping or sparger. No significant loads were observed by the instruments and no damage to piping or the sparger was found during the post test inspection, thus the acceptance criteria has been met.

D. Conclusions:

The response of the piping system, including the feedsparger, to the induced waterhammer was acceptable. The results provide assurance that the system, as designed, will not experience damaging waterhammer even after a prolonged period of feed flow interruption.

To meet the requirements of CESSAR Section 14.2.12.2.3, "Pre Core Reactor Coolant System Expansion Measurements", the following tests were conducted:

a. 91HF-1RC01 - RCS EXANSION MEASUREMENTS
b. 91HF-1RC16 - NSSS PIPE STOP INSTALLATION AND GAP MEASUREMENT TEST
c. 91HF-1RC20 - PRE CORE PUMP DEMONSTRATION TEST RCS THERMAL EXPANSION MEASUREMENTS

2.7.1.8 91HF-1RC01 - RCS EXPANSION MEASUREMENTS:

A. Test Objective:

The purpose of this test was to demonstrate the unobstructed freedom of the RCS to expand and contract during plant heatup and cooldown and to verify the correct sizing of various RCS support shims.

Included in this test were all major RCS components including RCS piping, with the exception of the RCS pipe stops.

B. Test Description:

At the various test plateaus, RCS components were observed for even expansion by:

a.) visual observation
b.) go-no go measurements
c.) measurements at predetermined locations

These measurements were compared to the original ambient measurements and also against each other to assure that no component was locked up.

Feeler guages, vernier calipers, tape measures and similar hand tools were used to obtain the required measurements. Capacitance probes were used on an experimental basis to measure the gaps at the Reactor Vessel upper and lower lateral supports. Additionally, thermocouples were installed to measure temperature at the top and bottom of the Reactor support column.

C. Test Results:

The obtained measurements were within the required acceptance criteria, with the exception of the #2 pressurizer key at the 565°F plateaus which has been documented by TERs and an SFR. The system responded well and the repeatability during the various heatup/cooldown cycles was acceptable.

A retest was successfully conducted on the #2 pressurizer key during the Hot Pump Test in accordance with 91HF-1RC20, "PreCore Pump Demonstration Test RCS Thermal Expansion Measurements".

D. Conclusions:

As installed, the RCS expanded as was expected with no binding or sticking of the major components. Movements were as expected and after cooldown all components returned to their starting position within a 1/16". The system as installed will perform as designed.

2.7.1.9 91HF-1RC16 - NSSS PIPE STOP INSTALLATION AND GAP MEASUREMENT TEST

A. Test Objective:

The purpose of the procedure was to verify the position of the RCS pipe stop bases and saddles so that the RCS piping is free to expand and contract during heatup and cooldown of the plant during Precore Hot Functional testing. Also to obtain the necessary measurements to position the RCS pipe stop bases and saddles so that gaps and position parameters are within design limits and to obtain necessary measurements to enable proper sizing of pipe stop shims.

Included in the test were the Reactor Coolant System piping and associated pipe stops.

B. Test Description:

Various methods were employed to take the different measurements required by the procedure. Ball and wire gauges were used to perform the go-no go checks. They were comprised of either balls strung on cable or stranded wire, of a specified diameter, passed between the pipe and the stop to ensure a minimum gap is within the acceptance criteria. The actual gap between the pipe and the stop were measured using machined balls of varying sizes attached to rods. Points were measured, on the periphery, based on markings identified prior to start of the procedure. Other dimensions such as centerline of pipe to centerline of saddle offset and RCS piping three directional translation were measured with calibrated 6" steel rules. Also, internal gaps between the RCS piping and the pipe stops were measured using calibrated sliding wedges and scissor type gauges.

C. Test Results:

Data collected was within the acceptance criteria with the exception of several stops. These stops were repositioned at 565°F to meet the acceptance criteria. Due to accessibility problems with the D stops, these particular stops where repositioned after cooldown and their acceptability verified during the Hot Pump Demonstration Test per procedure 91HF-1RC20.

D. Conclusions:

The RCS expanded and contracted as predicted with no binding. Movements were as expected and all piping, after cooldown, returned to its original position, ± 1/32". The system performed as designed. All pipe stops were acceptable in the final position except the D stops as described above.

2.7.1.10 91HF-1RC20 PRECORE PUMP DEMONSTRATION TEST RCS THERMAL EXPANSION MEASUREMENTS

A. Test Objective:

The purpose of this test was to demonstrate the unobstructed freedom of the RCS to expand and contract during plant heatup and cooldown. Also, to verify the correct sizing of various RCS support shims and that the RCS returned to its approximate starting position and to ascertain the correct installation of the RCS pipe stops.

Included in this test were all major RCS components including RCS piping and RCS pipe stops.

