NRR-PMDAPEm Resource

From: Harrison Albon [awharrison@STPEGS.COM]
Sent: Wednesday, April 29, 2015 9:35 AM
To: Watford, Margaret; Regner, Lisa
Cc: Stang, John; Kee, Ernie; Blossom, Steven
Subject: FW: Revised white paper for next week public meeting
Attachments: white paper.pdf

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Maggie, Lisa,

For talking points for our public call next week I am forwarding an updated RoverD description that includes additional detail on the debris generation and transport per our conversation in the previous public call. Note that we have not yet revised the LERF description. As Ernie says, it is quite large (173 pages), but by far the largest part of that is the computer files, so it is not as daunting as it looks. Changes are marked with change bars and we added line numbers (which won't be in the supplement version). I do not believe there is any sensitive or proprietary information in the attachment.

Regards,
Wayne Harrison
STP Licensing
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Mail Envelope Properties (8C918BCF8596FB49BD20A610FA5920CF0228A02B)

Subject: FW: Revised white paper for next week public meeting
Sent Date: 4/29/2015 9:35:12 AM
Received Date: 4/29/2015 9:35:46 AM
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Files	**Size**	**Date & Time**
MESSAGE	710	4/29/2015 9:35:46 AM
white paper.pdf	3592136	

Options
Priority: Standard
Return Notification: No
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Sensitivity: Normal
Expiration Date:
Recipients Received: Follow up

RoverD:
Use of Test Data in GSI-191 Risk Assessment

List of contributors and affiliation

Edition date, time - Wednesday 29th April, 2015, 07:45

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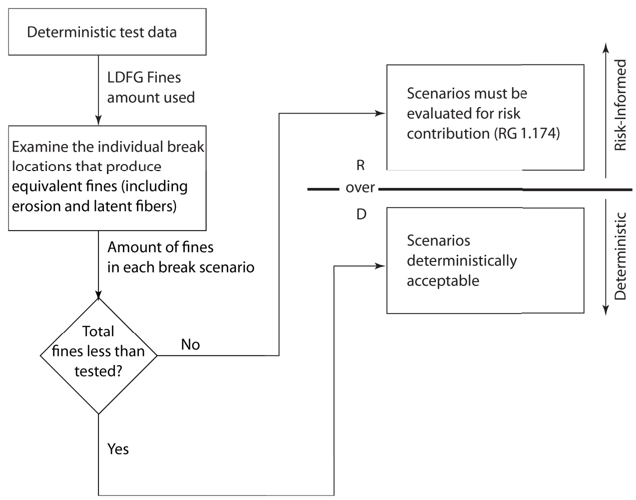
1 Introduction

RoverD is a method that follows the guidance of NRC (2011) to assess the risk associated with concerns raised in GSI-191. RoverD uses test data and NRC (2011) guidance to evaluate the magnitude of LOCAs required to exceed a performance threshold that is established by testing for effects again associated with concerns raised in GSI-191. The performance threshold is set low, set to underestimate the true level where functionality may be lost, so that risk for strainer failure is overestimated. Even when adopting a low performance threshold, the risk is shown to be very small (NRC, 2011).

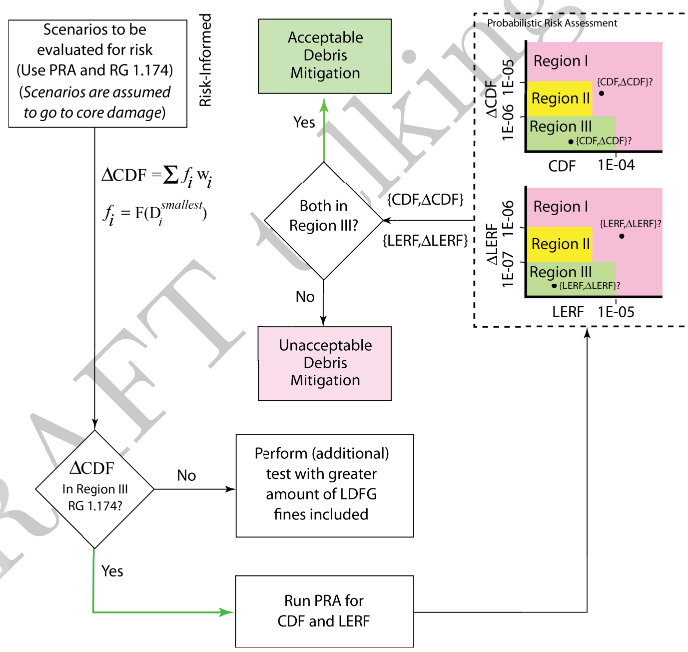
RoverD separates the risk estimate into two categories of scenarios designated as 'deterministic' and 'risk-informed' as illustrated in Figure 1a. The deterministic scenarios are those in which the LDFG fiber fines estimated to arrive in the ECCS sump following LOCA are equal to, or less than, the amount of fines used in acceptable strainer testing. The limit is set using testing methods intended to determine the maximum ECCS strainer head loss for the tested condition. For example, single failure criteria are adopted in combination with conditions known to overestimate head loss such as chemical quantities and morphology, strainer flow rate, and particulate amounts that includes mechanical processing of fiber. If the strainer performance test shows a LOCA scenario will not cause any strainer performance requirements to be exceeded, then that scenario will not result in failure and is categorized as deterministic as shown in Figure 1a.

The term 'acceptable testing' refers to so-called deterministic tests performed under circumstances that would not be realized in a design basis accident as mentioned above. Such tests can be used to establish a bounding envelope of performance (low performance threshold) for the realistic scenarios realized or hypothesized. Using test data that includes unrealizable circumstances may result in scenarios that would fall outside the bounding envelope defined by such test data. The risk for any such scenarios is required to meet a 'very small' threshold as shown in Figure 1b.

In the following, the various analyses required to complete a RoverD assessment are summarized. The steps required to complete a RoverD analysis are summarized in Section 2. Section 3 summarizes the way RoverD fiber generation, transport, erosion, and latent fiber quantity are established. Section 4 summarizes the LOCA frequency determination for scenarios in the risk-informed category. The basic approach uses top-down frequency partitioning. In-vessel analyses are described in Section 5 including blockage analyses for HLB and CLB (scenario success criteria), fuel fiber limits, boric acid precipitation. Core performance metrics must be met in addition to strainer performance. Section 6 summarizes evaluation of core performance metrics.



(a) RoverD separates those scenarios that go to success deterministically from those that are assumed to go to failure and require risk-informed analysis



(b) Flow chart showing the RoverD evaluation process following categorization of scenarios to determine risk acceptability. In this depiction, the frequency, f_i, of break at any location is determined by the diameter as determined in NUREG 1829.

Figure 1: The two basic elements of RoverD are separating scenarios into risk-informed or deterministic categories and then subsequently evaluating the risk.

2 RoverD risk quantification summary

RoverD involves the following steps to assess the risk associated with the concerns raised in GSI-191:

1. Perform a test that has some margin to failure following accepted protocols (see AREVA, 2008)

   Note the amount of fine tested (in this case, 191.78 lbm) as well as the configuration (in this case, two ECCS trains). The plant configuration is important to ensure whether the test bounds other plant states. Fine fiber is used because it is the transportable form of the LDFG created in the break scenario

   Note that the test results must be applied to strainer performance criteria to ensure they are met using deterministic analysis requirements (e.g., vortexing, structural margin, flashing, etc.)

2. In-vessel performance criteria (core cooling, including fiber effects, boric acid precipitation) must be met under the conditions tested

3. Run CASA Grande to itemize all break locations, break sizes, and amount of LDFG fines in the sump (including erosion and latent fiber)

4. Compare the amount of fiber fines in each break scenario to the tested amount (AREVA, 2008)

   If the amount is equal to or less than the tested amount, categorize the scenario 'deterministic'.

   If the amount exceeds (that is, 'over') the tested amount, categorize the scenario 'risk-informed'

5. Evaluate the risk contribution (including in-vessel) of scenarios in the risk-informed category against the Regulatory Guide 1.174 quantitative criteria for {CDF,ΔCDF}, {LERF,ΔLERF}

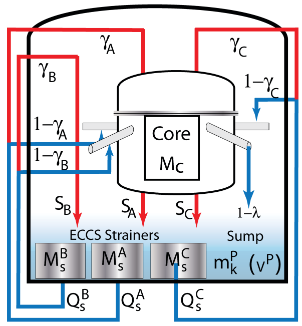
   Assign change in core damage frequency to the frequency from (5)

   Check {CDF,ΔCDF} against the quantitative requirement of Regulatory Guide 1.174, Region III

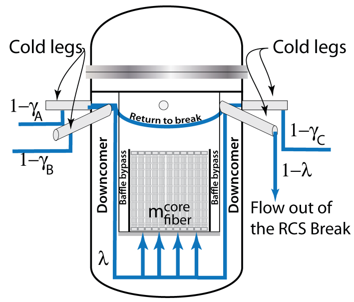
   Check {LERF,ΔLERF} against the quantitative requirement of Regulatory Guide 1.174, Region III

   Verify other requirements (for example, safety margin, defense in depth) of Regulatory Guide 1.174 are met

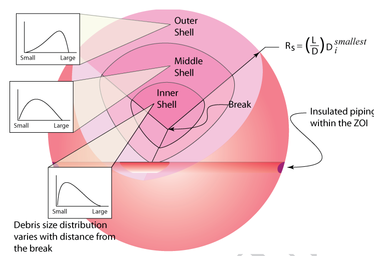
6. If all requirements are met for the risk-informed category, the performance is acceptable



(a) Fiber flow paths for a three train plant (trains A, B, and C) in containment after ECCS recirculation showing flow splits, γ, between total ECCS injection and ECCS



(b) Fiber flow paths through the reactor vessel following ECCS recirculation showing the additional flow split (λ) to the core and the break



(c) Conceptual illustration of three zones of destruction potential within the ZOI showing how the debris distribution shifts towards larger sizes further from the break

Figure 2: Flow paths through the containment and reactor vessel following the start of ECCS recirculation showing where fiber mass (m) is conserved (ECCS strainers, ECCS sump, and the reactor core)

3 Reactor containment building debris generation and transport

NEI (2004) documented an acceptable methodology for determining the amount of debris generated in a LOCA of any particular size by defining a ZOI. Within the ZOI, specific size distributions of LDFG particles can be estimated using acceptable methods (Figure 2c).

The amount and type of each debris species transported to the ECCS sump is governed by logic trees developed to estimate the amounts captured and sequestered, and the amounts that would continue to transport (for example see NEI, 2004, ppg 3-45, 3-53). RoverD uses a 'worst case' set of assumptions in development of the STP debris transport logic tree.

The flow paths through the RCB with the water flowing out of the breach in the RCS as well as with water from sources such as ECCS and CSS during the recirculation phase are shown in Figures 2a and 2b. CASA Grande performs mass conservation of debris species in the containment pool (M_p), on the ECCS strainers, (M_s) and in the reactor core, (M_c), (Figure 6). Although different size particles are created from partially destroyed fiberglass insulation strands within the ZOI (Figure 2c), the smallest particles that transport readily through the RCB are 'fines'. Larger and partially destroyed LDFG insulation either do not transport or quickly sink in the ECCS sump and remain there. Over time, water flowing through the RCB tends to erode some of the larger particles captured outside of the ECCS sump into fine particles. Besides LDFG either destroyed or eroded into fine particles, fine

particles from tramp dust and dirt need to be taken into account.

A break size and location define a scenario from which is derived the amount of LDFG fines that arrive in the ECCS sumps. The methodology for examining many thousands of possible break sizes, orientations, truncation of ZOIs, transport of fines, and erosion of LDFG requires a computational framework implemented on a computer.

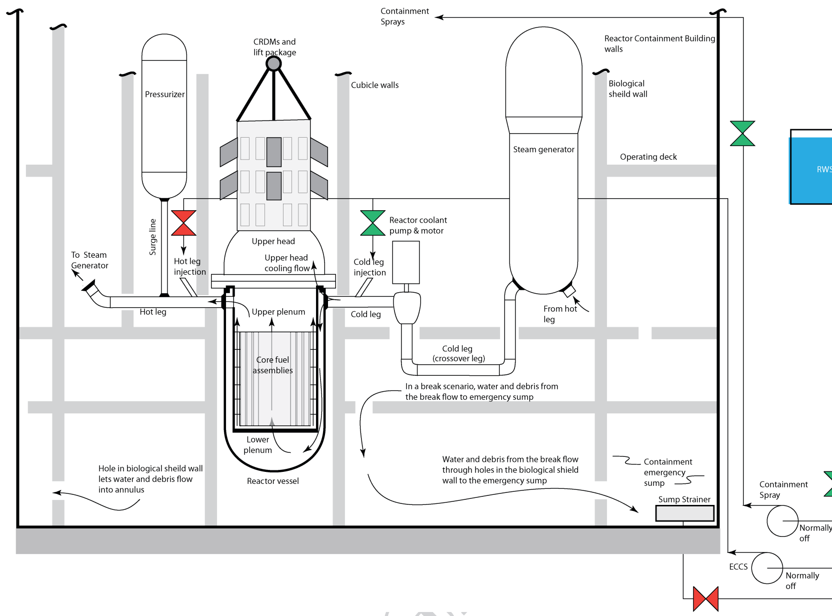


Figure 3: Simplified arrangement of the reactor system, ECCS and CSS with flow directions shown during normal operation for the intact plant and flows in the emergency systems when demanded. The arrangement has been distorted so the flows and equipment can be seen. Shown as well are flow paths from hypothesized breaks out to the ECCS sump.

3.1 Computer implementation of debris generation & transport

As mentioned previously, generation, transport and erosion of LDFG fines requires a computational framework implemented on a computer. Alion Science & Technology (2015) has developed a generalized computer implementation inside of CASA Grande that uses a STP plant-specific CAD model of the RCB. The methodology used to obtain the amount of LDFG fines generated and transported to the STP RCB recirculation pool for each postulated break is described in the following sections. This automated calculation of fiberglass debris is consistent with the steps used to calculate the amount of fine fiber introduced to the test flume (AREVA, 2008).

The computational framework for calculating fibrous debris generation inside of CASA Grande can be summarized in three items:

1. Importing CAD geometry,
2. Line of sight grouping of voxels that can be seen by each weld location that are not shadowed by concrete, and
3. Insulation debris generation for each weld location based on scenario specific break size.

3.1.1 Import of CAD geometry

There are three types of geometry files that are imported into a CASA Grande simulation for use in the insulation debris generation routines:

1. pipe extract insulation data files,
2. equipment insulation text files, and
3. concrete STL files.

These three types of geometry files and descriptions of how they are imported and used in the CASA Grande debris generation routines are described below.

Pipe extract insulation data Pipe data are extracted from the piping assembly in the 3D containment CAD model using a proprietary AutoDesk Inventor add-in (created by AutoDesk for Alion). The data include all information about piping and piping insulation needed to rebuild the piping insulation geometry numerically inside of CASA Grande. Specifically, pipe extract insulation data includes pipe segment lengths, pipe names, pipe insulation types, Cartesian coordinates of extracted points on pipe centerlines (Work-Point), bend radii of extracted Work-Points, inner and outer diameters of insulation shells, and Work-Point types (i.e. valve, hangar, weld, etc.). An example of a pipe segment in a pipe extract insulation input file is Table 1.

