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WCAP-17100-P/NP, Revision 1
Project Number 694

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U.S. Nuclear Regulatory Commission
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Subject: Pressurized Water Reactor Owners Group
Comments to the NRC Draft Safety Evaluation for Pressurized Water Reactor Owners Group (PWROG) on Topical Report (TR) WCAP-17100-P/NP, Revision 1, "PRA Model for the Westinghouse Shut Down Seal", PA-RMSC-0499

References:

1. NRC Letter, John R. Jolicoeur, Chief, Licensing Processes Branch of NRR to Mr. Tony Nowinowski of the PWR Owners Group Program Management Office, "Draft Safety Evaluation for Pressurized Water Reactor Owners Group Topical Report WCAP-17100-P/NP, Revision 1, "PRA Model for the Westinghouse Shut Down Seal", (TAC No. ME1785), December 20, 2010.

This letter provides the PWROG comments on the draft Safety Evaluation (SE) for WCAP-17100-P/NP, Revision 1. As requested, the comment package includes a markup to the draft SE, Enclosure 1, and a Table of the recommended changes, Enclosure 2.

Following receipt of the final Safety Evaluation for WCAP-17100-P/NP Revision 1, the SE will be incorporated into the approved version and will be issued as WCAP-17100-P-A Revision 1 and WCAP-17100-NP-A Revision 1.

D048
NRC
Designated as Original
3/17/11
Jonathan Rowley

If you have any questions, please do not hesitate to contact me at (704) 382-8619 or Mr. W. Anthony Nowinowski, Program Manager of the PWR Owners Group, Program Management Office at (412) 374-6855.

Sincerely,

T. Zachariah Approving for M. Arey

Melvin L. Arey Jr., Chairman
Pressurized Water Reactor Owners Group

MLA:TZ:las

Enclosures: (2)

cc: PWROG Management Committee
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1 DRAFT SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

2
3 TOPICAL REPORT WCAP-17100-P/NP, REVISION 1,

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5 "PRA MODEL FOR THE WESTINGHOUSE SHUT DOWN SEAL" (PA-RMSC-0499)

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7 PRESSURIZED WATER REACTOR OWNERS GROUP

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9 PROJECT NO. 694

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12 1.0 INTRODUCTION AND BACKGROUND

13
14 By letter dated July 17, 2009 (Agencywide Documents Access and Management System
15 (ADAMS) Accession No. ML092170346), the Pressurized Water Reactor (PWR) Owners Group
16 (PWROG) requested U.S. Nuclear Regulatory Commission (NRC) staff review of Topical Report
17 (TR) WCAP-17100-P/NP, Revision 0, "PRA Model for the Westinghouse Shutdown Seal." A
18 meeting between the PWROG representatives and the NRC staff was held on July 29, 2009, for
19 the PWROG to explain the information contained within TR WCAP-17100-P/NP, Revision 0. By
20 letter dated September 29, 2009 (ADAMS Accession No. ML092660201), the NRC staff
21 accepted TR WCAP-17100-P/NP, Revision 0, for review. In a letter dated November 30, 2009
22 (ADAMS Accession No. ML093140165), the NRC staff transmitted a Request for Additional
23 Information (RAI) to the PWROG. On January 13, 2010, the PWROG representatives met with
24 NRC staff to explain the draft RAI responses and officially submitted the RAI responses by letter
25 dated January 27, 2010 (ADAMS Accession No. ML103160275). By letter dated March 4, 2010
26 (ADAMS Accession No. ML101020571), the PWROG submitted TR WCAP-17100-P/NP,
27 Revision 1, which incorporated the RAI responses previously submitted on January 27, 2010. A
28 telephone call was held with the PWROG on April 1, 2010, to answer additional questions
29 concerning TR WCAP-17100-P/NP, Revision 1, and the PWROG submitted answers to the
30 additional questions by letter dated May 19, 2010 (ADAMS Accession No. ML103160276).

31
32 The Westinghouse Electric Company (Westinghouse) has developed a reactor coolant pump
33 (RCP) shut down seal (SDS) that, when actuated, is expected to restrict reactor coolant system
34 (RCS) inventory losses to very small leakage rates during plant events that arise from the loss
35 of all RCP seal cooling. The SDS is a thermally actuated, passive device that is to be physically
36 installed in existing seal packages between each RCP No. 1 seal and the No. 1 seal leak-off line
37 to provide a leak-tight seal in the event of existing seal failure due to elevated temperature
38 conditions following the loss of RCP seal cooling. Westinghouse anticipates that installation of
39 the SDS will provide a basis for a new RCP seal behavior model.

40
41 The TR reported, in part, on the testing and analysis to verify the performance of the SDS. The
42 testing has included individual component tests as well as tests of the entire seal assembly. A
43 Probabilistic Risk Assessment (PRA) model was developed for the SDS that is based on the
44 failure modes and effects analysis (FMEA) and the subsequent testing and analysis. The
45 statistically based failure probability for the SDS to fail to actuate and seal to very low leakage is

1 derived from the test data. Plants installing the Westinghouse SDS will likely change its PRA to
2 credit this enhanced safety capability. However, this safety evaluation (SE) does not approve
3 the installation of the SDS.