B. Test Description:

During heatup and cooldown of the RCS, the RCS components and pipe stops were observed for even expansion and adequate clearances by:

a.) visual observation
b.) go-no go measurements
c.) measurements at predetermined locations

These measurements were compared to the original ambient measurements and also against each other to assure that no component was locked up.

Feeler gauges, vernier calipers, tape measures, and similar hand tools were used to obtain the measurements of the RCS components.

For the RCS pipe stops various methods were employed to obtain the different dimensions required by the procedure. Ball and wire gauges were used to perform the go-no go checks. They were comprised of machined balls strung on cable or standard wire of a specified diameter. The balls were passed between the pipe and the stop to ensure a minimum gap was within the acceptance criteria. The actual gaps between the pipe and the stop were measured using machined balls of varying sizes attached to rods. Specified locations were measured on the periphery of the stops based on markings identified prior to the start of the procedure.

Also, where required, internal gaps between the RCS piping and the pipe stops were measured using calibrated sliding wedges and scissor type gauges.

C. Test Results:

The obtained data fell within the acceptance criteria. Comparison of the data with measurements obtained during precore HFT showed repeatability of system expansion and contraction, once the system was allowed to soak for an extended period of time. For the purpose of the test, all acceptance criteria were met.

D. Conclusions:

As installed, the RCS expanded and contracted as expected with no binding or sticking of the major components. The RCS pipe stops are installed to maintain acceptable gaps during the completed heatup/cooldown cycle. No further testing of this system will be required during future thermal cycles. The procedure as written and the measurement methods employed were adequate to produce the required data.

2.7.2 POST CORE HOT FUNCTIONAL TEST PHASE:

To meet the additional requirements of FSAR Sections 3.9.2 and 14.B.11 the following tests were performed during Post-Core HFT.

a. 73HF-1ZZ11 PIPING VERIFICATION PRE-CORE CARRYOVER TESTS
b. 73HF-1ZZ09 B.O.P. PIPING THERMAL EXPANSION TEST (POST CORE HOT FUNCTIONAL)

2.7.2.1 73HF-1ZZ11 PIPING VERIFICATION PRE-CORE CARRY OVER TESTS

A. Test Objective:

To test open carryover items from the following Pre-Core HFT procedures: 91HF-1ZZ06, and 91HF-1ZZ14.

This test was divided into two main parts, steady-state vibration and thermal expansion test of the auxiliary steam supply to the seal injection heat exchanger and thermal expansion test of specific areas of CH, SG, and RC Systems.

B. Test Description:

At various test plateaus, the piping systems were observed and measurements taken at predetermined locations, to determine the migration of the pipe due to thermal movement of the piping system.

During heatup and cooldown, the system piping and supports were checked by visual observation, by measurements taken with instruments and by hand rulers at selected locations.

The systems to be tested were operated in their normal operational mode, as required by their applicable station operating procedure. While in normal operational mode, the system piping, applicable branch piping and components were observed for vibration. The acceptablility of the vibrations experienced was determined by visual inspection and supplemented by portable vibrometer readings at preselected locations.

C. Test Results:

Monitoring and testing of the auxiliary steam supply to the seal injection heat exchanger has not yet been accomplished. An attempt was made to perform this test, but there was some difficulty in meeting the specific test requirements. This test will be completed in the future, as a retest, when the required operating conditions can be met.

Testing of the CH, SC, and RC Systems was completed. All data has been analyzed and found acceptable.

D. Conclusions:

This test is complete and the results satisfactory, with the exception of the Auxiliary Steam to the Seal Injection Heat Exchanger.

2.7.2.2 73HF-1ZZ09 B.O.P. PIPING THERMAL EXPANSION TEST (POST CORE HOT FUNCTIONAL)

A. Test Objective:

The purpose of this test was to observe and document the thermal movement of the SI, SG and RC piping systems relative to their respective whip restraints during the heat up of the plant during Post Core Hot Functional Testing. This test also included the restraints that did not meet the acceptance criteria of 91HF-1ZZ13, "B.O.P. Piping Thermal Expansion Test (Pre Core Dump Demonstration Test)." Shims and energy absorbing material blocks had previously been installed, and it was also the purpose of this test to verify the unobstructed freedom of the piping systems while maintaining the prescribed maximum/minimum clearances for those systems operating at design temperatures or controlled by RCS equipment movement.