Table 1: Pipe Extract insulation data file example. The data include three header records and pipe work point data in columns: Inventor Ipart (.ipt Name), work point ID (Point), Cartesian coordinates (X, Y, and Z), bend radii (Rad), inner insulation shell diameter (ID), outer insulation shell diameter (OD), and work point type (WP).

extracted data

12-11-26 South Texas Plant.iam
Number of Points = 26. Number of Straights = 9. Unit of Length = Inches.

.ipt Name	Point	X	Y	Z	Rad	ID	OD	WP
30MS-1002-GA2 [NUKON]:1	0	-137.14	369.14	1404.88	0	32.75	38.75	
30MS-1002-GA2 [NUKON]:1	1	-137.14	369.14	1441.89	0	32.75	38.75	WELD
30MS-1002-GA2 [NUKON]:1	2	-137.14	369.14	1496.75	49.12	32.75	38.75	
30MS-1002-GA2 [NUKON]:1	3	-193.84	367.73	1496.75	0	32.75	38.75	FW0060

continued next page . . .

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extracted data								
30MS-1002-GA2 [NUKON]:1	4	-301.05	365.07	1496.75	49.12	32.75	38.75	
30MS-1002-GA2 [NUKON]:1	5	-301.05	365.07	1420.97	0	32.75	38.75	WELD1
30MS-1002-GA2 [NUKON]:1	6	-301.05	365.07	1271.75	0	32.75	38.75	FW0002
30MS-1002-GA2 [NUKON]:1	7	-301.05	365.07	1202.25	0	32.75	38.75	HL5016
30MS-1002-GA2 [NUKON]:1	8	-301.05	365.07	1173.99	0	32.75	38.75	HL5015
30MS-1002-GA2 [NUKON]:1	9	-301.05	365.07	1148.88	0	32.75	38.75	HL5009
30MS-1002-GA2 [NUKON]:1	10	-301.05	365.07	1047	49.12	32.75	38.75	
30MS-1002-GA2 [NUKON]:1	11	-343.48	407.5	1047	0	32.75	38.75	HL5008
30MS-1002-GA2 [NUKON]:1	12	-386.54	450.55	1047	0	32.75	38.75	WELD2
30MS-1002-GA2 [NUKON]:1	13	-417.99	482.01	1047	49.12	32.75	38.75	
30MS-1002-GA2 [NUKON]:1	14	-461.28	438.72	1047	0	32.75	38.75	WELD3
30MS-1002-GA2 [NUKON]:1	15	-489.05	410.95	1047	0	32.75	38.75	HL5006
30MS-1002-GA2 [NUKON]:1	16	-613.41	286.59	1047	0	32.75	38.75	FW0004
30MS-1002-GA2 [NUKON]:1	17	-660	240	1047	49.12	32.75	38.75	
30MS-1002-GA2 [NUKON]:1	18	-660	120	1047	49.12	32.75	38.75	
30MS-1002-GA2 [NUKON]:1	19	-660	120	986.02	0	32.75	38.75	HL5001
30MS-1002-GA2 [NUKON]:1	20	-660	120	964.3	0	32.75	38.75	HL5002
30MS-1002-GA2 [NUKON]:1	21	-660	120	801	49.12	32.75	38.75	
30MS-1002-GA2 [NUKON]:1	22	-721.12	120	801	0	32.75	38.75	FW005A
30MS-1002-GA2 [NUKON]:1	23	-834.94	120	801	0	32.75	38.75	FW0006
30MS-1002-GA2 [NUKON]:1	24	-849.94	120	801	0	32.75	38.75	
30MS-1002-GA2 [NUKON]:1	25	-957.94	120	801	0	32.75	38.75	
Point to Point Length: 1748.53								

The data from each pipe segment in the Pipe Extract insulation file are read into CASA Grande and used to create a numerical reconstruction of the piping insulation with volume elements called voxels; where each voxel's volume is modeled to reside at its center point. The user can specify the numerical resolution of the piping insulation reconstruction (with voxels) in the CASA Grande simulation by defining linear resolution and number of azimuthal bins in the simulation input deck (Listing 1).

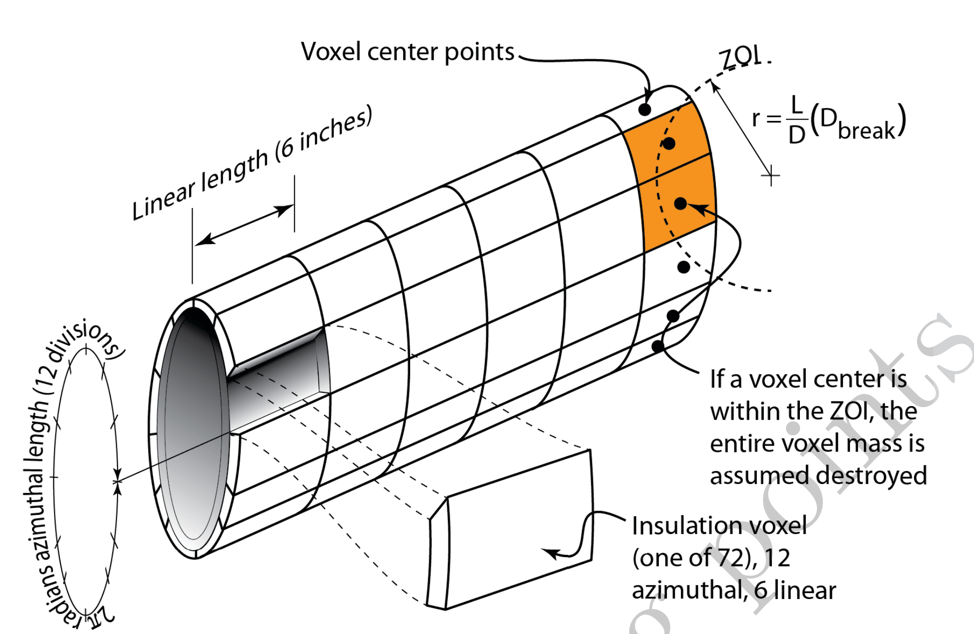


Figure 4: Illustration of insulation discretization on piping. The discretization is defined in input as shown in the input fragment in Table 1

Listing 1: Input fragment for defining piping insulation discretization

```
% ----------------------------------------------------------------------------
''Spatial Resolution for Discretizing Insulation''
% ----------------------------------------------------------------------------
% (must repeat weld target sort if these are changed)
% (delete all master files and rerun with new delL and Nangbin)

% Linear Resolution (inches)
6

% Azimuthal Bins in 2 Pi Radians on Pipes
12


\% ----------------------------------------------------------------------------
```

An example of how the piping discretization works for a straight pipe is illustrated in Figure 4. The illustration shows how the insulation is discretized on the pipe. Also shown is the way the ZOI interacts with the voxels defined by azimuthal and linear parameters.

The pipe actually appears transparent in the ZOI (spherical or hemispherical) and if the center-point of the voxel is within the ZOI the entire insulation volume within the voxel is assumed destroyed.

Equipment extract data Equipment insulation voxels are defined differently than the piping because equipment shapes may be fairly arbitrary as compared to pipes. Therefore, equipment voxels are defined in files with X, Y, Z coordinates defining the center of a voxel having volume, V and insulation type (as appropriate).

The simplicity of the equipment insulation definition files allow them to be created text file or spreadsheet. The STP equipment definitions were created from high-resolution STL exports of equipment insulation from the CAD software. The STL files were pre-processed to supply the necessary Cartesian coordinate data.

Concrete STL file The concrete input file is a STL data file containing all CAD-defined plant concrete structure geometry and is used to represent robust barriers (insulation shielding) in the insulation destruction computations. The STL data file is interpreted as a collection of surface triangle faces (facets) and respective unit surface normal direction vectors in three-space such that the line-of-sight can be defined from the ZOI point of origin. The CAD generated STL files resolve detailed features such as door casings and cylindrical pipe penetrations. All surfaces defined as robust barriers in the concrete input file are used to truncate ZOIs centered on weld locations. Insulation shielding by large equipment such as the steam generators and RCPs is not credited in the STP CASA Grande debris generation calculation.

3.1.2 Line of sight calculations

Before debris generation is calculated for varying break sizes at each weld location, a line of sight grouping of insulation not shadowed by concrete is performed. These computations analyze each weld location and save the insulation voxels that are not shadowed by concrete along with their associated spatial location and volume information in a voxel packet specific to each weld. This step organizes visible (non-shadowed) voxels into weld specific voxel packets that make ZOI calculations of destroyed insulation faster during simulations over all weld locations in containment

3.1.3 Weld location based debris generation

After CAD geometry is imported and line of sight voxel computations are performed, weld location-based insulation debris generation can be calculated for scenario specific break sizes. Each scenario specific break is numerically represented by either a spherical ZOI for double-ended guillotine breaks (DEGB) or by a hemispherical ZOI for partial breaks. For both spherical and hemispherical breaks, the individual voxel center point locations from

the voxel packet (Section 3.1.2) for the scenario-specific weld location are compared to the spherical or hemispherical ZOI centered on the current weld location for interference. Any insulation voxel with a centerpoint voxel from the weld specific voxel packet that is inside the ZOI is counted as destroyed, and all destroyed voxels are summed for each insulation debris type to yield total insulation generation for the analyzed break scenario. User-defined ZOI sizes for each insulation type are properly applied during the debris generation process.

3.2 Fine fiber debris sources

There are four sources of fine fiber debris that must be considered for each break scenario modeled for STP: Nukon®, Thermal-Wrap®, Microtherm® (Alion Science & Technology, 2014b) and latent fiber (Alion Science & Technology, 2008). Note that the fixed amount of latent fiber specified as input for the plant is applied to every break scenario and that Nukon®, Thermal-Wrap® and MicrothermÍ generation is scenario specific. The ZOI sizes and insulation debris size distributions used for the CASA Grande computations of each modeled fiber type at STP are described in this section.

Insulation specific ZOIs Each of the three insulation types, mentioned in Section 3.2 analyzed for fiber fine destruction in the STP RoverD methodology, have individually defined ZOIs based on jet testing. The maximum ZOIs used for each of the STP fiber-producing insulation types are summarized below in Table 2 and are based on the standard deterministic approach promulgated by NEI (2004, Volume 1 and 2).

Table 2: Summary of the ZOIs for fiber-producing insulation

Insulation Type	ZOI $\left(\frac{radius}{breakdiameter}\right)$	Reference
Nukon®	17.0	(NEI, 2004)
Thermal-Wrap®	17.0	(NEI, 2004)
Microtherm®	28.6	(NEI, 2004)

In the way previously illustrated in Figure 2c, the ZOIs for Nukon® and Thermal-Wrap® insulation are shells with different percentages of debris sizes created within each shell. Along with fiber fines produced, debris sizes are calculated from each shell for small pieces, large pieces, and intact blankets (Alion Science & Technology, 2009). The proprietary ZOI size distributions of LDFG (percent each of small pieces, large pieces, and intact blankets) destroyed by a postulated ZOI are consistent with the NRC (2008) report.

Fibrous latent debris sources The bounding latent debris mass of 200 lbm as suggested by NEI (2004, Volume 1), was used as the latent debris source for the STP evaluation. fifteen percent (30 lbm) of the 200 lbm latent debris was introduced as fiber fines based

on the safety evaluation report promulgated by NEI (2004, Volume 2) (15% fiber and 85% particulate by mass).

Destroyed volume mass All destroyed insulation volume was converted to mass using the manufactured densities :

- Nukon® $2.4\,\frac{lbm}{ft^3}$ (NEI, 2004, Volume 1)
- Thermal-Wrap® $2.4\,\frac{lbm}{ft^3}$ (NEI, 2004, Volume 1)
- Microtherm® $15\,\frac{lbm}{ft^3}$ (Alion Science & Technology, 2014b)

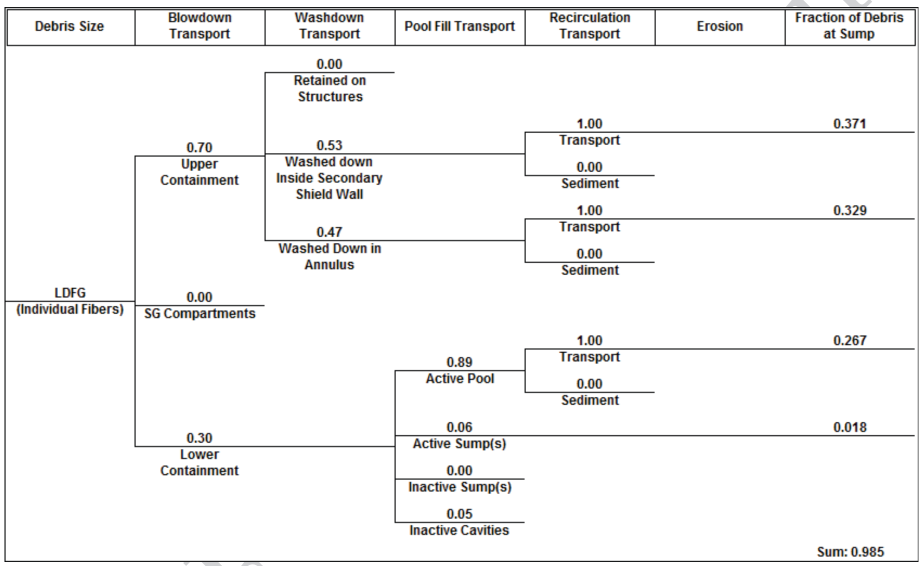


Figure 5: Schematic representation of the transport logic tree used to obtain the mass of fiber fines transported to the RCB sump.

3.2.1 Fiber fines debris transport

Once the amounts and distributions of fiber types are known, a transport logic tree, Figure 5, is used to arrive at the amount of fiber distributed to various areas of the RCB. Only fiber fines generated from the break are analyzed this way, the other two sources of fiber fines, latent fiber and eroded fiber, are transported directly to the sump. The transport fractions are representative of a break in the Steam Generator compartment, which bound transport fractions that would represent other possible break locations in the RCB.

Fiber fines from the ZOI The majority of fiber fines (98.5%) destroyed from insulation in the ZOI are transported to the containment pool. The other 1.5% of debris not transported to the RCB sump is trapped in inactive cavities during pool fill. The transport modes and their contributing fractions to the RCB sump for ZOI-generated fiber fines are described below.

Blowdown Fiber fines were initially calculated to be blown to upper and lower containment at 30% and 70%, respectively (Alion Science & Technology, 2014a). The percentages blown to upper and lower containment were calculated as volume fractions taken as ratios of the open containment volume in upper containment and lower containment compared to the total open containment volume. This proportion of fibrous fines transport was assumed (Alion Science & Technology, 2014a) to be reasonable because fine debris generated by the LOCA jet would be easily entrained and carried with blow down flow.

Wash Down All (100%) of the fiber fines blown to upper containment is washed down and homogenized in the containment pool. Note that wash down fractions from upper containment were split between the "Inside Secondary Shield Wall" and "Annulus" compartments; because both of these compartments are at the pool level, and because fine debris was assumed homogenized, these fraction are inconsequential except for their combined total which is 100%.

Pool Fill 5% of the fiber fines transported to lower containment during blow down is trapped in inactive cavities. This pool fill transport fraction of 5% is less than the NEI (2004) SER suggested maximum inactive cavity pool fill transport fraction of 15%. Although 6% of the debris blown to lower containment was calculated to arrive on strainers early as a function of initial sheeting flow, this only affects debris arrival timing in a full CASA Grande calculation and does not affect the total fraction that can reach the strainers. The RoverD methodology depends only on the amount of fine fiber introduced to the containment pool.

