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Title NORTH ANNA UNITS 1&2, PRESSURIZER SURGE NOZZLE WELD OVERLAY ENGINEERING EVALUATION OF INSURGE/OUTSURGE TRANSIENTS

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PURPOSE AND SUMMARY OF RESULTS:

Purpose (Rev. 000):

This document is a non-proprietary version of AREVA NP Document 32-9045275-001. The proprietary information removed from 32-9045275-001 is indicated by a pair of square brackets " [ ]." The geometry and operating condition are Dominion Power proprietary. The purpose of this evaluation is to assess the effect of the insurge and outsurge transients on the Surge Nozzle Structural Weld Overlay (SWOL).

The severity of the insurge/outsurge transients for the Surge Nozzle Structural Weld Overlay requires elastic-plastic analysis. Since the time required for the elastic-plastic analysis is significant, the analysis cannot be completed before the plant restart. The purpose of this evaluation is to assess the effect of the insurge and outsurge transients on the North Anna Surge Nozzle Structural Weld Overlay and provide assurance for safe operation of the plant for a limited number of cycles. A complete re-analysis including the insurge and outsurge transients is scheduled to be completed by the end of 2007.

Conclusion:

It is judged that [ ] Heat ups and Cool downs with total of [ ] cycles of these insurge and outsurge transients are acceptable. Please note that a detailed ASME Section III code analysis is planned to provide a detailed evaluation of the complete number of cycles by the end of 2007.

THE FOLLOWING COMPUTER CODES HAVE BEEN USED IN THIS DOCUMENT:

CODE/VERSION/REV	CODE/VERSION/REV

THE DOCUMENT CONTAINS ASSUMPTIONS THAT MUST BE VERIFIED PRIOR TO USE ON SAFETY-RELATED WORK

☐ YES
☒ NO

RECORD OF REVISIONS

Revision Number	Affected Pages	Description	Date
000	All	Original Release	04/2007

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1. PURPOSE

The purpose of this evaluation is to assess the effect of the insurge and outsurge transients on the Surge Nozzle Structural Weld Overlay (SWOL).

Due to severity of the insurge/outsurge transients, the Surge Nozzle Structural Weld Overlay requires elastic-plastic analysis. Since the time required for the elastic-plastic analysis is significant, the analysis cannot be completed before the plant restart. The purpose of this evaluation is to assess the effect of the insurge and outsurge transients on the North Anna Surge Nozzle Structural Weld Overlay and provide assurance for safe operation of the plant for a limited number of cycles. A complete re-analysis including the insurge and outsurge transients is scheduled to be completed by the end of 2007.

2. ANALYTICAL METHODOLOGY

The insurge and outsurge transients will only impact the secondary and fatigue criteria and crack growth analysis. The SWOL was sized to meet the requirements of Code Case N-740-1 (Reference 7). The sizing calculation ensures the SWOL is capable of transferring the loads between the piping and nozzle. Therefore, the SWOL meets all the primary requirements defined by the ASME Code. By definition, the insurge and outsurge transients will not affect the primary stresses and therefore the primary Code requirements are not affected by the addition of these transients.

The general methodology for the evaluation of the unanalyzed transients on ASME code criteria are:

1) Evaluate the severity of the transients based on temperature and pressure difference between starting and ending time point, flow rates, number of occurrences, temperature gradients and other factors affecting stresses usage factors and ratcheting.
2) If transients are found to be severe, evaluation of their impact on ASME criteria will be performed using comparison to similar surge nozzle geometries subjected to similar loads.
3) Reconcile the design and transient differences between the North Anna surge nozzles and the DC Cook nozzles. Nozzle dimensions that impact stresses in the overlaid region are: nozzle inside diameter, nozzle outside diameter, weld overlay thickness, thermal sleeve thickness and placement, head thickness, head radius. Loads that impact the stresses are transients and external loads. Finally, materials must be compared for their physical properties and allowable limits.

3. KEY ASSUMPTIONS

There are no major assumptions for this calculation. Minor assumptions are noted where applicable.

4. SEVERITY ASSESSMENT OF ADDITIONAL INSURGE/OUTSURGE TRANSIENTS

Upon review of Reference 1, it was concluded that the additional insurge/outsurge transients are of severe nature and would affect secondary stresses, fatigue and possibly other applicable ASME criteria.

5. NOZZLES COMPARISON

DC Cook Units 1, 2 surge nozzles were selected because they are nearly identical to the North Anna Units 1, 2 surge nozzles. The DC Cook surge nozzles were analyzed in detail to the ASME Section III code and reported in Reference 2 and Reference 3.

