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WILLIAM F. CONWAY
EXECUTIVE VICE PRESIDENT
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161-03591-WFC/RAB/DAF

November 13, 1990

Docket No. STN 50-530

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Mail Station P1-37
Washington, D. C. 20555

Dear Sir:

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Unit 3
PVNGS Unit 3 Piping Verification Test Summary
File: 90-F-056-026; 90-136-419

Attached, please find the PVNGS Unit 3 piping verification test summary, in accordance with Section 3.9.2 of the Safety Evaluation Report (SER), November, 1981.

If you have further questions on this matter, please contact Mr. M. E. Powell of my staff at (602) 340-4981.

Sincerely,

WFConway

WFC/RAB/DAF/pmm

Attachment

cc: J. B. Martin
A. H. Gutterman
A. C. Gehr
D. H. Coe

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PVNGS UNIT III PIPING VERIFICATION

Test Summary

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LIST OF ABBREVIATIONS

AF -	Auxiliary Feedwater System
APS -	Arizona Public Service
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
NED -	Nuclear Engineering Department
PAT -	Power Ascension Testing
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 III 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 Guides 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 (future testing will be to OMa-1988)

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 14.2.12.2.14, "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 objective of the piping verification program was to ensure the structural and functional integrity of the piping systems. The piping verification program was conducted in three separate test steps: thermal expansion, steady-state vibration, and dynamic effects testing. 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 allowable stress generated from piping supports, hangers, stops, pipe whip restraints, or the piping itself. Assurance of the operability of snubbers was also verified.

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.

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

2.2 INITIAL TEST CONDITIONS:

A. All quality class mechanical snubbers have been tested per PVNGS Station Procedure 73TI-9ZZ03, "Snubber Pre-Service Inspection."

B. Inspection for possible obstructions before 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 Feed sparger and restoring Auxiliary Feedwater Flow.

B. Power Ascension Testing

   1. Main Steam

      a. Rapid closure of turbine stop valves at 100 percent power level.

      b. Actuation of atmospheric 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 S/G economizer inlet. Testing also involved 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. The following tests were performed to fulfill these requirements: 91HF-3ZZ08; 91HF-3ZZ12; 91HF-3RC01; 73HF-3ZZ09; 73HF-3RC02; 73HF-3RC01; 73PA-3ZZ04; 73PA-3ZZ09.

B. Steady-State Vibration

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

2. Velocity measurements, made with portable instrumentation, were 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.

   The following tests were performed to fulfill these requirements: 91HF-3ZZ06; 73PA-3ZZ02.

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 through visual inspection.

2. Visual inspections were performed prior to and after the system had undergone a transient. Piping, pipe whip restraints, pipe supports, penetration sleeves (where piping passes through walls and floors), or other components in the system were inspected for signs of damage.

   The following tests were performed to fulfill these requirements: 91HF-3ZZ07; 91HF-3FW02; 73PA-3ZZ03.

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 was 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, were not greater than one-half the alternating stress intensity at 106 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 below predetermined maximum allowable loads.

2. 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 APS,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 by the PVNGS Test Results Review Group (TRRG) 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. Section 2.7.3 addresses the tests performed during Power Ascension Testing.

2.7.1 PRE-CORE HOT FUNCTIONAL TEST PHASE

a. 91HF-3ZZ06 - B.O.P. Piping Steady State Vibration Test

b. 91HF-3ZZ07 - B.O.P. Piping Dynamic Transient Test

c. 91HF-3ZZ08 - B.O.P. Piping Thermal Expansion Test

d. 91HF-3ZZ12 - B.O.P. Piping Whip Restraint and 5-Way Restraint Thermal Expansion Test

e. 91HF-3FW02 - Auxiliary Feedwater Waterhammer Test

f. 91HF-3RC01 - RCS Expansion Measurements

2.7.1.1 91HF-3ZZ06 - 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 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.

D. Conclusions:

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

2.7.1.2 91HF-3ZZ07 - 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 [lead Vent Systems]

B. Test Description:

For this test, each system was inspected prior to the transient for damaged insulation, pipes, 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.