Recirculation All fibrous fines were assigned a conservative recirculation transport fraction of 100%. CFD calculations were not used to predict the amount of fines that may settle on the pool floor. One hundred percent transportability preserves the match between fine fiber introduced to the containment pool for each analyzed break scenario and the amount of fine fiber introduced by AREVA (2008) in the flume test. Credit for realistic settling is an inherent part of the test conditions.

Eroded fines Three types of erosion were considered for small and large pieces of fibrous debris held up on containment structures:

1. CSS spray flow

2. Break flow
3. Pool recirculation (Alion Science & Technology, 2014a)

The percentage of small and large fibrous insulation pieces eroded into fines as a result of CSS flow is assigned the maximum value of 1% as found by Rao et al. (1998). The percentage of small and large pieces eroded into fines by break flow is negligible in the STP RCB since debris is blown away from the break location. Based on Alion Science & Technology (2011) testing that shows a maximum of 7% of small and large fibrous insulation pieces erode to fiber fines in 30 days of testing fibrous erosion by recirculation flow, 7% are eroded to fines. Total fractions of small and large fibrous debris held up on containment structures, their corresponding erosion fractions and resulting total fiber fines transport fractions homogenized in the containment pool have been provided in Table 3.

Table 3: Erosion modes and erosion percentages summary of smalls and large pieces eroded to fines.

Insulation Size	Erosion Mode	Held Up Fraction	Erosion Fraction	Total Fines from Pieces
Small Pieces	Spray	36.5%	1.0%	0.4%
	Recirculation	23.8%	7.0%	1.7%
Large Pieces	Sprayed	100.0%	1.0%	1.0%
	Recirculation	0.0%	7.0%	0.0%

3.3 Fiber collection in the ECCS

A flow network that approximates the transport and capture of debris in containment in a CLB is shown in Figure 6. The primitive data for this system are: (1) time-dependent flows $Q_s(\cdot)$ and $Q_c(\cdot)$, (2) scalars V_p, $M_p(0)$, and γ. The flows are time-dependent due to the influence of Q_c on λ. Q_c as a function of time is obtained from a table and is governed by the decay heat level. Table 4 lists the first few entries in the table. Given these model primitives, an analysis of the time-dependent accumulation of debris on the strainer, core, and in the pool can be performed. These functions are governed by a set of non-linear differential equations. The non-linearity arises due to the *filtration function*, as shall become apparent in the following.

3.4 Mass conservation

The transportable debris from the hypothesized LOCA moves down into the containment emergency sump forming a pool of water (Figure 3). The initial concentration of debris in the containment emergency sump water pool is $C_p(0) = \frac{M_p(0)}{V_p}$. At the start of the ECCS recirculation phase, we assume all the transportable debris is in the pool. Hence, there is none on the strainer or the core ($M_s(0) = 0$ and $M_c(0) = 0$). The rate of accumulation of the debris on the strainer and the core is almost entirely governed by the amount by the

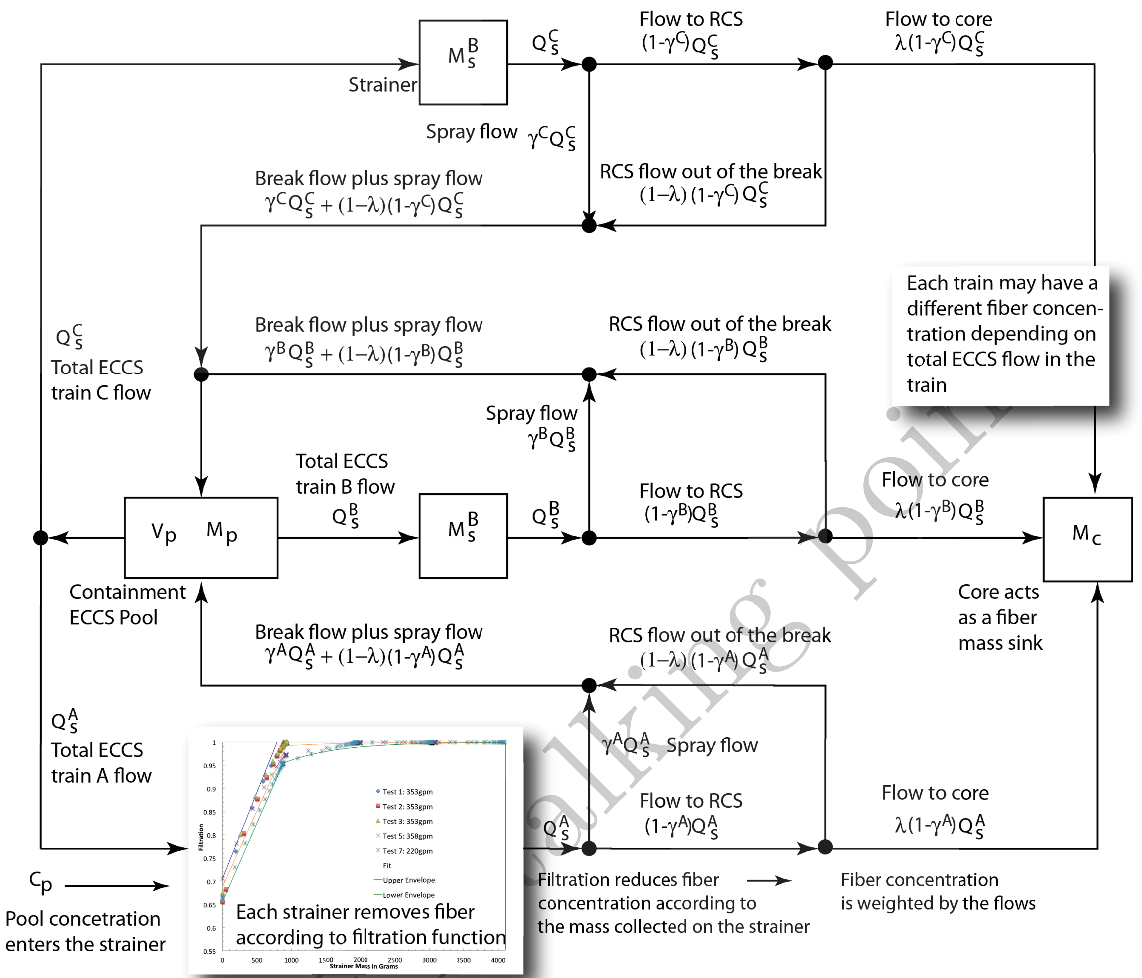


Figure 6: Flow network for the three STP ECCS and CSS trains showing the three places debris is caught: the pool, the strainer, and the core during a CLB scenario. Shown as well are the various flow splits that take place between the places debris is caught. The flow split λ is defined by the amount of flow demanded by the core to remove decay heat.

Table 4: Example of the first few flows that would result from a decay heat load in a 40K MWd/MTU exposure assuming 3853 MW operation history. Note that the time is not shifted to account for delay to start of recirculation following LLOCA

Hour	Flow (gpm)	Hour	Flow (gpm)
0	2141.1	0.0125	1467.4
0.0025	2141.1	0.015	1401.1
0.005	1964.3	0.0175	1352.5
0.0075	1718.6	0.02	1314.1
0.01	1564.8	0.0225	1281.8

amount of fiber that penetrates the strainer and is subsequently transported to the core as a result of the core flow rate. The governing conservation equations are:

$$\frac{d}{dt}M_s^k(t) = Q_s^k(t)C_p(t)f(M_s^k(t)), \tag{1a}$$

$$\frac{d}{dt}M_c(t) = Q_c(t)C_p(t)\frac{\sum_k\left[\left(1-f(M_s^k(t))\right)\left(1-\gamma^k\right)Q_s^k(t)\right]}{\sum_k\left[(1-\gamma^k)Q_s^k(t)\right]}, \tag{1b}$$

$$0 = \frac{d}{dt}M_p(t) + \frac{d}{dt}\sum_k M_s^k(t) + \frac{d}{dt}M_c(t), \tag{1c}$$

where k is the strainer index. Wherever k appears the index is taken over all the values in $\{A, B, C\}$, i.e., the three strainers. The initial conditions and boundary conditions are:

1. $f(M_s)$ is a fraction between 0 and 1 Figure 7, dependent on the amount of mass on the strainer (Ogden et al., 2013, Figure 13)[1],

2. $Q_s(\cdot)$ should be treated generally as a function of time to model pumps turning on and off (discrete tabular function),

3. $Q_c(\cdot)$ is a known function of time (discrete tabular function based on decay heat demand),

4. V_p is a given constant value for any particular scenario,

[1] Ogden et al. (2013) used test data from measurements performed on one of the 20 strainer modules in each STP ECCS train. As a consequence, the data must be scaled to the full strainer area (scaled by a factor of 20) when applied to the full plant.

5. The initial mass on the core is $M_c(0) = 0$,
6. The initial mass in the pool, $M_p(0)$, is given,
7. And $C_p(t) = M_p(t)/V_p$.

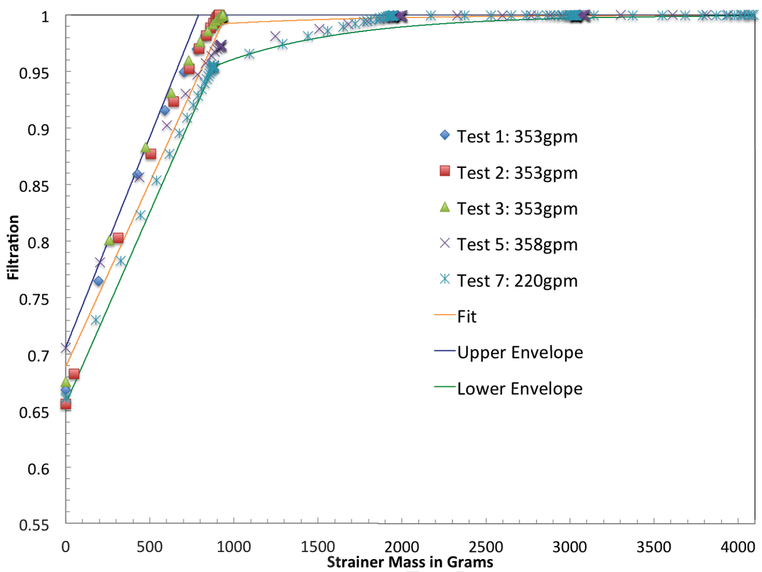


Figure 7: Filtration efficiency fits as a function of mass compared to measured data for the STP ECCS strainer modules. Efficiency fits obtained for the upper, central, and lower limits of the measurements are compared to the measured data.

3.5 Implementation

FIDOE is a Python script developed at the University of Texas at Austin under STP grant BO4425 and is implemented on OS X for production. Apple distributes OS X (Release 10.10) with Python; however, Python was updated to a later version (Version 3.4.2) to run FIDOE. The open-source PANDAS library (http://pandas.pydata.org/) is used in the FIDOE implementation.

The mass conservation equations and implementation in Python are described in ML15091A440 (Powell, 2015, Attachment 7) and again in this document (Section 3.4).

Validation of the conservation equations took place over about a two month period during which time period some changes were made to the original proposed formulation. Validation and verification of the software was performed by the University of Texas at Austin and STP. Verification and validation was independently performed by STP GSI-191 Oversight personnel. YK.risk, LLC also performed validation.

FIDOE is densely commented and the source code is self-explanatory. In this section, the elements of the Python module are described in more detail.

3.5.1 Input/Output Format

The inputs are in the form of two flat files, which are read via the function `ReadParams`, using Python's 'pandas' library (http://pandas.pydata.org/). The first flat file is indexed on time and takes on the following form as an example:

```
t,Q_s_a,Q_s_b,Q_s_c,Q_c
0,9600,9600,9600,2000
5,0,9600,9600,1500
⋮
```

The header `t` represents the time index for any time series of inputs (in minutes), while the headers `Q_s_a`, `Q_s_b`, `Q_s_c`, and `Q_c` represent the flow rates through the three strainers and the core, respectively. It is assumed that the flow rates in gallons per minute (gpm) through the strainers are known as an explicit function of time. These flow rates include the ECCS and CSS flows through each strainer. In the example above, the flow rate through the first strainer (A) would be 9600 gpm over the first 5 minutes, and 0 thereafter.

The second flat file consists of inputs that are constant over time and takes on the following form as an example:

```
Initial Mass:
M_p_0,87000
M_s_a_0,0
M_s_a_0,0
M_s_c_0,0
M_c_0,0
⋮
```

This describes the initial mass (in grams) of debris in the pool, the three trains, and on the core, respectively, at the start of the simulation. Additional inputs specified in this input file include the pool volume, strainer recirculation rates, the function type used to describe the relationship between debris on a strainer and the filtration fraction of that strainer, and parameters associated with that function type.

The output consists of a single time series flat file and a plot of debris on the strainers and the core over time, up to a given threshold. The output flat file takes on the following form:

```
t,M_s_a,M_s_b,M_s_c,M_c
0,9600,9600,9600,2000
5,0,9600,9600,1500
⋮
```

3.5.2 Class MassCalculator

The FIDOE module contains a single class, MassCalculator. The following tasks are completed in MassCalculator on initialization, with parameters as given by the function ReadParams as input:

- Read or set default pool volume (gallons) and initial mass in pool (grams)
- Read or set default initial mass on strainers
- Read or set default initial mass on core
- Read or set default gamma, the percentage of water flowing back to the strainers
- Read or set default strainer flow rates, in gpm
- Read or set default core flow rate, in gpm
- Read or set default filtration rate for any strainer (as a function of mass on the strainer)
- Alert the user of any default values that are used, due to a lack of specified inputs

Within this class, there are several accessors

3.5.3 Strainer and core flow rate retrieval

Strainer flow rates are obtained from three functions, getFlowRateStrainerA, getFlowRateStrainerB, and getFlowRateStrainerC. The core flow rate is obtained using the procedure getFlowRateCore. All four procedures take the time period as a single input, and return the flow rate out of the three ECCS strainers, in gallons per minute. Time-dependent flows are used as read from values stored in the class at initialization.

3.5.4 Filtration Function by Strainer

The function getFiltrationRate receives a single input, the mass on the strainer, and returns the fraction of debris that will attach to the strainer (rather than pass through) given that mass. We assume that this filtration rate includes any potential losses due to shedding, as that is embedded in the equations calculated by Ogden et al. (2013). The

filtration function given in (Ogden et al., 2013) is a function of the mass on a strainer module, and there are 20 modules on each strainer, so we divide the mass input by 20 to arrive at the filtration function.

