APS
A subsidiary of Pinnacle West Capital Corporation

Palo Verde Nuclear Generating Station

John H. Hesser
Vice President
Nuclear Engineering

Tel. 623-393-5553
Fax 623-393-6077

Mail Station 7605
P. O. Box 52034
Phoenix, Arizona 85072-2034

102-06175-JHH/GAM
April 28, 2010

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Dear Sirs:

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Units 1, 2, and 3
Docket Nos. STN 50-528, 50-529 and 50-530
Supplemental Response to Request for Additional Information (RAI) B3.1-4 Regarding Analyzed Design Basis Transients, and License Renewal Application (LRA) Amendment No. 14

By letter dated December 29, 2009, the NRC issued a request for additional information (RAI) related to the PVNGS license renewal application (LRA). Arizona Public Service Company (APS) submitted a response to the RAI in letter no. 102-06134, dated February 19, 2010. A supplement to the APS response to RAI B3.1-4 is provided in Enclosure 1 to replace the response provided in the February 19, 2010, submittal. This supplemental RAI response, along with associated LRA Section 4.3.1 changes in Amendment No. 14 in Enclosure 2, is intended to clarify and correct LRA Section 4.3.1 as discussed with the NRC staff. Markup pages showing the changes to the text portions of LRA Section 4.3.1 are provided in Enclosure 3. Conforming changes to other affected LRA sections to reflect these Section 4.3.1 changes will be submitted by May 28, 2010.

Commitment No. 39 in LRA Table A4-1 is being revised as shown in Enclosure 2. In addition, a new Commitment No. 55 is being added to Table A4-1 as shown in Enclosure 2 for the following:

> The transient in UFSAR Table 3.9-1 Sheet No. 9 Item No. I.E.1.b, and Sheet No. 18, Item No. III.A.1.f, "Standby to SI hot leg injection check valve stroke test to standby (using the HPSI pump)," will be added to the cycle counting surveillance procedure 73ST-9RC02 by August 25, 2010.

A138
NRR

Should you need further information regarding this submittal, please contact Russell A. Stroud, Licensing Section Leader, at (623) 393-5111.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on 4/28/10
(date)

Sincerely,

[signature]

JHH/RAS/GAM

Enclosures:

1. Supplemental Response to Request for Additional Information (RAI) B3.1-4 Regarding Analyzed Design Basis Transients
2. Palo Verde Nuclear Generating Station License Renewal Application Amendment No. 14
3. Markup Showing Changes to LRA Section 4.3.1

cc:	E. E. Collins Jr.	NRC Region IV Regional Administrator
	J. R. Hall	NRC NRR Project Manager
	L. K. Gibson	NRC NRR Project Manager
	R. I. Treadway	NRC Senior Resident Inspector for PVNGS
	L. M. Regner	NRC License Renewal Project Manager
	G. A. Pick	NRC Region IV (electronic)

ENCLOSURE 1

Supplemental Response to Request for Additional Information (RAI) B3.1-4 Regarding Analyzed Design Basis Transients

NRC RAI B3.1-4 (From NRC letter to APS dated December 29, 2009)

Background:

The Detection of Aging Effects element of the Metal Fatigue of Reactor Coolant Pressure Boundary AMP in the GALL Report states that the program provides for periodic update of the fatigue usage calculations.

Issue:

The Program Description element states that the LRA, Section 4.3, AMP monitors and tracks the number of critical thermal and pressure transients for the selected reactor coolant system components. Subsection 4.3.1.4, "Present and Projected Status of Monitored Locations," of the LRA states that a composite worst-case (composite-unit) envelope of operating transients was created including only the highest accumulation of each transient experienced among the three units from 1985 through 2005. However, the applicant did not provide individual plant data for each unit that was used to develop the composite-unit envelope.

Request:

Provide the accumulation of transients for each of the three units that were used to develop the composite-unit envelope for the period from 1985 to 2005.

APS Supplemental Response to RAI B3.1-4

Section 4.3.1 of the License Renewal Application (LRA) has been revised and supplements the prior response submitted in APS letter no. 102-06134, dated February 19, 2010. The revision is provided in LRA Amendment No. 14 in Enclosure 2. This revision incorporates the following changes:

1. Revised Table 4.3-2 to clearly show correspondence between the LRA and the Updated Final Safety Analysis Report (UFSAR).

2. Revised Table 4.3-2 to identify transients that are tracked, provided justification for those transients that are not tracked, and clarified UFSAR limits.

3. Changed "global" monitoring to "cycle counting."

4. Simplified the transient projection process and clarified that it is not intended to be used for action.

5. Revised the discussion on how the transient count data was recovered.

6. Revised Table 4.3-3 to be consistent with the UFSAR transients, replaced the worst case unit with actual totals for all three units, and provided the new simplified projections.

7. Revised the location-specific monitoring points. Table 4.3-4 now identifies the NUREG/CR-6260 locations and the pressurizer spray nozzle location.

8. Incorporated miscellaneous clarifications and editorial changes.

ENCLOSURE 2

Palo Verde Nuclear Generating Station
License Renewal Application Amendment No. 14

LRA Section	Page Nos.	RAI No.
4.3	4.3-1 through 4.3-42	B3.1-4
Table A4-1, Item 39	A-54	B3.1-4
Table A4-1, Item 55	A-59	B3.1-4

4.3 METAL FATIGUE ANALYSIS

This section addresses design of mechanical system components supported by fatigue analyses; and also of components whose design depends on an assumed number of load cycles without a calculated fatigue usage factor.

Section 4.6 describes fatigue in the containment vessel.

Section 4.7.4, describes corrosion and fatigue crack growth and stability in the primary coolant nozzles.

Fatigue analyses are required for piping, vessels, and heat exchangers designed to the American Society of Mechanical Engineers *Boiler and Pressure Vessel Code,* Section III, *Rules for Construction of Nuclear Power Plant Components,* Division 1, "Metal Components," Subsection NB, "Requirements for Class 1 Components" (ASME III Class 1).[1] Fatigue analyses may also be invoked for Class 1 pump and valve pressure boundaries.

Fatigue analyses are required for portions of the reactor pressure vessel internals designed to American Society of Mechanical Engineers *Boiler and Pressure Vessel Code,* Section III, *Rules for Construction of Nuclear Power Plant Components,* Division 1, "Metal Components," Subsection NG, "Core Support Structures."

The design of piping and vessels to certain other codes and code sections, including ASME III Class 2 and 3, ANSI-ASME B31.1, and ASME VIII Division 2, may assume a stated number of full-range thermal and displacement cycles.

Section 4.3 also describes fatigue analyses and evaluations of a limited number of other non-Class 1 components that were evaluated to these and similar rules.

Basis of Fatigue Analyses

ASME III Class 1 design specifications define a set of static and transient load conditions for which components are to be designed. Although original design specifications commonly state that the transient conditions are for a 40-year design life, the fatigue analyses themselves are based on the specified number of occurrences of each transient rather than on this lifetime. The design number of occurrences of each transient for use in the fatigue analyses was specified to be larger than the number of occurrences expected during the 40-year licensed life of the plant, based on engineering experience and judgment. This provides an allowance for future changes in design or operation that may affect system design transients.

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[1] Titles are from the 1971 edition of the code, as used for the reactor vessel. Later editions reorganized the Section III material and removed the Division 1 title, so that this subsection became "Division 1 — Subsection NB, Class 1 Components".

Operating experience at PVNGS and at other similar units has demonstrated that the assumed frequencies of design transients, and therefore the number of transient cycles assumed for a 40-year life, were conservative; and that with few exceptions the design numbers are not expected to be exceeded within a 60-year life. The exceptions are of two kinds.

First, the NRC, industry, and specific plants, including PVNGS, have identified some transient loads on some components that were not foreseen in the original design process; for example thermally stratified flow in the pressurizer surge line and feedwater system, and Combustion Engineering Infobulletin 88-09. These cases have required evaluations to assess their significance and some have required revision to design specifications and analyses.

Second, plant and industry operating experience has identified a few cases where cycles were being accumulated more rapidly than originally anticipated. At PVNGS, these were principally due to first-of-a-kind startup and shutdown cycles during the early plant life.

Fatigue cycles are currently tracked in a PVNGS surveillance test procedure, 73ST-9RC02 "Reactor Coolant System Transient and Operational Cycles," as required by PVNGS Technical Specification 5.5.5 "Component Cyclic or Transient Limit." In the text of this discussion the activities governed by 73ST-9RC02 will be referred to as the "current fatigue monitoring program." The enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (See LRA Appenbix B section B3.1) will continue to track events to ensure that appropriate re-evaluation or other corrective action is initiated if an action limit is reached. Action limits will permit completion of corrective actions before the design basis number of events is exceeded. See Section 4.3.1.5.

The Industry Operating Experience Review (OE) program ensures that industry experience is evaluated and incorporated in plant analyses and procedures. The OE program includes review of experience that may indicate concerns with fatigue effects. Any necessary evaluations are conducted under the plant corrective action program. The OE program has remained responsive to both industry and plant-specific emerging issues and concerns.

4.3.1 Enhanced Fatigue Aging Management Program (B3.1)

The current fatigue monitoring program is a cycle counting program with one location-specific cumulative usage factor (CUF) calculation (Pressurizer Spray Nozzle). No later than two years prior to the period of extended operation, the current fatigue monitoring program governed by 73ST-9RC02 will be enhanced to include additional location-specific CUF calculations and an automated and computerized management software program for cycle counting and fatigue usage factor tracking. The automated and computerized software program will be used to supplement manual counting.

The enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will use cycle counting (CC), cycle based fatigue CUF calculations (CBF) and stress based fatigue CUF calculations (SBF) (see methods discussion below) to monitor fatigue. FatiguePro® will be used for cycle counting and cycle-based fatigue (CBF) monitoring methods. FatiguePro® is an EPRI licensed product.

APS commits to the use of a fatigue monitoring software program that incorporates a three-dimensional, six-element stress tensor method meeting ASME III NB-3200 requirements for stress-based fatigue monitoring (SBF). APS also commits to the implementation of this method for SBF monitoring at least two years prior to the period of extended operation.

The enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will monitor plant transients as required by PVNGS Technical Specification 5.5.5. Cumulative usage factors (CUFs) will be calculated for a subset of ASME III Class 1 reactor coolant pressure boundary vessel and piping locations, and component locations with Class 1 analyses. The enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will provide action limits on cycles and on CUF that will initiate corrective actions before the licensing basis limits on fatigue effects at any location are exceeded.

Scope

The scope of the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will include all ASME Section III Class 1 components and components with Class 1 fatigue analysis and will monitor their fatigue usage by a combination of cycle counting and CUF monitoring.

Methods

The Cycle Counting (CC) monitoring method in Table 4.3-4 means that the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will not periodically calculate accumulated fatigue usage at the location. However, transient event cycles affecting the location (e.g. plant heatup and plant cooldown) will be counted and tracked to ensure that the numbers of transient events assumed by the design basis calculations will not be exceeded. Cycle counting is the method used by the current fatigue monitoring program for all monitored components except the pressurizer spray nozzle. Cycle counting ensures fatigue usage does not exceed 1.0. It is employed as the preferred method of monitoring due to its simplicity.

Cycle-based fatigue (CBF) monitoring will consist of (a) automated cycle counting; supported as needed by manual data entry for infrequent events, and (b) CUF computation based on the counted cycles. The component CUF contributions due to each cycle are determined from the component Class I fatigue analysis. CBF is a more complex and resource intensive method than CC because it goes beyond counting of cycles to evaluate the CUF contributions of each cycle. Three CBF methods will be used, Per-Cycle CBF (CBF-C), Per-Cycle CBF with partial cycles (CBF-PC), and Event-Pairing CBF (CBF-EP).

The CBF-C and CBF-PC methods will compute fatigue usage for a component by determining a location-specific fatigue usage increment for each counted event, and then adding up those increments for all events in the cycle record. CBF-PC will be used for some components, where the fatigue severity of individual plant events can be scaled using partial-cycle curves. A partial-cycle curve assigns a fractional severity to a cycle, as compared to a full design cycle, based upon significant characteristics of that event, such as temperature difference or heatup rate.

CBF-EP is derived from the application of Miner's rule for combining fatigue effects, under the guidance of ASME III, NB-3222.4. This method will use an event-pairing table which assumes that the effect of pairs of monitored events is equal to the effect of similar pairs of design basis events.

Stress-based fatigue (SBF) monitoring will compute a "real time" stress history for a given component from actual temperature, pressure, and flow histories. SBF monitoring uses data collected from existing plant instruments to calculate local pressure and temperature, and the corresponding stress history at the critical location in the component. The stress history is analyzed to identify stress cycles, and then a CUF is computed using the formulas defined in ASME Code Section III sub-article NB-3200. SBF is the most complex and resource intensive method of fatigue monitoring, but it is the most accurate method and requires fewer conservative assumptions than CC or CBF methods.

Corrective Action Limits

The enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) corrective actions will be initiated whenever an action limit is reached, for either the number of transient cycles or calculated fatigue usage factor. In the current fatigue monitoring program cycle action limits are set at 90% of the allowed cycles for each transient, and a CUF action limit of 0.65 is set for the pressurizer spray nozzle. In the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) corrective action limits will be set to permit completion of corrective actions before the design basis number of events is exceeded, or before the cumulative usage factor exceeds the code limit of 1.0. See Section 4.3.1.5 for the description of these actions and action limits, for the basis for the margins between the fatigue usage factor action limits and the code usage factor limit of 1.0, and for the basis for the margins between the cycle count action limits and the design basis cycle count assumptions.

Analytical Margins

Fatigue analyses incorporate several conservative assumptions and methods. These ensure that usage factors predicted by the design calculation will exceed (or "bound") the usage factors actually accumulated by the components. These conservatisms are discussed below.

<u>Fatigue Design Curve with Margin for Uncertainties and Moderate Environmental Effects:</u> The ASME Section III fatigue S-N curves (allowable alternating stress intensity versus number of cycles) are based on regression analysis of a large number of fatigue data points for samples strain-cycled in air, with adjustments for the elastic modulus and departure from zero mean stress for elastic cycling, less a design margin for uncertainties, including modest

environmental effects (ASME III - 1965, Par. N-415). The design margin is a factor of 2 on stress or a factor of 20 on cycles, whichever produced the lower, more conservative allowable for the data set.

Bounding Parameters for Transients: Fatigue analyses assume a given number of cycles of each of a set of transient events. Actual event cycles are seldom as severe as those considered in the analysis; the resulting stress ranges are lower, and the contributions to cumulative usage factor are therefore lower.

Use of Stress Based Fatigue: Since an automated six-element stress tensor fatigue calculation will calculate stresses from the actual event severity, usage factors reported by the software program at locations for which the stress-based method is used will be more realistic than values predicted by the code analysis for the same number of cycles, or which would be determined by cycle-count monitoring.

Actual Number of Event Cycles versus Design Number of Cycles: The analytical limit for a fatigue analysis is a cumulative usage factor at any location of 1.0. The design CUF is the sum of all contributing partial usage factors resulting from the total of all design basis events at their design number of occurrences. Therefore, even if the analysis showed a calculated usage factor of 1.0 for a location, and even if the design basis number of cycles were reached for one event, the fact that all contributing cycle types will not simultaneously arrive at their assumed limit indicates that some fatigue margin would remain.

Action limits in the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will be set below the cycle count assumed by the analysis to ensure that actual component usage remains bounded by the assumptions used in the design calculations, or that appropriate reevaluation or other corrective action is initiated if an action limit is reached. Action limits will permit completion of corrective actions before the design basis number of events is exceeded. Therefore, the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will ensure that there is ample margin to the CUF limit of 1.0.

4.3.1.1 Licensing Basis of the PVNGS Component Cyclic or Transient Limit Program

The "Component Cyclic or Transient Limit" program is required by Technical Specification 5.5.5, which states: "This program provides controls to track the UFSAR Section 3.9.1.1 cyclic and transient occurrences to ensure that components are maintained within the design limits."

UFSAR Section 3.9.1.1 includes, by reference, information and transient definitions from several UFSAR sections and tables, which represent conservative estimates for design purposes (see Table 4.3-1). The UFSAR states that this information accounts for all expected transients, and that the number and severity of the design transients exceeds those which may be anticipated during the 40-year life of the plant. These transients are listed in Table 4.3-2.

Table 4.3-1 - PVNGS Unit 1, 2, and 3 Licensing and Design Basis Transient Citations from UFSAR 3.9.1.1

UFSAR Section or Table	Applicable Scope of Transient Data
Section 3.7.3.2	Operating Basis Earthquake (OBE) Cycles
Table 3.9.1-1	ASME III Class 1 Components by the NSSS Vendor (CE)
Table 3.9-1	ASME III Class 1 Piping Not by the NSSS Vendor (CE)
Section 3.9.3	ASME III Class 2 and 3 Components
Section 5.4.1	Reactor Coolant Pumps
Section 5.4.2	Steam Generators
Section 5.4.3	Reactor Coolant Piping
Section 5.4.10	Pressurizer

4.3.1.2 Enhanced PVNGS Fatigue Management Program (B3.1)

The enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) differs from the current fatigue monitoring program in the following two respects:

1. The current fatigue monitoring program is a manual cycle counting program. The enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will include an automated and computerized software program to support safe operation of PVNGS for the period of extended operation.

