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U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
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Subject: Palo Verde Nuclear Generating Station (PVNGS)
Unit 2
Docket No. STN 50-529 (License NPF-51)
PVNGS Unit 2 Piping Verification Test Summary
File: 87-F-056-026; 87-136-419

Dear Sir:

Attached, please find the PVNGS Unit 2 piping verification test summary, in accordance with Section 3.9.2 of the SER.

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

Very truly yours,

J. G. Haynes

J. G. Haynes
Vice President
Nuclear Production

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PVNGS UNIT II PIPING VERIFICATION PROGRAM

TEST SUMMARY

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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

LIST OF ABBREVIATIONS (Cont'd)

PC -	Fuel Pool Cooling and Cleanup System
PVNGS -	Palo Verde Nuclear Generating Station
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 II PIPING VERIFICATION PROGRAM
TEST SUMMARY

1.0 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 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."

2.0 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, spring 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 snubber 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 DEFINITION OF TEST MODES:

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 containment 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. 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 METHOD OF TEST VERIFICATION:

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 measurements 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 noticeable 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-2ZZ06 - B.O.P. Piping Steady State Vibration Test
b. 91HF-2ZZ07 - B.O.P. Piping Dynamic Transient Test
c. 91HF-2ZZ08 - B.O.P. Piping Thermal Expansion Test
d. 91HF-2ZZ12 - B.O.P. Piping Whip Restraint and 5-Way Restraint Thermal Expansion Test
e. 91HF-2FW02 - Auxiliary Feedwater Waterhammer Test
f. 91HF-2RC01 - RCS Expansion Measurements
g. 91HF-2RC16 - NSSS Pipe Stop Installation and Gap Measurement Test

2.7.1.1 91HF-2ZZ06 - 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 acceptability.

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 Transfer 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 acceptability 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 following:

a. Auxiliary Steam to Auxiliary Feedwater Pump Turbine

b. Auxiliary Steam to Liquid Radwaste Evaporator
c. Auxiliary Steam to Boric Acid Concentrator
d. Auxiliary Steam to Seal Injection Heat Exchanger
e. Condensate Transfer System
f. Diesel Generator "B"
g. Diesel Fuel Oil Transfer System, Train "B"
h. Shutdown Cooling System "Warm-Up Bypass" Mode

The above systems were tested as they became available either prior to or during Post Core HFT per procedure 73HF-2ZZ11, 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-2ZZ07 - 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
RC - Reactor and Pressurizer Head Vent Systems

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, the 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 valve.

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. During pressurizer vent testing, vent valve RC-HV-108 failed to open. This section of the procedure was performed during post core HFT per procedure 73HF-2ZZ11.

D. Conclusions:

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

2.7.1.3 91HF-2ZZ08 - B.O.P. PIPING THERMAL EXPANSION

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 system were tested:

DG - Diesel Generator System
AS - Auxiliary Steam System
CH - Chemical and Volume Control System
SI - Safety Injection System
RC - Reactor Coolant System
SG - Steam Generator System
SS - Nuclear Sampling 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 points. All the data taken was compared to the cold ambient data for assurance of proper movements and stress acceptability.

B. 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 73HF-2ZZ11 during Post Core Hot Functional Testing.

C. Conclusions:

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

2.7.1.4 91HF-2ZZ12 B.O.P. PIPING WHIP RESTRAINT AND 5-WAY RESTRAINT THERMAL EXPANSION 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 heatup and cooldown during Hot Functional Testing. 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, 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 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-2ZZ09, "Pipe Whip Restraint Measurements." All other restraints were acceptable and thus this procedure was closed out and the test results accepted.

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

2.7.1.5 91HF-2FW02 - 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 the #1 Steam Generator.

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. The post test feedwater sparger inspection has as of yet not been conducted and is an outstanding item for this procedure.

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 feed-piping or sparger. No significant loads were observed by the instruments and no damage to the piping was found during the post test inspection, thus the acceptance criteria has been met.

D. Conclusions:

The response of the piping system to the induced waterhammer was acceptable. Even though the sparger has not been inspected, the results of the Units 1 and 3 feedring inspections 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-2RC01 - RCS Expansion Measurements
b. 91HF-2RC16 - NSSS Pipe Stop Installation and Gap Measurement Test

2.7.1.6 <u>91HF-2RC01 - RCS EXPANSION MEASUREMENTS</u>:

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 gages, vernier calipers, tape measures and similar hand tools were used to obtain the required measurements. Thermocouples were installed to measure temperature at the top and bottom of the reactor support columns.