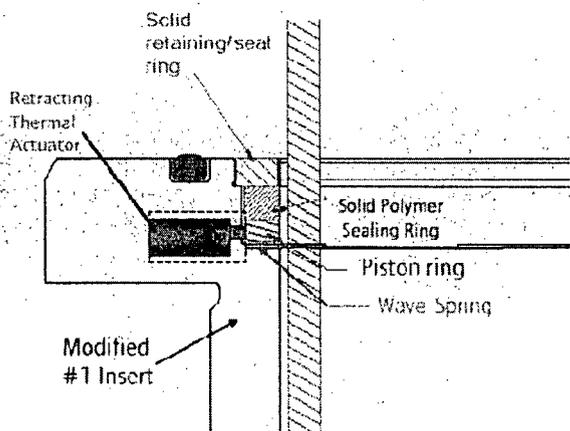
4 5 1.1. Discussion

6
7 For PWRs using Westinghouse RCPs, the potential for the loss of all RCP seal cooling resulting
8 in seal failure-induced loss-of-coolant accidents (LOCAs) increases the likelihood of core
9 damage. Seal LOCA has been a dominant contributor in several NRC and licensee PRA
10 models. Most of these events are initiated by either a loss of alternating current (AC) power
11 impacting seal cooling or other events contributing to the loss of component cooling and service
12 water systems. For Westinghouse RCPs, the loss of all seal cooling is the combined loss of
13 thermal barrier cooling and seal water injection. In many plants, component cooling water
14 (CCW) provides RCP thermal barrier cooling as well as cooling to charging pumps which in turn
15 provide seal injection. For such plants, a loss of CCW alone would result in a potential loss of
16 seal cooling and injection which has the potential to cause a seal LOCA. For RCPs with high
17 temperature ("improved") O-ring seals, the NRC staff has found it acceptable to evaluate
18 potential seal failure-induced LOCAs using the Westinghouse Owners Group (WOG) 2000 seal
19 leakage model presented in WCAP-15603-A, Revision 1 (Reference 1). The WOG 2000 model
20 assumes the onset of seal failure within 13 minutes following the loss of cooling and apportions
21 four discrete failure probabilities based on flow rates with 480 gallons per minute (gpm) being
22 the maximum rate from each RCP seal package. To use the WOG 2000 model, licensees had
23 to justify timely trip of running RCPs and perform cooldown/depressurization to less than 1710
24 pounds per square inch differential within two hours following the loss of cooling. With the
25 inclusion of the SDS described in TR WCAP-17100-P/NP, Revision 1, licensees will be allowed
26 to use a new seal cooling failure model that greatly reduces leakage of reactor coolant following
27 a loss of seal cooling.

28 29 1.2. Summary of Design of SDS

30
31 The RCP SDS is located between the No. 1 and No. 2 seals, just upstream of the No. 1 seal
32 leak-off line in the housing of the No. 1 insert, encircling the shaft. The No. 1 seal insert is
33 modified by machining out a portion of the inner diameter at the top flange. Until activated, the
34 SDS is completely contained within the space once taken by the No. 1 insert prior to
35 modification. Thus the annulus between the No.1 insert and the shaft is unaltered. The leak-off
36 through the No. 1 seal is expected to be unimpeded on its way to the No. 1 seal leak-off line and
37 should not be affected during normal operation of the rotating equipment.

38
39 The SDS is composed of an actuating device and a sandwich composed of a wave spring, a
40 piston ring, a polymer ring, and a retaining ring. The actuating device holds the piston ring
41 "open" permitting No. 1 seal leak-off to flow up the shaft to the No. 1 seal leak-off line. The
42 polymer ring is sandwiched between the piston ring and the retaining ring. The retaining ring is
43 shrink-fitted and retains all of the SDS components. When assembled in the pump, the
44 retaining ring is further retained in place by the RCP seal housing located directly above it. The
45 wave spring is designed to maintain contact between the three rings.



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The activating portion of the seal is made up of a retractable spacer holding the ends of a piston ring open. The retractable spacer is activated by a thermally responsive piston device. When the fluid coming through the No. 1 seal increases to the temperature that causes the actuator to retract the spacer from the piston ring, the piston ring snaps closed against the shaft, providing a significant flow restriction and causing the pressure to build on the back side of the polymer ring. With the flow severely restricted, the pressure at the piston ring approaches the RCS pressure which forces the polymer ring against the shaft, creating a leak-tight seal. While the piston ring provides a substantial flow restriction, the primary sealing ring is a polymer material that, when acted upon by the very high pressure drop induced by the piston ring interrupting the flow through the annulus, is constricted around the shaft and upwards against a retaining ring. As the primary sealing ring constricts, it creates greater pressure drop which in turn further constricts the ring tighter around the shaft and upwards. This pressure drop also forces the piston ring and retaining ring upwards, ensuring a tight seal between all the sealing surfaces. The polymer ring design is expected to conform to pump shaft out-of-roundness, scratches, dents, debris, roughness, and other surface anomalies. Westinghouse maintains that an advantage of the polymer is its ability to slip along the shaft axially and shift with it radially and still maintain a tight seal. This is because it is a continuous ring with a low coefficient of friction. The piston ring, once it initiates sealing, is no longer required for the polymer ring to seal.