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-3ZZ08 - 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 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

SG - Steam Generator System

SS - Nuclear Sampling System

B. Test Description

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 ability 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. Four TE's were resolved during the test. Two TE's, TE-02 & TE-04, covered a disconnected hanger. TE-01 was for an Auxiliary steam line warmed up prior to the cold ambient walk down. TE-03 was for hangers that were inaccessible at temperature due to hot lines.

D. Conclusions:

The B.O.P. piping, as installed, expanded and returned to normal as was expected. Therefore, the systems are acceptable.

2.7.1.4 91HF-3ZZ12 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 SG and RC piping systems relative to their respective whip restraints for the heatup and cooldown during Hot Functional Testing. Verification of the unobstructed movement of the piping system while

maintaining prescribed maximum/minimum clearances for those systems operating at design temperatures was also an objective of this test.

B. Test Description:

The referenced piping systems were observed at the various test plateaus during plant heatup and cooldown ambient (70 F, 460 F, 565 F, 350 F, 280 F, and 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 acceptance criteria has been met by all restraints with respect to paragraphs 1.2.1 and 1.2.3 from the procedure in that pipe movement was not restrained at any of the monitored pipe whip restraint locations, and all measured gaps were above the prescribed minimum. The acceptance criteria as defined by paragraph 1.2.2 was not achieved as indicated by the installed surface thermocouple. Additionally, for several restraints, the required gaps were not obtained. Test Exception 02 and SFR 3-XX-079 address these discrepancies by evaluating the safety significance of each measurement. The discrepancies were evaluated as acceptable or reworked to within the acceptance criteria. Therefore, all measured gaps were acceptable for continued testing. There was no observed case of rubbing or crushing of the energy absorbing material (EAM).

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-3ZZ09, "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-3FW02 - 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 S/G. This test verified the systems ability to withstand the waterhammer induced by these conditions.

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 01 water level was lowered below the feedring (15% on narrow range instrumentation). After 90 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 #1 S/G auxiliary feed ring was inspected for damage after the plant attained ambient conditions following HFT.

C. Test Results:

The inspection of the auxiliary feedwater piping following the dynamic event was satisfactory. The installed instrumentation (load cells) on the auxiliary feedwater line showed no extreme forces were applied to the piping during the test. The visual inspection of the feed sparger and associated pipe supports also showed no damage due to the induced transient.

D. Conclusions:

The response of the piping system to the induced waterhammer was acceptable. No abnormalities either

visually or by instrumentation were observed.

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

2.7.1.6 91HF-3RC01 - 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 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 pressurizer keys 3 and 4 which have been documented by TERs and SFRs. The system responded as expected 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-3RC02.

D. Conclusions:

The reactor coolant system (RCS) and its major components expanded and contracted thermally as expected except at the points described above which were retested successfully during the performance of 73HF-3RC02.

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-3ZZ09 - Pipe Whip Restraint Measurements
b. 73HF-3RC02 - RCS Thermal Expansion Measurements

2.7.2.1 73HF-3ZZ09 PIPE WHIP RESTRAINT MEASUREMENTS

A. Test Objective:

The purpose of this test was to observe and document the thermal movement of the SG and RC piping systems relative to their respective whip restraints during plant heatup during post Core Hot Functional Testing. This test also included the restraints that did not meet the acceptance criteria of 91HF-3ZZ12, "B.O.P. Piping Whip Restraint and 5-Way Restraint Thermal Expansion Test." Shims and energy absorbing material blocks had previously been installed.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 (ambient, 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 was 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 provided the basis to give certain assurances that the piping systems were not "hard-up" against the restraints during power ascension when entry into containment was prohibited.

C. Test Results

All pipe whip restraints have met the acceptance criteria of not inhibiting pipe movement. The specific gap criteria has not been met by several of the restraints. These whip restraints were either evaluated "accept as is" or reworked and monitored during the power ascension stage of testing.

D. Conclusions

Even though not all measured gaps of the pipe whip restraints fell within the stated acceptance criteria some were determined to meet all the applicable design requirements, one was reworked and monitored during power ascension and the rest were added to the acceptance criteria of 73PA-3ZZ09 and monitored during power ascension testing.