C. Test Results:

Most of the obtained measurements were within the required acceptance criteria, with the exception of the #4 pressurizer key and several of the loop 1A and 2B upper lateral support gaps at the 565°F plateaus which has been documented by TERs and SFRs. The system responded well and the repeatability during the various heatup/cooldown cycles was acceptable. The above components were reworked and successfully tested during Post Core Hot Functional Testing per procedure 73HF-2RC02.

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.

2.7.1.7 91HF-2RC16 - 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 Pre-core 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 was measured with snap gages. 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 6" steel rules. Also, internal gaps between the RCS piping and the pipe stops were measured using Go-No Go type gages.

C. Test Results:

Data collected was generally 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 were to be repositioned after cooldown.

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.

2.7.2 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-2ZZ11 - Piping Verification Pre-Core Carryover Tests
b. 73HF-2ZZ09 - Pipe Whip Restraint Measurements
c. 73HF-2RC02 - RCS Thermal Expansion Measurements
d. 73HF-2RC01 - RCS Pipe Stop Measurements

2.7.2.1 73HF-2ZZ11 PIPING VERIFICATION PRE-CORE CARRY OVER TEST

A. Test Objective:

To test open carryover items from the following Pre-Core HFT procedures:

a. 91HF-2ZZ06
b. 91HF-2ZZ07
c. 91HF-2ZZ08
d. 91HF-2FW02

This procedure was divided into four sections according to the requirements of the above procedures; steady-state vibration testing, dynamic transient testing, thermal expansion measurements and the #1 steam generator feedring inspection.

B. Test Description:

1. Steady-State Vibration Testing:

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 acceptability of the vibrations experienced was determined by visual inspection and supplemented by portable vibrometer readings at preselected locations.

2. Dynamic Transient Testing:

For this test the pressurizer vent piping was inspected prior to opening the pressurizer vent valve to identify and document any existing damage. After cycling of the valve (HV-108), the piping was again inspected for any damage that may have been caused by the transient.

3. Thermal Expansion Testing:

At various test plateaus, the piping systems were observed and measurements taken at predetermined locations, to determine the movement 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.

4. Feedring Inspection:

The downcomer feed sparger was to be visually inspected to verify that no damage has occurred due to the waterhammer test conducted per 91HF-2FW02.

C. Test Results:

1. All of the steady-state vibration testing was successfully accomplished with the exception of the auxiliary steam piping to the seal injection heat exchanger. Operational considerations made it impossible to operate the system. TER 04 was written to address this problem and the subsequent EER 86-AS-20 deleted the requirements for testing this portion of piping.

2. All of the requirements of the dynamic transient test on the pressurizer vent piping have been met during this test.

3. All of the thermal expansion testing requirements have been met with the exception of the auxiliary steam to the seal injection heat exchanger. The thermal expansion testing of this piping has also been deleted per TER 04 and EER-AS-20.

4. Due to the unavailability of the Steam Generator for an internal inspection of the feedring this portion of the procedure has not been completed. This open item is being tracked on SIMS as open work order #192196 and will be performed during the next scheduled Steam Generator inspection. Based on the results of the feedwater waterhammer tests in Units 1 and 3 and the results of the external feedwater piping inspection in Unit 2 it is expected that the inspection will be satisfactory.

D. Conclusions:

All the systems that were tested per this procedure performed as expected with no abnormal system behavior noted. For systems that could not be tested, adequate engineering justification exists to satisfy the requirements of the procedure.

2.7.2.2 73HF-2ZZ09 PIPE WHIP RESTRAINT MEASUREMENTS

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-2ZZ12, "B.O.P. Piping Whip Restraint and 5-Way Restraint Thermal Expansion 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 the previous hot functional test 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. Fourteen 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-2ZZ09, "Pipe Whip Restraints Thermal Expansion Measurements."

D. Conclusions:

1. Even though not all measured gaps of the pipe whip restraints fell within the stated acceptance criteria, BPC Engineering determined that the fourteen restraints are acceptable in the "as is" condition and meet all applicable design requirements.