5.1 GEOMETRY

The following table summarizes key geometrical dimensions of DC Cook Unit1, DC Cook Unit2 and North Anna surge nozzles. Compared are dimensions that are significant for stresses.

Table 5.1-1 Geometry Comparison

Figure 5.1-1 Model of DC Cook Unit 1 Surge Nozzle

Figure 5.1-2 Model of DC Cook Unit 2 Surge Nozzle

Figure 5.1-3 Model of North Anna Unit 1 and 2 Surge Nozzle

5.2 LOADS

The following is comparison of loads applied on DC Cook Unit 1, DC Cook Unit 2 and North Anna pressurizer surge nozzles.

5.2.1 Transients

The following is a tabulation of the insurge/outsurge transients comparison between DC Cook Unit 1, 2 and the North Anna Units 1, 2 pressurizer surge nozzles.

Table 5.2-1 Insurge/Outsurge Transient Comparison

5.2.2 External Loads

The following tabulation shows a comparison for the external loads between DC Cook Unit 1, 2 and North Anna Units 1, 2 pressurizer surge nozzle.

Dead Weight (DW) and DBE loads are not considered here. DW does not contribute to the stress intensity ranges. DBE is not considered since it is a Faulted condition load and therefore is not required for the Primary + Secondary Stress Intensity check and fatigue.

Table 5.2-2 DC Cook Unit 1 External Loads

Table 5.2-3 DC Cook Unit 2 External Loads

Table 5.2-4 North Anna External Loads

5.3 MATERIALS

Connections of materials of dissimilar physical properties such as thermal expansion, Young's modulus, specific heat, thermal conductivity and density would affect secondary stresses. In addition, stress allowable limits will affect the ASME criteria.

The following table shows a comparison of the materials used for DC Cook Unit 1, 2 and North Anna Units 1, 2 surge nozzles.

Table 5.3-1 Material Comparison

6. EVALUATION OF NOZZLE DIFFERENCES

1) Geometry: A review of geometrical differences indicates that all three nozzles configurations are very similar. Parameters critical for stresses such as OD and ID at the overlaid region are nearly identical. The only difference between North Anna Units 1, 2 and DC Cook Units 1, 2 is at the minimum safe end ID that differs within [ ]. The overlay thicknesses have minor variations. This will produce an insignificant impact on stresses, and subsequently any crack growth that may occur. Other variations are also judged to have negligible effects on stresses.

2) Transients: There is one similar transient between DC Cook Units 1, 2 and North Anna Units 1, 2. The insurge/outsurge of [ ]deltaT occurs[ ]times for both DC Cook Units. North Anna experiences

[ ]occurrences. This is the most severe and bounding transient for all the plants. This transient is more severe for DC Cook Units 1 and 2 since the average temperature gradient is larger, the pressure change during insurge/outsurge is significantly higher and finally, the flow rate is significantly higher. Due to these increased severities, DC Cook surge nozzles are expected to experience noticeably higher stresses and its ranges.

3) External Loads: There is a wide spread of external loads between each unit, however, there is relatively small contribution of external loads to stresses and usage factor since during insurge/outsurge, there is no stratification load. (It must be pointed out that stratification loads have been considered for the North Anna PRZ Surge nozzle analysis, Reference 6). The thermal expansion is assumed to have a small contribution to fatigue and stresses since the insurge/outsurge is a relatively short event (small variation of thermal expansion load) that happens at the beginning of heat up and end of cool down. Finally, it is very unlikely that OBE will consistently happen during the insurge/outsurge. Therefore, the OBE will not affect stress ranges due to the insurge/outsurge events.

4) Materials: The materials for the head and surge nozzle of North Anna Unit 1 &2 are not the same as at D. C. Cook U1. The difference in Young's modulus is about[ ]and the difference in coefficient of thermal expansion is about[ ]. It is judged that this difference will cause some impact on stresses, but the impact on stresses and usage is judged to be of low significance that will not invalidate this conservative comparison evaluation. Since the materials for the head and surge nozzle of North Anna Unit 1 &2 are the same as for D. C. Cook U2, the stresses and usage factor are comparable.

The pipe and elbow material for North Anna Units 1 and 2 is different compared to D. C. Cook U1 and U2. However, all the materials are [ ] and the differences in the properties are insignificant.