The piston ring provides a secondary method to reduce No. 1 leak-off flow in the event of a polymer ring failure caused by a poorly sealing polymer ring or an inadvertent actuation. If the SDS actuates on a stationary sealing surface and the polymer ring fails to seal, the piston ring restricts flow to 1.5-7 gpm. If the polymer ring is removed, i.e. RCP is allowed to continue to operate and the polymer ring is completely worn away, analysis states that the piston ring will wear a gouge into the sealing surface until the ring's two ends meet. The leak-off flow through the RCP shaft/retaining ring annulus will be restricted to 19 gpm.

Installation of the SDS is projected to reduce RCS inventory losses through the RCP seals, following a loss of seal cooling, to a negligible amount requiring no additional RCS makeup to achieve a stable state with the reactor core being cooled. The design basis for the SDS is contained in Section 3.1.2 of TR WCAP-17100-P/NP, Revision 1. In Westinghouse's

1 development of the design basis, an 8-hour station blackout (SBO) coping time and 72-hour fire
2 cold shutdown time were considered with a seal leakage rate of under 1 gpm.

3 4 2.0 REGULATORY EVALUATION

5
6 The NRC's policy statement on the use of PRA methods in nuclear regulatory activities
7 (Reference 2) encourages greater use of PRAs to improve safety decision-making and improve
8 regulatory efficiency. Examples of where elements of risk-informed decision-making are
9 currently used include: the reactor oversight process, the significance determination process,
10 the implementation of several risk-informed rules, backfit and generic safety issue analyses, and
11 modifying an individual plant's licensing basis. The NRC's policy statement also states that the
12 PRAs used in support of regulatory decisions should be as realistic as practicable.

13
14 Regulatory programs which will be directly impacted by a change in modeling potential seal
15 LOCAs include Title 10 of the *Code of Federal Regulations* Part 50.48 (10 CFR 50.48), "Fire
16 Protection," Appendix R to 10 CFR Part 50, "Fire Protection Program for Nuclear Power
17 Facilities Operating Prior to January 1, 1979;" 10 CFR 50.63, "Loss of all alternating current
18 power;" and 10 CFR 50.65, "Requirements for monitoring the effectiveness of maintenance at
19 nuclear power plants." The regulation at 10 CFR 50.63 states that all plants holding a license
20 under 10 CFR Part 50 shall be able to withstand for a specified duration and recover from a
21 SBO. The regulation at 10 CFR 50.48 states that all plants holding a license under 10 CFR
22 Part 50 or 10 CFR Part 52 must have an NRC-approved fire protection plan. Appendix R to
23 10 CFR Part 50 requires that pressurizer level indication be maintained on-scale in the event of
24 a fire to allow for RCS pressure control and allow for a means to obtain safe shutdown.
25 Appendix R to 10 CFR 50 also requires that a plant be able to maintain hot shutdown conditions
26 following a design basis fire and then achieve cold shutdown within 72 hours.

27
28 Other programs and processes which are impacted by the SDS are the Reactor Oversight
29 Process (ROP), Mitigating Systems Performance Indicators (MSPI), and Risk-informed
30 Technical Specifications initiatives 4b and 5b submittals. Installation of the SDS is made to an
31 existing RCP seal package and therefore constitutes a change, test, or experiment to the
32 facility. Therefore, it is expected that licensees perform a 10 CFR 50.59, "Changes, tests, and
33 experiments," assessment.

34
35 The NRC staff reviewed the models presented in TR WCAP-17100-P/NP, Revision 1, and
36 compared it with the existing models for Westinghouse high temperature O-ring seals as
37 described in WCAP-15603-A, Revision 1. The SDS represents a significant departure in
38 modeling seal failure since successful actuation of the SDS with timely trip of RCPs is expected
39 to preclude any substantial leakage. With the issuance of TR WCAP-17100-P/NP, Revision 1,
40 as modified with additional NRC staff conditions identified in this SE, an alternative RCP seal
41 package model will be recognized by the NRC for those plants that opt to install the SDS in
42 existing Westinghouse seal packages with high-temperature O-rings.

43 44 3.0 TECHNICAL EVALUATION

45
46 The NRC staff review of TR WCAP-17100-P/NP, Revision 1 was evaluated from a safety and
47 reliability basis. The NRC staff's evaluation included verification that the applicant followed the
48 applicable regulatory guidance, performed independent calculations, and validated that the
49 appropriate assumptions were made. Westinghouse performed testing and statistical analysis
50 of test data, directed by a FMEA, to determine the reliability of the SDS to limit flow to design

1 basis levels. The following were major areas of consideration for the NRC staff in evaluating the
2 risk aspects of the SDS.