2. The current fatigue monitoring program is cycle based and includes only one specific location for CUF monitoring (pressurizer spray nozzle). The enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will continue to count cycles and will also monitor CUF values as specified in Table 4.3-4 for bounding locations subject to environmentally assisted fatigue (locations identified through implementation of NUREG/CR-6260). Usage factor monitoring will include environmental effects at NUREG/CR-6260 locations.

Table 4.3-2 – PVNGS Units 1, 2, and 3 Licensing Basis Transients

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 UFSAR Table 3.9.1-1	5 UFSAR Table 3.9-1 (Sheet No. - Item No.)	6 Other UFSAR Reference	7 UFSAR Category	8 Notes
1	Reactor Coolant System (excluding pressurizer) heatup from 70F to hot standby conditions at a rate of ≤l00F/hr.	500 (The reactor vessel studs shall be limited to 250 occurrences)	Sheet 1	1-I.A.1.a 13-II.B.1.a 21-Note *		Normal	
2	Reactor Coolant System (excluding pressurizer) cooldown from hot standby conditions to 70F at a rate of ≤100F/hr	500 (The reactor vessel studs shall be limited to 250 occurrences)	Sheet 1	1-I.A.1.d 13-II.B.1.a 21-Note*		Normal	
3	5%/minute power ramp increase, from 15% to 100% power	15000	Sheet 1	1-I.A.1.b 13-II.B.1.b		Normal	To reach this number the plant would have to experience a power increase on the average of once every 31.5 hours of operation in 60 years with a 90% capacity factor. Since the PVNGS units operate as base loaded plants this is not credible. This item is not counted.
4	5%/minute power ramp decrease, from 100% to 15% power	15000	Sheet 1	1-I.A.1.c 13-II.B.1.b		Normal	To reach this number the plant would have to experience a power decrease on the average of once every 31.5 hours of operation in 60 years with a 90% capacity factor. Since the PVNGS units operate as base loaded plants this is not credible. This item is not counted.

Table 4.3-2 – PVNGS Units 1, 2, and 3 Licensing Basis Transients

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 UFSAR Table 3.9.1-1	5 UFSAR Table 3.9-1 (Sheet No. - Item No.)	6 Other UFSAR Reference	7 UFSAR Category	8 Notes
5	10% power step increase, from 90% to 100% power	2000		6-I.C.1.a 15-II.D.1.a		Normal	
6	10% power step decrease, from 100% to 90% power	2000		6-I.C.1.b 15-II.D.1.a		Normal	
7	Normal cyclic variations at 100 % power; +/-80 psi, +/-10F	1.E+06	Sheet 1	6-I.C.1.c 7-I.C.1.d		Normal	Per UFSAR Table 3.9.1-1 "This condition is selected based on 1 million cycles approximating an infinite number of cycles so that the limiting stress is the endurance limit." Therefore the transient does not impact fatigue usage. This item is not counted.
8	Startup of one reactor coolant pump at hot standby conditions	1000		1-I.A.1.e		Normal	
9	Coastdown of one reactor coolant pump at hot standby conditions	1000		1-I.A.1.f		Normal	
10	Adding 40F feedwater at 875 gpm to the steam generator through the downcomer feedwater nozzle when at hot standby conditions	15000			5.4.2.1.C	Normal	
11	Pressurizer heatup from 70F to 653F at a rate of $\leq$200F/hr	500	Sheet 1	1-I.A.1.a		Normal	

Table 4.3-2 – PVNGS Units 1, 2, and 3 Licensing Basis Transients

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 UFSAR Table 3.9.1-1	5 UFSAR Table 3.9-1 (Sheet No. - Item No.)	6 Other UFSAR Reference	7 UFSAR Category	8 Notes
12	Pressurizer cooldown from 653F to 70F at a rate of ≤200F/hr	500	Sheet 1	1-I.A.1.d		Normal	
13	Shift from normal to maximum purification flow at 100% power	1000		8-I.D.1.a 11-II.A.1.a		Normal	
14	Standby to SI cold leg injection check valve stroke test to standby (using charging pumps)	160		9-I.E.1.a 18-III.A.1.e		Normal	
15	High-pressure safety injection header check valve test	40		11-II.A.1.b		Normal	
16	Turbine roll test at hot standby	10		7-I.C.1.e		Normal	
17	Initiation of auxiliary spray during cooldown	500		12-II.A.1.c		Normal	This transient is tracked by pressurizer cooldown events.
18	Startup of SDC system from standby to shutdown cooling (RCS >200F) to shutdown cooling (RCS <200F) to standby	500		18-III.A.1.b		Normal	

Table 4.3-2 – PVNGS Units 1, 2, and 3 Licensing Basis Transients

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 UFSAR Table 3.9.1-1	5 UFSAR Table 3.9-1 (Sheet No. - Item No.)	6 Other UFSAR Reference	7 UFSAR Category	8 Notes
19	Startup of safety injection system from standby to injection to short term recirculation to long term recirculation to shutdown cooling to standby	10		18-III.A.1.a		Normal	
20	Standby to LPSI pump test to standby	500		18-III.A.1.d		Normal	
21	Standby to HPSI pump test to standby	500		18-III.A.1.c		Normal	
22	Adding 40F feedwater at 875 gpm to the steam generator through the downcomer feedwater nozzle during loading conditions	500			5.4.2.1.D	Normal	
23	Adding 100F feedwater at 875 gpm to the steam generator through the downcomer feedwater nozzle during loading conditions	500			5.4.2.1.E	Normal	
24	Pressure transients of 85 psi across the primary divider plate in either direction caused by starting and stopping reactor coolant pumps	4000			5.4.2.1.H	Normal	

Table 4.3-2 – PVNGS Units 1, 2, and 3 Licensing Basis Transients

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 UFSAR Table 3.9.1-1	5 UFSAR Table 3.9-1 (Sheet No. - Item No.)	6 Other UFSAR Reference	7 UFSAR Category	8 Notes
25	Standby to SI hot leg injection check valve stroke test to standby (using the HPSI pump)	30		9- I.E.1.b 18-III.A.1.f		Normal	This is conducted during refueling outages. It is not currently being counted because it was recently identified and added to UFSAR Table 3.9-1. It will be added to the cycle counting surveillance procedure 73ST-9RC02 by August 25, 2010, as shown in Commitment No. 55 in Table A4-1.
26	Low-low volume control tank/charging pump suction diversion to RWT	80		9-I.D.2.d 12-II.A.2.b		Upset	
27	Pressurizer level control, failure to full open	100		9-I.D.2.e		Upset	
28	Coastdown of one reactor coolant pump at 100% power (no reactor trip)	10		2-I.A.2.a		Upset	This transient is not counted in surveillance procedure 73-ST-9RC02, but its affect would be assessed in the corrective action program since it would be an Anticipated Transient Without Scram (ATWS) event.
29	Spurious reactor trips (including operator error) at 100% power	50 (RCS) 240 (CVCS)		3-I.A.2.h 13-II.B.2.d		Upset	
30	Loss of reactor coolant system flow	40		13-II.B.2.a		Upset	
31	Arbitrary load rejection, from 100% to 15% power	40		7-I.C.2.a 16.II.D.2.a		Upset	

Table 4.3-2 – PVNGS Units 1, 2, and 3 Licensing Basis Transients

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 UFSAR Table 3.9.1-1	5 UFSAR Table 3.9-1 (Sheet No. - Item No.)	6 Other UFSAR Reference	7 UFSAR Category	8 Notes
32	OBE Condition - Full-load cycles about a mean value of zero and with an amplitude equal to the maximum response produced during the entire OBE event	200	Sheet 2		3.7.3.2	Upset	
33	Inadvertent control element assembly drop, at 100% power	40		2-I.A.2.c 13-II.B.2.b		Upset	
34	Inadvertent control element assembly withdrawal from 0% power	40		2-I.A.2.d 13-II.B.2.c		Upset	
35	Loss of charging and recovery at 100% power	200		8-I.D.2.b 12-II.A.2.d		Upset	
36	Loss of letdown and recovery at 100% power	300		8-I.D.2.a 12-II.A.2.a		Upset	
37	Charging cycles (on/off) during an extended loss of letdown	800		9-I.D.2.f 12-II.A.2.e		Upset	
38	Depressurization by spurious actuation of pressurizer spray control valve(s) at 100% power (normal and auxiliary spray valves are considered)	40		2-I.A.2.e 13-II.B.2.e		Upset	
39	Partial loss of condenser cooling at 100% power	40		5-I.B.2.e 15-II.C.2.b		Upset	

Table 4.3-2 – PVNGS Units 1, 2, and 3 Licensing Basis Transients

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 UFSAR Table 3.9.1-1	5 UFSAR Table 3.9-1 (Sheet No. - Item No.)	6 Other UFSAR Reference	7 UFSAR Category	8 Notes
40	Excess feedwater flow due to control system malfunction at 100% power	40		5-I.B.2.d 15-II.C.2.c		Upset	
41	Turbine trip without accompanying reactor trip at 100% power	40 (RCS) 120 (CVCS)		7.I.C.2.d 16.II.D.2.b		Upset	
42	Inadvertent actuation of one main steam line isolation valve at 100% power	5 (RCS) 40 (CVCS)		7.I.C.2.c 16.II.D.2.c		Upset	
43	Inadvertent actuation of one turbine bypass valve or atmospheric dump valve at 100% power	40		7.I.C.2.b 16.II.D.2.d		Upset	
44	Seismic Event up to & including One-Half of the Safe Shutdown Earthquake, at 100% Power	2		10-I.F.2.a 17-II.E.2.a		Upset	
45	Inadvertent isolation of one main feedwater heater at 100% power	5		4-I.B.2.c-		Upset	
46	Loss of Feedwater Flow (to S/G)	85		15.II.C.2.a		Upset	
47	Inadvertent initiation of auxiliary spray at 100% power	5		8-I.D.2.c 12-II.A.2.c		Upset	

Table 4.3-2 – PVNGS Units 1, 2, and 3 Licensing Basis Transients

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 UFSAR Table 3.9.1-1	5 UFSAR Table 3.9-1 (Sheet No. - Item No.)	6 Other UFSAR Reference	7 UFSAR Category	8 Notes
48	System leak due to rupture of largest instrument or sampling connection at 100% power	40		3-I.A.2.i		Upset	
49	Inadvertent closure of one main feedwater valve at 100% power	40		4-I.B.2.a		Upset	
50	Inadvertent trip of one main feedwater or one main condensate pump at 100% power	40		4-I.B.2.b		Upset	
51	Inadvertent closure of all main feedwater valves (due to loss of pressure in compressed air system) at 100% power	5		5-I.B.2.f		Upset	
52	Startup of one reactor coolant pump at 50% power	10		2-I.A.2.b		Upset	The plant design will not allow the reactor to be critical without all four reactor coolant pumps operating. This item is not counted.
53	Loss of an electrical bus supplying two reactor coolant pumps at 100% power	40		2-I.A.2.g		Upset	
54	Standby to spurious startup of a normally secured pump/spurious stopping of a normally running pump/spurious valve opening/spurious valve closure	40		10-I.E.2.a 19-III.A.2.a		Upset	

Table 4.3-2 – PVNGS Units 1, 2, and 3 Licensing Basis Transients

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 UFSAR Table 3.9.1-1	5 UFSAR Table 3.9-1 (Sheet No. - Item No.)	6 Other UFSAR Reference	7 UFSAR Category	8 Notes
55	Rx Trips, Turbine Trips and Loss of RCS Flow	480	Sheet 2			Upset	
56	Adding 40F feedwater at 1750 gpm to the steam generator through the downcomer feedwater nozzles with the flow initiated 30 seconds after a loss of normal feedwater	280			5.4.2.1.G	Upset	
57	Pressurization by spurious actuation of all pressurizer heaters at 100% power	10		2-I.A.2.f 14-II.B.3.c		Upset Emergency	
58	Depressurization due to inadvertent actuation of one secondary safety valve at 100% power	10		7-I.C.3.a		Emergency	Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses. Item is counted, but is not required to be counted.
59	Loss of offsite and onsite ac power, with retention of onsite emergency ac and dc power at 100% power	5		11-I.F.3.a 17-II.E.3.a		Emergency	Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses. Item is counted, but is not required to be counted.
60	Depressurization of the SIS, CSS, SCS by full opening of a safety or relief valve without reseating	5		19-III.A.3.a		Emergency	Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses. Item is counted, but is not required to be counted.
61	Depressurization due to inadvertent actuation of one pressurizer safety valve at 100% power	1		3-I.A.3.a		Emergency	Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses. Item is not required to be counted.

Table 4.3-2 – PVNGS Units 1, 2, and 3 Licensing Basis Transients

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 UFSAR Table 3.9.1-1	5 UFSAR Table 3.9-1 (Sheet No. - Item No.)	6 Other UFSAR Reference	7 UFSAR Category	8 Notes
62	Depressurization due to inadvertent actuation of one pressurizer safety valve	5		14-II.B.3.a		Emergency	Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses. Item is not required to be counted.
63	Opening of one primary safety valve at 100%	5		14-II.B.3.d		Emergency	Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses. Item is not required to be counted.
64	Adding 40F feedwater at 1750 gpm to the steam generator through the downcomer feedwater nozzles during a steam line break	1 MSLB event with 7 feedwater addition cycles			5.4.2.1.F	Faulted	Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses. Item is counted, but is not required to be counted.
65	Single reactor coolant pump shaft seizure at 100% power	1		3-I.A.4.b		Faulted	Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses. Item is counted, but is not required to be counted.
66	Major loss of coolant incident (system operating mode dependent upon design application for worst case conditions)	1		3-I.A.4.c		Faulted	Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses. Item is counted, but is not required to be counted.
67	Single reactor coolant pump sheared shaft at 100% power	1		4-I.A.4.d		Faulted	Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses. Item is counted, but is not required to be counted.
68	Class 2 line break	1		12-II.A.4.a		Faulted	Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses. Item is counted, but is not required to be counted.

Table 4.3-2 – PVNGS Units 1, 2, and 3 Licensing Basis Transients

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 UFSAR Table 3.9.1-1	5 UFSAR Table 3.9-1 (Sheet No. - Item No.)	6 Other UFSAR Reference	7 UFSAR Category	8 Notes
69	Seismic event up to and including the safe shutdown earthquake (system operating mode dependent upon design application for worst case conditions)	1		11-I.F.4.a 17-II.E.4.a		Faulted	Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses. Item is counted, but is not required to be counted.
70	Major rupture of the safety injection system at the highest system pressure encountered during a normal operating mode; namely, rupture during the first phase of the preoperational hydrostatic test	1		19-III.A.4.a		Faulted	Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses. Item is not required to be counted.
71	The concurrent loading produced by normal operation at full power, plus the design basis earthquake, plus loss-of-coolant accident (pipe rupture) are used to determine the faulted plant loading condition.	1	Sheet 2			Faulted	Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses. Item is counted, but is not required to be counted.
72	Major rupture in the main feedwater piping (system operating mode dependent upon design application for worst case conditions)	1		5-I.B.4.a 15-II.C.3.a		Faulted Emergency	Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses. Item is counted, but is not required to be counted.

Table 4.3-2 – PVNGS Units 1, 2, and 3 Licensing Basis Transients

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 UFSAR Table 3.9.1-1	5 UFSAR Table 3.9-1 (Sheet No. - Item No.)	6 Other UFSAR Reference	7 UFSAR Category	8 Notes
73	Major rupture in the auxiliary feedwater piping (system operating mode dependent upon design application for worst case conditions)	1		6-I.B.4.b 15-II.C.3.b		Faulted Emergency	Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses. Item is counted, but is not required to be counted.
74	Major rupture in the main steam piping (system operating mode dependent upon design application for worst case conditions)	1		8-I.C.4.a 16.II.D.3.a		Faulted Emergency	Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses. Item is counted, but is not required to be counted.
75	Control element assembly ejection at 0% power	1		3-I.A.4.a 14-II.B.3.b		Faulted Emergency	Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses. Item is counted, but is not required to be counted.
76	Loss of Secondary Pressure: One cycle of a postulated loss of secondary pressure due to a complete double ended severance of one steam generator or feedwater nozzle, but not simultaneously. These are not considered credible events in forming the design basis of the reactor coolant system. However, they are included to demonstrate that the reactor coolant system components will not fail structurally in the unlikely event that one of these events occur.	Not Credible	Sheet 2			Faulted	This item is not counted because per UFSAR Table 3.9.1-1 "These are not considered credible events in forming the design basis of the reactor coolant system. However, they are included to demonstrate that the reactor coolant system components will not fail structurally in the unlikely event that one of these events occur."