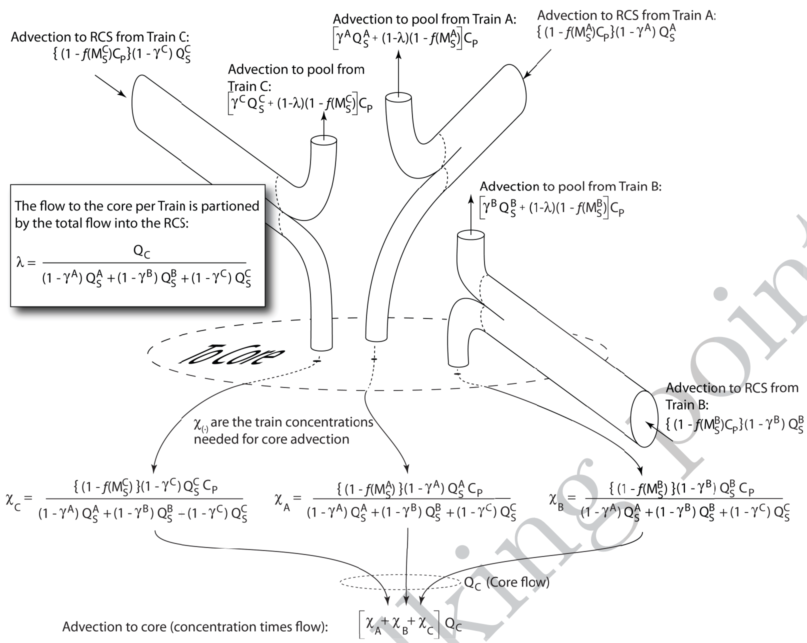


Figure 8: default

Rates of changes of debris by location The functions `getDeltaMassStrainerA`, `getDeltaMassStrainerA`, and `getDeltaMassStrainerC` take the time (in minutes) and an input vector of the masses in the strainers, core and containment pool as inputs, and returns the rate of advection through strainers A, B, and C, respectively, using (1a). The function `getDeltaMassCore` takes the same set of inputs and returns the rate of advection through the core, as described in (1b); this calls on the function `getNetPassThroughRate`, which calculates the sum of χ_A, χ_B, and χ_C at the bottom of Figure 8. Finally, the function `getDeltaMassPool` takes the same set of inputs and returns the rate of change of debris in the pool, as given in (1c). These functions are aggregated through the function `getAllDeltas`.

ODE Solver The function `SolveForCoreMass` takes the time period as an input, and numerically solves the system of functions as given in `getAllDeltas` by calling the 'LSODA' solver, which is the default solver in Python and part of the ODEPACK suite of differential equation solvers Hindmarsh (1983).

3.5.5 Interface

After calling the module through a Python interpreter, the following procedure takes place:

- The user is prompted to enter the name or filepath of the time-indexed and constant inputs file, the maximum timespan to solve (in minutes), and the desired name of the results output.
- The input files are read via the function `ReadParams`.
- The class `MassCalculator` is initialized. Any missing inputs to the class are noted in the console output as are the default values used in their place.
- For 1000 points between zero minutes and the timespan given as input, the system of ODE's given in `SolveForCoreMass`.
- Plots of mass on each strainer and on the core are created, and a table of these values are saved under the filename given as input.

3.6 Results

(1a) to (1c) were integrated in an application that uses well-known ordinary differential equation solvers[2] implemented in a Python application to obtain $M_c(t)$ (Listing 13). The application is designed to provide solutions for different initial conditions and boundary conditions supplied in simple text files. The application is fully described in Section 10 with code listing and input files.

The amount of fiber bypassed to the core is primarily dependent on the initial sump pool concentration, $C_p(t=0)$, the filtration efficiency, $f(\cdot)$, and the decay heat demand, $Q_c(t)$ which is a fixed function of time. The pool concentration is defined by the amount of LDFG arriving in the ECCS sump pool for each D_i^{small} and the pool volume. The filtration efficiency is based on data with uncertainty (Figure 7).

Uncertainty associated with the variables, $C_p(t=0)$ and $f(\cdot)$ is evaluated by looking at lower and "upper bound" values for the variables. The threshold amount of LDFG fines in all the risk-informed scenarios (Table 12)is approximately 192 lbm (the amount tested). Assuming the total amount of LDFG transported to the sump is double the amount of fines, an upper bound for fiber mass in the pool for risk-informed scenarios would be about 550 lbm (note that smalls don't fully transport to the strainer). A reasonable upper pool volume limit is approximately 550,000 gal and reasonable lower limit is approximately 300,000 gal.

[2] "lsoda" from the class, scipy.integrate.ode, is implemented. From the scipy.integrate.ode documentation: 'Real-valued Variable-coefficient Ordinary Differential Equation solver, with fixed-leading-coefficient implementation. It provides automatic method switching between implicit Adams method (for non-stiff problems) and a method based on backward differentiation formulas (BDF) (for stiff problems).'

Table 5: Core mass accumulation for bounding cases of initial ECCS sump pool fiber concentration $C_p(t = 0)$ and upper and lower bounds of filter efficiency.

$C_p(t = 0)$ gm/GAL	**lower**:$f(M_s^k(t = 150 \text{ min.}))$	**upper**:$f(M_s^k(t = 150 \text{ min.}))$
High (0.832)	441	247
Low (0.158)	400	241

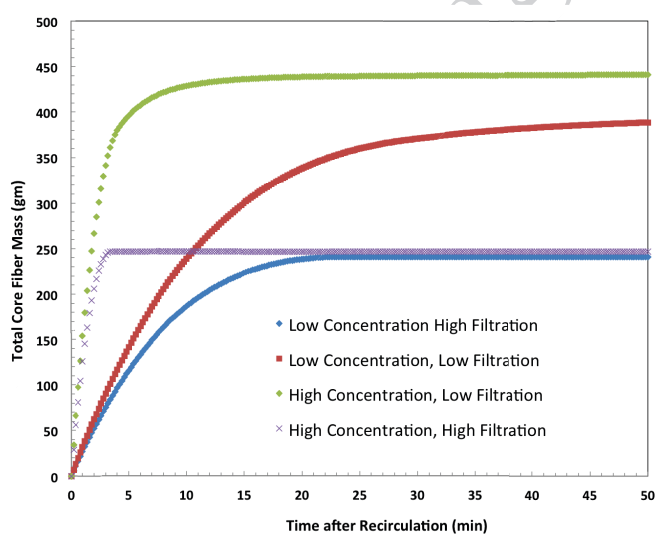


Figure 9: Comparison of bounding cases for core LDFG accumulation after start of ECCS recirculation. The mass accumulation should be divided by 193 to obtain gm/FA.

3.7 Sensitivity studies for fixed penetration fraction

Previous investigators have used, or are familiar with, a so-called 'fixed filtration' constant to estimate core fiber loading (Andreychek and McNamee, 2014, for example) and (for example ACRS, 2015, discussions on pages 209 and 210). To relate results of a fixed filtration constant approach to a fit of the measured data to the accumulated mass (as explained in Section 3.4) a version of FIDOE was created to investigate fixed fiber penetration values. The updated version of FIDOE uses (1) for mass conservation but $f()$ is a constant value set by the user in input. The updated version of FIDOE is provided in **??** along with input and output files.

Four levels of fixed filtration, 0.4, 0.5 0.6, and 0.7 were applied at three levels of total strainer flow (5063 gpm, 6750 gpm, and 8438 gpm), and three levels of starting pool fiber concentration (0.11 gm/gal, 0.17 gm/gal, and 0.39 gm/gal). Note that the minimum measured filtration for STP ECCS strainers as shown in Figure 7 is roughly 0.65. Results of the fixed filtration study are summarized in Table 6. Although the accumulation under this assumption (fixed filtration) will clearly be more than for the measured behavior, the sensitivities help confirm that the accumulated fiber on the core with 192 lbm in the sump will be less than 15 gm/FA.

Table 6: Sensitivity study of core fiber loading, $M_c(t = 400min)$, using fixed filtration at three initial pool concentration ($C_p(0)$) levels: “Normal” = $0.17\frac{gm}{gal}$, “Low” = $0.11\frac{gm}{gal}$, and “High” = $0.39\frac{gm}{gal}$ (full block design)

Normal Concentration			
	M_c (gm/FA) at strainer flow of:		
Filtration	6750 gpm	8438 gpm	5063 gpm
0.4	18.1	28.3	15.0
0.5	13.0	16.0	10.4
0.6	8.8	10.9	7.3
0.7	5.7	7.3	4.7
Low Concentration			
	M_c (gm/FA) at strainer flow of:		
Filtration	6750 gpm	8438 gpm	5063 gpm
0.4	13.5	16.8	11.4
0.5	9.8	11.9	7.8
0.6	6.7	8.3	5.4
0.7	4.4	6.03	3.6
High Concentration			
	M_c (gm/FA) at strainer flow of:		
Filtration	6750 gpm	8438 gpm	5063 gpm
0.4	25.9	31.6	20.7
0.5	17.6	22.8	14.0
0.6	11.9	15.5	9.8
0.7	7.8	10.4	6.5

4 LOCA frequencies

In general, the ECCS strainer may operate under several different plant states. Most of the plant states tested will be congruent with deterministic assumptions on train availability (plant states). In the risk-informed category of RoverD, scenarios associated with plant states not tested would be relegated to failure, or could be assessed for risk based on their risk contribution in a way similar to the states tested. Because different plant states may need to be evaluated, depending on details associated with the test used in the RoverD assessment, an additional step may need to be taken to account for plant states not tested.

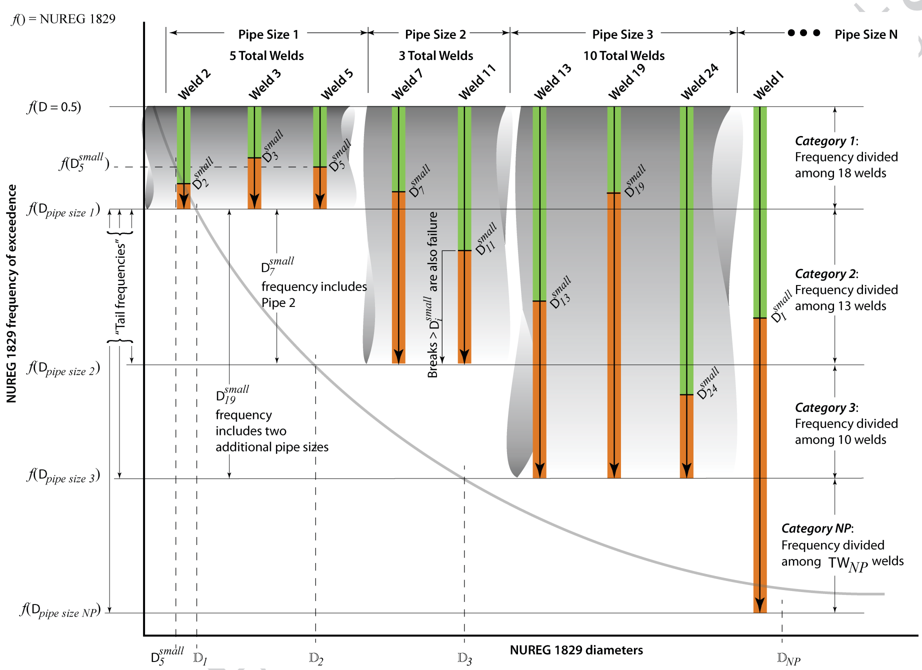


Figure 10: The top down approach assigns equally-weighted frequency in intervals between pipe diameter extents. As D_i^{small} becomes larger, the total number of welds in successive categories decreases.

4.1 ΔCDF frequency determination

A fundamental goal of the RoverD approach is to determine the total frequency of breaks that fall into the risk-informed category. In a preprocessing step known as RoverD's *fetch stage*, CASA Grande runs are performed to identify all weld locations, with corresponding break sizes, which produce more than the allowable amount of fiber fines.

With fetch completed, RoverD has data that can be thought of as ordered pairs consisting of a weld index and a break size. For now, assume that I weld locations are

in the risk-informed category and these locations are indexed by $i = 1, \ldots, I$. Each weld location i then has a corresponding break size D_i^{small} which caused it to be placed in the risk-informed category. It is possible that for a single weld, multiple break scenarios caused it to be put in this category. If so, define D_i^{small} to be the smallest such break size.

Now, recall that the goal is to determine the overall frequency of events that generate too many fiber fines. Two primary principles are adhered to in order to obtain the top-down frequency:

1. In the limiting case for which every weld and every break above x is considered "bad" (that is, at that break size, more fines come to the sump than were tested), Φ should equal to $f(x)$, the NUREG 1829 exceedence frequency at x,

2. In the top-down method, RoverD should depend on the number of welds in the RoverD fetch file, for any (fixed) plant. In particular, Φ should increase if welds are added to the set of "bad" welds.

For each weld i in the risk-informed category the goal is to determine the frequency of breaks that exceed D_i^{small}. This is called $F(D_i^{small})$ and is the frequency of unacceptable events caused by that particular weld. Then, the overall frequency of unacceptable events caused by breaks in the risk-informed category is simply the sum of these frequencies:

$$\Phi = \sum_{i=1}^{I} F(D_i^{small}).$$

In general, as shown in Figure 10, interpolation is required to obtain frequencies at break sizes, D_{small}, and pipe diameters other than the data in Table 7. Because the Tregoning et al. frequency data 'fall off' so quickly as break size increases, two methods are reviewed, linear-linear and log-linear (Figure 11).

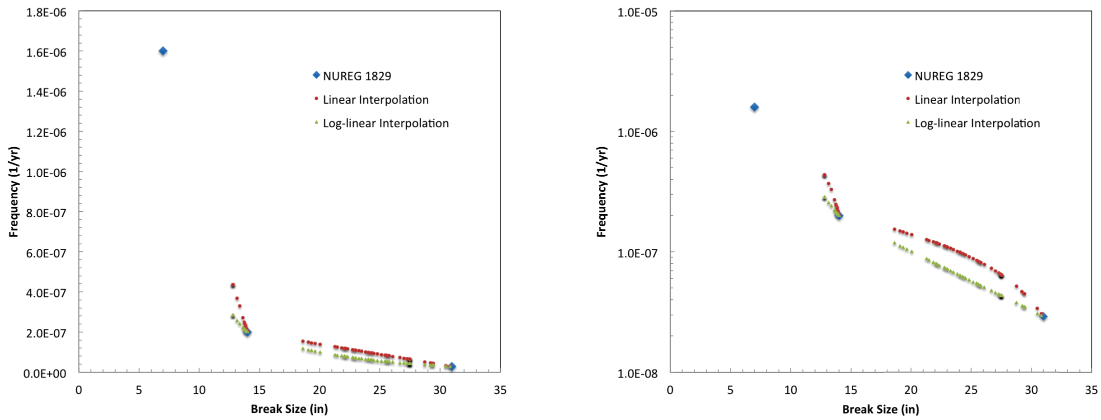
The log-linear method interpolates for the frequency at break size x in the interval a and b with the log of the frequencies, ϕ_a and ϕ_b which appears to be a more natural fit in a log-linear presentation (Figure 11a):

$$\phi_x = 10^{\log_{10}\phi_a + (\log_{10}\phi_b - \log_{10}\phi_a)\frac{x-a}{b-a}}. \tag{2}$$

The linear-linear method is interpolates frequency (Φ_x) linearly at x (break size) values. Of course, it appears to be a natural fit between data in a linear-linear presentation (Figure 11b):

$$\phi_x = \phi_a + (\phi_b - \phi_a)\frac{(x-a)}{(b-a)}. \tag{3}$$

To explain the calculations, we first focus on a particular weld from Figure 10. In particular, we examine Weld 5 in a pipe of category 1, which is denoted by $\mathbb{D}_1$. To determine $F(D_5^{small})$, the goal is to be consistent with NUREG-1829. Any particular quantile value in



(a) Example data at the upper NUREG 1829 break sizes shown in a linear plot format (linear-linear interpolation data form a straight line between data points)

(b) Example data at the upper NUREG 1829 break sizes shown in a log-linear plot format (log-linear interpolation data form a straight line between data points)

Figure 11: Using linear interpolation or log-linear interpolation of NUREG 1829 data (Tregoning et al., 2008) produce different inter-point interpolation behaviors on different graph formats.