3
4 3.1 Statistical Analysis of Failure of SDS to Seal

5
6 In Section 3.2.3.1.2 of TR WCAP-17100-P/NP, Revision 1, in evaluating the ability of the SDS
7 to remain sealed for the assumed 8-hour SBO coping time, Westinghouse used a One
8 Sample T-test methodology on test leakage data. The observed leak rates were less than the
9 precision of the flow measurement instrumentation. Westinghouse proposed treating the
10 observed data as normal where the mean was determined to be that of the flow detectable by
11 the most precise instrument. Westinghouse concluded that the level of conservatism used in
12 the data resulted in estimated mean flow rates that were projected to be 10,000 times greater
13 than the lowest detectable flow. The NRC staff had a concern about using the behavior of the
14 instrumentation itself as a surrogate in developing a statistical model and probability distribution.
15 The NRC staff believes that this may not accurately reflect conditions of flow from a failed SDS
16 that would behave independent of test instrument precision. Westinghouse responded by
17 performing a Bayesian analysis described in Section 3.2.3.1.2 of TR WCAP-17100-P/NP,
18 Revision 1. A Jeffreys non-informative prior distribution was applied to the data from the
19 24-22 tests which yielded a failure rate of 0.0227-0217 failures per demand of the SDS. In
20 Section 3.2.3.1.2 of TR WCAP-17100-P/NP, Revision 1, Westinghouse described the
21 conservatism of using a Bayesian approach to analyze test data. The NRC staff recognizes that
22 components of the SDS were tested in environmental conditions approaching those seen in
23 RCPs. However, the NRC staff believes that it would be prudent to adopt the higher failure rate
24 of 0.0217 per demand until better data can be collected from operating experience.

25
26 In evaluating the longevity of the SDS, Westinghouse observed no failures. With no observed
27 failures, Westinghouse estimated mean time to failure using a Weibull analysis approach with
28 the assumption of failure at the conclusion of the two longest successful tests. The NRC staff
29 agrees with this conservative assumption given no data for the long-term life of the SDS.

30
31 3.2 Parametric Uncertainty and the Common Cause Failure Treatment of Multiple Reactor
32 Coolant Pumps

33
34 For modeling simplicity, Section 3.3.4 of TR WCAP-17100-P/NP, Revision 1, assumes that all
35 RCPs for the affected unit experience the same leakage scenario for a failed SDS. It states that
36 this modeling approach is likely conservative, but that to rigorously address multiple RCP
37 leakage scenarios would make the model very complicated. The NRC staff concurs with the
38 assessment that to address the RCPs individually would involve a greater level of complexity,
39 including the need to address the potential common cause conditions (e.g., RCP seal inlet
40 temperatures) and common cause failure modes between RCPs. The NRC staff agrees with
41 the simplification in approach to assessing common cause failure. The NRC staff expects that a
42 single SDS failure rate of 0.0217 would be used to represent all SDS installed in the plant. The
43 NRC staff also agrees with the assumption for parametric uncertainty that, absent of operating
44 data, an error factor of 10 is reasonable. However, the NRC staff differs on use of the WOG
45 2000 model alone for assessing the consequence of SDS failure to actuate. Instead, licensees
46 should use the appropriate RCP seal leakage model which was applicable to the type of seal
47 package installed in their RCPs prior to modification to the SDS. For example, the WOG 2000
48 model should only be applicable to those RCP seals with Westinghouse high-temperature O-
49 rings.

1 3.3 Inadvertent Actuation of SDS

2
3 A concern was raised by the NRC staff that inadvertent actuation of the SDS on a fully rotating
4 RCP shaft while seal cooling is available might create a new, previously unanalyzed condition
5 which could result in failure of the existing RCP seals. As described in Section 3.2.3.11.5 of
6 TR WCAP-17100-P/NP, Revision 1, Westinghouse performed two 1200 revolutions per minute
7 (rpm) tests to model the impact of inadvertent actuation of a SDS while a RCP is operating at
8 full speed. Inadvertent actuation of seals is assumed by Westinghouse to be detected by
9 licensees since the decrease in the seal leak-off rate will trigger an alarm due to reaching the
10 low flow alarm setpoint. This alarm requires tripping of the RCP. Based on results from these
11 tests and the assumption that licensees will trip pumps upon receipt of the low flow alarm,
12 Westinghouse concluded that there will be no damage to the existing RCP seals since any large
13 debris from a catastrophically failed SDS will be contained within the area of the SDS. Small
14 debris is assumed by Westinghouse to safely pass through to the No. 1 seal leak-off line
15 strainer. The NRC staff noted that these tests did not adequately prove that an inadvertent SDS
16 actuation without an RCP trip would not have a detrimental impact on the existing RCP seal
17 package. Additionally, the NRC staff determined that the description and analysis of the effects
18 to the RCP seal package, plant systems, and RCS from the debris of an inadvertently actuated
19 SDS was not complete. More information is needed on the effects of an inadvertent actuation to
20 fully determine the impacts on the SDS PRA model or the plant-wide PRA model.