Table 4.3-2 – PVNGS Units 1, 2, and 3 Licensing Basis Transients

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 UFSAR Table 3.9.1-1	5 UFSAR Table 3.9-1 (Sheet No. - Item No.)	6 Other UFSAR Reference	7 UFSAR Category	8 Notes
77	Reactor Coolant System hydrostatic test	10	Sheet 3	4-I.A.5.a 14-II.B.5.a		Test	
78	Secondary system hydrostatic test	10		6-I.B.5.a	5.4.2.1.A	Test	
79	Reactor Coolant System leak test	200	Sheet 3	4-I.A.5.a 14-II.B.5.b		Test	
80	Secondary system leak test	200		6-I.B.5.b	5.4.2.1.B	Test	
81	CVCS System Hydrostatic Test	40		13-II.A.5.a		Test	
82	Standby to preoperational hydrostatic test to standby	10		20-III.A.5.a		Test	
83	Standby to inservice hydrostatic test to standby	10		20-III.A.5.b		Test	

4.3.1.3 Seismic History

Design analyses that compare seismic stresses against allowable stresses, in the absence of any consideration of the number of cycles or of fatigue effects, are not TLAAs. However, design of structures, systems, and components may include seismic loads in fatigue analyses, or may assume a stated number of seismic load cycles for purposes of establishing an allowable stress or stress range. Significant earthquakes at the site can therefore increase the accumulated fatigue usage factor. The site seismic history can therefore affect the disposition of TLAAs. However, no significant earthquakes have occurred at PVNGS since construction.

For design purposes the PVNGS safe shutdown earthquake (SSE) and operating basis earthquake (OBE) are defined as 0.20 g and 0.10 g ground motion, respectively. Analyses of Seismic Category I structures used a conservative design basis 0.25 g SSE and 0.13 g OBE [UFSAR 3.7].

For the purposes of evaluating actual events at PVNGS, an SSE is defined as one with a modified-Mercalli intensity level 8 (ground motion of 0.15 to 0.33 g or above); and an OBE is defined as one with a modified-Mercalli intensity level 7 (ground motion of 0.072 to 0.15 g). No SSE or OBE has occurred to date. The site has recorded seven minor earthquakes as of 2008, some of these not strong enough to qualify as recordable "earthquake events." The strongest had a ground motion of only 0.015 g, or about 12% of the acceleration, and therefore the applied loads, of a design basis 0.13 g OBE.

4.3.1.4 Present and Projected Status of Monitored Locations

Summary Description

The current fatigue monitoring program transient cycle count procedure, 73ST-9RC02, recorded accumulated transient events for the 9 transients listed in Appendix J of the procedure since the Unit 1 startup in 1985. This transient list did not include every transient in UFSAR Section 3.9.1.1 because, prior to implementation of Improved Technical Specifications in 1998, the Technical Specifications required monitoring only transients that are now in UFSAR Section 3.9.1.1.1. In 1995 (after 10 years of Unit 1 operation), the cycle count procedure was revised to include the 48 remaining UFSAR transients listed in Appendix K of the procedure. In the 1995 record of the revised procedure, accumulation for all transient events not counted to date was assumed at 25% of the limiting value for the 40-year design. After the 1995 revision of the cycle count procedure, transients were recorded and were added to the 25% accumulation assumed in 1995.

APS Fatigue Cycle Count Verification

The goal of the APS fatigue cycle count verification was to reduce the uncertainty created by the 25% accumulation assumed in 1995.

Scope

The scope of the cycle count verification included all transients required to be monitored by PVNGS Technical Specifications 5.5.5.

Recount Method

Several APS employees and contractor personnel were designated based on their long-term familiarity with PVNGS to perform document reviews. The reviewers examined the microfilmed control room logs, NRC Monthly Operating Reports and LERs for the period prior to January 1996 for all three PVNGS units. The personal recollections and records of unit personnel were used to supplement the record review, and a best-source total was determined for each monitored transient. The best-source total was added to the actual count of events following 1995 to obtain a best-source total as of the end of 2005. These best-source totals as of the end of 2005 are reported in Table 4.3-3, Columns 4, 5, and 6.

Transient Projections

Transient totals were projected to the end of the PEO for information only. The projections predict that 10 CFR 54.21(c)(1)(iii) aging management will be successful and that in most cases future corrective actions will not be necessary. However, the projections are not intended to justify 10 CFR 54.21(c)(1)(i) validations, or to provide revised design bases for 10 CFR 54.21(c)(1)(ii) analysis revisions. The projections are based on a linear extrapolation as follows:

1. The shortest period of operation as of the end of 2005 was 18 years in Unit 3 and the longest was 20 years in Unit 1, so a scaling factor of 3.33 (60 years extended life divided by 18 years shortest operation) was used to project totals to the end of the PEO. In a few special cases a scaling factor of 6.66 was used when the available data covered a ten year period. These exceptions are noted and explained in Table 4.3-3.
2. The highest total accumulation for an event was selected without regard to which unit it occurred in.
3. A highest unit 60 year projection (column 7) as of the end of the PEO was obtained by multiplying the highest total accumulation for each event by the scaling factor.

Example:

Event #1 RCS Heatup highest unit total was in Unit 2 (64 heatups). 64 X 3.33=213. The highest unit 60 year projection (column 7) is 213.

It should be noted that only a few events such as recurring test events lend themselves to projection with well defined assumptions, so the projections presented in Table 4.3-3 are only best-estimates. Early plant history involved a number of first-of-a-kind issues that may make the projections artificially high, and end of life issues may make the projections artificially low. Therefore, consistent with aging management, no attempt has been made to reanalyze or implement other corrective actions based on these projections. Corrective actions will be triggered by the action limits that will be established in the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1)

Table 4.3-3, PVNGS Units 1, 2, and 3 Fatigue Cycle Count and Projections

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 Unit 1 Accumulation as of January 2006	5 Unit 2 Accumulation as of January 2006	6 Unit 3 Accumulation as of January 2006	7 Highest Unit 60 yr Projection (Highest Unit Total X 3.33)	8 Notes
1	Reactor Coolant System (excluding pressurizer) heatup from 70F to hot standby conditions at a rate of ≤l00F/hr.	500 (The reactor vessel studs shall be limited to 250 occurrences)	62	64	59	213	
2	Reactor Coolant System (excluding pressurizer) cooldown from hot standby conditions to 70F at a rate of ≤100F/hr	500 (The reactor vessel studs shall be limited to 250 occurrences)	61	63	58	212	
3	5%/minute power ramp increase,from 15% to 100% power	15000	Not Counted	Not Counted	Not Counted	Not Counted	This item is not counted. To reach this number the plant would have to experience a power increase on the average of once every 31.5 hours of operation in 60 years with a 90% capacity factor. Since the PVNGS units operate as base loaded plants this is not credible.
4	5%/minute power ramp decrease,from 100% to 15% power	15000	Not Counted	Not Counted	Not Counted	Not Counted	This item is not counted. To reach this number the plant would have to experience a power decrease on the average of once every 31.5 hours of operation in 60 years with a 90% capacity factor. Since the PVNGS units operate as base loaded plants this is not credible.
5	10% power step increase, from 90% to 100% power	2000	264	248	206	879	

Table 4.3-3, PVNGS Units 1, 2, and 3 Fatigue Cycle Count and Projections

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 Unit 1 Accumulation as of January 2006	5 Unit 2 Accumulation as of January 2006	6 Unit 3 Accumulation as of January 2006	7 Highest Unit 60 yr Projection (Highest Unit Total X 3.33)	8 Notes
6	10% power step decrease, from 100% to 90% power	2000	142	144	98	480	
7	Normal cyclic variations at 100 % power; +/-80 psi, +/-10F	1.E+06	Not Counted	Not Counted	Not Counted	Not Counted	This item is not counted. Per UFSAR Table 3.9.1-1 "This condition is selected based on 1 million cycles approximating an infinite number of cycles so that the limiting stress is the endurance limit." Therefore the transient does not impact fatigue usage.
8	Startup of one reactor coolant pump at hot standby conditions	1000	273	281	275	936	
9	Coastdown of one reactor coolant pump at hot standby conditions	1000	269	275	268	916	
10	Adding 40F feedwater at 875 gpm to the steam generator through the downcomer feedwater nozzle when at hot standby conditions	15000	0*	0*	0*	13*	* Note that per UFSAR 5.4.2.1 this is a SG transient. SGs were replaced in the fall outages of 2003, 2005 and 2007 for U2, U1 and U3 respectively resetting this event to zero. Therefore, the U1 and U3 totals are reported as zero. Two events were counted in U2 between 1995 and 2005. Although both occurred prior to SGR they were assumed to apply to the replacement SG's to calculate a projection for conservatism. Since the accumulation period was 10 years versus 20 years the scaling factor was doubled to 6.66

Table 4.3-3, PVNGS Units 1, 2, and 3 Fatigue Cycle Count and Projections

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 Unit 1 Accumulation as of January 2006	5 Unit 2 Accumulation as of January 2006	6 Unit 3 Accumulation as of January 2006	7 Highest Unit 60 yr Projection (Highest Unit Total X 3.33)	8 Notes
11	Pressurizer heatup from 70F to 653F at a rate of ≤200F/hr	500	86	83	77	286	
12	Pressurizer cooldown from 653F to 70F at a rate of ≤200F/hr	500	85	82	76	285	
13	Shift from normal to maximum purification flow at 100% power	1000	250	250	250	833	
14	Standby to SI cold leg injection check valve stroke test to standby (using charging pumps)	160	0	0	0	0	PVNGS has never done this ASME Section XI test under hot conditions and has no plans to do it at temperature.
15	High-pressure safety injection header check valve test	40	0	0	0	0	PVNGS has never done this ASME Section XI test under hot conditions and has no plans to do it at temperature.
16	Turbine roll test at hot standby	10	3	3	2	10	Recount activities did not identify this test in U2 logs. However, since it is part of initial plant testing a value of 3 was assumed to equal the highest actual count.
17	Initiation of auxiliary spray during cooldown	500	85	82	76	285	This transient is tracked by pressurizer cooldown events.
18	Startup of SDC system from standby to shutdown cooling (RCS >200F) to shutdown cooling (RCS <200F) to standby	500	136	148	145	493	

Table 4.3-3, PVNGS Units 1, 2, and 3 Fatigue Cycle Count and Projections

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 Unit 1 Accumulation as of January 2006	5 Unit 2 Accumulation as of January 2006	6 Unit 3 Accumulation as of January 2006	7 Highest Unit 60 yr Projection (Highest Unit Total X 3.33)	8 Notes
19	Startup of safety injection system from standby to injection to short term recirculation to long term recirculation to shutdown cooling to standby	10	0	0	0	0	
20	Standby to LPSI pump test to standby	500	239	228	252	839	The original assumption of a monthly run has shown to be an underestimation. This surveillance is run 10% more frequently than required to ensure test intervals are not exceeded, and it is conducted for post maintenance testing. Due to the predictable nature of this transient it is probable that the cycle counting action limit will be reached prior to the end of the PEO.
21	Standby to HPSI pump test to standby	500	246	222	243	819	The original assumption of a monthly run has shown to be an underestimation. This surveillance is run 10% more frequently than required to ensure test intervals are not exceeded, and it is conducted for post maintenance testing. Due to the predictable nature of this transient it is probable that the cycle counting action limit will be reached prior to the end of the PEO.

Table 4.3-3, PVNGS Units 1, 2, and 3 Fatigue Cycle Count and Projections

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 Unit 1 Accumulation as of January 2006	5 Unit 2 Accumulation as of January 2006	6 Unit 3 Accumulation as of January 2006	7 Highest Unit 60 yr Projection (Highest Unit Total X 3.33)	8 Notes
22	Adding 40F feedwater at 875 gpm to the steam generator through the downcomer feedwater nozzle during loading conditions	500	0*	0	0*	0	* Note that per UFSAR 5.4.2.1 this is a SG transient. SGs were replaced in the fall outages of 2003, 2005 and 2007 for U2, U1 and U3 respectively resetting this event to zero. Therefore, the U1 and U3 totals are reported as zero. U2 count is actual data.
23	Adding 100F feedwater at 875 gpm to the steam generator through the downcomer feedwater nozzle during loading conditions	500	0*	0	0*	0	* Note that per UFSAR 5.4.2.1 this is a SG transient. SGs were replaced in the fall outages of 2003, 2005 and 2007 for U2, U1 and U3 respectively resetting this event to zero. Therefore, the U1 and U3 totals are reported as zero. U2 count is actual data.
24	Pressure transients of 85 psi across the primary divider plate in either direction caused by starting and stopping reactor coolant pumps	4000	0*	224**	0*	2238**	* Note that per UFSAR 5.4.2.1 this is a SG transient. SGs were replaced in the fall outages of 2003, 2005 and 2007 for U2, U1 and U3 respectively resetting this event to zero. Therefore, the U1 and U3 totals are reported as zero. ** The U2 total is based on assuming all RCP starts and stops reported between '95 - '05 in transients 8 & 9 apply to the RSG. The sum (56) was multiplied by 6 assuming all 4 RCPs experienced a start and stop for each Mode 3 start and stop plus 2 pump start/stop cycles for sweeps. This was multiplied by 6.66 to account for the 336 being accumulated in a 10 year period versus 20 years.

Table 4.3-3, PVNGS Units 1, 2, and 3 Fatigue Cycle Count and Projections

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 Unit 1 Accumulation as of January 2006	5 Unit 2 Accumulation as of January 2006	6 Unit 3 Accumulation as of January 2006	7 Highest Unit 60 yr Projection (Highest Unit Total X 3.33)	8 Notes
25	Standby to SI hot leg injection check valve stroke test to standby (using the HPSI pump)	30	16	17	16	57	This transient is conducted during refueling outages. It is not currently being counted because it was recently identified and added to UFSAR Table 3.9-1. It will be counted when added to the cycle counting surveillance procedure 73ST-9RC02. Totals are estimated and reflect one performance per refueling through the end of 2005 plus a margin of five events.
26	Low-low volume control tank/charging pump suction diversion to RWT	80	20	20	20	67	
27	Pressurizer level control, failure to full open	100	25	25	25	83	
28	Coastdown of one reactor coolant pump at 100% power (no reactor trip)	10	0	0	0	0	T This transient is not counted in surveillance procedure 73-ST-9RC02, but its affect would be assessed in the corrective action program since it would be an Anticipated Transient Without Scram (ATWS) event.
29	Spurious reactor trips (including operator error) at 100% power	50 (RCS) 240 (CVCS)	33	32	26	110	
30	Loss of reactor coolant system flow	40	4	2	2	13	

Table 4.3-3, PVNGS Units 1, 2, and 3 Fatigue Cycle Count and Projections

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 Unit 1 Accumulation as of January 2006	5 Unit 2 Accumulation as of January 2006	6 Unit 3 Accumulation as of January 2006	7 Highest Unit 60 yr Projection (Highest Unit Total X 3.33)	8 Notes
31	Arbitrary load rejection, from 100% to 15% power	40	6	7	14	47	
32	OBE Condition - Full-load cycles about a mean value of zero and with an amplitude equal to the maximum response produced during the entire OBE event	200	0	0	0	0	
33	Inadvertent control element assembly drop, at 100% power	40	3	2	5	17	
34	Inadvertent control element assembly withdrawal from 0% power	40	0	0	0	0	
35	Loss of charging and recovery at 100% power	200	7	0	2	23	
36	Loss of letdown and recovery at 100% power	300	17	18	10	60	
37	Charging cycles (on/off) during an extended loss of letdown	800	64	1	2	213	
38	Depressurization by spurious actuation of pressurizer spray control valve(s) at 100% power (normal and auxiliary spray valves are considered)	40	0	1	1	3	

Table 4.3-3, PVNGS Units 1, 2, and 3 Fatigue Cycle Count and Projections

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 Unit 1 Accumulation as of January 2006	5 Unit 2 Accumulation as of January 2006	6 Unit 3 Accumulation as of January 2006	7 Highest Unit 60 yr Projection (Highest Unit Total X 3.33)	8 Notes
39	Partial loss of condenser cooling at 100% power	40	1	0	0	3	
40	Excess feedwater flow due to control system malfunction at 100% power	40	2	0	1	7	
41	Turbine trip without accompanying reactor trip at 100% power	40 (RCS) 120 (CVCS)	14	7	6	47	
42	Inadvertent actuation of one main steam line isolation valve at 100% power	5 (RCS) 40 (CVCS)	0	1	1	3	
43	Inadvertent actuation of one turbine bypass valve or atmospheric dump valve at 100% power	40	2	1	0	7	
44	Seismic Event up to & including One-Half of the Safe Shutdown Earthquake, at 100% Power	2	0	0	0	0	
45	Inadvertent isolation of one main feedwater heater at 100% power	5	0	0	0	0	
46	Loss of Feedwater Flow (to S/G)	85	9	8	11	37	
47	Inadvertent initiation of auxiliary spray at 100% power	5	0	0	1	3	

Table 4.3-3, PVNGS Units 1, 2, and 3 Fatigue Cycle Count and Projections

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 Unit 1 Accumulation as of January 2006	5 Unit 2 Accumulation as of January 2006	6 Unit 3 Accumulation as of January 2006	7 Highest Unit 60 yr Projection (Highest Unit Total X 3.33)	8 Notes
48	System leak due to rupture of largest instrument or sampling connection at 100% power	40	0	0	0	0	
49	Inadvertent closure of one main feedwater valve at 100% power	40	1	0	0	3	
50	Inadvertent trip of one main feedwater or one main condensate pump at 100% power	40	7	8	11	37	
51	Inadvertent closure of all main feedwater valves (due to loss of pressure in compressed air system) at 100% power	5	1	0	0	3	
52	Startup of one reactor coolant pump at 50% power	10	0	0	0	0	The plant design will not allow the reactor to be critical without all four reactor coolant pumps operating. This item is not counted.
53	Loss of an electrical bus supplying two reactor coolant pumps at 100% power	40	2	4	4	13	
54	Standby to spurious startup of a normally secured pump/spurious stopping of a normally running pump/spurious valve opening/spurious valve closure	40	0	1	0	3	

Table 4.3-3, PVNGS Units 1, 2, and 3 Fatigue Cycle Count and Projections

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 Unit 1 Accumulation as of January 2006	5 Unit 2 Accumulation as of January 2006	6 Unit 3 Accumulation as of January 2006	7 Highest Unit 60 yr Projection (Highest Unit Total X 3.33)	8 Notes
55	Rx Trips, Turbine Trips and Loss of RCS Flow	480	104	81	63	346	
56	Adding 40F feedwater at 1750 gpm to the steam generator through the downcomer feedwater nozzles with the flow initiated 30 seconds after a loss of normal feedwater	280	0*	0*	0*	13*	* Note that per UFSAR 5.4.2.1 this is a SG transient. SGs were replaced in the fall outages of 2003, 2005 and 2007 for U2, U1, and U3, respectively, resetting this event to zero. Therefore, the U1 and U3 totals are reported as zero. Two events were counted in U2 between 1995 and 2005. Although both occurred prior to SGR they were assumed to apply to the replacement SG's to calculate a projection for conservatism. Since the accumulation period was 10 years versus 20 years the scaling factor was doubled to 6.66
57	Pressurization by spurious actuation of all pressurizer heaters at 100% power	10	2	2	2	7	
58	Depressurization due to inadvertent actuation of one secondary safety valve at 100% power	10	5	2	0	17	Item is not required to be counted. Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses.
59	Loss of offsite and onsite ac power, with retention of onsite emergency ac and dc power at 100% power	5	1	2	2	7	Item is not required to be counted. Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses.