Table 7: NUREG-1829 (Tregoning et al., 2008, Table 7.19) for the mean, median, 5th percentile, and 95th percentile exceedence frequency values for current-day estimates STP PRA break sizes for small, medium and large LOCA are, less than 2 in (small), 2 in to 6 in (medium), greater than 6 in (large).

		NUREG-1829 Values			
Category	Break Size (in)	**5th**	**Median**	**Mean**	**95th**
cat_1	$\frac{1}{2}$	6.80E-05	6.30E-04	1.90E-03	7.10E-03
cat_2	$1\frac{5}{8}$	5.00E-06	8.90E-05	4.20E-04	1.60E-03
cat_3	3	2.14E-07	3.4E-06	1.6E-05	6.1E-05
cat_4	7	1.4E-08	3.1E-07	1.6E-06	6.1E-06
cat_5	14	4.1E-10	1.2E-08	2.0E-07	5.8E-07
cat_6	31	3.5E-11	1.19E-09	2.9E-08	8.00E-08

Table 7 may be used as the basis. For example, the PRA LOCA initiating event frequencies are based on the mean value. Let $f(D_5^{small})$ be the exceedance frequency for a break of size D_5^{small} as implied by a selected quantile value in Table 7. In general, such a quantity must be interpolated from the values in the NUREG-1829 categories.

Plant-wide, the frequency of breaks of size D_5^{small} and larger is

$$f(D_5^{small}).$$

Shown down the right side of Figure 10 are categories defined by increasing pipe sizes. We define $Cat(D_i^{small})$ as $0 < \mathbb{D}_1 < D_2 < \ldots < \mathbb{D}_{j-1} < D_i^{small} < \mathbb{D}_j \ldots < \mathbb{D}_{n-1} < \mathbb{D}_n$, $Cat(D_i^{small}) = j$. Every weld that can experience a break of size D_5^{small} or larger contributes to the overall frequency. Hence, it is deduced that:

$$F(D_5^{small}) = \frac{f(D_5^{small})}{TW_1},$$

where TW_n for pipe size n is the total number of welds in pipes of this category or larger.

For a pipe in category 2, the calculation is similar. However, it should be noted that the denominator in the equation above depends only on the size of the break and not the category of pipe in which the weld resides. So, for Weld 7 in pipe category 2, D_7^{small} is smaller than $\mathbb{D}_1$. In this case, the frequency of a break of size D_7^{small} is

$$F(D_7^{small}) = \frac{f(D_7^{small})}{TW_1}.$$

For Weld 11, it is

$$F(D_{11}^{small}) = \frac{f(D_{11}^{small})}{TW_2}.$$

Now for any weld i in pipe category n with a smallest break size D_i^{small} a general formula can be written:

$$F(D_i^{small}) = \frac{f(D_i^{small})}{TW_{Cat(D_i^{small})}}. \tag{4}$$

$Cat(D_i^{small})$ is the pipe category corresponding to D_i^{small}. For example, if Category 1 is 1-inch pipes and category 2 is 2-inch pipes, then for a break of 1.75in, $Cat(1.75in) = 2$.

Now, let R_n be the set of all welds which are in the risk-informed category and are associated with pipes of category n. Then, the frequency of unacceptable events due to weld breaks in pipes of category n can be written as:

$$\sum_{i \in R_n} F(D_i^{small}).$$

Finally, the overall frequency of events in the risk-informed category is given by:

$$\Phi = \sum_{n=1}^{NP} \sum_{i \in R_n}^{I} F(D_i^{small}). \tag{5}$$

4.2 Plant states not tested

Single ECCS/CSS train operation is not assumed in a deterministic STP LOCA evaluation. However, in a risk-based assessment, single train operation is possible and for certain scenarios, single train operation is assessed to go to success in the PRA. In the STP ECCS design, single train operation would result in twice the debris load on the operating strainer. Therefore, the breaks that could be tolerated would be those with one half the tested (two-train operation) debris load.

The break frequency description above would apply in the same way to the single train operation, but would clearly result in higher frequencies due to the increased debris load. To account for the increased risk, (5) could be assessed for the cases where two or three trains are operating (cases either tested or bounded by the test) and assessed again for the untested case (single train operation) with the higher frequency. For example, if f_2 is the success frequency for two or more trains operating and f_1 is the success frequency for single train operation, (5) can be rewritten to accommodate the total frequency, $\hat{\Phi}$, for both operating states:

$$w_j = \frac{f_j}{\sum_j f_j};\ j = 1, 2, \tag{6a}$$

$$\Phi_j = w_j \sum_{n=1}^{NP} \sum_{i \in R_n}^{I} F(D_i^{small}), \tag{6b}$$

$$\hat{\Phi} = \sum_j \Phi_j. \tag{6c}$$

4.3 ΔLERF frequency

Because the STP RCFC are independent of the concerns raised in GSI-191, and because their design can remove decay and maintain contamination RCB limits within design, concerns raised in GSI-191 would not result in containment failure. The RCFC design allows for simplification of LERF. That is, for the STP design, the change in early release frequency could be assumed directly proportional to the change in core damage frequency:

$$\Delta LERF = LERF_{MOR} \left(\frac{\Delta CDF}{CDF_{MOR}} \right) \tag{7}$$

4.4 Results

STP has two Cases (Case 1 and Case 2) other than the condition tested (AREVA, 2008) that are bounding for fine fiber amounts. The tested deterministic case assumed two of the three STP ECCS strainers in operation (single failure criterion). Case 1 is the most likely case when all three strainers are in operation. In this case, far less fiber will accumulate on each strainer than for the tested case. Therefore, Case 1 is bounded by the tested case.

However, Case 2 corresponds to a case where only one train of the three STP ECCS strainers are in operation. Although this case is beyond design basis, it needs to be considered in the risk analysis since at least twice as much fiber would accumulate on the single strainer than when two or more strainers are in operation. In this case, only 1/2 the tested amount of fine fiber can be assumed to be tolerated.

4.5 ΔCDF results

When all cases are considered using (6), a slightly higher ΔCDF is estimated than when only one strainer is in operation. Table 8 summarizes the ΔCDF estimate for geometric and arithmetic averages from Tregoning et al. (2008). The frequencies for the bounding cases are $f_2 = 3.32E - 6yr^{-1}$ (Case 1) and $f_1 = 4.34E - 8yr^{-1}$ (Case 2). As shown, the median ΔCDF is within Region III of the Regulatory Guide 1.174 evaluation ($\ll 1.0E{-}06$). Interpolation of Table 7 is done using the linear-linear method, (3).

Table 8: Case 1 and Case 2 results for geometric (GM) and arithmetic (AM) aggregations of Tregoning et al. (2008, Tables 7.11 and 7.19) data. Frequencies are in events/yr. Also shown are the results for a DEGB-only model for the locations that go to failure.

Continuum Break Model						
Quantile	Case 1 GM	Case 1 AM	Case 2 GM	Case 2 AM	$\hat{\Phi}$ (GM)	$\hat{\Phi}$ (AM)
5^{th}	2.64E-10	6.47E-09	3.68E-09	2.36E-08	3.08E-10	6.69E-09
50^{th}	7.50E-09	1.68E-07	8.30E-08	4.92E-07	8.47E-09	1.72E-07
95^{th}	3.43E-07	4.79E-06	1.81E-06	1.24E-05	3.62E-07	4.89E-06
Mean	1.17E-07	1.56E-06	5.10E-07	3.93E-06	1.22E-07	1.59E-06
DEGB-Only Model						
5^{th}	9.83E-11	8.18E-09	1.14E-09	1.66E-08	1.12E-10	8.29E-09
50^{th}	2.86E-09	2.07E-07	2.64E-08	3.90E-07	3.16E-09	2.09E-07
95^{th}	1.47E-07	7.06E-06	6.85E-07	1.21E-05	1.54E-07	7.13E-06
Mean	5.12E-08	2.06E-06	2.03E-07	3.61E-06	5.32E-08	2.08E-06

As shown in Table 8, only the 95^{th} percentile of the arithmetic mean estimate exceeded the Region III criterion in (NRC, 2011). As described in the letter to the NRC dated May

Table 9: ΔLERF evaluation for geometric and arithmetic means of the Continuum and DEG-only models.

Model	ΔLERF using $\hat{\Phi}$ (GM)	ΔLERF using $\hat{\Phi}$ (AM)
Continuum break model	7.67E-09	9.99E-08
DEGB-only model	3.34E-09	1.31E-07

22, 2014 (ML14149A434), the geometric method of aggregation is the most appropriate estimator of LOCA frequency from (Tregoning et al., 2008).

4.6 ΔLERF results

Due to independence of RCB integrity from the concerns raised in GSI-191, ΔLERF is very small. Using (7), ΔLERF values were calculated based on baseline CDF and LERF values of 9.2E-06 (CDF) and 5.78E-07 (LERF). The results are summarized in Table 9.

5 RCS Thermal-hydraulics

Vaghetto and Hassan (2013) studied the behavior of the RCS for scenarios where the fuel channels and the core bypass flow paths were fully blocked. They showed that, unless the LOCA was large and located on the cooling water return side (cold leg) of the RCS, then debris blockage is not a concern. Simulations were conducted using the STP RELAP5 model to analyze the reactor system response under hypothetical core blockage scenarios during selected LOCAs. The purpose of these calculations was to identify the scenarios which may produce an increase in the PCT and, subsequently, a potential core damage among selected LOCAs of different break sizes and locations under full core and core bypass blockage. The simulations performed are listed below:

1. SLOCA in Cold Leg
2. SLOCA in Hot Leg
3. MLOCA in Cold Leg
4. MLOCA in Hot Leg
5. DEGB in Cold Leg
6. DEGB in Hot Leg

Table 10 summarizes the basic assumptions and boundary conditions for the simulations. The simulations were designed to create a theoretically worst-case condition by blocking the core when the decay load is maximum. Both core and core bypass (baffle flow) were assumed to be instantaneously blocked after the sump switchover at the inlet. PCT was

used as figure of merit to determine the success or failure of the scenario simulated. All the cases which produced a PCT less than 800°F were assumed to be successful. The cases where the maximum PCT was found to diverge after the core blockage time (exceeding the limiting temperature of 800°F) were considered failing cases which may lead to core damage. Table 11 summarizes the results obtained.

Table 10: Summary of boundary conditions and assumptions of the STP core blockage analyses

Parameter	Simulation Condition
ECCS	3 Trains
Break location	Cold leg B (bottom)
Core blockage simulation	Instantaneous k-loss increase at sump switchover
Reactor power (MWt)	3853
Axial power shape	Double peak (0.15 and 0.8 core height)
Actinides	RELAP5-3D default model
Decay heat	ANS73
RWST temperature	85°F
ECCS flow	Nominal (realistic)

Table 11: Results of blockage scenarios showing scenarios that had PCT less than 800°F (Pass) and those that exceeded 800°F (Fail).

	Break location	
Break Size	Cold leg	Hot leg
Small	Pass	Pass
Medium	Fail	Pass
Large	Fail	Pass

6 Core performance metrics

In addition to satisfying the strainer performance metrics, certain core performance must be acceptable with the amount of LDFG fines tested as well. There are two metrics, separately evaluated but ultimately having the same consequence, that must be found acceptable to categorize a scenario as deterministic. Decay heat removal considering LDFG blockage of the core cooling channels and freedom from boric acid precipitation must be found acceptable.

Ogden et al. (2013) have shown that the amount of fiber penetrating through the ECCS sump screen is a function of ECCS LDFG loading. In order for the screen performance metrics as tested (again AREVA, 2008, for example) to serve as the 'worst case' condition for deterministic characterization, the amount of fiber passing through the ECCS strainers needs to be less than that tested by the PWROG as acceptable.

6.1 Core cooling

The PWROG (2011) has tested performance of the reactor core fuel assemblies under deterministically challenging conditions, and developed a performance metric in terms of the allowable amount of LDFG fiber accumulation on the reactor fuel assemblies. The currently accepted allowable amount of fiber accumulation for STP cores is 15 grams of fiber per FA. The PWROG fuel assembly testing was performed to investigate heat removal with particulate, chemical precipitates, and LDFG fiber present in the fuel assemblies but boric acid precipitation was not a consideration in the PWROG testing. As shown in the uncertainty analysis in Section 3 (Table 5), the maximum total fiber captured in the core in a CLB is calculated to be 441 gm. The STP cores use 193 FAs, resulting in a high estimate of fiber loading of less than 3 gm/FA.

As described in Section 5, HLB scenarios (as well as small break scenarios) can succeed regardless of the fiber amounts transported to the core. The analysis in Section 5 show full blockage of all flow into the core during SLOCA and HLB will not cause loss of adequate cooling.

6.2 Boric acid precipitation

In addition to heat removal, the reactor core must remain below the precipitation limit for boric acid during the first few hours of the hypothesized LOCA. As a consequence of the presence of LDFG fiber transported to the fuel assemblies, boric acid buildup may be more than with the fuel assemblies clear of obstructions. Boric acid precipitation is a second core performance metric that must be evaluated as acceptable with the fraction of the tested amount of LDFG fibers passing through the ECCS strainers to the core (Section 3). The time required to reach HLSO time must be acceptable with no lower plenum mixing since it has not been determined how much fiber would allow lower plenum mixing to reduce boric acid concentration. Therefore, the deterministic STP HLSO time does not rely on lower plenum mixing.

7 Application

The RoverD method may be interesting to utility investigators who would want to screen their plant risk against the concerns raised in GSI-191. The RoverD method could be used to design a test (or test series) having the objective to obtain a predefined risk margin.

That is, one could sequentially test starting with fiber amounts that would just meet the Regulatory Guide 1.174 Region III requirements and subsequently lesser amounts (down to that amount which just creates a fiber covering on the ECCS screen) to demonstrate margin. Alternatively, perhaps preferably, one would perform simulation to design a test that would help ensure sufficiently low risk (risk in Region III of Regulatory Guide 1.174) would be realized.

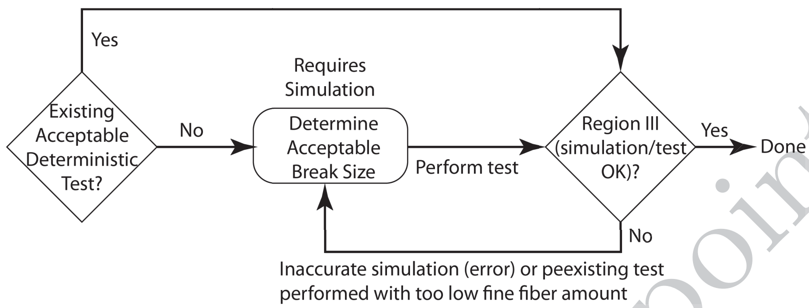


Figure 12: Process for establishing risk thresholds depending on whether an acceptable test has been previously performed or if one should be designed to achieve a specific risk goal.

Figure 12 shows a simple flow path that would accomplish this process. With an existing acceptable test, analysis would be performed to understand if it provides sufficient margin or not. If not, or absent an existing acceptable test, one would first simulate their plant to find the amount of fines transported to the sump for all possible pipe breaks. The scenarios from such a simulation could then be used to design a test (for example using CASA Grande) that would meet acceptable deterministic testing criteria. A test could be then performed and the results compared to the simulation to ensure the design is met, otherwise, a refinement to the test design could be made based on lessons learned.