21
22 For model 100 RCPs, Westinghouse noted that there was insufficient time to trip the RCPs on a
23 non-SBO loss of seal cooling. A recommendation should be developed by Westinghouse to
24 address this issue.

25
26 3.4 Trip of RCPs and Use of the PRA Model

27
28 The NRC staff reviewed the illustrative event tree model in Figure 3-13 and failure probabilities
29 presented in Section 3.3 of TR WCAP-17100-P/NP, Revision 1. The top events that
30 Westinghouse considered in modeling the SDS are summarized below:

- 31
32
- 33 • SDS Actuates - This top event represents the successful operation of the retracting
34 actuator to retract the spacer from the piston ring and allow the piston ring to close on
35 the RCP shaft. SDS successful actuation is defined as the withdrawal of the spacer
36 from the piston ring when the fluid temperature in the SDS region is in the range of
37 250 °F to 290 °F and the clamping of the piston ring on the shaft (or sleeve) to constrict
38 flow from the No. 1 RCP seal such that RCS pressure builds on the back side of the
39 polymer ring.
 - 40 • Pump Shaft Stops Rotating - This top event represents a stopped RCP shaft prior to or
41 shortly after SDS actuation such that an effective seal can be made by the polymer ring.
42 The shaft is considered to stop rotating if the pump motor is tripped (either manually or
43 by a loss of power) upon a loss of all RCP seal cooling. A loss of all seal cooling is
44 characterized by a loss of seal injection and a loss of thermal barrier cooling (CCW),
45 both of which are alarmed in the control room. A manual trip can be assumed to
46 occur if the pump is tripped within the expected operator response time shown in
47 TR WCAP-17100-P/NP, Revision 1, Table 3-20, after the loss of all RCP seal cooling
48 event occurs. If the pump has not been tripped within the allowable time window,
49 Westinghouse assumes that the piston ring will still clamp tightly on the shaft but the
50 polymer may degrade sufficiently such that it does not seal at its design basis leakage
51 rate of less than 1 gpm.

- 1 • Polymer Ring Initially Seals – This top event is the probability that the polymer ring
2 initially seals and limits leakage from the RCS for the first eight hours of the event. The
3 tests performed to measure the leak-tightness and survivability of the polymer ring on a
4 static shaft provide a statistical failure probability in the first eight hours of less than
5 0.02274-0217 percent at an average leak rate of less than 1 gpm level.
6
- 7 • Polymer Ring Remains Sealed – This top event is the probability that the polymer ring
8 initially seals and limits leakage from the RCS for the 8- to 24-hour time period. The
9 tests performed to measure the leak-tightness and survivability of the polymer ring on a
10 static shaft provide a statistical failure probability in the 8- to 24-hour period of less than
11 10 percent at the average leakage rate of less than 1 gpm. Failure to remain sealed for
12 the 24-hour period would introduce a leakage rate of less than 2 gpm through the seal
13 package as limited by the actuation of the piston ring.
14

15 Westinghouse used the following outcomes in its event tree analysis:

- 16
- 17 • Less than 1 gpm leakage - For the smooth surface tests of the SDS assembly sealing
18 capability, the polymer ring formed a leak-tight seal against the shaft. However, in the
19 case of scratches on the shaft, a leakage rate as high as 0.73 gpm was observed. For
20 the Model 93A pumps, a new shaft sleeve will be installed along with the SDS and
21 modified No. 1 insert to preclude initial scratches. However, to allow for minor scratches
22 during installation of the SDS, a leakage rate of less than 1 gpm was assumed. For the
23 Model 93, 93A1, and 100 pumps where the SDS will seal against the shaft that may be
24 scratched during previous pump maintenance activities, larger scratches may be
25 present. The Westinghouse criterion for scratches will assure that any scratches in
26 excess of that predicted to result in leakage greater than 1 gpm will be repaired with a
27 qualified repair process.
28
- 29 • 2 gpm leakage - For the cases in which the piston ring actuates but the polymer ring
30 does not seal leak-tight against the pump shaft or the polymer ring suffers from long
31 term degradation, the leakage rate will be in excess of 1 gpm. For those cases in which
32 the faces of the SDS seal components remain in contact (e.g., no break-up of the
33 polymer ring), a limiting value of 2 gpm is used. The 2 gpm flow is rounded-up from the
34 maximum design flow of 1.5 gpm for conditions of an actuated piston ring with the
35 polymer ring in its original position. Westinghouse indicated that there are no known
36 mechanisms for break-up of the polymer ring as long as rotation of the pump shaft has
37 stopped within a short time after SDS actuation.
38
- 39 • 19 gpm leakage - For cases in which the SDS actuates but the pump shaft continues to
40 rotate because the pump motor is not tripped in a timely manner, the polymer ring would
41 overheat and begin to degrade. The Westinghouse analysis showed that even if the
42 polymer ring completely disappears and the piston ring wears to its maximum extent
43 possible, the leakage would be limited to 19 gpm. This assumes that the entire pressure
44 differential is carried across the SDS and no credit is taken for the No. 1 seal in limiting
45 RCS inventory losses. Westinghouse assumed that leakage rates will not increase to
46 those levels in the WOG 2000 model.
47
- 48 • WOG 2000 Model - For cases in which the SDS fails to actuate, the flow past the SDS
49 will be unimpeded since it fits entirely within the volume of the No. 1 insert that was

