Vogtle Evaluation of GSI-191 Risk for Breaks outside First Isolation Valve

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Revision 1, 8/3/2016

1. Purpose and Scope

In the preliminary evaluations of the overall risk associated with GSI-191 for Vogtle, breaks outside the first isolation valve (OFIV) were excluded based on a qualitative assessment of the low likelihood of the valve failure (along with the low likelihood of a break in these locations and a GSI-191 failure given that the break and valve failure occur). During the NARWHAL NRC audit, the staff questioned whether these breaks should be included in the overall risk quantification.

This white paper describes the methodology for qualitatively and quantitatively evaluating breaks past the first isolation valve and provides results for Vogtle based on the current NARWHAL model.

2. General Methodology

This section describes the process that should be taken to evaluate the impact of OFIV breaks on the overall risk associated with GSI-191.

First, a qualitative assessment should be performed to determine if these breaks represent a significant risk contributor. Specifically, it should be determined whether the potential OFIV breaks have a) any unique or especially problematic debris sources or b) factors that would result in significantly larger quantities of debris transported to the strainer(s) compared to similar size breaks inside the first isolation valve. If not, the risk impact from the OFIV breaks can reasonably be assumed to have a negligible impact on the overall risk quantification because the risk contribution from an OFIV break with an isolation valve failure and subsequent strainer/core failure is low compared to the risk contribution from a break and subsequent strainer/core failure for similar welds inside the first isolation valve.

If the qualitative assessment identifies the potential for a significant risk contribution from the OFIV breaks, the following steps can be taken to quantitatively determine the risk impact:

1. The frequency for pipe breaks at OFIV welds must be determined. The loss of coolant accident (LOCA) frequencies defined in NUREG-1829 are solely focused on LOCAs "that initiate by unisolable primary system side failures that can be exacerbated by material degradation with age" (see Page 2-1 of NUREG-1829, Volume 1). Since OFIV weld breaks are isolable (assuming the valve doesn't fail), the overall LOCA frequencies in NUREG-1829 do not apply to these welds. However, after the NUREG-1829 frequencies are distributed to each of the welds inside the first isolation valve, the break frequency for an OFIV weld can be reasonably estimated by assuming it has the same frequency as a similar weld inside the first isolation valve.
2. The probability of valve failure must be determined. Valve failure includes a valve spuriously opening/rupturing or failing to close on demand. NUREG/CR-6928 provides

the failure rates shown below, which indicates that the probability of an isolation valve failure resulting in an unisolable LOCA is on the order of 1E-03 or less.

Component Failure Mode	Failure Rate (NUREG/CR-6928)
Air-operated valve fails to operate (open or close)	9.51E-04/demand
Air-operated valve spurious operation (open or close)	1.31E-07/hour
Air-operated valve large internal leak	1.94E-09/hour
Air-operated valve large external leak	3.86E-09/hour
Check valve spurious operation (open or close)	3.48E-09/hour
Check valve large internal leak	6.15E-09/hour
Check valve large external leak	7.35E-10/hour
Motor-operated valve fails to operate (open or close)	9.63E-04/demand
Motor-operated valve spurious operation (open or close)	3.39E-08/hour
Motor-operated valve large internal leak	2.02E-09/hour
Motor-operated valve large external leak	2.29E-09/hour

3. The conditional failure probability of a GSI-191 failure (strainer, pump, and and/or core failures due to the effects of debris) must be determined for the OFIV breaks. This can be done using NARWHAL in the same way that GSI-191 failures are evaluated for other breaks. (This includes evaluating GSI-191 effects for different equipment configurations.)
4. The overall risk contribution of the OFIV breaks can then be calculated by multiplying the break frequency by the valve failure probability and the GSI-191 conditional failure probability (taking into consideration the weighted contribution of the various equipment configurations).

3. NARWHAL Analysis of Vogtle OFIV Breaks

At Vogtle, there are 48 Class 1 ISI welds outside the first isolation valve out of a total of 930 Class 1 ISI welds. Most of the insulation at Vogtle is low density fiberglass, and the welds outside the first isolation valve do not have any unique sources of debris or factors that would result in significantly different debris generation and transport. Therefore, a qualitative assessment indicates that the OFIV breaks can be assumed to have a negligible impact on risk.