Utility investigators could directly derive (Table 7), the risk margin margin desired. As indicated in Figure 12, inaccuracies in the simulation may result in a test that doesn't provide sufficient margin. At this point, another test could be designed based on lessons learned to converge on an acceptable result. If the test demonstrates acceptable ECCS and core performance metrics for the deterministic classifications and the risk is acceptable, then low risk can be asserted for the concerns raised in GSI-191 for the particular plant.

8 Weld list

In the following, tables summarize the STP scenarios in the RoverD assessment. Table 12 summarizes the STP RoverD risk-informed scenarios. For these scenarios, the minimum amount of fiber (the amount associated with smallest D_i) at each location is listed in the Amount column.

Table 13 summarizes the STP RoverD scenarios associated with locations that don't exceed the tested amount of fiber at the maximum possible (DEGB) break size. For these scenarios, the column 'Margin' corresponds to the additional amount of fiber required at the location that would be need to exceed the tested amount. The f_i column also is the associated DEGB frequency.

Similar data are provided in Table 14 and Table 15 for the single train cases studied. In this case, there are more locations that have D_i^{small} that exceed the criterion because the acceptance quantity of fiber fines is one half the tested amount (due to half the surface area available for capture).

Table 12: Data for weld locations in the risk-informed category listing the i^{th} weld number, mass of fiber in the sump for the scenario (lbm), location name (ID), Break size (Size), scenario frequency, f_i (mean quantile, geometric aggregation), Category, and NUREG 1829 data category

No.	Amount (lbm)	Location	Size (in)	f_i	NUREG 1829 Cat.
1	207.16	16-RC-1412-NSS-8	12.814	4.37E-07	Cat. 4
2	191.78	29-RC-1101-NSS-RSG-1A-IN-SE	13.922	2.16E-07	Cat. 4
3	191.95	29-RC-1101-NSS-5.1	13.939	2.12E-07	Cat. 4
4	192.23	29-RC-1201-NSS-5.1	14.120	1.99E-07	Cat. 5
5	192.60	29-RC-1201-RSG-1B-IN-SE	14.127	1.99E-07	Cat. 5
6	195.55	29-RC-1301-RSG-1C-IN-SE	14.342	1.97E-07	Cat. 5
7	196.62	29-RC-1301-NSS-5.1	14.405	1.96E-07	Cat. 5
8	196.03	29-RC-1401-NSS-RSG-1D-IN-SE	14.620	1.94E-07	Cat. 5
9	196.51	29-RC-1401-NSS-4.1	14.650	1.93E-07	Cat. 5
10	192.74	29-RC-1101-NSS-4	14.721	1.93E-07	Cat. 5
11	192.05	29-RC-1301-NSS-4	14.948	1.90E-07	Cat. 5
12	191.87	29-RC-1201-NSS-4	14.953	1.90E-07	Cat. 5
13	194.24	29-RC-1401-NSS-3	15.172	1.88E-07	Cat. 5
14	193.97	31-RC-1102-NSS-2	16.525	1.75E-07	Cat. 5
15	194.36	31-RC-1202-NSS-RSG-1B-ON-SE	16.724	1.73E-07	Cat. 5
16	195.82	31-RC-1102-NSS-RSG-1A-ON-SE	16.760	1.72E-07	Cat. 5
17	201.09	31-RC-1202-NSS-2	16.819	1.72E-07	Cat. 5
18	191.78	31-RC-1202-NSS-3	17.020	1.70E-07	Cat. 5
19	192.64	31-RC-1302-NSS-2	17.209	1.68E-07	Cat. 5
20	201.67	31-RC-1202-NSS-1.1	17.279	1.67E-07	Cat. 5
21	194.24	31-RC-1102-NSS-3	17.338	1.66E-07	Cat. 5
22	192.56	31-RC-1302-NSS-1.1	17.593	1.64E-07	Cat. 5
23	193.22	31-RC-1302-NSS-RSG-1C-ON-SE	17.659	1.63E-07	Cat. 5
24	192.46	31-RC-1202-NSS-4	17.665	1.63E-07	Cat. 5
25	193.39	31-RC-1302-NSS-3	17.674	1.63E-07	Cat. 5
26	211.20	31-RC-1102-NSS-1.1	17.793	1.62E-07	Cat. 5
27	193.53	31-RC-1402-NSS-RSG-1D-ON-SE	17.876	1.61E-07	Cat. 5
28	196.61	31-RC-1102-NSS-4	18.126	1.58E-07	Cat. 5
29	197.10	31-RC-1402-NSS-1.1	18.140	1.58E-07	Cat. 5
30	191.86	31-RC-1402-NSS-2	18.233	1.57E-07	Cat. 5
31	192.24	31-RC-1302-NSS-4	18.367	1.56E-07	Cat. 5
32	192.93	31-RC-1402-NSS-3	19.246	1.47E-07	Cat. 5

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No.	Amount (lbm)	Location	Size (in)	f_i	NUREG 1829 Cat.
33	192.77	31-RC-1202-NSS-8	19.297	1.47E-07	Cat. 5
34	191.93	27.5-RC-1103-NSS-1	19.454	1.45E-07	Cat. 5
35	192.02	31-RC-1102-NSS-8	19.547	1.44E-07	Cat. 5
36	192.16	27.5-RC-1203-NSS-1	19.584	1.44E-07	Cat. 5
37	192.23	31-RC-1402-NSS-4	20.225	1.37E-07	Cat. 5
38	192.27	31-RC-1302-NSS-8	20.367	1.36E-07	Cat. 5
39	191.80	27.5-RC-1303-NSS-1	21.007	1.30E-07	Cat. 5
40	192.07	31-RC-1202-NSS-9	21.114	1.28E-07	Cat. 5
41	192.04	31-RC-1102-NSS-9	21.255	1.27E-07	Cat. 5
42	192.16	27.5-RC-1403-NSS-1	22.068	1.19E-07	Cat. 5
43	191.94	31-RC-1402-NSS-8	22.155	1.18E-07	Cat. 5
44	191.79	31-RC-1302-NSS-9	23.040	1.09E-07	Cat. 5
45	191.96	31-RC-1402-NSS-9	25.303	8.63E-08	Cat. 5

Table 13: DEGB data (largest break size) for weld locations in the deterministic category showing listing the i^{th} weld number, the margin to the mass of fiber in the sump produced to the tested amount (lbm), location name, Break size (Size), scenario DEGB frequency, f_i (mean quantile, geometric aggregation), and NUREG 1829 data category

No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
46	163.2	0.75-CV-1122-BB1-1	0.614	1.75E-03	Cat. 1
47	163.2	0.75-CV-1122-BB1-2	0.614	1.75E-03	Cat. 1
48	163.3	0.75-CV-1124-BB1-1	0.614	1.75E-03	Cat. 1
49	163.3	0.75-CV-1124-BB1-2	0.614	1.75E-03	Cat. 1
50	163.3	0.75-CV-1126-BB1-1	0.614	1.75E-03	Cat. 1
51	163.1	0.75-CV-1126-BB1-2	0.614	1.75E-03	Cat. 1
52	163.3	0.75-CV-1128-BB1-1	0.614	1.75E-03	Cat. 1
53	163.3	0.75-CV-1128-BB1-2	0.614	1.75E-03	Cat. 1
54	163.1	0.75-RC-1001-BB1-1	0.614	1.75E-03	Cat. 1
55	163.0	0.75-RC-1002-BB2-1	0.614	1.75E-03	Cat. 1
56	163.0	0.75-RC-1112-BB1-1	0.614	1.75E-03	Cat. 1
57	162.9	0.75-RC-1114-BB1-1	0.614	1.75E-03	Cat. 1
58	163.0	0.75-RC-1125-BB1-1	0.614	1.75E-03	Cat. 1
59	162.9	0.75-RC-1125-BB1-2	0.614	1.75E-03	Cat. 1
60	163.0	0.75-RC-1126-BB1-1	0.614	1.75E-03	Cat. 1
61	163.0	0.75-RC-1212-BB1-1	0.614	1.75E-03	Cat. 1
62	162.9	0.75-RC-1214-BB1-1	0.614	1.75E-03	Cat. 1
63	163.0	0.75-RC-1221-BB1-1	0.614	1.75E-03	Cat. 1
64	163.0	0.75-RC-1221-BB1-2	0.614	1.75E-03	Cat. 1
65	163.0	0.75-RC-1312-BB1-1	0.614	1.75E-03	Cat. 1
66	162.9	0.75-RC-1324-BB1-1	0.614	1.75E-03	Cat. 1
67	163.0	0.75-RC-1423-BB1-1	0.614	1.75E-03	Cat. 1
68	163.1	0.75-SI-1130-BB2-1	0.614	1.75E-03	Cat. 1
69	163.1	0.75-SI-1132-BB1-1	0.614	1.75E-03	Cat. 1
70	163.1	0.75-SI-1218-BB1-1	0.614	1.75E-03	Cat. 1

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
71	163.1	0.75-SI-1223-BB2-1	0.614	1.75E-03	Cat. 1
72	162.9	0.75-SI-1315-BB1-1	0.614	1.75E-03	Cat. 1
73	163.2	0.75-SI-1323-BB1-1	0.614	1.75E-03	Cat. 1
74	163.1	0.75-SI-1327-BB1-1	0.614	1.75E-03	Cat. 1
75	163.1	0.75-SI-1327-BB1-2	0.614	1.75E-03	Cat. 1
76	163.1	0.75-SI-1327-BB1-3	0.614	1.75E-03	Cat. 1
77	163.1	0.75-SI-1328-BB2-1	0.614	1.75E-03	Cat. 1
78	162.7	1-RC-1003-BB1-1	0.815	1.49E-03	Cat. 1
79	163.0	1-RC-1123-BB1-1	0.815	1.49E-03	Cat. 1
80	162.9	1-RC-1422-BB1-1	0.815	1.49E-03	Cat. 1
81	161.6	1.5-RC-1412-NSS-1	1.338	7.98E-04	Cat. 1
82	163.2	2(1.5)-CV-1122-BB1-1	1.338	7.98E-04	Cat. 1
83	163.0	2(1.5)-CV-1122-BB1-2	1.338	7.98E-04	Cat. 1
84	163.2	2(1.5)-CV-1124-BB1-1	1.338	7.98E-04	Cat. 1
85	162.9	2(1.5)-CV-1124-BB1-2	1.338	7.98E-04	Cat. 1
86	162.7	2(1.5)-CV-1126-BB1-1	1.338	7.98E-04	Cat. 1
87	162.8	2(1.5)-CV-1126-BB1-2	1.338	7.98E-04	Cat. 1
88	163.0	2(1.5)-CV-1128-BB1-1	1.338	7.98E-04	Cat. 1
89	162.8	2(1.5)-CV-1128-BB1-2	1.338	7.98E-04	Cat. 1
90	163.0	2-CV-1121-BB1-1	1.689	4.01E-04	Cat. 2
91	162.8	2-CV-1121-BB1-2	1.689	4.01E-04	Cat. 2
92	162.7	2-CV-1121-BB1-3	1.689	4.01E-04	Cat. 2
93	162.5	2-CV-1122-BB1-1	1.689	4.01E-04	Cat. 2
94	162.6	2-CV-1122-BB1-2	1.689	4.01E-04	Cat. 2
95	162.6	2-CV-1122-BB1-3	1.689	4.01E-04	Cat. 2
96	162.6	2-CV-1122-BB1-4	1.689	4.01E-04	Cat. 2
97	162.6	2-CV-1122-BB1-5	1.689	4.01E-04	Cat. 2
98	162.8	2-CV-1122-BB1-6	1.689	4.01E-04	Cat. 2
99	162.6	2-CV-1124-BB1-1	1.689	4.01E-04	Cat. 2
100	162.5	2-CV-1124-BB1-10	1.689	4.01E-04	Cat. 2
101	162.5	2-CV-1124-BB1-11	1.689	4.01E-04	Cat. 2
102	163.0	2-CV-1124-BB1-12	1.689	4.01E-04	Cat. 2
103	162.9	2-CV-1124-BB1-13	1.689	4.01E-04	Cat. 2
104	162.6	2-CV-1124-BB1-2	1.689	4.01E-04	Cat. 2
105	162.6	2-CV-1124-BB1-3	1.689	4.01E-04	Cat. 2
106	162.5	2-CV-1124-BB1-4	1.689	4.01E-04	Cat. 2
107	162.5	2-CV-1124-BB1-5	1.689	4.01E-04	Cat. 2
108	162.5	2-CV-1124-BB1-6	1.689	4.01E-04	Cat. 2
109	162.7	2-CV-1124-BB1-7	1.689	4.01E-04	Cat. 2
110	162.6	2-CV-1124-BB1-8	1.689	4.01E-04	Cat. 2
111	162.5	2-CV-1124-BB1-9	1.689	4.01E-04	Cat. 2
112	163.1	2-CV-1126-BB1-1	1.689	4.01E-04	Cat. 2
113	162.4	2-CV-1126-BB1-10	1.689	4.01E-04	Cat. 2
114	162.5	2-CV-1126-BB1-11	1.689	4.01E-04	Cat. 2
115	163.1	2-CV-1126-BB1-2	1.689	4.01E-04	Cat. 2
116	163.0	2-CV-1126-BB1-3	1.689	4.01E-04	Cat. 2

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
117	162.9	2-CV-1126-BB1-4	1.689	4.01E-04	Cat. 2
118	162.9	2-CV-1126-BB1-5	1.689	4.01E-04	Cat. 2
119	162.9	2-CV-1126-BB1-6	1.689	4.01E-04	Cat. 2
120	162.8	2-CV-1126-BB1-7	1.689	4.01E-04	Cat. 2
121	161.9	2-CV-1126-BB1-8	1.689	4.01E-04	Cat. 2
122	161.8	2-CV-1126-BB1-9	1.689	4.01E-04	Cat. 2
123	163.3	2-CV-1128-BB1-1	1.689	4.01E-04	Cat. 2
124	163.1	2-CV-1128-BB1-2	1.689	4.01E-04	Cat. 2
125	163.0	2-CV-1128-BB1-3	1.689	4.01E-04	Cat. 2
126	163.0	2-CV-1128-BB1-3A	1.689	4.01E-04	Cat. 2
127	162.9	2-CV-1128-BB1-3B	1.689	4.01E-04	Cat. 2
128	162.9	2-CV-1128-BB1-4	1.689	4.01E-04	Cat. 2
129	162.9	2-CV-1128-BB1-5	1.689	4.01E-04	Cat. 2
130	162.9	2-CV-1128-BB1-6	1.689	4.01E-04	Cat. 2
131	162.8	2-CV-1128-BB1-7	1.689	4.01E-04	Cat. 2
132	162.8	2-CV-1141-BB1-1	1.689	4.01E-04	Cat. 2
133	162.9	2-CV-1141-BB1-2	1.689	4.01E-04	Cat. 2
134	162.7	2-RC-1003-BB1-1	1.689	4.01E-04	Cat. 2
135	162.4	2-RC-1003-BB1-2	1.689	4.01E-04	Cat. 2
136	162.0	2-RC-1120-BB1-1	1.689	4.01E-04	Cat. 2
137	162.2	2-RC-1120-BB1-2	1.689	4.01E-04	Cat. 2
138	161.6	2-RC-1121-BB1-1	1.689	4.01E-04	Cat. 2
139	162.7	2-RC-1121-BB1-2	1.689	4.01E-04	Cat. 2
140	162.7	2-RC-1121-BB1-3	1.689	4.01E-04	Cat. 2
141	162.7	2-RC-1121-BB1-3A	1.689	4.01E-04	Cat. 2
142	162.8	2-RC-1121-BB1-3B	1.689	4.01E-04	Cat. 2
143	162.9	2-RC-1121-BB1-4	1.689	4.01E-04	Cat. 2
144	161.9	2-RC-1219-BB1-1	1.689	4.01E-04	Cat. 2
145	162.1	2-RC-1219-BB1-2	1.689	4.01E-04	Cat. 2
146	161.6	2-RC-1220-BB1-1	1.689	4.01E-04	Cat. 2
147	162.8	2-RC-1220-BB1-2	1.689	4.01E-04	Cat. 2
148	162.8	2-RC-1220-BB1-3	1.689	4.01E-04	Cat. 2
149	162.9	2-RC-1220-BB1-4	1.689	4.01E-04	Cat. 2
150	161.8	2-RC-1319-BB1-1	1.689	4.01E-04	Cat. 2
151	162.2	2-RC-1319-BB1-2	1.689	4.01E-04	Cat. 2
152	162.2	2-RC-1321-BB1-1	1.689	4.01E-04	Cat. 2
153	162.4	2-RC-1321-BB1-4	1.689	4.01E-04	Cat. 2
154	162.4	2-RC-1321-BB1-5	1.689	4.01E-04	Cat. 2
155	162.5	2-RC-1321-BB1-6	1.689	4.01E-04	Cat. 2
156	162.0	2-RC-1417-BB1-1	1.689	4.01E-04	Cat. 2
157	162.1	2-RC-1417-BB1-2	1.689	4.01E-04	Cat. 2
158	161.6	2-RC-1418-BB1-1	1.689	4.01E-04	Cat. 2
159	162.2	2-RC-1418-BB1-2	1.689	4.01E-04	Cat. 2
160	162.2	2-RC-1418-BB1-3	1.689	4.01E-04	Cat. 2
161	162.3	2-RC-1418-BB1-4	1.689	4.01E-04	Cat. 2
162	162.4	2-RC-1418-BB1-5	1.689	4.01E-04	Cat. 2