1 machined for SDS installation. The 3-stage RCP seal will behave as described in
2 TR WCAP-10541 (Reference 3) and TR WCAP-15603, Revision 1-A (Reference 4).

3
4 3.5 Documentation Requirements

5
6 The RCP seal leakage model, including any related bases and analyses, used by licensees
7 must be documented in the licensee-controlled PRA documentation. This documentation must
8 include the licensee's evaluation of and determination that the plant-specific procedures and
9 conditions support the applicability of the model used.

10
11 If, on a plant-specific basis, the SDS model is used in a manner different than described in
12 TR WCAP-17100-P/NP, Revision 1, as modified by the conditions, limitations, and modifications
13 imposed by this SE, or if it is used for plant-specific conditions and procedures that are different
14 than typically assumed for Westinghouse plants, then the licensee must provide a justification
15 for that model, including its supporting analyses and related bases, in their licensee-controlled
16 PRA documentation. In addition, a summary discussion of these differences in the plant-
17 specific model used by the licensee must be included in any risk-informed license applications
18 submitted to the NRC for review and approval.

19
20 4.0 LIMITATIONS AND CONDITIONS

21
22 The NRC staff finds that the models and parameters in Section 3.4 of this SE are acceptable for
23 use in plant-specific PRAs and in support of risk-informed applications provided they are
24 supplemented and used in accordance with the following limitations, conditions, and
25 modifications:

- 26
27 1. The model can ~~only~~ be used to describe the consequence of loss of reactor seal cooling
28 in PRAs after the SDS is installed on Model 93A RCPs. The NRC staff also approves
29 the model for use on Model 93 and Model 93A-1 RCPs provided that there are no
30 significant changes to the SDS design other than the sealing surface (93A sleeve vs.
31 shaft for the model 93 and 93A) and dimensional changes to the SDS components to
32 accommodate the different sealing surface. Any other differences must be tested to the
33 same level of rigor as that described in the WCAP-17100-P/NP and submitted to NRC
34 for approval does not approve the use of PRA models with the SDS installation on any
35 pumps other than Model 93A RCPs.
36
37 2. The RCP seal packages with floating ring seals shall be removed prior to installation of
38 the SDS.
39
40 3. Licensees shall consider additional sequences that might be introduced in the Level 2
41 PRA model for changes in high pressure core melt progressions.
42
43 4. A plant-specific Human Error Probability must be developed for failure to trip RCPs in a
44 timely manner as described in Table 3-20 of TR WCAP-17100-P, Revision 1. A seal
45 leakage rate of 19 gpm shall be assumed for failure resulting in a SDS leakage through
46 a rotating shaft (i.e., after a fail to trip RCPs in a timely manner event).
47
48 5. Licensees should initially assume a failure rate of ~~0.0227~~ 0.217 failures per demand for
49 the SDS failing to actuate which may be updated with ~~Bayesian~~ Bayesian methods as
50 operational data is gained. This failure rate is to be used to represent all RCPs with the
51 SDS and not each individual RCP.

- 1
2 6. Any impact of SDS debris on the RCP seal package or the RCS from an inadvertent
3 actuation should be included in each plant-specific SDS PRA model in a manner
4 consistent with the 50.59 assessment performed for SDS installation.
5
6 7. A recommendation should be developed by Westinghouse to address the insufficient
7 time to trip the model 100 RCPs, on a non-SBO loss of seal cooling.
8
9 8. This SE does not approve the installation of the SDS. The 50.59 assessment should be
10 used to determine required approvals and processes for installation.
11

12 In developing revised procedures, the NRC staff expects that licensees shall adhere to the
13 following Westinghouse restrictions:
14

- 15 • Re-establishing seal injection or thermal barrier cooling should not be performed if RCP
16 seal cooling has been lost and the temperatures exceed the criteria for RCP shutdown.
17
18 • Re-establishing seal injection should not be performed if the SDS has not actuated after
19 RCP seal cooling has been lost and the temperatures exceed the criteria for RCP
20 shutdown.
21
22 • Cooling down (at less than or equal to 100 °F per hour) and depressurize the RCS
23 following a loss of all seal cooling event to prevent thermal shock to the RCP seal
24 package, to minimize RCS inventory loss through the RCP seals, and maximize
25 recovery time. RCS cooldown and depressurization can be delayed until plant
26 stabilization and equipment status checks have been completed if it can be diagnosed
27 that the SDS has actuated and provides a tight seal.
28
29 • Consider the rapid diagnosis of a loss of seal cooling event followed by tripping of the
30 RCPs based on high temperatures or low flow due to loss of charging pump and CCW
31 flow.
32
33 • Provide training on diagnosing and taking action on any indication of abnormal seal
34 behavior.
35
36 • Do not start oil lift pumps to aid in natural circulation cooling of the reactor core when all
37 RCP seal cooling is lost.