Table 4.3-3, PVNGS Units 1, 2, and 3 Fatigue Cycle Count and Projections

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 Unit 1 Accumulation as of January 2006	5 Unit 2 Accumulation as of January 2006	6 Unit 3 Accumulation as of January 2006	7 Highest Unit 60 yr Projection (Highest Unit Total X 3.33)	8 Notes
60	Depressurization of the SIS, CSS, SCS by full opening of a safety or relief valve without reseating	5	1	1	1	3	Item is not required to be counted. Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses.
61	Depressurization due to inadvertent actuation of one pressurizer safety valve at 100% power	1	0	0	0	0	Item is not required to be counted. Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses.
62	Depressurization due to inadvertent actuation of one pressurizer safety valve	5	0	0	0	0	Item is not required to be counted. Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses.
63	Opening of one primary safety valve at 100%	5	1	0	0	3	Item is not required to be counted. Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses.
64	Adding 40F feedwater at 1750 gpm to the steam generator through the downcomer feedwater nozzles during a steam line break	1 MSLB event with 7 feedwater addition cycles	0*	0	0*	0	*Note that per UFSAR 5.4.2.1 this is a SG transient. Since the U1 and U3 SGs were replaced after January 2005 the total is reported as zero here. Item is not required to be counted. Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses.
65	Single reactor coolant pump shaft seizure at 100% power	1	0	0	0	0	Item is not required to be counted. Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses.

Table 4.3-3, PVNGS Units 1, 2, and 3 Fatigue Cycle Count and Projections

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 Unit 1 Accumulation as of January 2006	5 Unit 2 Accumulation as of January 2006	6 Unit 3 Accumulation as of January 2006	7 Highest Unit 60 yr Projection (Highest Unit Total X 3.33)	8 Notes
66	Major loss of coolant incident (system operating mode dependent upon design application for worst case conditions)	1	0	0	0	0	Item is not required to be counted. Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses.
67	Single reactor coolant pump sheared shaft at 100% power	1	0	0	0	0	Item is not required to be counted. Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses.
68	Class 2 line break	1	0	0	0	0	Item is not required to be counted. Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses.
69	Seismic event up to and including the safe shutdown earthquake (system operating mode dependent upon design application for worst case conditions)	1	0	0	0	0	Item is not required to be counted. Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses.
70	Major rupture of the safety injection system at the highest system pressure encountered during a normal operating mode; namely, rupture during the first phase of the preoperational hydrostatic test	1	0	0	0	0	Item is not required to be counted. Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses.

Table 4.3-3, PVNGS Units 1, 2, and 3 Fatigue Cycle Count and Projections

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 Unit 1 Accumulation as of January 2006	5 Unit 2 Accumulation as of January 2006	6 Unit 3 Accumulation as of January 2006	7 Highest Unit 60 yr Projection (Highest Unit Total X 3.33)	8 Notes
71	The concurrent loading produced by normal operation at full power, plus the design basis earthquake, plus loss-of-coolant accident (pipe rupture) are used to determine the faulted plant loading condition.	1	0	0	0	0	Item is not required to be counted. Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses.
72	Major rupture in the main feedwater piping (system operating mode dependent upon design application for worst case conditions)	1	0	0	0	0	Item is not required to be counted. Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses.
73	Major rupture in the auxiliary feedwater piping (system operating mode dependent upon design application for worst case conditions)	1	0	0	0	0	Item is not required to be counted. Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses.
74	Major rupture in the main steam piping (system operating mode dependent upon design application for worst case conditions)	1	0	0	0	0	Item is not required to be counted. Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses.
75	Control element assembly ejection at 0% power	1	0	0	0	0	Item is not required to be counted. Emergency and faulted events are not fatigue cycles in Class 1 fatigue analyses.

Table 4.3-3, PVNGS Units 1, 2, and 3 Fatigue Cycle Count and Projections

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 Unit 1 Accumulation as of January 2006	5 Unit 2 Accumulation as of January 2006	6 Unit 3 Accumulation as of January 2006	7 Highest Unit 60 yr Projection (Highest Unit Total X 3.33)	8 Notes
76	Loss of Secondary Pressure: One cycle of a postulated loss of secondary pressure due to a complete double ended severance of one steam generator or feedwater nozzle, but not simultaneously. These are not considered credible events in forming the design basis of the reactor coolant system. However, they are included to demonstrate that the reactor coolant system components will not fail structurally in the unlikely event that one of these events occur.	Not Credible	**Not Counted***	**Not Counted***	**Not Counted***	Not Counted	This item is not counted because per UFSAR Table 3.9.1-1 "These are not considered credible events in forming the design basis of the reactor coolant system. However, they are included to demonstrate that the reactor coolant system components will not fail structurally in the unlikely event that one of these events occur."
77	Reactor Coolant System hydrostatic test	10	1	1	1	3	
78	Secondary system hydrostatic test	10	1	1	1	3	The U2 RSG was subject to one preservice hydrostatic test prior to receipt. The associated piping experienced one hydrostatic test during original construction. The leak test following replacement was done at normal operating pressure. The U1 and U3 reflect the same sequence of events.
79	Reactor Coolant System leak test	200	5	4	2	17	

Table 4.3-3, PVNGS Units 1, 2, and 3 Fatigue Cycle Count and Projections

1 Row No.	2 Transient Title (Shaded items are not counted)	3 Limiting Value	4 Unit 1 Accumulation as of January 2006	5 Unit 2 Accumulation as of January 2006	6 Unit 3 Accumulation as of January 2006	7 Highest Unit 60 yr Projection (Highest Unit Total X 3.33)	8 Notes
80	Secondary system leak test	200	50	50	50	167	
81	CVCS System Hydrostatic Test	40	1	1	1	3	
82	Standby to preoperational hydrostatic test to standby	10	2	2	2	7	
83	Standby to inservice hydrostatic test to standby	10	2	2	2	7	

4.3.1.5 Enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) Scope, Action Limits, and Corrective Actions

Scope

The scope of the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will include all ASME Section III Class 1 components and components with Class 1 fatigue analysis and will monitor their fatigue usage by a combination of cycle counting and CUF monitoring as noted in Table 4.3-4.

Method

The "Fatigue Management Method" column of Table 4.3-4 indicates the method the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will use to track fatigue usage for each component. These are stress-based fatigue (SBF), cycle-based fatigue (CBF-C - per cycle, CBF-PC - per cycle with partial cycles, or CBF-EP - event pairing), and CC. The CC method will be used for components whose cumulative usage can be shown to be satisfactory with this highly conservative monitoring approach. Most of the NUREG/CR-6260 locations and the pressurizer spray nozzle require more sophisticated CBF or SBF algorithms to periodically calculate accumulated fatigue usage and demonstrate that component usage remains less than one. Transient event cycles that are required to be monitored by PVNGS Technical Specifications 5.5.5 will continue to be tracked to ensure that the numbers of transient events assumed by the design basis calculations will not be exceeded. This cycle counting monitoring method will demonstrate design basis compliance for the components using CC monitoring. See Table 4.3-2 for the list of tracked transients.

Corrective Action Limits and Corrective Actions

The PVNGS current fatigue monitoring program is based on cycle counting with one location tracked by a CUF calculated using CBF-PC (pressurizer spray nozzle), and it incorporates a cycle based action limit of 90% of the design event occurrences and a CUF based action limit of 0.65 for the pressurizer spray nozzle usage. The current fatigue monitoring program requires this evaluation at least once per fuel cycle. The current action limits are established to allow action to be taken in time to prevent exceeding the maximum number of allowed cycles or a pressurizer spray nozzle CUF of 1.0, as applicable, and should provide at least one fuel cycle of warning.

During the period of extended operation, projections indicate that certain allowable cycles and fatigue limits may be approached. Therefore, specific and targeted action limits will be necessary to ensure actual fatigue limits are not exceeded. Those action limits have not yet been developed. As the transition to the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) and FatiguePro® is implemented, there are certain embedded administrative tools in FatiguePro® that will allow for specification of action limits based on projected fatigue usage at specific locations that account for actual cumulative fatigue. The action limits can be based on the time required to implement expected or projected mitigating actions (such as component replacements or revisions to ASME Code Fatigue Analyses of Record) prior to actual fatigue limits being exceeded.

Action Limit Margins

The enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) corrective action limits will ensure that corrective actions are taken before the design limits are exceeded. Corrective action limits will ensure that appropriate reevaluation or other corrective actions are initiated while sufficient margin remains to allow at least one occurrence of the worst case (highest fatigue usage per cycle) low probability transient that is included in design specifications, without exceeding the code limit CUF of 1.0. For NUREG/CR-6260 locations, CUF calculation will be done using the appropriate Fen environmental factor.

Cycle Count Action Limits and Corrective Actions

Cycle Counting monitoring (CC) action limits for the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will be established based on the design-specified number of cycles. Since sufficient margin must be maintained to accommodate any design transient regardless of probability, the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) corrective actions will be taken before the remaining number of allowable occurrences for any specified transient becomes less than one. Corrective actions will be required when the cycle count for any of the significant contributors to usage factor is projected to reach the action limit defined in the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) before the end of the next fuel cycle.

<u>Cycle Counting Corrective Actions to be incorporated into the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1):</u> If a cycle count action limit is reached, corrective actions will be performed as necessary:

1. Review of fatigue usage calculations.
   - To determine whether the transient in question contributes significantly to CUF.
   - To identify the components and analyses affected by the transient in question.
   - To ensure that the analytical bases of the high-energy line break (HELB) locations are maintained.
   - To ensure that the analytical bases of the fatigue crack growth and stability analysis in support of relief from ASME Section XI flaw removal and inspection requirements for hot leg small-bore half nozzle repairs are maintained.
2. Evaluation of remaining margins on CUF based on cycle-based or stress-based CUF calculations using the PVNGS fatigue management software.
3. Redefinition of the specified number of cycles (e.g., by reducing specified numbers of cycles for other transients and using the margin to increase the allowed number of cycles for the transient that is approaching its specified number of cycles).
4. Redefinition of the transient to remove conservatism in predicting the range of pressure and temperature values for the transient.

These actions are designed to determine how close the usage is to 1.0, and from those determinations, set new action limits. Further actions for cumulative fatigue usage action limits may be invoked if good engineering judgment determines that is necessary.

Cumulative Fatigue Usage Action Limits and Corrective Actions

The enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will use an automated three-dimensional, six-element stress tensor, stress-based fatigue management software module (the SBF module, meeting ASME III NB-3200 requirements) to continually monitor cumulative usage factor (CUF) at the stress-based fatigue monitoring locations, and cycle-based CUFs will be calculated periodically. The CUF action limits for the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will be established to provide two to three fuel cycles of warning prior to exceeding a CUF of 1.0.

CUF Action Limit Margins: To provide adequate time for corrective actions and adequate margin to permit continued operation, corrective actions for the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will be required when calculated CUF (from cycle based or stress based monitoring) for any monitored location is projected to reach 1.0 within the next 2 or 3 fuel cycles. In order to assure sufficient margin to accommodate occurrence of a low probability transient, corrective actions must also be taken while there is still sufficient margin to accommodate at least one occurrence of the worst case (highest fatigue usage per cycle) design transient event. Action limits will be established to permit completion of corrective actions before the usage factor reaches 1.0.

For PVNGS locations identified in NUREG/CR-6260 and described in Section 4.3.4, "Effects of the Reactor Coolant System Environment on Fatigue Life of Piping and Components (Generic Safety Issue 190)," this action limit will be based on accrued fatigue usage calculated with the F_{en} factors required for including effects of the reactor coolant environment.

For example, if inadvertent RCS depressurization, when adjusted for the environmental effects of the reactor coolant system at a NUREG/CR-6260 location, causes 20% of the total allowable fatigue usage, corrective action for that location would be required before calculated usage (including the environmental effects factor, F_{en}) reached 0.8.

CUF Corrective Actions: If a CUF action limit is reached, corrective actions will be performed as necessary:

1. Determine whether the scope of the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) must be enlarged to include additional affected reactor coolant pressure boundary locations. This determination will ensure that other locations do not approach design limits without an appropriate action.
2. Enhance fatigue monitoring to confirm continued conformance to the code limit.
3. Repair/modify the component.
4. Replace the component.
5. Perform a more rigorous analysis of the component to demonstrate that the design code limit will not be exceeded.

6. Modify plant operating practices to reduce the fatigue usage accumulation rate.
7. Perform a flaw tolerance evaluation and impose component-specific inspections, under ASME Section XI Appendices A or C (or their successors), and obtain required approvals by the NRC.

Table 4.3-4 - Summary of Fatigue Usage from Class 1 Analyses, and Method of Management by the Metal Fatigue of Reactor Coolant Pressure Boundary Program

1 Number	2 Component	3 Maximum Design Basis CUF (40 year Analysis unless otherwise noted)	4 Reason For Monitoring	5 Fatigue Management Method (See Section 4.3.1 for description)
1	**RPV Inlet Nozzle**	0.07308	NUREG/CR-6260	CBF-C
2	**RPV Outlet Nozzle**	0.309574	NUREG/CR-6260	CBF-C
3	**RPV Wall and Bottom Head Juncture**	0.0012	NUREG/CR-6260	CC
4	**Surge Line (Elbow)**	0.937	NUREG/CR-6260	SBF
5	**Charging Inlet Nozzle**	0.9205	NUREG/CR-6260	CBF-EP
6	**Shutdown Cooling Line Elbow**	0.1118	NUREG/CR-6260	CBF-EP
7	**Safety Injection Nozzles (Loop 1 and Loop 2)**	0.3409	NUREG/CR-6260	CBF-PC
8	**Pressurizer Spray Nozzle**	0.9923	High CUF	CBF-PC
9	**All other locations subject to fatigue monitoring**			CC (Locations not specifically called out in this table will be monitored by counting design transients.)

LRA Table A4-1 Commitment 39, page A-54, is revised to read as follows (deleted text is struck out, new text is underlined):

Table A4-1 License Renewal Commitments

Item No.	Commitment	LRA Section	Implementation Schedule
39	The current fatigue monitoring program is a cycle counting program with one location- specific cumulative usage factor (CUF) calculation (Pressurizer Spray Nozzle). No later than two years prior to the period of extended operation, the current fatigue monitoring program governed by 73ST-9RC02 will be enhanced to include additional location-specific CUF calculations and an automated and computerized management software program for cycle counting and fatigue usage factor tracking. The automated and computerized software program will be used to supplement manual counting. The enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will use cycle counting (CC), cycle based fatigue CUF calculations (CBF) and stress based fatigue CUF calculations (SBF) to monitor fatigue. FatiguePro® will be used for cycle counting and cycle-based fatigue (CBF) monitoring methods. FatiguePro® is an EPRI licensed product. APS commits to the use of a fatigue monitoring software program that incorporates a three-dimensional, six-element stress tensor method meeting ASME III NB-3200 requirements for stress-based fatigue monitoring (SBF). APS also commits to the implementation of this method for SBF monitoring at least two years prior to the period of extended operation. The enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will monitor plant transients as required by PVNGS Technical Specification 5.5.5. Cumulative usage factors (CUFs) will be calculated for a subset of ASME III Class 1 reactor coolant pressure boundary vessel and piping locations, and Class 2 steam generator locations with Class 1 analyses. The enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program	4.3.1 Fatigue Aging Management Program A2.1 B3.1 Metal Fatigue of Reactor Coolant Pressure Boundary A3.2 Metal Fatigue Analysis	No later than two years prior to the period of extended operation[1].