To quantitatively evaluate OFIV breaks, four NARWHAL simulations were run using the current Vogtle model. The simulations evaluated breaks inside and outside the first isolation valve for two equipment configurations (all pumps available and single train failure).

For the case with all pumps available, the ZOI Debris database was updated to only analyze the breaks outside the first isolation valves. No other inputs were changed. The same inputs were used for the single train failure case, with the exception that the configuration file was modified to remove a single train (both RHR and CS) from operation at the beginning of the simulation.

Figure 1 through Figure 3 show a comparison of the RHR Strainer fiber loading, RHR strainer calcium phosphate loading, and core inlet fiber loading, respectively, for breaks inside and outside the first isolation valve when all pumps are available. None of the OFIV breaks failed the GSI-191 limits. As shown in these figures, there are no significant differences for the OFIV breaks. The conventional and chemical debris loads from breaks inside and outside the first isolation valve are similar for similar break sizes. The largest weld outside the first isolation valve is 10.5 inches. When all pumps are available, the smallest break size where any failures were observed was 16 inches.

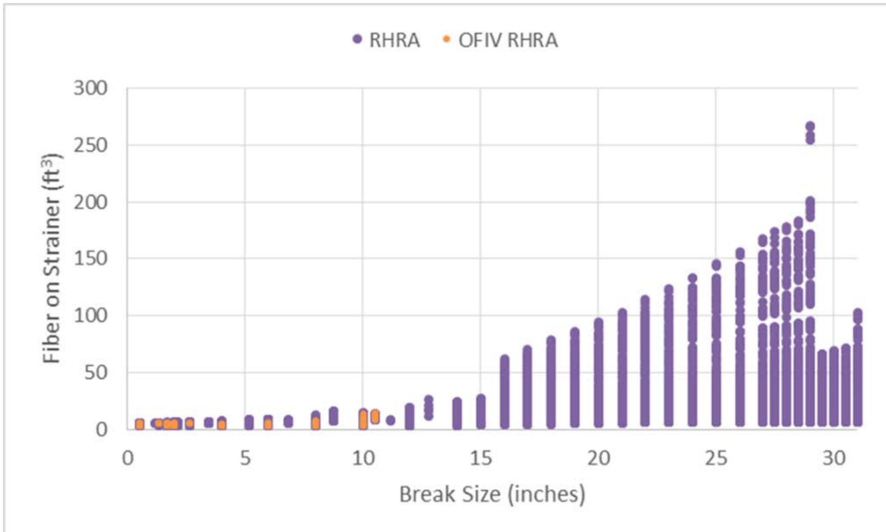

Figure 1 – Fiber Load on RHR A Strainer (all pumps available)

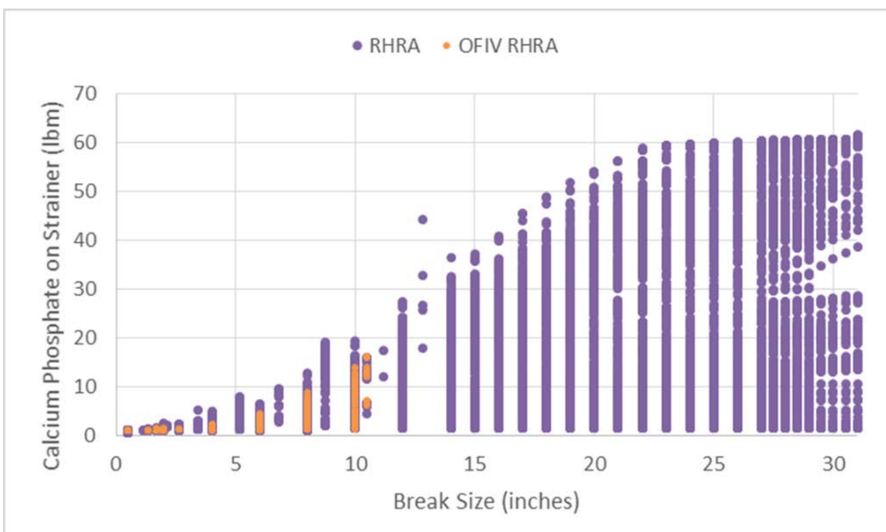

Figure 2 – Calcium Phosphate Load on RHR A Strainer (all pumps available)

