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23-3

Structural Performance Criteria Issue

Summary: Industry proposal to limit application of factor of 3 to normal full power operation should be rejected. The industry White Paper submitted in support of their proposal contains a lot of misinformation. Further, it raises questions about the completeness of information provided in CE and BW topical reports which the staff reviewed in the context of license amendment requests (e.g., sleeves, plugging limits) through the years. Something really smells in Denmark.

Original Staff Proposal:

> SG tubing shall maintain margin of 3 against burst under the full range of normal operating conditions and anticipated transients.

Industry Proposal:

> SG tubing shall maintain margin of 3 against burst under normal full power operation.

Industry White Paper Positions

> Industry proposal concerning performance criteria is consistent with NRC testimony and Regulatory Guide 1.121 and with what staff has reviewed and approved.
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> In general, satisfaction of industry proposed criterion will ensure that primary membrane stresses are less than yield over the full range of normal operating conditions and anticipated transients. However, NEI 97-06 guidelines will be revised calling for the need to ensure that primary membrane stresses are less than yield over the full range of normal operating conditions and anticipated transients.
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> For design, it is appropriate under Section III of Code to base min wall requirements on normal full power conditions rather than on design conditions. Industry survey indicates this has been the industry practice and was reviewed and approved by NRC staff.

Discussion:

> Initially, I had trouble understanding why the industry was so hot on this issue. My experience has been that maximum operational dPs associated with full power operating condition essentially bounded operational and upset events in general. However, information in the White Paper provided recently by the industry reveals that heatup/cooldown and reactor trips at CE and BW units involve much more severe dPs than full power operation. At CE units, for example, max dPs during heatup/cooldown at CE units range to 2150 psi

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compared to 1430 psi at normal full power. At BW units, max dPs during heatup/cooldown range to 2050 psi compared to 1275 psi at normal full power.

I have gone back and done a rough check of CE and BW topical reports referenced in various license amendment requests (dealing with sleeving and plugging limits). These included:

- CEN-633-P regarding the application of Leak Limiting Alloy 800 Sleeves to CE plants.
- CEN-630-P regarding the application of Leak Tight Sleeves to CE and Westinghouse plants.
- BAW-10146, "Determination of Minimum Required Tube Wall Thickness for 177-FA Once Through SGs"

My reading of these reports is consistent with what I had previously understood to be the case; namely, normal full power dPs essentially bound the max dPs over the full range of normal operating conditions and anticipated transients. So, either the White Paper contains mis-information concerning heatup/cooldown conditions and reactor trips or the previous CE and BW reports contained mis-information which was part of the staff's basis for approving the associated LARs.

Performance Criteria Considerations

The staff's performance criteria proposal addresses the full range of normal operating conditions (including heatup/cooldown) and anticipated transients (including ractor trip). This is consistent with ASME Code Section III and Section XI which also provide stress limits and safety factors applicable to operational and anticipated transients and is consistent with Regulatory Guide 1.121.

The industry is proposing to limit the factor of three criterion to normal full power only. Based on an industry survey (which may not bound the most extreme situations) described in the industry White Paper and ignoring any contribution to burst contributed by differential thermal stresses, safety factors for operational heatup/cooldwn transient could be as low as 1.87 and for reactor trips could be as low as 2.26. These safety factors may even be lower depending on flaw types and the magnitude of differential thermal stresses.

Industry is incorrect in stating that its proposal to limit the factor of 3 criterion to normal full power operation is consistent with RG 1.121. C.2.a.(2) of RG 1.121 states that tubes "should have a factor of safety against failure by bursting <u>under normal operating conditions</u> (not simply normal full power operation) of not less than 3 at any tube location." Heatup/cooldown is a normal operating condition. This point is further clarified in C.3.a.(1) which states that "normal plant

conditions" include "startup, operation in the power range, hot standby, and cooldown." C.3.a.(1) also includes "all anticipated transients" as a "normal plant condition." Anticipated transients may include upset conditions (e.g., reactor trip) which in Code space would be treated as service level b rather than service level a. So, the RG definition is actually lumping service level a and b loadings together and conservatively treating them as service level a. This approach was not unique to SG tubes at the time it was written. Until recently, flaw evaluation procedures for Austenitic SS Piping in Section XI of the Code also lumped service level a and b together and applied the service level a safety factors.