B. Test Description:

The referenced piping systems were observed at the various test plateaus during plant heatup (AMB, 280°F, 340°F, 565°F after 2 hour soak, and 565°F after 7 days). Measurements were taken at predetermined locations to determine the movement of the pipe relative to the whip restraints due to the thermal movement of the piping system or thermal movement of some major piece of equipment (i.e. Steam Generator) which imposed movement upon the piping system in question (i.e. Safety Injection and Shut Down Cooling). These observations and measurements were compared to data obtained during previous hot functional tests and data obtained at plant ambient conditions. The data obtained for those systems that did not reach design temperature during this test will be utilized to forecast design clearances when these systems do reach plant operating temperatures during power ascension testing. Information concerning repeatability, tolerance, and reliability of the instrumentation will provide the basis to give certain assurances that the piping systems are not "hard-up" against the restraints during power ascension when entry into containment will be barred.

C. Test Results:

1. Five pipe whip restraints met the acceptance criteria, as defined by the maximum/minimum allowable gap, of this procedure.

2. The remaining pipe whip restraints did not meet the acceptance criteria by either not achieving their design temperatures or by not meeting the required operational gaps. These restraints were reworked, as required, and monitoring was conducted during power ascension testing per 73PA-1ZZ09, "Pipe Whip Restraints Thermal Expansion Measurements".

D. Conclusions:

As installed the SI, SG and RC piping systems moved as predicted relative to their respective whip restraints; however, many of the lines did not achieve their design temperatures. Thus, the results of this procedure were used as interim data to assist in resizing several of the pipe whip restraints. With the exception of 5 restraints all remaining data was verified to be acceptable during power ascension testing, in accordance with procedure 73PA-1ZZ09, "Pipe Whip Restraints Thermal Expansion Measurements".

2.7.3 POWER ASCENSION TESTING

To meet the test objective of FSAR Section 14.B.11 applicable during power ascension testing, the following procedures have been implemented.

a. 73PA-1ZZ02 B.O.P. Piping Steady State Vibration Test
b. 73PA-1ZZ03 B.O.P. Piping Dynamic Transient Test
c. 73PA-1ZZ04 B.O.P. Piping Thermal Expansion Test
d. 73PA-1ZZ09 Pipe Whip Restraints Thermal Expansion Measurements
e. 73PA-1SG04 Dynamic Transient Test (Main Feedwater)

2.7.3.1 73PA-1ZZ02 B.O.P. PIPING STEADY STATE VIBRATION TEST

A. Test Objective:

The objective of this procedure was to verify, by observation and by measurements at selected locations, that the vibrations of the systems are either not visually detectable or are less then 2.5 in/sec of velocity when measured. The Main Steam and Main Feedwater Systems have been tested at the full power plateau.

B. Test Description

The piping systems, identified in the procedure, have been visually inspected for apparent vibrations and at selected points vibration measurements have been obtained via a vibrometer.

This test was conducted at the 100 percent power plateau, and included the Main Steam and Main Feed piping in the Turbine building, the MSSS and in Containment up to the secondary shield wall.

C. Test Results:

The piping did not exhibit any vibrations and met both the visual and measured acceptance criteria.

D. Conclusions

The designated systems met the acceptance criteria. No further testing is required.

2.7.3.2 73PA-1ZZ03 B.O.P. PIPING DYNAMIC TRANSIENT TEST

A. Test Objective:

The purpose of this procedure was to verify, visually and thru installed instrumentation, the adequancy of the piping systems and their supports during transient conditions such as pump starts and stops and valve closures during normal plant operations.

The following piping systems were tested:

Main Steam Piping to the Atmospheric Dump Valves.
Main Steam Piping to the Turbine Stop/Control Valves

B. Test Description:

For this test, 17 Load Sensing Pins were installed at various hanger locations to record any loads that might be imposed on the piping systems and the restraints. Additionally, the piping was inspected, prior to and after the transient, to visually verify that no damage had occurred.

The piping to the Atomospheric Dump Valves was tested at 35% power.

The response of the Main Steam Piping to a fast closure of the Turbine Stop Valves was observed during the Turbine Rollback/Trip at the 50, 80 and 100 percent power plateaus.

C. Test Results:

Where Load Cells were installed, the measured loads were within the acceptable calculated values as determined by BPC Stress Engineering. The visual inspection did not reveal any apparent damage due to the transients, thus, all acceptance criteria has been met for all test plateaus.

D. Conclusions:

The piping systems and their supports, as installed, are adequate to safely accomodate expected transients without incurring damage.

2.7.3.3 73PA-1ZZ04 B.O.P. PIPING THERMAL EXPANSION TEST

A. Test Objective:

The objective of this test was to verify that the selected piping can freely expand and contract during power operations without interference from supports or other piping and structures. The piping systems tested were the Downcomer Feedwater and Main Feedwater Piping.