Item No.	Commitment	LRA Section	Implementation Schedule
	(B3.1) will provide action limits on cycles and on CUF that will initiate corrective actions before the licensing basis limits on fatigue effects at any location are exceeded. ~~(1) The existing Metal Fatigue of Reactor Coolant Pressure Boundary program will be enhanced to provide guidelines and requirements for tracking both transient cycle counts and fatigue usage of selected components, using FatiguePro® software, to maintain the fatigue usage factor of these components less than 1.0. The enhanced program will include tracking of cumulative usage, counting of transient cycles, manual recording of selected transients, review of plant cycle data, and review of the resulting usage factor data.~~ ~~(2) The Metal Fatigue of Reactor Coolant Pressure Boundary program will be enhanced to include a computerized program to track and manage both cycle counting and fatigue usage factor. FatiguePro® will be used for cycle counting and cycle-based fatigue (CBF) monitoring methods. FatiguePro® is an EPRI licensed product. A fatigue monitoring software program that incorporates a three-dimensional, six-element model meeting ASME III NB-3200 requirements will be used for stress-based fatigue monitoring (SBF).~~ ~~(3) The Metal Fatigue of Reactor Coolant Pressure Boundary program will be enhanced to include additional Class 1 locations with high calculated cumulative usage factors, Class 1 components for which transfer functions have been developed for stress-based monitoring, and Class 2 portions of the steam generators with a Class 1 analysis and high calculated cumulative usage factors. The specific locations are listed in Table 4.3-4, "Summary of Fatigue Usage from Class 1 Analyses, and Method of Management by the Metal Fatigue of Reactor Coolant Pressure Boundary Program."~~ ~~(4) The Metal Fatigue of Reactor Coolant Pressure Boundary program will be~~		

Item No.	Commitment	LRA Section	Implementation Schedule
	~~enhanced with additional cycle count and fatigue usage action limits including appropriate corrective actions to be invoked if a component approaches a cycle count action limit or a fatigue usage action limit. Action limits shall be chosen with the intent that they will permit completion of corrective actions before the design limits are exceeded.~~ (RCTSAI 3246934)		

LRA Table A4-1 Commitment No. 55, page A-59, is being added as follows (new text is underlined):

Item No.	Commitment	LRA Section	Implementation Schedule
55	The transient in UFSAR Table 3.9-1 Sheet No. 9 Item No. I.E.1.b, and Sheet No. 18, Item No. III.A.1.f, "Standby to SI hot leg injection check valve stroke test to standby (using the HPSI pump)," will be added to the cycle counting surveillance procedure 73ST-9RC02 by August 25, 2010. (RCTSAI 3469024)	4.3.1 Fatigue Aging Management Program (Table 4.3-2, Row No. 25	8/25/10

ENCLOSURE 3

Markup Showing Changes to LRA Section 4.3.1

4.3 METAL FATIGUE ANALYSIS

This section addresses design of mechanical system components supported by fatigue analyses; and also of components whose design depends on an assumed number of load cycles without a calculated fatigue usage factor.

Section ~~4.6, "Containment Liner Plate, Equipment Hatch and Personnel Air Locks, Penetrations, and Polar Crane Brackets,"~~ 4.6 describes fatigue in the containment vessel.

~~Section 4.7.4, "Fatigue Crack Growth and Fracture Mechanics Stability Analyses of Half-Nozzle Repairs to Alloy 600 Material in Reactor Coolant Hot Legs; Absence of a TLAA for Supporting Corrosion Analyses,"~~Section 4.7.4, describes corrosion and fatigue crack growth and stability in the primary coolant nozzles.

Fatigue analyses are required for piping, vessels, and heat exchangers designed to the American Society of Mechanical Engineers *Boiler and Pressure Vessel Code,* Section III, *Rules for Construction of Nuclear Power Plant Components,* Division 1, "Metal Components," Subsection NB, "Requirements for Class 1 Components" (ASME III Class 1).[1] Fatigue analyses may also be invoked for Class 1 pump and valve pressure boundaries.

Fatigue analyses are required for portions of the reactor pressure vessel internals designed to American Society of Mechanical Engineers *Boiler and Pressure Vessel Code,* Section III, *Rules for Construction of Nuclear Power Plant Components,* Division 1, "Metal Components," Subsection NG, "Core Support Structures."

The design of piping and vessels to certain other codes and code sections, including ASME III Class 2 and 3, ANSI-ASME B31.1, and ASME VIII Division 2, may assume a stated number of full-range thermal and displacement cycles.

Section 4.3 also describes fatigue analyses and evaluations of a limited number of other non-Class 1 components that were evaluated to these and similar rules.

Basis of Fatigue Analyses

ASME III Class 1 design specifications define a set of static and transient load conditions for which components are to be designed. Although original design specifications commonly state that the transient conditions are for a 40-year design life, the fatigue analyses themselves are based on the specified number of occurrences of each transient rather than on this lifetime. The design number of occurrences of each transient for use in the fatigue analyses was specified to be larger than the number of occurrences expected during the

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1 Titles are from the 1971 edition of the code, as used for the reactor vessel. Later editions reorganized the Section III material and removed the Division 1 title, so that this subsection became "Division 1 — Subsection NB, Class 1 Components".

40-year licensed life of the plant, based on engineering experience and judgment. This provides an allowance for future changes in design or operation that may affect system design transients.

Operating experience at PVNGS and at other similar units has demonstrated that the assumed frequencies of design transients, and therefore the number of transient cycles assumed for a 40-year life, were conservative; and that with few exceptions the design numbers are not expected to be exceeded within a 60-year life. The exceptions are of two kinds.

First, the NRC, industry, and specific plants, including PVNGS, have identified some transient loads on some components that were not foreseen in the original design process; for example thermally stratified flow in the pressurizer surge line and feedwater system, and Combustion Engineering Infobulletin 88-09, "**Error! Reference source not found.**." These cases have required evaluations to assess their significance and some have required revision to design specifications and analyses.

Second, plant and industry operating experience has identified a few cases where cycles were being accumulated more rapidly than originally anticipated. At PVNGS, these were principally due to first-of-a-kind startup and shutdown cycles during the early plant life. The enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program will

Fatigue cycles are currently tracked in a PVNGS surveillance test procedure, 73ST-9RC02 "Reactor Coolant System Transient and Operational Cycles" as required by PVNGS Technical Specification 5.5.5 "Component Cyclic or Transient Limit.". In the text of this discussion the activities governed by 73ST-9RC02 will be referred to as the "current fatigue monitoring program". The enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (See LRA Appenbix B section B3.1) will continue to track events to ensure that appropriate re-evaluation or other corrective action is initiated if an action limit is reached. Action limits will permit completion of corrective actions before the design basis number of events is exceeded. See "**Error! Reference source not found.**" in Section 4.3.1.5.

The Industry Operating Experience Review (OE) program ensures that industry experience is evaluated and incorporated in plant analyses and procedures. The OE program includes review of experience that may indicate concerns with fatigue effects. Any necessary evaluations are conducted under the plant corrective action program. The OE program has remained responsive to both industry and plant-specific emerging issues and concerns.

4.3.1 Enhanced Fatigue Aging Management Program (B3.1)

The current fatigue monitoring program is a cycle counting program with one location-specific cumulative usage factor (CUF) calculation (Pressurizer Spray Nozzle). No later than two years prior to the period of extended operation, the Metal Fatigue of Reactor Coolant Pressure Boundarycurrent fatigue monitoring program governed by 73ST-9RC02 will be enhanced to include additional location-specific CUF calculations and an automated and computerized management software program for cycle counting and fatigue usage factor tracking and management program.. The automated and computerized software program will be used to supplement manual counting.

The enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will use cycle counting (CC), cycle based fatigue CUF calculations (CBF) and stress based fatigue CUF calculations (SBF) (see methods discussion below) to monitor fatigue. FatiguePro® will be used for cycle counting and cycle-based fatigue (CBF) monitoring methods. FatiguePro® is an EPRI licensed product.

For stress-based fatigue monitoring (SBF), APS commits to the use of a fatigue monitoring software program that incorporates a three-dimensional, six-element modelstress tensor method meeting ASME III NB-3200 requirements, and for stress-based fatigue monitoring (SBF). APS also commits to the implementation of this method for SBF monitoring at least two years prior to the period of extended operation.

The enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will monitor plant transients and cumulativeas required by PVNGS Technical Specification 5.5.5. Cumulative usage factors (CUFs) will be calculated for a subset of ASME III Class 1 reactor coolant pressure boundary vessel and piping locations, and Class 2 steam generator locations with Class 1 analyses, to ensure that reevaluation or other corrective. The enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will provide action is initiated if an action limit is reached. Action limits on cycles and on CUF that will permit completion ofinitiate corrective actions before the licensing basis limits on fatigue effects, in all locations, at any location are exceeded.

Scope

_The PVNGSMetalscope of the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program will monitor the (B3.1) will include all ASME Section III Class I components and piping listedClass 2 portions of the steam generators with a Class 1 analysis and will monitor their fatigue usage by a combination of cycle counting and CUF monitoring in Table_4.3_4.

Methods

The "Global"Cycle Counting" (CC) monitoring method in Table 4.3-4Table 4.3-4. means that the fatigue managementenhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will not periodically calculate accumulated fatigue usage at the location. However, transient event cycles affecting the location (e.g. plant heatup and plant cooldown) will be counted and tracked to ensure that the numbers of transient events assumed by the design basis calculations will not be exceeded. "Global - Replaceable" applies to bolting with predicted lifetime usage factors greater than 1.0, and which will therefore be replaced as required Cycle counting is the method used by the current fatigue monitoring program for all monitored components except the pressurizer spray nozzle. Cycle counting ensures fatigue usage does not exceed 1.0. It is employed as the preferred method of monitoring due to its simplicity.

~~Stress-based fatigue (SBF) monitoring will compute a "real time" stress history for a given component from actual temperature, pressure, and flow histories. SBF is intended for those high fatigue components where a more refined approach is necessary to show long term structural acceptability. SBF monitoring depends on "global-to-local" correlation or "transfer" functions which calculate local transient pressures and temperatures from data collected by the limited number of plant instruments, and from them, local stresses and fatigue usage.~~

Cycle-based fatigue (CBF) monitoring will consist of (a) automated cycle counting; supported as needed by manual data entry for infrequent events, and (b) CUF computation based on the counted cycles. ~~It is intended for components where long-term structural acceptability can readily be shown based on cycle counts alone. Three CBF methods will be~~The component CUF contributions due to each cycle are determined from the component Class I fatigue analysis. CBF is a more complex and resource intensive method than CC because it goes beyond counting of cycles to evaluate the CUF contributions of each cycle. Three CBF methods will be used, Per-Cycle CBF (CBF-C), Per-Cycle CBF with partial cycles (CBF-PC), and Event-Pairing CBF (CBF-EP).

The CBF-C and CBF-PC methods will compute fatigue usage for a component by determining a location-specific fatigue usage increment for each counted event, and then adding up those increments for all events in the cycle record. CBF-PC will be used for some components, where the fatigue severity of individual plant events can be scaled using partial-cycle curves. A partial-cycle curve assigns a fractional severity to a cycle, as compared to a full design cycle, based upon significant characteristics of that event, such as temperature difference or heatup rate.

CBF-EP is derived from the application of Miner's rule for combining fatigue effects, under the guidance of ASME III, NB-3222.4. This method will use an event-pairing table which assumes that the effect of pairs of monitored events is equal to the effect of similar pairs of design basis events.

Stress-based fatigue (SBF) monitoring will compute a "real time" stress history for a given component from actual temperature, pressure, and flow histories. SBF monitoring uses data collected from existing plant instruments to calculate local pressure and temperature, and the corresponding stress history at the critical location in the component. The stress history is analyzed to identify stress cycles, and then a CUF is computed using the formulas defined in ASME Code Section III sub-article NB-3200. SBF is the most complex and resource intensive method of fatigue monitoring, but it is the most accurate method and requires fewer conservative assumptions than CC or CBF methods.

Corrective Action Limits

~~Corrective actions will be initiated whenever a cycle count or fatigue usage action limit is reached. Action limits will~~ The enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) corrective actions will be initiated whenever an action limit is reached, for either the number of transient cycles or calculated fatigue usage factor. In the current fatigue monitoring program cycle action limits are set at 90% of the allowed cycles for each transient, and a CUF action limit of 0.65 is set for the pressurizer spray nozzle. In the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) corrective action limits will be set to permit completion of corrective actions before the design basis number of events is exceeded, or before the cumulative usage factor exceeds the code limit of 1.0. See Section 4.3.1.5 for the description of these actions and action limits, for the basis for the margins between the fatigue usage factor action limits and the code usage factor limit of 1.0, and for the basis for the margins between the cycle count action limits and the design basis cycle count assumptions.

Analytical Margins

Fatigue analyses incorporate several conservative assumptions and methods. These ensure that usage factors predicted by the design calculation will exceed (or "bound") the usage factors actually accumulated by the components:. These conservatisms are discussed below.

Fatigue Design Curve with Margin for Uncertainties and Moderate Environmental Effects: The ASME Section III fatigue S-N curves (allowable alternating stress intensity versus number of cycles) are based on regression analysis of a large number of fatigue data points for samples strain-cycled in air, with adjustments for the elastic modulus and departure from zero mean stress for elastic cycling, less a design margin for uncertainties, including modest environmental effects (ASME III - 1965, Par. N-415). The design margin is a factor of 2 on stress or a factor of 20 on cycles, whichever produced the lower, more conservative allowable for the data set.

Bounding Parameters for Transients: Fatigue analyses assume a given number of cycles of each of a set of transient events, each transient event is defined by limiting pressure and temperature transients and other load conditions.. Actual event cycles are seldom as severe as those considered in the analysis; the resulting stress ranges are lower, and the contributions to cumulative usage factor are therefore lower.

Use of Stress Based Fatigue: Since an automated six-element stress-based tensor fatigue calculation will calculate stresses from the actual event severity, usage factors reported by the software program at locations for which the stress-based method is used will be more realistic than values predicted by the code analysis for the same number of cycles, or which would be determined by cycle-count monitoring.

"The stress-based algorithms will accurately calculate the actual fatigue effects. The automated six-element stress monitoring software will use the same methods as an ASME III code analysis to calculates a three-dimensional, six-component state of stress at critical locations monitored by the SBF methodology.

Actual Number of Event Cycles versus Design Number of Cycles: The analytical limit for a fatigue analysis is a cumulative usage factor at any location of 1.0~~, calculated as~~. The design CUF is the sum of all contributing partial usage factors ~~for~~resulting from the total of all design basis events at their design number of ~~cycles of each of the design basis cyclic loading events.~~ occurrences. Therefore, even if the analysis showed a calculated usage factor ~~at the~~of 1.0 ~~limit~~ for a location, and even if the design basis number of cycles were reached for one event ~~of a set~~, the fact that all contributing cycle types will not simultaneously arrive at their assumed limit indicates that some fatigue margin would remain ~~to the 1.0 limit~~.

~~For locations for which~~Action limits in the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program ~~maintains a current estimate of fatigue usage factor based on cycle counting, action limits are~~(B3.1) will be set below the cycle count assumed by the analysis to ensure that actual ~~plant experience~~component usage remains bounded by the assumptions used in the design calculations, or that appropriate reevaluation or other corrective action is initiated if an action limit is reached. Action limits will permit completion of corrective actions before the design basis number of events is exceeded. Therefore, the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will ensure that there is ample margin to the ~~cumulative usage factor analytic~~CUF limit of 1.0.

4.3.1.1 Licensing ~~and Design~~ Basis of the PVNGS Component Cyclic ~~and~~or Transient Limit Program

The "Component Cyclic or Transient Limit" program is required by Technical Specification 5.5.5 which states: "This program provides controls to track the UFSAR Section 3.9.1.1 cyclic and transient occurrences to ensure that components are maintained within the design limits."

UFSAR Section 3.9.1.1 includes, by reference, information and transient definitions from several UFSAR sections and tables, which represent conservative estimates for design purposes ~~listed in~~(see Table 4.3-1~~Table 4.3-1.~~). The ~~FSAR~~UFSAR states that this information accounts for all expected transients, and that the number and severity of the design transients exceeds those which may be anticipated during the 40-year life of the plant.

Table 4~~-~~.3-1 - PVNGS Unit 1, 2, and 3 Licensing and Design Basis Transient Citations from UFSAR 3.9.1.1

UFSAR Section or Table	Applicable Scope of Transient Data
Section 3.7.3.2	Operating Basis Earthquake (OBE) Cycles
Table 3.9.1-1	ASME III Class 1 Components by the NSSS Vendor (CE)
Table 3.9-1	ASME III Class 1 Piping Not by the NSSS Vendor (CE)
Section 3.9.3	ASME III Class 2 and 3 Components[1]
Section 5.4.1	Reactor Coolant Pumps

Table 4-.3-1 - PVNGS Unit 1, 2, and 3 Licensing and Design Basis Transient Citations from UFSAR 3.9.1.1

UFSAR Section or Table	Applicable Scope of Transient Data
Section 5.4.2	Steam Generators
Section 5.4.3	Reactor Coolant Piping
Section 5.4.10	Pressurizer

4.3.1.2 Enhanced PVNGS Fatigue Management Program (B3.1)

The enhanced fatigue management program (Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) differs from the current fatigue monitoring program in the following two respects:

1) The current fatigue monitoring program is a manual cycle counting program. The enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will include an automated and computerized software program to support safe operation of PVNGS for the period of extended operation. The enhanced program

2) The current fatigue monitoring program is cycle based and includes only one specific location for CUF monitoring (pressurizer spray nozzle). The enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will continue to count cycles and will also monitor fatigue effects for a subset of ASME III Class 1 reactor coolant pressure boundary vessel and pipingCUF values as specified in Table 4.3-4 for bounding locations, and Class 2 steam generator secondary side subject to environmentally assisted fatigue (locations with Class 1 analyses. Table 4.3-2 lists those plant transients that form the basis for the cyclic duty for which components were designedidentified through implementation of NUREG/CR-6260). Usage factor monitoring will include environmental effects at NUREG/CR-6260 locations.

