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Subject: OTSG Analysis Question Responses
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From: "Powell, Sidney C." <SIDNEY.POWELL@pgnmail.com>
To: "'jmg4@nrc.gov'" <jmg4@nrc.gov>
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Subject: OTSG Analysis Question Responses

See the answers below.

Sid Powell

-----Original Message-----
From: Cecilia, Loretta V.
Sent: Thursday, June 28, 2001 5:12 PM
To: Powell, Sidney C.
Subject: FW:

Sid ,
-----Original Message-----
From: Esquillo, Virgilio M.
Sent: Thursday, June 28, 2001 10:27 AM
To: Cecilia, Loretta V.
Subject:

(1) Please describe qualitatively why the SBLOCA is the limiting accident from load carrying capability considerations for CR-3 OTSG repair rerolls. Highlight some of the main system differences between CR-3 and Oconee which contribute to the higher loads during an SBLOCA event at CR-3 .

The key reason why Crystal River 3 has the SBLOCA as the more limiting accident from a tube load (and hence, repair product) perspective lies in its design features. It is useful to contrast CR-3 against the Oconee units, which has the Main Steam Line Break (MSLB) as the limiting tube load event. While both units share the Once-Through Steam Generator (OTSG) design, these feature differences affect the accident progression and its impact on the OTSG tubes. Some key differences are as follows:

1. CR-3 has a safety-grade, single failure proof Emergency Feedwater Initiation and Control (EFIC) system. Oconee does not.

EFIC actuates components in response to sudden changes in secondary conditions. A decrease in main steam pressure to approximately 600 psig will initiate a series of actions to isolate the faulted Once-Through Steam Generator (OTSG). EFIC will initiate a closure of the Main Steam Isolation Valves (MSIVs), which would limit the induced cooldown. EFIC would also terminate main feedwater flow to the OTSGs, and only permits emergency feedwater flow to the intact OTSG, via the Feed-Only-Good-Generator (FOGG) logic.

In contrast, the lack of an EFIC or similar system does not readily assure the positive and automatic isolation of the secondary to limit cooldown effects - including those on tube load.

2. CR-3 has MSIVs. Oconee does not.

Each of CR-3's OTSGs has two main steam lines, for a total of four potential break locations. Each line has an MSIV. At the onset of an MSLB, the MSIVs on the faulted OTSG close first, but the intact OTSG is isolated by its MSIVs a few seconds later. The former ensures that the blowdown is limited to only one of the two main steam lines on the faulted OTSG. The latter isolation ensures that uncontrolled cooldown paths do not exist through the intact OTSG. This series of actions ensures that the impact of the cooldown is lessened.

In contrast, the lack of MSIVs does not readily assure the limitation of the blowdown; thus exacerbating cooldown effects.

These are the principal reasons why the SBLOCA is the limiting event at CR-3 from the tube load perspective.

(2) It is the staff's understanding that the MSLB is the governing accident from considerations of leakage , both for the Oconee and CR-3 OTSG repair rerolls. Please clarify why plastic deformation of the tubes would lead to a more conservative evaluation of the tubes from leakage considerations.

The plastic deformation of the tubes during an MSLB accident would be caused by the cross-flow occurring in the tube bundle region. Oconee's response describes how the MSLB causes cross-flow loads that produce bending moments on the tubes "due to the lateral restraint" provided by the tubesheet and tube support plates. Some tube bowing and plastic deformation result from these bending moments. Plastic deformation has two effects: one on tube load, and another on tube leakage.

Tube Loads

The Oconee response qualifies the impact of the bowing and plastic deformation on tube loads by stating:

"A 1997 analysis shows that the bowing of the tubes imparts an axial load of approximately 250 lbs tensile, which is 10 times less than the axial loads due to the Oconee maximum temperature differential that occurs approximately 10 minutes into the transient."

A similar kind of phenomenon would occur during an MSLB at CR-3, although to a much smaller degree and at a much different time because of plant-specific features (presented above). Regardless, the response accurately reflects how Oconee recognizes that the axial loads from purely thermal loads dominate the impact on re-roll qualification. Moreover, the response states

that:

"Therefore, the evaluation of the tubes without accounting for plastic deformation was a conservative approach."

From a tube load perspective, this approach is justified. A typical stress-strain diagram for structural material (e.g., steel) shows that as strain increases, stress approaches an asymptotic value. Thus, instead of having the stress value mitigated by this behavior, no credit is taken for deformation.

Tube Leakage

It is recognized that the Oconee response included a discussion of cross-flow effects, but as they pertain to tube loads. In order for the discussion to apply to tube leakage, some examination of the cross-flow dynamic is necessary. At the onset of the event, flows induced by the blowdown through the broken steam line would exert lateral (i.e., perpendicular to axial) forces that would tend to bow the faulted OTSG's tubes, particularly those on the periphery. As the blowdown subsides, some tubes in the faulted OTSG would remain deformed.

Primary-to-secondary pressure differential is the more dominant factor for any resulting leakage from a MSLB, where in the faulted OTSG, the secondary side is essentially at containment pressure, and the primary can be at pressures as high as the pressurizer safety valve. However, it is intuitive that a bowed tube would tend to exacerbate leakage. A bowed tube would tend to alter the tight interference fit between the tube outer diameter and the tubesheet bore, introducing dilation.

The above discussion applies to CR-3, albeit to a much lesser extent than Oconee because of CR-3's design features. The CR-3-specific MSLB analysis credits the operation of these safety-related features in order to mitigate the tube load (and leakage) impact. For instance, local cooling of tubes by EFW spray, that contributes slightly to the axial load, would not occur in the faulted OTSG at CR-3. The MSLB analysis for CR-3 thus would adequately depict the phenomenon that could occur for this unlikely accident.

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