Industry is also incorrect in stating that its proposal to limit the factor of 3 criterion to normal full power operation is consistent with the James Knight testimony for Prairie Island. James Knight's testimony states that "the factor of safety against burst under normal operating conditions should not be less than three." Mr Knight did not state that the factor of 3 criterion only applies to normal full power operation. Mr. Knight also states that "normal operation" includes "startup and operational transients (e.g., loss of electrical load, loss of offsite power) that are included in the design specification of the plant." The context of this specific statement is during a discussion of the no yield criterion. However, in the next paragraph, Mr Knight again refers to "normal operation" and the applicability of the factor of 3 criterion. He does not redefine normal operation. There is nothing in Mr Knight's testimony to suggest that "normal operation" means one thing in the context of the no yield criterion and another thing in the context of the factor of three criterion.

The industry states in the White Paper that it will revise NEI 97-06 calling for the need to ensure that primary membrane stresses are less than yield over the full range of normal operating conditions and anticipated transients. Changes to this criterion will not be subject to NRC review and approval.

Irrespective of the "no-yield" criterion's regulatory status (licensee controlled parameter vs parameter requiring NRC review and approval), it is not clear what minimum factors against burst are assured for the full range of operational and anticipated transients when differential thermal loadings are considered.

Finally, the industry proposal creates an unjustifiable inconsistency among plants. On one hand, we have Westinghouse plants whose normal full power dP may be in excess of 1500 psi, typically bounding the range of operational and anticipated dP transients. The 3xdP criterion for these plants would be about 4500 psi. On the other hand, BW plants may have normal full power dPs on the order of 1275 psi. Thus, the 3xdP criterion for such plants would be about 3820 psi. This is significantly less than the criterion for Westinghouse plants even though BW plants have substantially higher max operational dPs than Westinghouse plants. (Again, max operational dPs for BW plants are on the order of 2050 psi.)

Design Considerations:

Industry White Paper position on design is incorrect. Design of steam generator tubes and repairs (e.g., sleeves) are subject to Section III of the Code. I don't think there is a dispute on that. Furthermore, industry submittals always claim that design is in accordance with Section III of the Code.

The White Paper states that NB-3324.1 is used to define minimum allowable wall thickness. This is a mis-application of NB-3324.1. As stated in NB-3324, NB-3324.1 is used to establish a tentative thickness for use in design and is not to be used to establish an acceptable wall thickness. Except in local regions ..., wall thickness should never be less than given in NB-3324.1. The wall thickness must also be such that appropriate Section III stress limits are satisfied for all design and service level conditions.

The White Paper states that when using NB-3324.1 to establish the min wall requirement, all submittals surveyed (by the White Paper authors) used normal full power dP in the NB-3324.1 equation. The White Paper states that these submittals were reviewed and approved by the NRC staff. While the survey may or may not be totally accurate, the use of normal full power dP is improper. NB-3324 clearly states, in English, that Design Pressure is to be used. Design Pressure is defined in NCA-2142.1 as being not less than the maximum pressure difference which exists under the most severe loadings for which the service level A limits apply. NCA-2142.4 states that service level A loadings are those identified in the Design Specifications to which the component may be subjected when performing its specified service function. Heatup/cooldown loadings should clearly be service level A and thus should be considered when determining the appropriate design pressure.

Regarding NRC staff review and approval of industry submittals, I don't think such approvals can be construed as an endorsement for deviating from Section III of the Code. I haven't gone back in any systematic fashion to verify the White Paper claims about how tube and sleeve wall thicknesses were sized. However, the industry submittals most certainly claimed that the tubes and sleeves were designed and analyzed to Section III of the Code. These submittals certainly did not highlight deviations from the Code nor specifically request approval of these deviations. For Westinghouse plants, this issue is particularly subtle since the normal full power dP essentially bounds all normal and upset dPs.

FSAR: Tube design differential pressure is 2485 psi.

Palo Verde

FSAR: Tube design differential pressure not described specifically.

However, wall thickness satisfies NB-3324.1 for dP of 2485 psi.

Heatup/Cooldown is operational transient.

Reactor Trip is an upset condition.

ABB-CE Letter LD-83-058 (allowable wall thinning calculation)

3dP criterion applied relative to to dP of 1180 psi.

1180 psi is equal to dP associated 100% normal full power operation and exceeds dP associated with hot standby (1080 psi).

DPs associated with heatup/cooldown and reactor trip were not reported.

Calvert Cliffs

FSAR Tube design differential pressure not described specifically.

However, wall thickness satisfies NB-3324.1 for dP of 2485 psi.

CE-633P (Leak Limiting sleeves)

Sleeve design differential pressure is 2500 psi.

Plugging Limit

Normal operating conditions for the "worst" case envelopment of ABB-CE Sgs is 1460 psi.

1460 psi is equal to 100% normal full power dP and exceeds the reported heatup/cooldown dP of 1350 psi and reactor trip and upset dP of 1350 psi.