7. RESULTS SUMMARY/CONCLUSION OF STRESS ANALYSIS

It is shown that DC Cook Units 1, 2 surge nozzles are comparable to North Anna Units 1, 2 surge nozzles. Conservative analyses for DC Cook Units 1 and 2 qualified the overlaid nozzles to all applicable requirements of the ASME code as indicated in conclusions of both documents, Reference 2 and Reference 3. It is expected that using the same level of conservatism as for the DC Cook calculations, North Anna surge nozzle analysis would yield lower, or at worst case, comparable results. The maximum increase of usage factor for[ ]heat up and cool down transients with total[ ] insurge/outsurges per Reference 3 for DC Cook U2 is [ ]. The contribution of the insurge/outsurge as a sub-cycle is[ ]. The maximum increase of usage factor prorated for[ ]heat up and cool down transients with total[ ]insurge/outsurges per Reference 2 for DC Cook U1 is[ ]. The prorated contribution of the insurge/outsurge as a sub-cycle is[ ]. The main difference in the usage factor is the level of conservatism. DC Cook U2 was first of a kind, thus more conservatisms were used. The maximum usage calculated for North Anna surge nozzle without the additional insurge/outsurge transients is[ ] per Reference 6. Considering usage factor of[ ] per Reference 10 of the un-overlaid original nozzle for full amount of design transient cycles to account for cycles spent, it is clear that the total[ ]usage factor will not exceed the allowable limit. In addition, there is no impact on primary stress magnitudes and limits.

The above comparison, the small contribution of the insurge/outsurge transients to fatigue, and the low fatigue usage calculated for the North Anna Analysis, provide the justification for accepting a small number of the un-analyzed transients. Since two insurge/outsurge events are considered for heat ups and two insurge/outsurge events are considered for cool downs per Reference 10, conservatively, it is judged that number of plant restart shall be limited to[ ] heatups and cooldowns combined with a total of[ ] cycles of these insurge/outsurge transients. This number of events can be imposed on the overlaid pressurizer surge nozzle with no impact to safety of North Anna Units 1, 2 without detailed analyses of these events performed. Please note that a detailed analysis is planned to provide a detailed evaluation of the complete number of cycles by the end of 2007.

8. RESULTS SUMMARY/CONCLUSION OF FRACTURE MECHANICS

For the limited number of proposed cycles, [ ]heatups and cooldowns combined with[ ] cycles of insurge/outsurge transients), the amount of crack growth is expected to be very small. Based on the fracture mechanics analyses performed to assess crack growth at the surge nozzles at DC Cook Units 1, 2 (References 8 & 9), the[ ]heatups and cooldowns combined with[ ]cycles of insurge/outsurge transients contributed no more than [ ]of crack growth. A similar amount of crack growth is expected at North Anna which is similar to the DC Cook units, as demonstrated by the comparison in Section 6.0. This amount of crack growth is much less than the value currently calculated for the remaining life of the North Anna surge nozzle. The crack growth analysis was performed considering the existence of a postulated flaw. Post-weld overlay NDE inspection of the surge nozzle was performed for the outer[ ]of the original pipe thickness as per the requirements of ASME Code Case N-740 and no indications were found. Therefore, for the limited period of time for which this justification is performed, it is assured that the weld overlay thickness is more than adequate to accommodate any potential crack growth due to the heatup/cooldown and insurge/outsurge transients.

9. REFERENCES

1 AREVA Document 38-9034638-002, "Required Engineering Input for North Anna Pressurizer Weld Overlays, North Anna Power Station Units 1 & 2."

2 AREVA Document 32-9028843-001, "DC Cook Unit 1 Pressurizer Surge Nozzle Weld Overlay Analysis."

3 AREVA Document 32-9011982-002, "DC Cook 2 Pressurizer-Surge Nozzle Weld Overlay Analysis."

4 AREVA Document 32-9022616-005, "DC Cook Unit 1 Pressurizer Nozzle Design Transient."

5 AREVA Document 32-9015165-000, "Flow in DC Cook Surge Line"

6 AREVA Document 32-9038239-000, "North Anna Units 1&2, Pressurizer Surge Nozzle Weld Overlay Analysis."

7 AREVA Document 32-9034323-003, "North Anna Units 1&2, Pressurizer Surge Weld Overlay Sizing Calculation-Surge Nozzle."

8 AREVA Document 32-9012181-001, "DC Cook Unit 2 Pressurizer Surge Nozzle Weld Overlay Crack Growth Evaluation"

9 AREVA Document 32-9028241-000, DC Cook Unit 1 Pressurizer Surge Nozzle Weld Overlay Crack Growth Evaluation."

10 AREVA Document 38-9046827-000, "Additional Engineering Input for North Anna Pressurizer Surge Nozzle Weld Overlays, North Anna Power Station Units 1 & 2."