B. Test Description:

For this test, 41 Displacement Transducers and 8 thermocouples were installed at various locations of the system. The obtained displacement data at each power plateau was forwarded to BPC Stress Engineering. Upon BPC Engineering acceptance of the data, the responsible engineer notified the Shift Supervisor that the Thermal Expansion of the system was acceptable and that power increase may continue. Additionally, visual inspection and manual measurements were taken on portions of the systems outside the containment. Testing was being performed at the 0, 20, 40, 60, 80, and 100 percent power plateaus.

C. Test Results:

The piping systems under test expanded and contracted in a predictable and acceptable manner and without interferences. No test exceptions were identified.

D. Conclusions:

This test was performed successfully with all data received being acceptable at each power plateau. No retesting is required. The systems tested expanded thermally as predicted.

2.7.3.4 73PA-1ZZ09 PIPE WHIP RESTRAINTS THERMAL EXPANSION MEASUREMENTS

A. Test Objective:

The objective of this test was to ensure that, after installation of shims and energy absorbing material (EAM) at the pipe whip restraint locations, no piping thermal movement is inhibited and that design clearances of the pipe whip restraints are met when the associated systems are at normal operating conditions. The piping systems tested were the Main Feedwater System, the Pressurizer Surge Piping and the Downcomer Feedwater Piping. This test also included the restraints that did not meet the acceptance criteria of 73HF-1ZZ09, "B.O.P. Piping Thermal Expansion Test (Post Core Hot Functional)."

B. Test Description:

This test was monitored entirely by remote instrumentation. A total of 42 Lanyards and 28 Linear Variable Displacement Transformers (LVDTs) were installed to monitor the gaps between the pipes and the restraints. A total of 17 Thermocouples to monitor the pipe surface temperature were also installed, one at each restraint monitored. The data was evaluated for actual gaps and also for established trends.

C. Test Results

The measured gaps at the pipe whip restraints were within the expected values, with the exception of six restraints. These six restraints will need minor adjustments to meet their acceptance criteria. However, all gaps were acceptable to continue plant operation to the planned outage.

D. Conclusions:

The six restraints that require modifications will be reworked during the first planned outage of sufficient duration. These restraints will be retested during power ascension following their completed modification.

An acceptable retest of these modified restraints will complete the requirements of this procedure. All other pipe whip restraints tested are acceptable.

To meet the requirements of CESSAR Section 14.2.12.5.17, "Main And Emergency Feedwater Systems Test", the following procedure was performed:

2.7.3.5 73PA-1SG04 - DYNAMIC TRANSIENT TEST (MAIN FEEDWATER)

A. Test Objective:

The purpose of this procedure was to demonstrate the operation of the Main Feedwater and Emergency Feedwater systems during Hot Standby, Startup and other normal operations, transients, and plant trips is satisfactory. This procedure was performed to verify the adequacy of the piping systems and supports during the above listed plant modes.

B. Test Description:

For this test, 13 Load Sensing Pins were installed at various hanger locations to record any loads that might have been imposed on the piping system and the respective restraints. Additionally, the piping was inspected, prior to and after the transients, to verify that no damage occurred as a result of the transient induced loads.

Monitoring of the feedwater transfer from the downcomers to the economizer was conducted at approximately 15 percent power. The acceptance criteria is defined by the maximum loads allowed at various load cells located throughout the system and that no piping or supports were damaged after the transfer. The feedwater transfer from the economizer to the downcomer was monitored during power decrease at about 14 percent power. The acceptance criteria is the same as discussed above. The FW system piping during a FW Pump Trip and the systems response during the restart of the second Main FW Pump at approximately 65 percent power was also monitored. Again, the acceptance criteria is the same as discussed above.

C. Test Results:

All measured loads were below the acceptable loads calculated for the specified loads pins. All loads measured were at or below 100 lbs. force. The visual inspection revealed that no damage was sustained by the piping, the supports or adjoining structures due to the transient response. Therefore, all stated acceptance criteria had been met for this procedure.

D. Conclusions:

The Main Feedwater System and Auxiliary Feedwater Systems, as installed, indicate that their design, construction and hangers are adequate to support all normally encountered operating modes without damage or apparent degregation.

3.0 CONCLUSION

The Piping Verification Program, as conducted at PVNGS Unit 1, has met all established licensing and regulatory requirements with the exception of the testing of the Auxiliary Steam portion to the Seal Injection Heat Exchanger, as discussed in Section 2.7.2.1, and the required reworking of six (6) Main Feedwater Pipe Whip Restraints, as discussed in Section 2.7.3.4.

The Steam supply to the Seal Injection Heat Exchanger is currently secured, thus the existing condition is not in violation of the intent of the program. When steam is supplied to the Heat Exchanger, Thermal Expansion and Steady State Vibration Testing will be performed on the steam portion of the system.

The Piping Verification Program for PVNGS Unit 1 is complete and acceptable, with the above exceptions. Upon completion of the retesting, a summary of the results will be submitted.