If the limiting value for the transient is not stated in the UFSAR; the limiting value is determined by the limiting number of transients from design specifications of affected systems and components, unless otherwise noted.

INSERT TABLE 4.3-2 HERE

Table 4.3-2 - PVNGS Unit 1, 2, and 3 Licensing and Design Basis Transients[1]

Transient[2]	Summary of Criteria	
	UFSAR	Limiting Number of Events[3]
Normal Events		
1. Plant Heatup, 100 °F/hr	500	500
2. Plant Cooldown, 100 °F/hr	500	500
3. Plant Loading, 5 %/min	15,000	15,000
4. Plant Unloading, 5 %/min	15,000	15,000
5. 10% Step Load Increase	2,000	2,000
6. 10% Step Load Decrease	2,000	2,000
7. Normal Plant Variation	10^6	10^6
8. Reactor Coolant Pump Starting	1,000	1,000
9. Reactor Coolant Pump Stopping	1,000	1,000
10. Cold Feedwater following Hot Standby (AFW)	NS[4]	15,000
11. Pressurizer Heatup, 200 °F/hr	500	500
12. Pressurizer Cooldown, 200 °F/hr	500	500
13. Shift from Normal to Maximum Purification Flow at 100% Power	1,000	1,000
14. Low-Low Volume Control Tank or Charging Pump Suction Diversion to RWT	80	80
15. Pressure Level Control, Failure to Open	100	100
16. Unbolting/Bolting of Reactor Coolant Pump Casing Studs	NS[4]	25
17. Detensioning/Tensioning of RV Head Studs	NS[4]	50
18. Safety Injection Check Valve Test	160	160
19. High Pressure Safety Injection Header Check Valve Test	40	40
20. Turbine Roll Test at Hot Standby	10	10
21. Auxiliary Spray During Cooldown	500	500
22. Initiation of Shutdown Cooling	500[5]	500
Upset Events		
23. Reactor Coolant Pump Coastdown at 100% Power	10	10
24. Reactor Trip	50/240[7]	50
25. Loss of Reactor Coolant Flow	40	40
26. Loss of Load (Load Rejection from 100 to 15% Power)	40	40
27. Operating Basis Earthquake	200	200
28. Inadvertent Control Element Assembly Drop	40	40
29. Inadvertent Control Element Assembly Withdrawal	40	40
30. Loss of Charging and Recovery	200	200
31. Loss of Letdown and Recovery	300	300
32. Extended Loss of Letdown	800[7]	800
33. Depressurization by Spurious Actuation of Pressurizer Spray Control Valves at 100% Power (Main & Aux. Spray)	40	40
34. Partial Loss of Condenser Cooling at 100% Power	40	40
35. Excess Feedwater at 100% Power	40	40

Table 4.3-2 - PVNGS Unit 1, 2, and 3 Licensing and Design Basis Transients[1]

Transient [2]	Summary of Criteria	
	UFSAR	Limiting Number of Events[3]
36. Turbine Trip Without Reactor Trip	40/120[7]	40
37. Inadvertent Actuation of Main Steam Line Isolation Valve	5/40[6]	5/40[6]
38. Opening One Atmospheric Dump Valve or Steam Bypass Valve at 100% Power	40	40
39. Seismic Event Up to and Including One-Half of the Safe Shutdown Earthquake, at 100% Power	2	2
40. Initiation of Safety Injection	10	10
41. Inadvertent Isolation of Feedwater Heater	5	5
42. Loss of Feedwater Flow to Steam Generators	85[7]	85
43. Loss of Reactor Coolant Pump Seal Coolant	NS[4]	40
44. Loss of Reactor Coolant Pump Seal Injection	NS[4]	40
45. Inadvertent Auxiliary Spray at 100% Power	5	5
46. System Leak due to Rupture of Instrument Line or Sampling Connection	40	40
47. Inadvertent Main Feedwater Isolation Valve Closure at 100% Power (One MFIV)	40	40
48. Inadvertent Feedwater or Condensate Pump Trip at 100% Power	40	40
49. Main Feedwater Isolation Valve Closures due to Loss of Air at 100% Power	5	5
50. Depressurization by Main Steam Safety Valve at 100% Power	10	10
51. Startup of One Reactor Coolant Pump at 50% Power	10	10
52. Loss of Electrical Bus Supplying two Reactor Coolant Pumps at 100% Power	40	40
53. Inadvertent Closure of All Main Feedwater Isolation Valves at 100% Power	NS[4]	5
54. Spurious Startup or Shutdown of SI Pump, or Spurious Opening or Closing of SI Isolation Valve	40	40
Test Events		
55. Primary Side Hydrostatic Test, 3115 psia, 100 – 400 °F	10	10
56. Secondary Side Hydrostatic Test	10	10
57. Primary Side Leak Test, 2250 psia, 100 - 400 °F	200	200
58. Secondary Side Leak Test, 820 psia to Design Pressure	200	200
59. CVCS System Hydrostatic Test	40	40
60. Low Pressure Safety Injection Pump Test[8]	500[5]	500
61. High Pressure Safety Injection Pump Test[8]	500[5]	500

4.3.1.3 Seismic History

Design analyses that compare seismic stresses against ~~stress allowables~~allowable stresses, in the absence of any consideration of the number of cycles or of fatigue effects, are not TLAAs. However, design of structures, systems, and components may include seismic loads in fatigue analyses, or may assume a stated number of seismic load cycles for purposes of establishing an allowable stress or stress range. Significant earthquakes at the site can therefore increase the accumulated fatigue usage factor~~; or~~. The site seismic history can ~~reduce~~affect the ~~analogous~~disposition of TLAAs. However, no significant ~~earthquake load cycles assumed, by the design, to be allowed for the remaining operating life~~earthquakes have occurred at PVNGS since construction.

~~The site seismic history can thereby affect the disposition of TLAAs. However, since construction no significant earthquakes have occurred at PVNGS to date.~~

For design purposes the PVNGS safe shutdown earthquake (SSE) and operating basis earthquake (OBE) are defined as 0.20 g and 0.10 g ground motion, respectively. Analyses of Seismic Category I structures used a conservative design basis 0.25 g SSE and 0.13 g OBE [UFSAR 3.7].

For the purposes of evaluating actual events at PVNGS, an SSE is defined as one with a modified-Mercalli intensity level 8 (ground motion of 0.15 to 0.33 g or above); and an OBE is defined as one with a modified-Mercalli intensity level 7 (ground motion of 0.072 to 0.15 g). No SSE or OBE has occurred to date. The site has recorded seven minor earthquakes as of 2008, some of these not strong enough to qualify as recordable "earthquake events." The strongest had a ground motion of only 0.015 g, or about 12% of the acceleration, and therefore the applied loads, of a design basis 0.13 g OBE.

4.3.1.4 Present and Projected Status of Monitored Locations

Summary Description

The current fatigue ~~management~~monitoring program transient cycle count procedure, 73ST-9RC02, recorded accumulated transient events for the 9 transients listed in Appendix J of the procedure since the Unit 1 startup in 1985. This transient list did not include every transient in ~~the FSAR.~~UFSAR Section 3.9.1.1 because, prior to implementation of Improved Technical Specifications in 1998, the Technical Specifications required monitoring only transients that are now in UFSAR Section 3.9.1.1.1. ~~Therefore, in~~ In 1995 (after 10 years of Unit 1 operation), the cycle count procedure was revised to include the 48 remaining ~~FSAR~~UFSAR transients listed in Appendix K of the procedure. In the 1995 record of the revised procedure, accumulation for all transient events not counted to date was assumed at 25% of the limiting value for the 40-year design. After the 1995 revision of the cycle count procedure, transients were recorded ~~on a case-by-case basis~~ and were added to the 25% accumulation assumed in 1995.

APS Fatigue Cycle Count Verification

The goal of the APS fatigue cycle count verification was to reduce the uncertainty created by the 25% accumulation assumed in 1995.

Scope

~~Transients adding significant fatigue to components were included in the APS transient recount. Transients not contributing significantly to fatigue were not included in the APS transient recount. The transients not included in the recount are retained in the composite worst-case unit accumulation, including the 25% accumulation assumed in 1995.~~

The scope of the cycle count verification included all transients required to be monitored by PVNGS Technical Specifications 5.5.5.

Recount Method

~~Unit 1 was the prototype Combustion Engineering System 80 plant. Due to a lack of operating experience, early Unit 1 operation included tests and events that did not generally occur as frequently in subsequent units. A cycle count record from Unit 1 should therefore be a conservative estimate for Unit 2 and Unit 3. However, Unit 1 had a 460-day outage, with Unit 2 running, but during which Unit 2 experienced many startup-shutdown transients. Therefore, APS has created a composite worst-case (composite unit) envelope including only the highest accumulation of each transient experienced among the three units from 1985 through 2005.~~

~~APS performed a best effort retrieval of the transient count data recorded from 1985 through 1995 (the "APS transient recount"). Sources for this effort included (1) NRC Information Reports for all three units, (2) Unit 1 control room logs from 1985 through 1995, (3) Unit 2 control room logs from 1986 through 1995, (4) Unit 3 control room logs from 1987 through 1995, and (45) interviews with plant personnel. The result of this data retrieval is the "worst-case APS transient recount from 1985 through 1995."~~

~~The 25% accumulation assumed in 1995 was subtracted from the totals recorded through 2005 in the cycle count procedure to obtain the accumulation from 1996 through 2005 for each transient. This accumulation from 1996 through 2005 was then added to the worst-case APS transient recount from 1985 through 1995 to obtain the composite worst-case unit accumulation of cycles from 1985 to 2005, for each transient.~~

Several APS employees and contractor personnel were designated based on their long-term familiarity with PVNGS to perform document reviews. The reviewers examined the microfilmed control room logs, NRC Monthly Operating Reports and LERs for the period prior to January 1996 for all three PVNGS units. The personal recollections and records of unit personnel were used to supplement the record review, and a best-source total was determined for each monitored transient. The best-source total was added to the actual count of events following 1995 to obtain a best-source total as of the end of 2005. These best-source totals as of the end of 2005 are reported in Table 4.3-3.

Transient Projections

A yearly accumulation rate must be calculated in order to accurately project transient accumulation through the period of extended operation. The yearly accumulation rate wascalculated by dividing the composite unit accumulation from 1985 through 2005 by the leastnumber of years of operation up to 2005 (Unit 3, operating period of 18 years). This resulted in the worst-case accumulation of cycles over the least amount of time. This accumulation rate was then multiplied by 22 (18+22=40) and added to the composite unit 2005 accumulation to calculate the projected accumulation at 40 years of operation. Similarly, the accumulation rate was multiplied by 42 (18+42=60) and added to the composite unit 2005 accumulation to calculate the projected accumulation at 60 years of operation.

***Transients not included in* the FSAR**

Some transients which are required by the fatigue management program to accurately calculate fatigue usage are not required to be monitored by the PVNGS FSAR, and were therefore not separately counted in the procedure through 2005. These transients were therefore included in the cycle count verification. However, there is no accumulation record of these transient events from 1996 through 2005. APS has therefore determined accumulation data from 1985 through 2005, the accumulation rate was then calculated by dividing this accumulation by the least number of years of operation up to 2005 (Unit 3, operating time of 18 years).

***Transients with a to date accumula*tion of zero**

The yearly accumulation rate for transients which to date have no accumulation was determined by dividing the design basis number of transient events by 40 years. This resulted in the original expected annual accumulation rate of transients, except that no transients have occurred to date. Therefore, the accumulation rate was determined by multiplying the original expected accumulation rate by the percentage of years left in the design basis (22/40).

Transients not expected to occur

No yearly accumulation rate was calculated for transients which are not expected to occur. For these transient events at least one event was assumed to occur during the period of extended operation.

~~*Table 4.3-3 - APS Fatigue Cycle Count Verification (Composite Worst-Case Unit), and Projections*[1, 2]~~

~~Transient[3]~~	~~Limiting Number of Events (Table 4.3-2)~~	~~Fatigue Management Program Transient Cycle Count Procedure (73ST-9RC02)~~		~~Worst-Case APS Transient Recount (1985-1995)~~	~~Composite Worst-Case Unit Accumulation (1985-2005)[4]~~	~~Accumulation Rate (per year)[5]~~	~~Projected to 40 years[6]~~	~~Projected to 60 years[7]~~
		~~(1985-1995) 25% Assumed[8]~~	~~Worst-Case (1985-2005) Incl. 25% Assumed~~					
~~**Normal Events**~~								
~~**1. Plant Heatup, 100°F/hr**~~	~~500~~	~~21~~	~~64~~	~~NC[9]~~	~~64[10]~~	~~3.56~~	~~143~~	~~214~~
~~**2. Plant Cooldown, 100°F/hr**~~	~~500~~	~~20~~	~~63~~	~~NC~~	~~63[10]~~	~~3.50~~	~~140~~	~~210~~
~~3. Plant Loading, 5%/min~~	~~15,000~~	~~NR[11]~~	~~NR~~	~~NC~~	~~NC~~	~~NC~~	~~NC~~	~~NC~~
~~4. Plant Unloading, 5%/min~~	~~15,000~~	~~NR~~	~~NR~~	~~NC~~	~~NC~~	~~NC~~	~~NC~~	~~NC~~
~~**5. 10% Step Load Increase**[12]~~	~~2,000~~	~~500~~	~~521~~	~~264[13]~~	~~264[13]~~	~~14.67~~	~~587~~	~~880~~
~~**6. 10% Step Load Decrease**[12]~~	~~2,000~~	~~NR~~	~~NR~~	~~144[13]~~	~~144[13]~~	~~8.00~~	~~320~~	~~480~~
~~7. Normal Plant Variation~~	~~10^6~~	~~NR~~	~~NR~~	~~NC~~	~~NC~~	~~NC~~	~~NC~~	~~NC~~
~~**8. RC Pump Starting**~~	~~1,000~~	~~250~~	~~281~~	~~NC~~	~~281[14]~~	~~15.61~~	~~625~~	~~937~~
~~**9. RC Pump Stopping**~~	~~1,000~~	~~250~~	~~275~~	~~NC~~	~~275[14]~~	~~15.28~~	~~612~~	~~917~~
~~**10. Cold Feedwater Following Hot Standby (AFW)**~~	~~15,000~~	~~3750~~	~~3752~~	~~NC~~	~~3752[14]~~	~~208.44~~	~~8,338~~	~~12,507~~
~~**11. Pressurizer Heatup, 200°F/hr**~~	~~500~~	~~NR~~	~~86~~	~~NC~~	~~86[10]~~	~~4.78~~	~~192~~	~~287~~
~~**12. Pressurizer Cooldown, 200°F/hr**~~	~~500~~	~~NR~~	~~85~~	~~NC~~	~~85[10]~~	~~4.72~~	~~189~~	~~284~~

Table 4.3-3 - APS Fatigue Cycle Count Verification (Composite Worst-Case Unit), and Projections[1, 2]

Transient[3]	Limiting Number of Events (Table 4.3-2)	Fatigue Management Program Transient Cycle Count Procedure (73ST-9RC02)		Worst-Case APS Transient Recount (1985-1995)	Composite Worst-Case Unit Accumulation (1985-2005)[4]	Accumulation Rate (per year)[5]	Projected to 40 years[6]	Projected to 60 years[7]
		(1985-1995) 25% Assumed[8]	Worst-Case (1985-2005) Incl. 25% Assumed					
13. Shift from Normal to Maximum Purification Flow at 100% Power	1,000	250	250	NC	250[14]	13.89	556	834
14. Low-Low Volume Control Tank/ Charging Pump Suction Diversion to RWT	80	20	20	NC	20[14]	1.11	45	67
15. Pressure Level Control, Failure to Open	100	25	25	NC	25[14]	1.39	56	84
16. Unbolting/ Bolting of RC Pump Casing Studs	25	NR	NR	19	19[15]	1.06	**43**[16]	**64**[16]
17. Tensioning/ Detensioning of RV Head Studs	50	NR	NR	17[13]	17[13]	0.94	38	**57**[16]
18. Safety Injection Check Valve Test[17]	160	NR	NR	0	0	[18]	1	1
19. High Pressure Safety Injection Header Check Valve Test	40	NR	NR	0	0	[18]	1	1
20. Turbine Roll Test at Hot Standby	10	NR	NR	3	3	[18]	4	4

Table 4.3-3 - APS Fatigue Cycle Count Verification (Composite Worst-Case Unit), and Projections[1, 2]