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38
39 If the SDS is installed in the RCPs over several outages, the NRC staff expects that licensees
40 PRA models will reflect both seal behaviors as appropriate by separately modeling the
41 probabilities and leakages for those RCPs with the SDS and the probabilities and leakages for
42 those RCPs without the SDS.
43

44 5.0 CONCLUSION

45
46 The NRC staff has found that the analysis of test data is reasonable because it relies on
47 accepted statistical analysis of observed test data. The NRC staff has found that associated
48 PRA and deterministic models in Section 3.4 above are acceptable because they appropriately

1 reflect the failure modes and scenarios of the SDS during normal, abnormal, and accident
2 conditions.

3
4 With the limitations and conditions listed in Section 4.0, TR WCAP-17100-P/NP, Revision 1,
5 may be referenced in plant-specific PRA as well as the basis for plant licensing basis station
6 blackout and fire protection coping strategies.

7
8 6.0 REFERENCES

- 9
10 1. Letter from Herbert Berkow, Director Project Directorate IV Division of Licensing Project
11 Management to Robert Bryan, Chairman Westinghouse Owners Group, Safety
12 Evaluation of Topical Report WCAP-15603, Revision 1, "WOG 2000 Reactor Coolant
13 Pump Seal Leakage Model for Westinghouse PWRs (TAC No. MB1714)," May 20, 2003.
14
15 2. U.S. Nuclear Regulatory Commission, "Use of Probabilistic Risk Assessment Methods in
16 Nuclear activities: Final Policy Statement," Federal Register, Volume 60, page 42622
17 (60 FR 42622), dated August 16, 1995.
18
19 3. WCAP-15041, Revision 2, "Reactor Coolant Pump Seal Performance Following a Loss
20 of All AC Power," Westinghouse Electric Company, November 1986.
21
22 4. WCAP-15603, Revision 1-A, "WOG 2000 Reactor Coolant Pump Seal Leakage Model
23 for Westinghouse PWRs," Westinghouse Electric Company, June 2003.

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28

29 Date: December 20, 2010

| Discussion of PWROG Comments on the Draft Safety Evaluation for WCAP-17100-P/NP | | | |
|---|------|--|---|
| Page | Line | Suggested Change | Basis for Change |
| 2 | 19 | Added "-A" to WCAP-15603 | The officially recognized version of the WCAP is WCAP-15603-A, Revision 1 |
| 3 | 26 | Change 1.5 gpm to 1.7 gpm | See OG-11-30, WCAP-17100-P/NP, Revision 1 Mark-Up at pages 18 and 82. As a result of an inquiry at the final design review, the leakage was re-assessed using maximum tolerances instead of nominal values. |
| 4 | 37 | Added "-A" to WCAP-15603 | The officially recognized version of the WCAP is WCAP-15603-A, Revision 1 |
| 5 | 19 | Changed the number of tests to 22 and the failure rate to 0.0217 per demand | See OG-11-30, WCAP-17100-P/NP, Revision 1 Mark-Up at page 42. When Table 3-3 was updated to be consistent with other tables in the report in response to an NRC RAI, there were actually 22 tests run which yields a reliability of 0.0217 per demand using Jeffreys non-informative prior methods. Also, note that a result of a concern raised at the SDS final design review in July 2010, 13 additional tests were performed as described in OG-11-xx to ensure the advertised reliability using a shape factor of 1 for the Weibull distribution as discussed on page 46 of the WCAP Mark-Up. However, Westinghouse does not seek additional credit for these 13 additional tests. |
| 5 | 24 | Added the failure rate to the sentence | Clarify that the "higher failure rate" refers to 0.0217 per demand. |
| 5 | 41 | Added sentence "The NRC staff expects that a single SDS failure rate of 0.0217 would be used to represent all SDS installed in the plant." | Clarify that the failure is not per RCP, consistent with previous usage of RCP seal failures such as the WOG2000 model. In other words, the SDS failure rate for a 3-loop plant with SDS in all RCPs would be 0.0217 and not 0.0651 (0.0217 x 3). |
| 7 | 5 | Changed failure rate to 0.0217 per demand | Change is consistent with change on page 5 of the draft SE |
| 7 | 5 | Deleted "percent" | "percent" is incorrect with the numerical value used. |