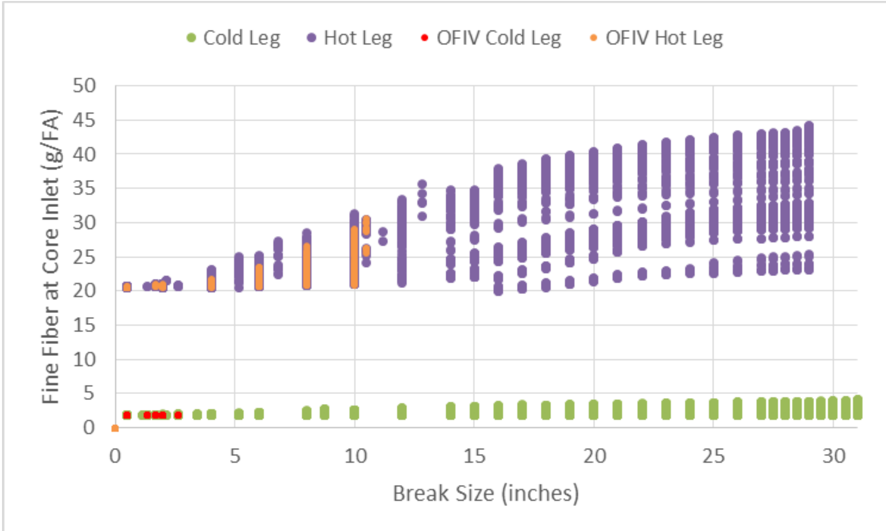

Figure 3 – Fiber Load at Core Inlet (all pumps available)

Figure 4 through Figure 6 show a comparison of the RHR Strainer fiber loading, RHR strainer calcium phosphate loading, and core inlet fiber loading, respectively, for breaks inside and outside the first isolation valve when a single train is assumed to fail at the start of the event. Since one train is assumed to have failed for this case, debris will transport to the single active RHR strainer rather than being divided between two active RHR strainers. This results in larger debris accumulations on the active RHR strainer (and less accumulation in the core). However, the comparison between breaks inside and outside the first isolation valve again show that there are no significant differences for similar size breaks. For single train operation, the smallest break size where any failures were observed was 12 inches, which is still larger than the largest OFIV weld.

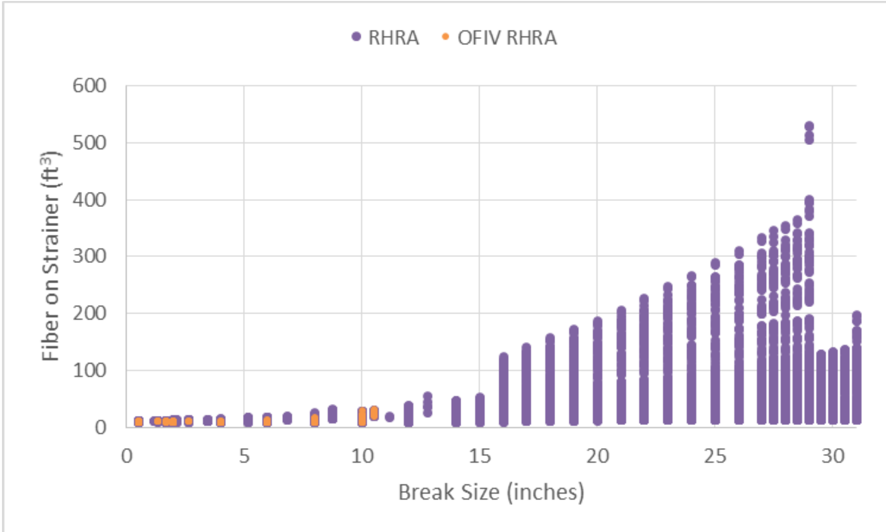

Figure 4 – Fiber Load on RHR A Strainer (single train failure)