Transient[3]	Limiting Number of Events (Table 4.3-2)	Fatigue Management Program Transient Cycle Count Procedure (73ST-9RC02)		Worst-Case APS Transient Recount (1985-1995)	Composite Worst-Case Unit Accumulation (1985-2005)[4]	Accumulation Rate (per year)[5]	Projected to 40 years[6]	Projected to 60 years[7]
		(1985-1995) 25% Assumed[8]	Worst-Case (1985-2005) Incl. 25% Assumed					
21. Auxiliary Spray During Cooldown	500	NR	NR	85[27]	85	4.72	189	284
22. Initiation of Shutdown Cooling	500	125	148	NC	148[14]	8.22	329	494
Upset Events								
23. RCP Coastdown at 100% Power	10	NR	NR	NC	NC	0.14[19]	4	6
24. Reactor Trip	50	13	19	28	34	1.89	76[16]	114[16]
25. Loss of Reactor Coolant Flow	40	10	12	2	4	0.22	9	14
26. Loss of Load (Load Reduction from 100 to 15% Power)	40	10	11	13	14	0.78	32	47[16]
27. Operational Basis Earthquake	200	NR	0	NC	0[10]	[18]	20[20]	20[20]
28. Inadvertent CEA Drop	40	10	11	5	6	0.33	14	20

Table 4.3-3 - APS Fatigue Cycle Count Verification (Composite Worst-Case Unit), and Projections[1, 2]

Transient[3]	Limiting Number of Events (Table 4.3-2)	Fatigue Management Program Transient Cycle Count Procedure (73ST-9RC02)		Worst-Case APS Transient Recount (1985-1995)	Composite Worst-Case Unit Accumulation (1985-2005)[4]	Accumulation Rate (per year)[5]	Projected to 40 years[6]	Projected to 60 years[7]
		(1985-1995) 25% Assumed[8]	Worst-Case (1985-2005) Incl. 25% Assumed					
29. Inadvertent CEA Withdrawal	40	10	10	0	0	[18]	1	1
30. Loss of Charging and Recovery	200	25	27	5	7	0.39	16	24
31. Loss of Letdown and Recovery	300	210	213	17	20	1.11	45	67
32. Extended Loss of Letdown	800	NR[26]	64[26]	2	66[26]	3.67	147	220
33. Depressurization by Spurious Actuation of Pressurizer Spray Control Valve at 100% Power (Main & Aux. Spray)	40	10	11	0	1	0.11	5	7
34. Partial Loss of Condenser Cooling at 100% Power	40	10	11	NC	11[14]	0.61	25	37
35. Excess Feedwater at 100% Power	40	10	10	2	2	0.11	5	7
36. Turbine Trip Without Reactor Trip	40	10	15	13	18	1.00	40[16]	60[16]

Table 4.3-3 - APS Fatigue Cycle Count Verification (Composite Worst-Case Unit), and Projections[1, 2]

Transient[3]	Limiting Number of Events (Table 4.3-2)	Fatigue Management Program Transient Cycle Count Procedure (73ST-9RC02)		Worst-Case APS Transient Recount (1985-1995)	Composite Worst-Case Unit Accumulation (1985-2005)[4]	Accumulation Rate (per year)[5]	Projected to 40 years[6]	Projected to 60 years[7]
		(1985-1995) 25% Assumed[8]	Worst-Case (1985-2005) Incl. 25% Assumed					
37. Inadvertent Actuation of Main Steam Line Isolation Valve	5/40[20]	2	3	1/5	1/5	0.06/0.28	3/12	4/17
38. Opening One ADV or Steam Bypass Valve, at 100% Power	40	10	11	1	2	0.11	5	7
39. Seismic Event up to and Including One-Half of the Safe Shutdown Earthquake, at 100% Power	2	NR	NR	NC	NC	[21]	NC	NC
40. Initiation of Safety Injection	10	NR	7	4	7[10]	0.39	**16**[16]	**24**[16]
41. Inadvertent Isolation of FW Heater	5	1	1	0	0	0.07[10]	2	3
42. Loss of Feedwater Flow to Steam Generators	85	21	22	12	13[22]	0.72	29	44

~~*Table 4.3-3 - APS Fatigue Cycle Count Verification (Composite Worst-Case Unit), and Projections*[1, 2]~~

~~Transient[3]~~	~~Limiting Number of Events (Table 4.3-2)~~	~~Fatigue Management Program Transient Cycle Count Procedure (73ST-9RC02)~~		~~Worst-Case APS Transient Recount (1985-1995)~~	~~Composite Worst-Case Unit Accumulation (1985-2005)[4]~~	~~Accumulation Rate (per year)[5]~~	~~Projected to 40 years[6]~~	~~Projected to 60 years[7]~~
		~~(1985-1995) 25% Assumed[8]~~	~~Worst-Case (1985-2005) Incl. 25% Assumed~~					
~~43. Loss of RCP Seal Coolant~~	~~40~~	~~NR~~	~~NR~~	~~NC~~	~~NC~~	~~NC~~	~~NC~~	~~NC~~
~~44. Loss of RCP Seal Injection~~	~~40~~	~~NR~~	~~NR~~	~~NC~~	~~NC~~	~~NC~~	~~NC~~	~~NC~~
~~**45. Inadvertent Auxiliary Spray at 100% Power**~~	~~5~~	~~1~~	~~2~~	~~0~~	~~1~~	~~0.06~~	~~3~~	~~4~~
~~46. System Leak due to Rupture of Instrument Line or Sampling Connection~~	~~40~~	~~10~~	~~10~~	~~0~~	~~0~~	~~0.55[10]~~	~~13~~	~~24~~
~~**47. Inadvertent MFIV Closure at 100% Power (One MFIV)**~~	~~40~~	~~10~~	~~10~~	~~1~~	~~1~~	~~0.06~~	~~3~~	~~4~~
~~**48. Inadvertent FW or Condensate Pump Trip at 100% Power**~~	~~40~~	~~10~~	~~11~~	~~10~~	~~11~~	~~0.61~~	~~25~~	~~37~~
~~**49. MFIV closures due to Loss of Air at 100% Power**~~	~~5~~	~~1~~	~~1~~	~~1~~	~~1~~	~~0.06~~	~~3~~	~~4~~

Table 4.3-3 - APS Fatigue Cycle Count Verification (Composite Worst-Case Unit), and Projections[1, 2]

Transient[3]	Limiting Number of Events (Table 4.3-2)	Fatigue Management Program Transient Cycle Count Procedure (73ST-9RC02)		Worst-Case APS Transient Recount (1985-1995)	Composite Worst-Case Unit Accumulation (1985-2005)[4]	Accumulation Rate (per year)[5]	Projected to 40 years[6]	Projected to 60 years[7]
		(1985-1995) 25% Assumed[8]	Worst-Case (1985-2005) Incl. 25% Assumed					
50. Depressurization by MSSV at 100% Power	10	2	2	5	5	0.28	12[16]	17[16]
51. Startup of one Reactor Coolant Pump at 50% Power	10	NR	NR	NC	NC	0.14[19]	4	6
52. Loss of Electrical Bus Supplying two RCPs at 100% Power	40	10	14	2	6	0.33	14	20
53. Inadvertent Closure of all MFIVs at 100% Power	5	NR	NR	NC	NC	[23]	NC	NC
54. Spurious Startup/ Shutdown of SI Pump or Spurious Opening/ Closing of SI Isolation Valve	40	10	10	1	1	0.06	3	4
Test Events								
55. Primary side Hydrostatic Test, 3125 psia, 100-400F	10	NR	1	NC	1[10]	[18]	2	2

Table 4.3-3 - APS Fatigue Cycle Count Verification (Composite Worst-Case Unit), and Projections[1, 2]

Transient[3]	Limiting Number of Events (Table 4.3-2)	Fatigue Management Program Transient Cycle Count Procedure (73ST-9RC02)		Worst-Case APS Transient Recount (1985-1995)	Composite Worst-Case Unit Accumulation (1985-2005)[4]	Accumulation Rate (per year)[5]	Projected to 40 years[6]	Projected to 60 years[7]
		(1985-1995) 25% Assumed[8]	Worst-Case (1985-2005) Incl. 25% Assumed					
56. Secondary Side Hydrostatic Test	10	3	3	1	1	(18)	2	2
57. Primary Side Leak Test, 2250 psia, 100-400F	200	NR	5	NC	5[10]	(18)	6	6
58. Secondary Side Leak Test, 820 psia to design pressure	200	50	50	1	1	(18)	2	2
59. CVCS System Hydrostatic Test	40	10	10	1	1	(18)	2	2
60. LPSI Pump Test	500[24]	125	268	125	268	14.89	**596**[16]	**894**[16]
61. HPSI Pump Test	500[25]	125	261	125	261	14.50	**580**[16]	**870**[16]

Basis for Reduced Cycle Counts

Transient 18, "Safety Injection Check Valve Test": The limiting number of 160 events in the UFSAR originated from the Combustion Engineering general specification. Combustion Engineering plants subsequently petitioned the NRC (in the early 1980's) for permission to not perform this quarterly test because of the significant fatigue which would result from inserting cold Safety Injection water. The quarterly test was never performed and never incorporated in the procedure. The check valve test is performed during a stage of startup at normal heatup pressure and temperature, resulting in no significant fatigue accumulation. This transient event is therefore not performed as originally characterized and analyzed and need not be tracked.

Transient 26, "Loss of Load": The projected number of events may not be reached because the loss of load transient is only significant to fatigue when it causes a turbine trip. This is avoided by performing turbine runback. If corrective actions to reanalyze components become necessary, they may include a revision of the definition of this transient event.

Transient 37, "Inadvertent Actuation of MSIV": Limiting numbers in the UFSAR are 5 events from 100% power and 40 events from an unspecified power level. Only one event for each unit has been recorded at 100% power.
ProgramTransient totals were projected to the end of the PEO for information only. The projections predict that 10 CFR 54.21(c)(1)(iii) aging management will be successful and that in most cases future corrective actions will not be necessary. However, the projections are not intended to justify 10 CFR 54.21(c)(1)(i) validations, or to provide revised design bases for 10 CFR 54.21(c)(1)(ii) analysis revisions. The projections are based on a linear extrapolation as follows:

1.The shortest period of operation as of the end of 2005 was 18 years in Unit 3 and the longest was 20 years in Unit 1, so a scaling factor of 3.33 (60 years extended life divided by 18 years shortest operation) was used to project totals to the end of the PEO. In a few special cases a scaling factor of 6.66 was used when the available data covered a ten year period. These exceptions are noted and explained in Table 4.3-3.

2. The highest total accumulation for an event was selected without regard to which unit it occurred in.

3. A highest unit 60 year projection (column7) as of the end of the PEO was obtained by multiplying the highest total accumulation for each event by the scaling factor.

Example:

Event #1 RCS Heatup highest unit total was in Unit 2 (64 heatups). 64 X 3.33=213. The highest unit 60 year projection (column 7) is 213.

It should be noted that only a few events such as recurring test events lend themselves to projection with well defined assumptions, so the projections presented in Table 4.3-3 are only best-estimates. Early plant history involved a number of first-of-a-kind issues that may make the projections artificially high, and end of life issues may make the projections artificially low. Therefore, consistent with aging management, no attempt has been made to reanalyze or implement other corrective actions based on these projections. Corrective actions will be triggered by the action limits that will be established in the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1)

INSERT TABLE 4.3-3 HERE

4.3.1.5 Enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) Scope, Action Limits, and Corrective Actions

Scope

The scope of the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will include ~~a bounding set of locations within existing~~all ASME Section-III Class~~ 1 vessel and piping fatigue analyses. This set includes the NUREG/CR-6260 sample locations. The scope of the bounding set of monitored locations is sufficient to ensure that fatigue in any other locations of concern, not included in the set, is within the same system and subject to the same transients, or within a system affected by the same transients.~~
~~Table 4.3-4 reflects the scope of the enhanced PVNGS fatigue management program. The enhanced program will include (1) Class 1 locations with high calculated cumulative usage factors, (2)~~ I components ~~listed in NUREG/CR-6260, (3) Class 1 components for which partial-cycle equations have been developed for stress-based monitoring, and (4)~~ and Class 2 portions of the steam generators with a Class 1 analysis and ~~high calculated cumulative usage factors~~will monitor their fatigue usage by a combination of cycle counting and CUF monitoring as noted in Table 4.3-4.

Method

The "Fatigue Management Method" column of Table 4.3-4 indicates the method the ~~automated software~~enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will use to track fatigue usage for each component. These are stress-based fatigue (SBF), cycle-based fatigue (CBF-C - per cycle, CBF-PC - per cycle with partial cycles, or CBF-EP - event pairing), and ~~"global."~~CC. The ~~"global"~~CC method will ~~only~~ be used for components ~~with low calculated design basis fatigue~~whose cumulative usage ~~values, for which~~can be shown to be satisfactory with this highly conservative monitoring approach. Locations with high end of life accumulated usage, such as most of the ~~fatigue management program does not~~NUREG/CR-6260 locations, require more sophisticated CBF or SBF algorithms to periodically calculate accumulated fatigue usage ~~to date. However, transient~~and demonstrate that component usage remains less than one. Transient event cycles that ~~have significant fatigue effects~~are required to be monitored by PVNGS Technical Specifications 5.5.5 will continue to be ~~counted and~~ tracked to ensure that the numbers of transient events assumed by the design basis calculations will not be exceeded. This ~~"global" coverage~~cycle counting monitoring method will ~~therefore suffice to~~ demonstrate design basis compliance for the components using CC monitoring. See Table 4.3-~~3~~2 for the list of tracked transients.

Corrective Action Limits and Corrective Actions

The PVNGS current fatigue ~~management~~monitoring program ~~currently~~is based on cycle counting with one location tracked by a CUF calculated using CBF-PC (Pressurizer spray nozzle), and it incorporates a cycle based action ~~limits that provide for evaluation and cycle count tracking of critical thermal and pressure transients to verify that the ASME Code CUF~~ limit of ~~1.0 and other~~ 90% of the design ~~limits will not be exceeded. The~~event occurrences and a CUF based action limit of 0.65 for the pressurizer spray nozzle usage. The current fatigue monitoring program requires this evaluation at least once per fuel cycle. ~~Action limits are based on a fixed percentage of allowed~~

~~cycles for components monitored by a maximum number of defined transients.~~ The current action limits are established to allow action to be taken in time to prevent exceeding the maximum number of allowed cycles or a pressurizer spray nozzle CUF of 1.0, as applicable, and should provide at least one fuel cycle of warning.

~~The enhanced program specifies corrective actions to be implemented to ensure that appropriate reevaluation or other corrective action is initiated if an action limit is reached.~~

During the period of extended operation, projections indicate that certain allowable cycles and fatigue limits may be approached. Therefore specific and targeted action limits will be necessary to ensure actual fatigue limits are not exceeded. Those action limits have not yet been developed. As the transition to the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) and FatiguePro © is implemented, there are certain embedded administrative tools in FatiguePro © that will allow for specification of action limits based on projected fatigue usage at specific locations that account for actual cumulative fatigue. The action limits can be based on the time required to implement expected or projected mitigating actions (such as component replacements or revisions to ASME Code Fatigue Analyses of Record) prior to actual fatigue limits being exceeded.

Action Limit Margins

~~Corrective action limits must~~The enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) corrective action limits will ensure that corrective actions are taken before the design limits are exceeded. Corrective action limits ~~must therefore~~will ensure that appropriate reevaluation or other corrective actions are initiated while sufficient margin remains to allow at least one occurrence of the worst case (highest fatigue usage per cycle) low probability transient that is included in design specifications, without exceeding the code limit CUF of 1.0. For NUREG/CR-6260 locations, CUF calculation will be done using the appropriate F_{en} environmental factor.

Cycle Count Action Limits and Corrective Actions

~~For~~ Cycle~~-Based Fatigue~~ Counting monitoring (~~CBF),~~CC) action limits ~~have been~~for the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will be established based on the design-specified number of cycles. ~~Usage factors in locations monitored by this method are most affected by transient events which are of low probability, and cycle counting of these events is therefore sufficient to account for the fatigue accumulation in them.~~

~~Cycle Count Action Limit Margins: In order to assure~~ Since sufficient margin must be maintained to accommodate ~~occurrence~~any design transient regardless of probability, the enhanced Metal Fatigue of ~~a low probability transient,~~Reactor Coolant Pressure Boundary program (B3.1) corrective actions ~~must~~will be taken before the remaining number of allowable occurrences for any specified transient~~, including the low-probability, higher-usage-factor events,~~ becomes less than one. ~~Other events counted by cycle-based monitoring contribute less per event to usage factor, but occur more frequently. To account for both cases, corrective~~ Corrective actions ~~are~~will be required when the cycle count for any of the significant contributors to usage factor is projected to reach the action limit defined in the ~~program~~enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) before the end of the next fuel cycle.

~~For example, in Table 4.3-3 the specified number of "Inadvertent Auxiliary Spray at 100% Power" transient events is (5) so corrective action would be required when 80% (4) of the specified cycles have occurred.~~

Cycle ~~Count~~Counting Corrective Actions~~:~~ to be incorporated into the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1): If a cycle count action limit is reached, ~~acceptable~~ corrective actions ~~include~~will be performed as necessary:

1) Review of fatigue usage calculations.