| Discussion of PWROG Comments on the Draft Safety Evaluation for WCAP-17100-P/NP | | | |
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| Page | Line | Suggested Change | Basis for Change |
| 8 | 27 to 31 | Change conditions for NRC approval for Model 93 and Model 93A-1 RCPs. | The SDS for the Model 93A RCP seals on a "new" sleeve that is provided with the SDS package. On the Model 93 and 93A-1, the SDS will seal directly on the pump shaft. Testing described in TR includes consideration of differences in the sealing surface for different RCP models (e.g., shaft scratches, ovality and surface finish. Some small dimensional changes may be necessary for the SDS components to accommodate the condition of the new sealing surface; these changes will not impact the function of the SDS. Also, testing will be performed on the SDS for these other pump models to ensure that the reliability and sealing function are at least as good as that described in WCAP-17100-P/NP, Revision 1. Therefore, NRC approval should extend to those pump models provided that there are no other significant differences in the components of the SDS. |
| 8 | 46 | Changed failure rate to 0.0217 per demand | Change is consistent with change on page 5 of the draft SE |
| 8 | 47 | Change "Bayesain" to "Bayesian" | Correct spelling of Bayesian |
| 8 | 48 | Added sentence "This failure rate is to be used to represent all RCPs with the SDS and not each individual RCP. " | Clarify that the failure is not per RCP, consistent with previous usage of RCP seal failures such as the WOG2000 model. In other words, the SDS failure rate for a 3-loop plant with SDS in all RCPs would be 0.0217 and not 0.0651 (0.0217 x 3). |
| 9 | 2 to 3 | Added the words "in a manner consistent with the 50.59 assessment performed for SDS installation" | The probability and consequences of inadvertent SDS actuation will be addressed in the plant specific 50.59 assessment. The PRA model should be consistent with the conclusions of the 50.59 assessment. That is, if the 50.59 assessment concludes that the consequences or probability of inadvertent actuation are negligible with respect to the plant design basis, then it should be acceptable to screen |

| Discussion of PWROG Comments on the Draft Safety Evaluation for WCAP-17100-P/NP | | | |
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| | | | inadvertent actuation out of the PRA model. |
| 9 | 8 to 9 | Added words "The 50.59 assessment should be used to determine required approvals and processes for installation." | The words were added to clarify that the 50.59 assessment is the appropriate process for determining required approvals for installation. |
| 9 | 14 to 19 | Clarified Westinghouse restrictions by breaking the old bullet into separate considerations for re-establishing thermal barrier cooling and seal injection. | The exact Westinghouse restrictions are not clear from the existing language. The PWROG and Westinghouse have provided alternate instructions as described in Section 3.5.1 of WCAP-17100-P/NP regarding re-establishing seal injection (but not for thermal barrier cooling). |
| 9 | 17 to 19 | Clarified the Westinghouse restriction on re-establishing seal injection. | If the SDS has actuated, cold water from re-establishing seal injection cannot reach the seal package due to the sealing action of the SDS. This may be a preferred makeup or boration strategy for some plants for some initiating events. As discussed in the response to RAI#8 for WCAP-17100-P/NP provided via OG-10-149, the consequences of re-establishing would be limited to damage to the pump shaft and radial bearing which is an economic impact and not a safety concern. Also note that the seal package would be disassembled and impacted prior to return to plant operation to ensure that there is no damage that would result in a safety concern. |
| 9 | 22 | Removed the words "to prevent thermal shock to the RCP seal package" | RCS cooldown and depressurization has no impact on the potential for thermal shock to the seal package regardless of whether the SDS has actuated. |
| 9 | 23 to 25 | Added "The RCS cooldown and depressurization can be delayed until plant stabilization and equipment status checks have been completed if it is diagnosed that the SDS has actuated and provides a tight seal." | In the current procedures, there is a high priority to begin RCS cooldown and depressurization to preserve RCS inventory. However, if the SDS has actuated and provides a tight seal, RCS cooldown and depressurization can be delayed until plant stabilization and plant equipment status checks have been completed. This provides for a |

| Discussion of PWROG Comments on the Draft Safety Evaluation for WCAP-17100-P/NP | | | |
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| | | | more orderly RCS cooldown and depressurization which minimizes the potential for operator errors. |
| 9 | 37 to 40 | Added a new limitation as follows: "If the SDS is installed in the RCPs over several outages, the NRC staff expects that licensees PRA models will reflect both seal behaviors as appropriate by separately modeling the probabilities and leakages for those RCPs with the SDS and the probabilities and leakages for those RCPs without the SDS." | Installation of the SDS at some plants may be done for one pump at each successive refueling outage (i.e., 6 years to complete all RCPs for a 4-loop plant on an 18 month outage schedule. This limitation would clarify that NRC expects the PRA model to be adjusted to reflect the as-operated plant by modeling the RCP seal mixture. |
| 10 | 2 to 3 | Added the words "as well as the basis for plant licensing basis station blackout and fire protection coping strategies." | Clarify that the approval extends to deterministic model in WCAP-17100-P/NP can be used as the basis for station blackout and fire protection coping strategies. |