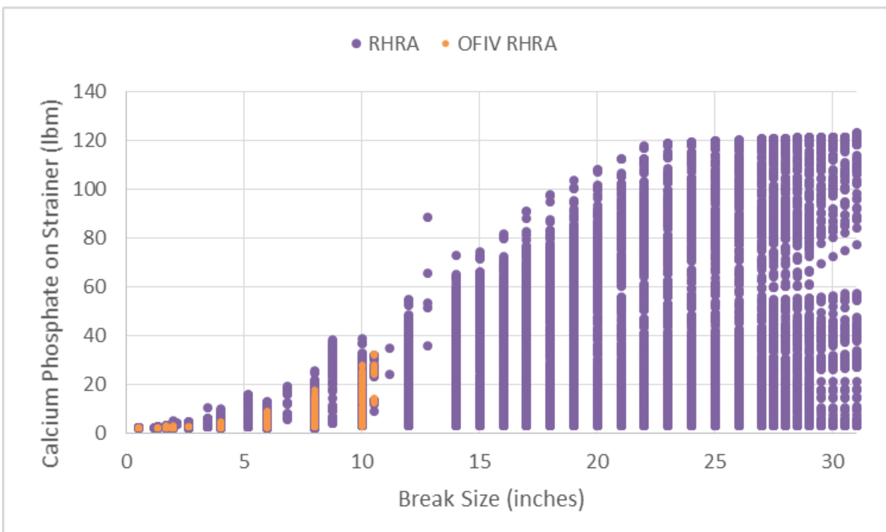

Figure 5 – Calcium Phosphate Load on RHR A Strainer (single train failure)

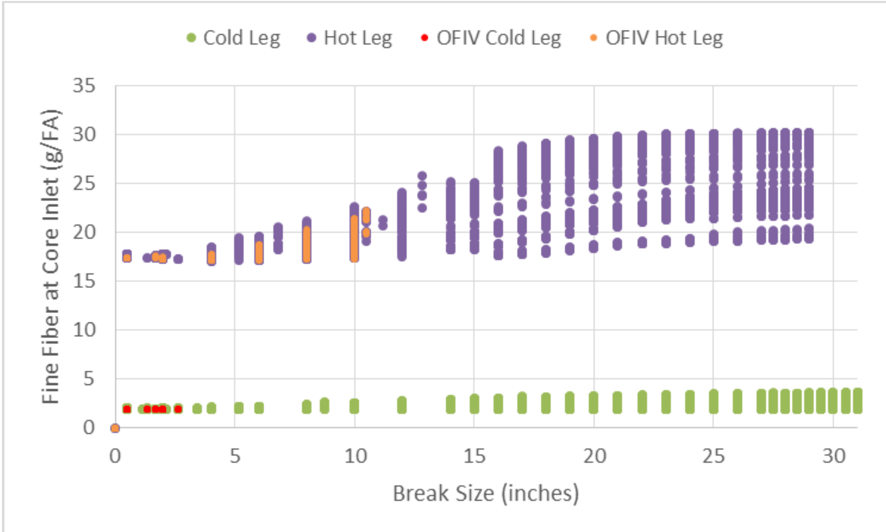

Figure 6 – Fiber Load at Core Inlet (single train failure)

4. Conclusions

As long as a qualitative assessment shows that there are no unique debris generation and transport factors associated with breaks outside the first isolation valve that would result in much higher GSI-191 conditional failure probabilities, a detailed quantitative analysis of these breaks is not necessary.

In general, due to the low probability of valve failure (<1E-03), and the relatively small number of welds between the first and second isolation valves, it is not expected that the risk contribution from these breaks would be significant unless there are factors that would cause the GSI-191 conditional failure probability to be much higher for breaks at these locations (i.e., unique debris sources or higher transport to the strainer). This qualitative assessment is supported by a quantitative evaluation of welds inside and outside the first isolation valve at Vogtle, which showed no GSI-191 failures and no significant differences for similar size breaks outside the first isolation valve.