- To determine whether the transient in question contributes significantly to CUF.
- To identify the components and analyses affected by the transient in question.
- To ensure that the analytical bases of the high-energy line break (HELB) locations are maintained.
- To ensure that the analytical bases of ~~a~~the fatigue crack growth and stability analysis in support of relief from ASME Section XI flaw removal and inspection requirements for hot leg small-bore half nozzle repairs are maintained.

2) Evaluation of remaining margins on CUF based on cycle-based or stress-based CUF calculations using the PVNGS fatigue management ~~program~~ software.

3) Redefinition of the specified number of cycles (e.g., by reducing specified numbers of cycles for other transients and using the margin to increase the allowed number of cycles for the transient that is approaching its specified number of cycles).

4) Redefinition of the transient to remove conservatism in predicting the range of pressure and temperature values for the transient.

~~Since the CBF action limits are based on a somewhat arbitrary cycle count that does not accurately indicate approach to the CUF = 1.0 fatigue limit, these~~These preliminary actions are designed to determine how close the ~~approach~~ usage is to ~~the~~ 1.0 ~~limit~~, and from those determinations, set new action limits. ~~If the CUF has approached 1.0 then further~~Further actions for cumulative fatigue usage action limits may be invoked if good engineering judgment determines that is necessary.

Cumulative Fatigue Usage Action Limits and Corrective Actions

~~The~~The enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will use an automated three-dimensional, six-element stress tensor, stress-based fatigue management ~~program~~ software module (the SBF module, meeting ASME III NB-3200 requirements) ~~will~~to continually monitor cumulative usage factor (CUF) at the stress-based fatigue monitoring locations, and cycle-based CUFs will be calculated periodically. The CUF action limits for the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will be ~~revised~~established to provide two to three fuel cycles of warning prior to exceeding a CUF of 1.0.

CUF Action Limit Margins: To provide adequate time for corrective actions and adequate margin to permit continued operation, corrective actions for the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) will be required when calculated CUF (from cycle based or stress based monitoring) for any monitored location is projected to reach 1.0 within the next 2 or 3 fuel cycles. In order to assure sufficient margin to accommodate occurrence of a low probability transient, corrective actions must also be taken while there is still sufficient margin to accommodate at least one occurrence of the worst case (highest fatigue usage per cycle) design transient event. Action limits will be established to permit completion of corrective actions before ~~either~~ the usage factor ~~limit of~~reaches 1.0 ~~or the design basis number of events, as applicable, is exceeded~~.

For PVNGS locations identified in NUREG/CR-6260 and described in Section ~~4.3.4,~~4.3.4, "Effects of the Reactor Coolant System Environment on Fatigue Life of Piping and Components (Generic Safety Issue 190)," this action limit ~~is~~will be based on accrued fatigue usage calculated with the F_{en} factors required for including effects of the reactor coolant environment.

For example, if inadvertent RCS depressurization, when adjusted for the environmental effects of the reactor coolant system at a NUREG/CR-6260 location, causes 20% of the total allowable fatigue usage, corrective action for that location would be required before calculated usage (including the environmental effects factor, F_{en}) reached 0.8.

CUF Corrective Actions: If a CUF action limit is reached, ~~acceptable~~ corrective actions ~~include~~will be performed as necessary:

1) Determine whether the scope of the ~~monitoring~~enhanced Metal Fatigue of Reactor Coolant Pressure Boundary program (B3.1) must be enlarged to include additional affected reactor coolant pressure boundary locations. This determination will ensure that other locations do not approach design limits without an appropriate action.

2) Enhance fatigue monitoring to confirm continued conformance to the code limit.

3) Repair/modify the component.

4) Replace the component.

5) Perform a more rigorous analysis of the component to demonstrate that the design code limit will not be exceeded.

6) Modify plant operating practices to reduce the fatigue usage accumulation rate.

7) Perform a flaw tolerance evaluation and impose component-specific inspections, under ASME Section XI Appendices A or C (or their successors), and obtain required approvals by the NRC.

Table 4.3-4 - Summary of Fatigue Usage from Class 1 Analyses, and Method of Management by the Metal Fatigue of Reactor Coolant Pressure Boundary Program

Component	Maximum Design Basis CUF[xxxvi]	Reason for Monitoring	Fatigue Management Method[xxxvii]
25. RPV Inlet Nozzle	0.073080	NUREG/CR-6260	CBF-C
26. RPV Outlet Nozzle	0.309574	NUREG/CR-6260	CBF-C
27. RPV Wall and Bottom Head Juncture	0.0012	NUREG/CR-6260	Global[xxxviii]
28. RPV Wall Transition	0.0035	Bounding location	Global
29. RPV CEDM Nozzles	U1&2 = 0.0066 U3 = 0.0018	Bounding location	Global
30. RPV Instrument Nozzles	U1 = 0.68 U2&3 = 0.140	High CUF	Global
31. RPV Core Stabilizer Lugs	0.0600	Bounding location	Global
32. RPV Flow Baffle	0.0030	Bounding location	Global
33. RPV Fuel Alignment Plate	U1&2 = 0.7207 U3 = 0.9176[xxxix]	High CUF	Global
34. RPV Surveillance Holder Assembly	0.0714	Bounding location	Global
35. RPV Integral Supports	0.2900	Bounding location	Global
36. RPV Support Pad Flange	0.06	Bounding location	Global
37. RPV Head Studs	0.8236	High CUF	CBF-EP
38. RPV Closure Head Flange	0.0258	Bounding location	Global
39. RPV Bottom Head Support Lugs	0.9536[xl]	Bounding location	Global, Bounded by RPV Head Studs
40. Pressurizer Surge Nozzle	0.9602	High CUF	SBF
41. Pressurizer Spray Nozzle	0.9923	High CUF	SBF
42. Pressurizer Bottom Head and Support Skirt	0.7223	High CUF	CBF-C
43. Pressurizer Heater Sleeve Outside Diameter Weld - Sleeve to Head Juncture J-Weld	0.884 (60-year)	High CUF	SBF
44. Pressurizer Manway Cover Plate Assembly Bolts	U1 = 0.345 U2&3 = 0.3752	Bounding location	Global
45. Pressurizer Safety and Relief Valve Lines	0.0048	Bounding location	Global
46. Pressurizer Spray Piping	0.3788[xli]	Bounding location	Global
47. Hot Leg Surge Nozzle	0.534	High CUF	SBF
48. Surge Line (Elbow)	0.9370	High CUF/ NUREG/CR-6260	SBF
49. Auxiliary Spray Tee	0.6348[6] [xlii]	High CUF	CBF-EP
50. Auxiliary Spray Line	0.563[6]	Bounding location	Global, Bounded by Auxiliary Spray Tee
51. Charging Inlet Nozzle	0.9205	High CUF/ NUREG/CR-6260	CBF-EP
52. CVCS Letdown Line	0.2063	Bounding location	Global
53. CVCS Charging Line	0.3189	Bounding location	Global
54. Hot Leg Elbow	0.0177	Bounding location	Global

Table 4.3-4 Summary of Fatigue Usage from Class 1 Analyses, and Method of Management by the Metal Fatigue of Reactor Coolant Pressure Boundary Program

Component	Maximum Design Basis CUF[xxxvi]	Reason for Monitoring	Fatigue Management Method[xxxvii]
55. Shutdown Cooling Outlet Nozzles	U1&3 = 0.8068 U2 U_{60} = 0.72[xliii]	Bounding location	Global, Bounded by Shutdown Cooling Lines
56. Shutdown Cooling Lines	0.702[xliv]	High CUF	CBF-C
57. Shutdown Cooling Line Elbow	0.1118	NUREG/CR-6260	CBF-EP
58. Safety Injection Nozzles (Loop 1 and Loop 2)	0.3409	NUREG/CR-6260	CBF-PC
59. Safety Injection Piping	0.5155	High CUF	CBF-EP
60. Safety Injection Piping Whip Restraint Lugs	U1 = 0.6015 U2&3 = 0.628	Bounding location	Global
61. Reactor Coolant Drain Lines	0.2302	Bounding location	Global
62. Reactor Coolant Pump Casing Studs	0.988	High CUF	CBF-EP
63. RCP Motor Stand Shell to Flange Juncture	0.668	Bounding location	Global
64. RCP Seal Housing	0.3830	Bounding location	Global
65. RSG Economizer Feedwater Nozzle	U1&3 = 0.90970 U2 = 0.981	High CUF	SBF
66. RSG Downcomer Feedwater Nozzle	U1&3 = 0.983 U2 = 0.996	High CUF	SBF
67. RSG Support Skirt	U1&3 = 0.08331 U2 = 0.155	Bounding location	Global
68. RSG Support Skirt Access Opening Region (Unit 1 & 3 Only)	U1&3 = 0.75104	Bounding location	Global, Bounded by Economizer/ Downcomer FW Nozzles
69. RSG Primary Head	–	–	–
Hot Side	U1&3 = 0.02895 U2 = 0.0309	Bounding location	Global
Cold Side	U1&3 = 0.08502 U2 = 0.0352	Bounding location	Global
70. RSG Primary Inlet Nozzle	U1&3 = 0.04857 U2 = 0.04634	Bounding location	Global
71. RSG Primary Outlet Nozzle	0.01683	Bounding location	Global
72. RSG Primary Manway (Cover and Pad)	U1&3 = 0.03494 U2 = 0.037	Bounding location	Global
73. RSG Primary Manway Studs	–	–	–
Hot Side	U1&3 = 6.53 U2 = 6.33	Bounding location	Global - Replaceable
Cold Side	U1&3 = 4.011 U2 = 4.67	Bounding location	Global - Replaceable
74. RSG Primary Divider Plate	U1&3 = 0.03 U2 = 0.06	Bounding location	Global
75. RSG Tubes	0	Bounding location	Global

~~*Table 4.3-4 - Summary of Fatigue Usage from Class 1 Analyses, and Method of Management by the Metal Fatigue of Reactor Coolant Pressure Boundary Program*~~

Component	Maximum Design Basis CUF(xxxvi)	Reason for Monitoring	Fatigue Management Method(xxxvii)
~~76. RSG Tube-to-Tubesheet Weld~~	~~U1&3 = 0.18816 U2 = 0.792~~	~~Bounding location~~	~~Global, Bounded by Economizer / Downcomer FW Nozzles~~
~~77. RSG Tubesheet~~	–	–	–
~~Hot Side~~	~~U1&3 = 0.06570 U2 = 0.928~~	~~Bounding location~~	~~Global, Bounded by Economizer / Downcomer FW Nozzles~~
~~Cold Side~~	~~U1&3 = 0.39410 U2 = 0.507~~	~~Bounding location~~	~~Global, Bounded by Economizer / Downcomer FW Nozzles~~
~~78. RSG Tubesheet to Shell (Stub Barrel) Junction~~			
~~Hot Side~~	~~U1&3 = 0.10059 U2 = 0.064~~	~~Bounding location~~	~~Global~~
~~Cold Side~~	~~U1&3 = 0.99876 U2 = 0.996~~	~~High CUF~~	~~CBF-EP~~
~~79. RSG Economizer Cylinder at Tubesheet Cold Side (Unit 1 & 3 Only)~~	~~U1&3 = 0.01075~~	~~Bounding location~~	~~Global~~
~~80. RSG Secondary Shell~~	~~U1&3 = 0.00773 U2 = 0.00899~~	~~Bounding location~~	~~Global~~
~~81. RSG Downcomer Blowdown Nozzle~~	~~U1&3 = 0.197 U2 = 0.273~~	~~Bounding location~~	~~Global~~
~~82. RSG Recirculation Nozzle~~	~~U1&3 = 0.099 U2 = 0.114~~	~~Bounding location~~	~~Global~~
~~83. RSG Steam Outlet Nozzle~~	~~U1&3 = 0.169 U2 = 0.1767~~	~~Bounding location~~	~~Global~~
~~84. RSG Secondary Manway Pad~~	~~U1&3 = 0.129 U2 = 0.140~~	~~Bounding location~~	~~Global~~
~~85. RSG Secondary Manway Studs~~	~~U1&3 = 0.618 U2 = 0.7714~~	~~Bounding location~~	~~Global - Replaceable~~
~~86. RSG Welded Secondary Handholes (Unit 1 & 3 Only)~~	~~U1&3 = 0.113~~	~~Bounding location~~	~~Global~~
~~87. RSG Welded Secondary Handhole Studs (Unit 1 & 3 Only)~~	~~U1&3 = 0.424~~	~~Bounding location~~	~~Global - Replaceable~~
~~88. RSG Stub Barrel Secondary Handhole~~	~~U1&3 = 0.940 U2 = 0.955~~	~~High CUF~~	~~CBF-EP~~
~~89. RSG Stub Barrel Secondary Handhole Studs~~	~~U1&3 = 1.35 U2 = 2.15~~	~~Bounding location~~	~~Global - Replaceable~~
~~90. RSG Upper Support Lugs~~	~~U1&3 = 0.405 U2 = 0.161~~	~~Bounding location~~	~~Global~~

Table 4.3-4 - Summary of Fatigue Usage from Class 1 Analyses, and Method of Management by the Metal Fatigue of Reactor Coolant Pressure Boundary Program

Component	Maximum Design Basis CUF(xxxvi)	Reason for Monitoring	Fatigue Management Method(xxxvii)
91. RSG Feedwater Distribution Box	U1&3 = 0.99201 U2 = 0.988	Bounding location	Global, Monitored by Economizer Feedwater Nozzle Location

INSERT TABLE 4.3-4 HERE

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[9] Transients not counted in the APS fatigue cycle count verification are marked as "NC."

[10] Transient was counted by the cycle count procedure since initial plant startup, therefore no cycles were assumed. The "Composite Worst-Case Unit Accumulation" is the same as the "(1985-2005)" procedure count.

[11] Transients not recorded in the 73ST-9RC02 procedure are marked as "NR."

[12] Transients 5 and 6 were not counted separately in the cycle count procedure; only 10% power increases were recorded in the procedure. Due to an incomplete transient description, the procedure only included power changes between 90% and 100% power.

[13] Transient was not separately counted in the cycle count procedure, therefore the APS recount included all occurrences from 1985-2005. The "Accumulation Rate" was calculated by taking the APS recount number and dividing by the least number of years in operation up to 19952005 (Unit 3 operating period of 18 years) to determine the worst-case number of events experienced per year. The "Composite Worst-Case Unit Accumulation" was calculated by multiplying the calculated "Accumulation Rate" by 10 years (1995 to 2005) and adding the result to the APS recount.

[14] Transient event does not contribute significantly to fatigue and is not counted by the Fatigue Management Program APS recount. The "Composite Worst-Case Unit Accumulation" includes the 25% accumulation assumed in 1995.

[15] The "Composite Worst-Case Unit Accumulation" for Transient 16, "Unbolting/Bolting of RC Pump Casing Studs," is a conservative estimate for a worst-case stud, extracted by review of maintenance work orders, for the APS fatigue cycle count verification.

[16] The APS fatigue cycle count verification resulted in higher than expected projected values for Transients 16, 17, 24, 26, 36, 40, and 50, 60, and 61. These transients will require re-evaluation or other corrective actions when action limits are reached.

[17] Transient 18, "Safety Injection Check Valve Test" is not counted specifically because the check valve test is performed during a stage of startup at normal heatup pressure and temperature, resulting in no significant fatigue accumulation.

[18] Transient is not expected to occur; therefore no "Accumulation Rate" value calculated for this transient. However, at least one occurrence was assumed to occur during the period of extended operation.

[19] Transient has no to-date accumulation through 2005. The "Accumulation Rate" was determined by dividing the design basis number of transient events by 40 years and multiplying the result by the percentage of years left in the design basis (22/40).

[20] UFSAR numbers of 5 events from 100% power; 40 events from an unspecified power level.

[21] Transient 39, "Seismic Event up to and including One-Half of the Safe Shutdown Earthquake, at 100% Power" is not counted specifically because it is included in the count for transient 27, "Operating Basis Earthquake."

[22] Transient 42, "Loss of Feedwater Flow (to S/G)" is not counted specifically by the Fatigue Management Program software because it is included in the sum of the counts for transients 47, 48, and 49.

[23] Transient 53, "Inadvertent Closure of all MFIVs at 100% Power" is not counted specifically because it is a duplicate of transient 49, "MFIV Closures due to Loss of Air at 100% Power".

[24] Transients 60 and 61, "LPSI and HPSI Pump Tests" are not listed as Licensing and Design Basis Transients. These are quarterly tests that add significant fatigue to the pumps and components upstream of the isolation valves.

[25] Transient 32, "Extended Loss of Letdown" was added to the 73ST-9RC02 procedure in 1998. At that point, 200 cycles were assumed for Unit 3 only (25% of design), and 0 cycles for Units 1 and 2. The actual data recorded from 19951985-2005 include 64 cycles of this transient for Unit 1, 01 cycles for Unit 2, and 2 cycles for Unit 3. The 73ST-9RC02 Worst-Case (1985-2005) column ignores the 200 assumed for Unit 3. The Worst-Case Composite Unit Accumulation for Transient 32, "Extended Loss of Letdown," is the 64 counted cycles from the Unit 1 surveillance data.

[26] Transient 21, "Auxiliary Spray During Cooldown," occurs during each occurrence of Transient 12, "Pressurizer Cooldown."