2.7.2.2 73HF-3RC02 - RCS THERMAL EXPANSION MEASUREMENTS

A. Test Objective:

The purpose of this procedure was to verify correct sizing of the S/G cross stop shims as well as to satisfy open test exceptions of the pre-core HFT procedure 91HF-3RC01 which involve gap measurements on the pressurizer keys #3 and #4. Another objective was to observe the RCS components again for even expansion.

B. Test Description:

As was the case during performance of 91HF-3RC01, the RCS components were observed for even expansion,

by visual observation, go-no-go measurements and measurements at predetermined locations, feeler gages, vernier calipers, tape measures and similar hand tools were used to obtain the required measurements.

C. Test Results:

All measurements were within the acceptance criteria. This test satisfies the retest requirements for 73HF-3RC01 TE #3 and #4.

D. Conclusions:

As installed the RCS expanded with no binding or sticking of the major components. All required measurements met the stated acceptance criteria.

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-3ZZ02 - BOP Piping Steady State Vibration Test

b. 73PA-3ZZ03 - BOP Piping Dynamic Transient Test

c. 73PA-3ZZ04 - BOP Piping Thermal Expansion Test

d. 73PA-3ZZ09 - PAT Pipe Whip Restraints Thermal Expansion Measurements

2.7.3.1 73PA-3ZZ02 BOP 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 were either not visually detectable or were 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 were visually inspected for apparent vibration. At selected points vibrations measurements were also taken. 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 met both the visual and measured acceptance criteria.

D. Conclusions:

The designated systems met the acceptance criteria and performed as designed.

2.7.3.2 73PA-3ZZ03 B.O.P. PIPING DYNAMIC TRANSIENT TEST

A. Test Objective:

The objective of this procedure was to verify, visually and through 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 operation. The piping systems tested were the Main Steam Piping to the Atmospheric Dump valves, Main Steam Piping to the Turbine Stop/Control valves, and the Downcomer and Main Feedwater Piping inside and outside of containment.

B. Test Description:

For this test, thirty load sensing clevis 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 a turbine trip at the 100% power plateau.

The feedwater piping was monitored during fast

closure of the turbine stop valves at 100% power. The feedwater piping was also monitored during the up and down power feedwater transfer at approximately 15% power.

C. Test Results:

Where load cells were installed, the measured loads were within the acceptable calculated values 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. TE-01 documented the deletion of the 50% and 80% trip as the commitment in the FSAR for dynamic transient testing was met by the 100% trip.

D. Conclusions:

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

2.7.3.3 73PA-3ZZ04 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, other piping, and structures. The piping systems tested were the Downcomer Feedwater and Main Feedwater Piping.

B. Test Description:

Forty two displacement transducers and ten thermocouples were installed at various locations in 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 ascension could continue. 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 tested expanded and contracted in a predictable and acceptable manner without interference. Two test exceptions were noted. TE-01 was written to allow system walk down before instrumentation data evaluation by BPC. TE-02 was written to allow closing of the procedure and tracking removal of the test instrumentation by work order.

D. Conclusions:

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

2 7.3.4 73PA-3ZZ09 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 was 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-3ZZ09, "Pipe Whip Restraint Measurements."

B. Test Description:

This test was monitored entirely by remote instrumentation. Fifty nine lanyards and twenty two linear variable differential transformers (LVDTs) were installed to monitor the gaps between the pipes and the restraints. Twenty one thermocouples to monitor the pipe surface temperature were also

installed, one at each restraint data point. The data was evaluated for actual gaps and also to establish trends.

C. Test Results:

The measured gaps at the pipe whip restraints were within the expected values, with the exception of six restraints. Two of the six restraints have been evaluated "accept as is" (EER 90-SG-034) and four restraints needed minor adjustments to meet their acceptance criteria.

D. Conclusions:

The four restraints that required modifications will be reworked during the first planned outage of sufficient duration, currently anticipated to begin in March, 1991. These modifications will bring the restraints within the acceptance criteria. These restraints will be inspected after modification to insure desired gaps have been achieved.

3.0 <u>CONCLUSION:</u>

The PVNGS Unit 3 Piping Verification Program has met all established licensing and regulatory requirements. The Piping Verification Program for PVNGS Unit 3 is complete and the results are acceptable.