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
163	162.6	2-RC-1418-BB1-6	1.689	4.01E-04	Cat. 2
164	162.3	2-RC-1419-BB1-1	1.689	4.01E-04	Cat. 2
165	162.5	2-RC-1419-BB1-2	1.689	4.01E-04	Cat. 2
166	162.5	2-RC-1419-BB1-3	1.689	4.01E-04	Cat. 2
167	162.8	2-RC-1419-BB1-4	1.689	4.01E-04	Cat. 2
168	161.8	31-RC-1102-NSS-5	1.689	4.01E-04	Cat. 2
169	161.5	31-RC-1102-NSS-6	1.689	4.01E-04	Cat. 2
170	161.8	31-RC-1202-NSS-5	1.689	4.01E-04	Cat. 2
171	161.4	31-RC-1202-NSS-7	1.689	4.01E-04	Cat. 2
172	161.7	31-RC-1302-NSS-5	1.689	4.01E-04	Cat. 2
173	161.8	31-RC-1402-NSS-5	1.689	4.01E-04	Cat. 2
174	161.4	31-RC-1402-NSS-7	1.689	4.01E-04	Cat. 2
175	161.3	2.5-RC-1003-BB1-1	2.125	2.73E-04	Cat. 2
176	161.5	2.5-RC-1003-BB1-2	2.125	2.73E-04	Cat. 2
177	161.6	2.5-RC-1003-BB1-3	2.125	2.73E-04	Cat. 2
178	161.6	2.5-RC-1003-BB1-4	2.125	2.73E-04	Cat. 2
179	161.6	2.5-RC-1003-BB1-5	2.125	2.73E-04	Cat. 2
180	161.6	2.5-RC-1003-BB1-6	2.125	2.73E-04	Cat. 2
181	158.9	31-RC-1102-NSS-7	2.626	1.26E-04	Cat. 2
182	158.9	31-RC-1202-NSS-6	2.626	1.26E-04	Cat. 2
183	158.9	31-RC-1302-NSS-6	2.626	1.26E-04	Cat. 2
184	158.9	31-RC-1402-NSS-6	2.626	1.26E-04	Cat. 2
185	161.1	3-RC-1003-BB1-1	2.626	1.26E-04	Cat. 2
186	161.2	3-RC-1003-BB1-2	2.626	1.26E-04	Cat. 2
187	161.2	3-RC-1015-NSS-1	2.626	1.26E-04	Cat. 2
188	160.6	3-RC-1015-NSS-10	2.626	1.26E-04	Cat. 2
189	160.7	3-RC-1015-NSS-11	2.626	1.26E-04	Cat. 2
190	161.2	3-RC-1015-NSS-12	2.626	1.26E-04	Cat. 2
191	161.9	3-RC-1015-NSS-13	2.626	1.26E-04	Cat. 2
192	163.0	3-RC-1015-NSS-14	2.626	1.26E-04	Cat. 2
193	163.1	3-RC-1015-NSS-15	2.626	1.26E-04	Cat. 2
194	162.1	3-RC-1015-NSS-16	2.626	1.26E-04	Cat. 2
195	161.4	3-RC-1015-NSS-2	2.626	1.26E-04	Cat. 2
196	161.6	3-RC-1015-NSS-3	2.626	1.26E-04	Cat. 2
197	162.2	3-RC-1015-NSS-4	2.626	1.26E-04	Cat. 2
198	162.7	3-RC-1015-NSS-5	2.626	1.26E-04	Cat. 2
199	163.2	3-RC-1015-NSS-6	2.626	1.26E-04	Cat. 2
200	163.3	3-RC-1015-NSS-7	2.626	1.26E-04	Cat. 2
201	163.3	3-RC-1015-NSS-8	2.626	1.26E-04	Cat. 2
202	160.6	3-RC-1015-NSS-9	2.626	1.26E-04	Cat. 2
203	159.6	3-RC-1106-BB1-25	2.626	1.26E-04	Cat. 2
204	159.6	3-RC-1206-BB1-28	2.626	1.26E-04	Cat. 2
205	159.6	3-RC-1306-BB1-28	2.626	1.26E-04	Cat. 2
206	159.7	3-RC-1406-BB1-25	2.626	1.26E-04	Cat. 2
207	153.8	27.5-RC-1103-NSS-3	3.438	1.44E-05	Cat. 3
208	155.6	27.5-RC-1103-NSS-5	3.438	1.44E-05	Cat. 3

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
209	156.2	27.5-RC-1303-NSS-4	3.438	1.44E-05	Cat. 3
210	155.2	27.5-RC-1403-NSS-3	3.438	1.44E-05	Cat. 3
211	155.4	27.5-RC-1403-NSS-4	3.438	1.44E-05	Cat. 3
212	155.2	31-RC-1302-NSS-7	3.438	1.44E-05	Cat. 3
213	161.8	4-CV-1001-BB1-1	3.438	1.44E-05	Cat. 3
214	162.3	4-CV-1001-BB1-2	3.438	1.44E-05	Cat. 3
215	162.3	4-CV-1118-BB1-1	3.438	1.44E-05	Cat. 3
216	161.5	4-CV-1118-BB1-2	3.438	1.44E-05	Cat. 3
217	160.3	4-CV-1120-BB1-1	3.438	1.44E-05	Cat. 3
218	159.9	4-CV-1120-BB1-2	3.438	1.44E-05	Cat. 3
219	159.0	4-RC-1000-BB1-1	3.438	1.44E-05	Cat. 3
220	159.7	4-RC-1000-BB1-2	3.438	1.44E-05	Cat. 3
221	159.7	4-RC-1000-BB1-3	3.438	1.44E-05	Cat. 3
222	160.1	4-RC-1000-BB1-4	3.438	1.44E-05	Cat. 3
223	160.1	4-RC-1000-BB1-5	3.438	1.44E-05	Cat. 3
224	159.9	4-RC-1000-BB1-6	3.438	1.44E-05	Cat. 3
225	159.8	4-RC-1000-BB1-7	3.438	1.44E-05	Cat. 3
226	158.6	4-RC-1000-BB1-8	3.438	1.44E-05	Cat. 3
227	159.1	4-RC-1003-BB1-1	3.438	1.44E-05	Cat. 3
228	159.2	4-RC-1003-BB1-2	3.438	1.44E-05	Cat. 3
229	159.1	4-RC-1003-BB1-3	3.438	1.44E-05	Cat. 3
230	158.6	4-RC-1003-BB1-4	3.438	1.44E-05	Cat. 3
231	154.3	4-RC-1123-BB1-1	3.438	1.44E-05	Cat. 3
232	160.6	4-RC-1123-BB1-10	3.438	1.44E-05	Cat. 3
233	161.4	4-RC-1123-BB1-11	3.438	1.44E-05	Cat. 3
234	161.8	4-RC-1123-BB1-12	3.438	1.44E-05	Cat. 3
235	161.8	4-RC-1123-BB1-13	3.438	1.44E-05	Cat. 3
236	162.0	4-RC-1123-BB1-14	3.438	1.44E-05	Cat. 3
237	161.8	4-RC-1123-BB1-15	3.438	1.44E-05	Cat. 3
238	159.8	4-RC-1123-BB1-16	3.438	1.44E-05	Cat. 3
239	159.1	4-RC-1123-BB1-17	3.438	1.44E-05	Cat. 3
240	157.7	4-RC-1123-BB1-18	3.438	1.44E-05	Cat. 3
241	157.7	4-RC-1123-BB1-19	3.438	1.44E-05	Cat. 3
242	161.8	4-RC-1123-BB1-2	3.438	1.44E-05	Cat. 3
243	158.7	4-RC-1123-BB1-20	3.438	1.44E-05	Cat. 3
244	161.8	4-RC-1123-BB1-3	3.438	1.44E-05	Cat. 3
245	161.8	4-RC-1123-BB1-4	3.438	1.44E-05	Cat. 3
246	161.9	4-RC-1123-BB1-5	3.438	1.44E-05	Cat. 3
247	161.9	4-RC-1123-BB1-6	3.438	1.44E-05	Cat. 3
248	161.8	4-RC-1123-BB1-7	3.438	1.44E-05	Cat. 3
249	161.8	4-RC-1123-BB1-8	3.438	1.44E-05	Cat. 3
250	160.1	4-RC-1123-BB1-9	3.438	1.44E-05	Cat. 3
251	161.2	4-RC-1126-BB1-1	3.438	1.44E-05	Cat. 3
252	160.2	4-RC-1126-BB1-2	3.438	1.44E-05	Cat. 3
253	159.9	4-RC-1126-BB1-3	3.438	1.44E-05	Cat. 3
254	160.0	4-RC-1126-BB1-4	3.438	1.44E-05	Cat. 3

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
255	159.3	4-RC-1126-BB1-5	3.438	1.44E-05	Cat. 3
256	156.0	4-RC-1126-BB1-6	3.438	1.44E-05	Cat. 3
257	155.4	4-RC-1320-BB1-1	3.438	1.44E-05	Cat. 3
258	161.4	4-RC-1320-BB1-10	3.438	1.44E-05	Cat. 3
259	161.5	4-RC-1320-BB1-11	3.438	1.44E-05	Cat. 3
260	161.5	4-RC-1320-BB1-12	3.438	1.44E-05	Cat. 3
261	156.0	4-RC-1320-BB1-2	3.438	1.44E-05	Cat. 3
262	156.6	4-RC-1320-BB1-3	3.438	1.44E-05	Cat. 3
263	158.8	4-RC-1320-BB1-4	3.438	1.44E-05	Cat. 3
264	159.2	4-RC-1320-BB1-5	3.438	1.44E-05	Cat. 3
265	159.6	4-RC-1320-BB1-6	3.438	1.44E-05	Cat. 3
266	159.9	4-RC-1320-BB1-7	3.438	1.44E-05	Cat. 3
267	160.2	4-RC-1320-BB1-8	3.438	1.44E-05	Cat. 3
268	161.1	4-RC-1320-BB1-9	3.438	1.44E-05	Cat. 3
269	160.8	4-RC-1323-BB1-1	3.438	1.44E-05	Cat. 3
270	161.0	4-RC-1323-BB1-2	3.438	1.44E-05	Cat. 3
271	161.5	4-RC-1323-BB1-3	3.438	1.44E-05	Cat. 3
272	156.6	4-RC-1323-BB1-4	3.438	1.44E-05	Cat. 3
273	156.1	4-RC-1420-BB1-1	3.438	1.44E-05	Cat. 3
274	155.8	4-RC-1422-BB1-1	3.438	1.44E-05	Cat. 3
275	161.8	4-RC-1422-BB1-10	3.438	1.44E-05	Cat. 3
276	161.8	4-RC-1422-BB1-11	3.438	1.44E-05	Cat. 3
277	159.8	4-RC-1422-BB1-12	3.438	1.44E-05	Cat. 3
278	160.6	4-RC-1422-BB1-13	3.438	1.44E-05	Cat. 3
279	160.8	4-RC-1422-BB1-14	3.438	1.44E-05	Cat. 3
280	161.2	4-RC-1422-BB1-15	3.438	1.44E-05	Cat. 3
281	161.7	4-RC-1422-BB1-16	3.438	1.44E-05	Cat. 3
282	162.0	4-RC-1422-BB1-17	3.438	1.44E-05	Cat. 3
283	161.8	4-RC-1422-BB1-18	3.438	1.44E-05	Cat. 3
284	162.0	4-RC-1422-BB1-19	3.438	1.44E-05	Cat. 3
285	156.7	4-RC-1422-BB1-2	3.438	1.44E-05	Cat. 3
286	162.1	4-RC-1422-BB1-20	3.438	1.44E-05	Cat. 3
287	160.3	4-RC-1422-BB1-21	3.438	1.44E-05	Cat. 3
288	159.8	4-RC-1422-BB1-22	3.438	1.44E-05	Cat. 3
289	159.6	4-RC-1422-BB1-23	3.438	1.44E-05	Cat. 3
290	157.4	4-RC-1422-BB1-3	3.438	1.44E-05	Cat. 3
291	156.8	4-RC-1422-BB1-4	3.438	1.44E-05	Cat. 3
292	157.4	4-RC-1422-BB1-5	3.438	1.44E-05	Cat. 3
293	161.6	4-RC-1422-BB1-6	3.438	1.44E-05	Cat. 3
294	161.6	4-RC-1422-BB1-7	3.438	1.44E-05	Cat. 3
295	161.6	4-RC-1422-BB1-8	3.438	1.44E-05	Cat. 3
296	161.6	4-RC-1422-BB1-9	3.438	1.44E-05	Cat. 3
297	148.9	6-RC-1003-BB1-1	5.189	8.12E-06	Cat. 3
298	150.4	6-RC-1003-BB1-10	5.189	8.12E-06	Cat. 3
299	150.2	6-RC-1003-BB1-11	5.189	8.12E-06	Cat. 3
300	147.6	6-RC-1003-BB1-11A	5.189	8.12E-06	Cat. 3