2. As installed the SI, SG and RC piping systems moved as predicted relative to their respective whip restraints; however, as expected, many of the lines did not achieve their design temperatures. These restraints were tested during power ascension testing, in accordance with procedure 73PA-2ZZ09, "Pipe Whip Restraints Thermal Expansion Measurements."

2.7.2.3 73HF-2RC02 - RCS THERMAL EXPANSION MEASUREMENTS

A. Test Objective:

The purpose of this procedure was to verify the correct sizing of the steam generator cross stop shims as well as to satisfy open test exceptions of the pre-core HFT procedure 91HF-2RC01 which involve gap measurements on the reactor vessel upper lateral supports and pressurizer key #4. Also to observe the RCS components again for even expansion.

B. Test Description:

As was the case during performance of 91HF-2RC01, the RCS components were observed for even expansion, at the various test plateaus, by:

a. Visual Observation
b. Go-No Go Measurements
c. Measurements at Predetermined Locations

Feeler gages, vernier calipers, tape measures and similar hand tools were used to obtain the required measurements.

C. Test Results:

The majority of the data taken met the stated acceptance criteria. The upper lateral supports at loops 1B and 2B did not meet the stated acceptance criteria, but were found acceptable "as is" based on an engineering review of the specific condition.

D. Conclusions:

As installed the RCS expanded again with no binding or sticking of the major components and all required gaps have been found acceptable in the as found condition.

2.7.2.4 73HF-2RC01 - RCS PIPE STOP MEASUREMENTS

This procedure was prepared and later cancelled due to the exemption to General Design Criteria 4 which eliminated the RCS pipe stops. After removal of the RCS pipe stop shims no further testing of the pipe stop gaps was required.

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-2ZZ02 - B.O.P. Piping Steady State Vibration Test
b. 73PA-2ZZ03 - B.O.P. Piping Dynamic Transient Test
c. 73PA-2ZZ04 - B.O.P. Piping Thermal Expansion Test
d. 73PA-2ZZ09 - P.A.T. Pipe Whip Restraints Thermal Expansion Measurements

2.7.3.1 73PA-2ZZ02 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.

The requirements of CESSAR Section 14.2.12.5.17, "Main and Emergency Feedwater Systems Test", were satisfied by portions of the following procedure.

2.7.3.2 73PA-2ZZ03 B.O.P. PIPING DYNAMIC TRANSIENT TEST

A. Test Objective:

The purpose of this procedure was to verify, visually and thru installed instrumentation, the adequacy 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
Downcomer and Main Feedwater Piping Inside and Outside of Containment

B. Test Description:

For this test, 30 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 Atmospheric 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.

The feedwater piping was monitored during fast closure of the Turbine Stop Valves at 50% as well as during the feedwater transfer at approximately 15% power both, during power increase and power decrease.

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. No evidence of damaging waterhammer was observed during the feedwater transfer.

D. Conclusions:

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

2.7.3.3 73PA-2ZZ04 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 systems 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 <u>73PA-2ZZ09 PIPE WHIP RESTRAINTS THERMAL EXPANSION MEASUREMENTS</u>

A. <u>Test Objective</u>:

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-2ZZ09, "Pipe Whip Restraint Measurements."

B. <u>Test Description</u>:

This test was monitored entirely by remote instrumentation. A total of 59 Lanyards and 22 Linear Variable Differential Transformers (LVDTs) were installed to monitor the gaps between the pipes and the restraints. A total of 21 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. <u>Test Results</u>:

The measured gaps at the pipe whip restraints were within the expected values, with the exception of five restraints. These five restraints needed minor adjustments to meet their acceptance criteria.

D. <u>Conclusions</u>:

The five restraints that required modifications were reworked during the first planned outage of sufficient duration and were retested during the power ascension following their completed modification.

The acceptable retest of these modified restraints completed the requirements of this procedure.

3.0 CONCLUSION:

The Piping Verification Program, as conducted at PVNGS Unit 2, has met all established licensing and regulatory requirements with the exception of the inspection of the Auxiliary Feedwater Sparger as discussed in Section 2.7.2.1.

The Piping Verification Program for PVNGS Unit 2 is complete and acceptable, with the above exceptions. Upon completion of the feedring inspection a summary of the results will be submitted.