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
301	145.9	6-RC-1003-BB1-11B	5.189	8.12E-06	Cat. 3
302	142.6	6-RC-1003-BB1-12	5.189	8.12E-06	Cat. 3
303	138.7	6-RC-1003-BB1-13	5.189	8.12E-06	Cat. 3
304	133.7	6-RC-1003-BB1-13A	5.189	8.12E-06	Cat. 3
305	129.6	6-RC-1003-BB1-14	5.189	8.12E-06	Cat. 3
306	148.9	6-RC-1003-BB1-2	5.189	8.12E-06	Cat. 3
307	148.9	6-RC-1003-BB1-3	5.189	8.12E-06	Cat. 3
308	149.1	6-RC-1003-BB1-4	5.189	8.12E-06	Cat. 3
309	149.4	6-RC-1003-BB1-5	5.189	8.12E-06	Cat. 3
310	150.0	6-RC-1003-BB1-6	5.189	8.12E-06	Cat. 3
311	148.3	6-RC-1003-BB1-7	5.189	8.12E-06	Cat. 3
312	144.4	6-RC-1003-BB1-8	5.189	8.12E-06	Cat. 3
313	143.9	6-RC-1003-BB1-9	5.189	8.12E-06	Cat. 3
314	143.9	6-RC-1003-BB1-9A	5.189	8.12E-06	Cat. 3
315	143.9	6-RC-1003-BB1-9B	5.189	8.12E-06	Cat. 3
316	129.7	6-RC-1003-BB1-PRZ-1-N2-SE	5.189	8.12E-06	Cat. 3
317	136.5	6-RC-1004-NSS-1	5.189	8.12E-06	Cat. 3
318	138.5	6-RC-1004-NSS-2	5.189	8.12E-06	Cat. 3
319	142.1	6-RC-1004-NSS-3	5.189	8.12E-06	Cat. 3
320	137.3	6-RC-1004-NSS-4	5.189	8.12E-06	Cat. 3
321	136.1	6-RC-1004-NSS-5	5.189	8.12E-06	Cat. 3
322	142.9	6-RC-1004-NSS-6	5.189	8.12E-06	Cat. 3
323	145.3	6-RC-1004-NSS-7	5.189	8.12E-06	Cat. 3
324	136.5	6-RC-1004-NSS-PRZ-1-N3-SE	5.189	8.12E-06	Cat. 3
325	134.4	6-RC-1009-NSS-1	5.189	8.12E-06	Cat. 3
326	136.1	6-RC-1009-NSS-2	5.189	8.12E-06	Cat. 3
327	140.7	6-RC-1009-NSS-3	5.189	8.12E-06	Cat. 3
328	136.8	6-RC-1009-NSS-4	5.189	8.12E-06	Cat. 3
329	133.7	6-RC-1009-NSS-5	5.189	8.12E-06	Cat. 3
330	132.6	6-RC-1009-NSS-6	5.189	8.12E-06	Cat. 3
331	134.1	6-RC-1009-NSS-7	5.189	8.12E-06	Cat. 3
332	137.3	6-RC-1009-NSS-8	5.189	8.12E-06	Cat. 3
333	140.0	6-RC-1009-NSS-9	5.189	8.12E-06	Cat. 3
334	134.6	6-RC-1009-NSS-PRZ-1-N4C-SE	5.189	8.12E-06	Cat. 3
335	131.5	6-RC-1012-NSS-1	5.189	8.12E-06	Cat. 3
336	139.0	6-RC-1012-NSS-10	5.189	8.12E-06	Cat. 3
337	139.6	6-RC-1012-NSS-11	5.189	8.12E-06	Cat. 3
338	133.0	6-RC-1012-NSS-2	5.189	8.12E-06	Cat. 3
339	134.0	6-RC-1012-NSS-3	5.189	8.12E-06	Cat. 3
340	134.3	6-RC-1012-NSS-4	5.189	8.12E-06	Cat. 3
341	136.9	6-RC-1012-NSS-5	5.189	8.12E-06	Cat. 3
342	137.7	6-RC-1012-NSS-6	5.189	8.12E-06	Cat. 3
343	139.0	6-RC-1012-NSS-7	5.189	8.12E-06	Cat. 3
344	138.5	6-RC-1012-NSS-8	5.189	8.12E-06	Cat. 3
345	135.8	6-RC-1012-NSS-9	5.189	8.12E-06	Cat. 3
346	131.4	6-RC-1012-NSS-PRZ-1-N4B-SE	5.189	8.12E-06	Cat. 3

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
347	132.1	6-RC-1015-NSS-1	5.189	8.12E-06	Cat. 3
348	139.7	6-RC-1015-NSS-10	5.189	8.12E-06	Cat. 3
349	150.6	6-RC-1015-NSS-11	5.189	8.12E-06	Cat. 3
350	152.5	6-RC-1015-NSS-12	5.189	8.12E-06	Cat. 3
351	152.8	6-RC-1015-NSS-13	5.189	8.12E-06	Cat. 3
352	151.9	6-RC-1015-NSS-14	5.189	8.12E-06	Cat. 3
353	151.8	6-RC-1015-NSS-15	5.189	8.12E-06	Cat. 3
354	134.0	6-RC-1015-NSS-2	5.189	8.12E-06	Cat. 3
355	135.3	6-RC-1015-NSS-3	5.189	8.12E-06	Cat. 3
356	134.2	6-RC-1015-NSS-4	5.189	8.12E-06	Cat. 3
357	132.0	6-RC-1015-NSS-5	5.189	8.12E-06	Cat. 3
358	131.3	6-RC-1015-NSS-6	5.189	8.12E-06	Cat. 3
359	131.2	6-RC-1015-NSS-7	5.189	8.12E-06	Cat. 3
360	134.1	6-RC-1015-NSS-8	5.189	8.12E-06	Cat. 3
361	136.5	6-RC-1015-NSS-9	5.189	8.12E-06	Cat. 3
362	162.7	6-SI-1108-BB1-1	5.189	8.12E-06	Cat. 3
363	162.6	6-SI-1108-BB1-2	5.189	8.12E-06	Cat. 3
364	162.0	6-SI-1108-BB1-3	5.189	8.12E-06	Cat. 3
365	154.6	6-SI-1108-BB1-4	5.189	8.12E-06	Cat. 3
366	159.9	6-SI-1111-BB1-1	5.189	8.12E-06	Cat. 3
367	159.8	6-SI-1111-BB1-2	5.189	8.12E-06	Cat. 3
368	162.7	6-SI-1208-BB1-1	5.189	8.12E-06	Cat. 3
369	162.7	6-SI-1208-BB1-2	5.189	8.12E-06	Cat. 3
370	162.0	6-SI-1208-BB1-3	5.189	8.12E-06	Cat. 3
371	155.6	6-SI-1208-BB1-4	5.189	8.12E-06	Cat. 3
372	160.6	6-SI-1211-BB1-1	5.189	8.12E-06	Cat. 3
373	160.4	6-SI-1211-BB1-2	5.189	8.12E-06	Cat. 3
374	159.7	6-SI-1308-BB1-1	5.189	8.12E-06	Cat. 3
375	160.9	6-SI-1308-BB1-2	5.189	8.12E-06	Cat. 3
376	161.2	6-SI-1308-BB1-3	5.189	8.12E-06	Cat. 3
377	160.1	6-SI-1308-BB1-4	5.189	8.12E-06	Cat. 3
378	149.0	6-SI-1327-BB1-1	5.189	8.12E-06	Cat. 3
379	149.5	6-SI-1327-BB1-2	5.189	8.12E-06	Cat. 3
380	150.0	6-SI-1327-BB1-3	5.189	8.12E-06	Cat. 3
381	149.5	6-SI-1327-BB1-4	5.189	8.12E-06	Cat. 3
382	150.4	6-SI-1327-BB1-5	5.189	8.12E-06	Cat. 3
383	151.2	6-SI-1327-BB1-6	5.189	8.12E-06	Cat. 3
384	152.2	6-SI-1327-BB1-7	5.189	8.12E-06	Cat. 3
385	131.8	29-RC-1101-NSS-2	6.813	2.27E-06	Cat. 3
386	131.9	29-RC-1201-NSS-2	6.813	2.27E-06	Cat. 3
387	131.4	29-RC-1301-NSS-2	6.813	2.27E-06	Cat. 3
388	142.1	8-RC-1114-BB1-1	6.813	2.27E-06	Cat. 3
389	143.6	8-RC-1114-BB1-2	6.813	2.27E-06	Cat. 3
390	142.1	8-RC-1114-BB1-3	6.813	2.27E-06	Cat. 3
391	139.2	8-RC-1114-BB1-4	6.813	2.27E-06	Cat. 3
392	135.5	8-RC-1114-BB1-5	6.813	2.27E-06	Cat. 3

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
393	132.2	8-RC-1114-BB1-6	6.813	2.27E-06	Cat. 3
394	142.4	8-RC-1214-BB1-1	6.813	2.27E-06	Cat. 3
395	143.9	8-RC-1214-BB1-2	6.813	2.27E-06	Cat. 3
396	142.6	8-RC-1214-BB1-3	6.813	2.27E-06	Cat. 3
397	139.6	8-RC-1214-BB1-4	6.813	2.27E-06	Cat. 3
398	136.0	8-RC-1214-BB1-5	6.813	2.27E-06	Cat. 3
399	132.9	8-RC-1214-BB1-6	6.813	2.27E-06	Cat. 3
400	140.9	8-RC-1324-BB1-1	6.813	2.27E-06	Cat. 3
401	142.5	8-RC-1324-BB1-2	6.813	2.27E-06	Cat. 3
402	141.5	8-RC-1324-BB1-3	6.813	2.27E-06	Cat. 3
403	140.4	8-RC-1324-BB1-4	6.813	2.27E-06	Cat. 3
404	136.2	8-RC-1324-BB1-5	6.813	2.27E-06	Cat. 3
405	132.9	8-RC-1324-BB1-6	6.813	2.27E-06	Cat. 3
406	159.1	8-RH-1108-BB1-1	6.813	2.27E-06	Cat. 3
407	158.8	8-RH-1108-BB1-2	6.813	2.27E-06	Cat. 3
408	141.7	8-RH-1112-BB1-1	6.813	2.27E-06	Cat. 3
409	143.2	8-RH-1112-BB1-1A	6.813	2.27E-06	Cat. 3
410	142.8	8-RH-1112-BB1-2	6.813	2.27E-06	Cat. 3
411	160.0	8-RH-1208-BB1-1	6.813	2.27E-06	Cat. 3
412	159.8	8-RH-1208-BB1-2	6.813	2.27E-06	Cat. 3
413	141.0	8-RH-1212-BB1-1	6.813	2.27E-06	Cat. 3
414	144.0	8-RH-1212-BB1-2	6.813	2.27E-06	Cat. 3
415	153.1	8-RH-1308-BB1-1	6.813	2.27E-06	Cat. 3
416	154.8	8-RH-1308-BB1-2	6.813	2.27E-06	Cat. 3
417	142.8	8-RH-1315-BB1-1	6.813	2.27E-06	Cat. 3
418	147.9	8-SI-1108-BB1-1	6.813	2.27E-06	Cat. 3
419	144.7	8-SI-1108-BB1-2	6.813	2.27E-06	Cat. 3
420	141.0	8-SI-1108-BB1-3	6.813	2.27E-06	Cat. 3
421	137.1	8-SI-1108-BB1-4	6.813	2.27E-06	Cat. 3
422	139.8	8-SI-1108-BB1-5	6.813	2.27E-06	Cat. 3
423	148.3	8-SI-1208-BB1-1	6.813	2.27E-06	Cat. 3
424	146.4	8-SI-1208-BB1-2	6.813	2.27E-06	Cat. 3
425	141.8	8-SI-1208-BB1-3	6.813	2.27E-06	Cat. 3
426	137.8	8-SI-1208-BB1-3A	6.813	2.27E-06	Cat. 3
427	140.9	8-SI-1208-BB1-4	6.813	2.27E-06	Cat. 3
428	144.1	8-SI-1327-BB1-1	6.813	2.27E-06	Cat. 3
429	131.3	8-SI-1327-BB1-10	6.813	2.27E-06	Cat. 3
430	137.0	8-SI-1327-BB1-11	6.813	2.27E-06	Cat. 3
431	144.7	8-SI-1327-BB1-2	6.813	2.27E-06	Cat. 3
432	145.0	8-SI-1327-BB1-3	6.813	2.27E-06	Cat. 3
433	145.8	8-SI-1327-BB1-4	6.813	2.27E-06	Cat. 3
434	147.5	8-SI-1327-BB1-5	6.813	2.27E-06	Cat. 3
435	145.6	8-SI-1327-BB1-6	6.813	2.27E-06	Cat. 3
436	141.0	8-SI-1327-BB1-7	6.813	2.27E-06	Cat. 3
437	136.2	8-SI-1327-BB1-8	6.813	2.27E-06	Cat. 3
438	134.9	8-SI-1327-BB1-9	6.813	2.27E-06	Cat. 3

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
439	157.3	10-RH-1108-BB1-1	8.500	1.30E-06	Cat. 4
440	145.6	10-RH-1108-BB1-10	8.500	1.30E-06	Cat. 4
441	157.0	10-RH-1108-BB1-1A	8.500	1.30E-06	Cat. 4
442	156.9	10-RH-1108-BB1-2	8.500	1.30E-06	Cat. 4
443	156.8	10-RH-1108-BB1-3	8.500	1.30E-06	Cat. 4
444	156.6	10-RH-1108-BB1-4	8.500	1.30E-06	Cat. 4
445	156.6	10-RH-1108-BB1-5	8.500	1.30E-06	Cat. 4
446	156.7	10-RH-1108-BB1-6	8.500	1.30E-06	Cat. 4
447	156.1	10-RH-1108-BB1-7	8.500	1.30E-06	Cat. 4
448	144.8	10-RH-1108-BB1-8	8.500	1.30E-06	Cat. 4
449	145.1	10-RH-1108-BB1-9	8.500	1.30E-06	Cat. 4
450	158.4	10-RH-1208-BB1-1	8.500	1.30E-06	Cat. 4
451	147.0	10-RH-1208-BB1-10	8.500	1.30E-06	Cat. 4
452	147.9	10-RH-1208-BB1-11	8.500	1.30E-06	Cat. 4
453	158.2	10-RH-1208-BB1-2	8.500	1.30E-06	Cat. 4
454	158.1	10-RH-1208-BB1-3	8.500	1.30E-06	Cat. 4
455	157.5	10-RH-1208-BB1-4	8.500	1.30E-06	Cat. 4
456	157.2	10-RH-1208-BB1-5	8.500	1.30E-06	Cat. 4
457	157.3	10-RH-1208-BB1-6	8.500	1.30E-06	Cat. 4
458	156.5	10-RH-1208-BB1-7	8.500	1.30E-06	Cat. 4
459	146.8	10-RH-1208-BB1-8	8.500	1.30E-06	Cat. 4
460	146.5	10-RH-1208-BB1-9	8.500	1.30E-06	Cat. 4
461	152.9	10-RH-1308-BB1-1	8.500	1.30E-06	Cat. 4
462	158.4	10-RH-1308-BB1-2	8.500	1.30E-06	Cat. 4
463	158.5	10-RH-1308-BB1-3	8.500	1.30E-06	Cat. 4
464	158.4	10-RH-1308-BB1-4	8.500	1.30E-06	Cat. 4
465	158.6	10-RH-1308-BB1-5	8.500	1.30E-06	Cat. 4
466	157.8	10-RH-1308-BB1-6	8.500	1.30E-06	Cat. 4
467	157.7	10-RH-1308-BB1-7	8.500	1.30E-06	Cat. 4
468	157.3	10-RH-1308-BB1-8	8.500	1.30E-06	Cat. 4
469	94.8	12-RC-1112-BB1-1	10.126	9.75E-07	Cat. 4
470	126.3	12-RC-1112-BB1-10	10.126	9.75E-07	Cat. 4
471	126.1	12-RC-1112-BB1-11	10.126	9.75E-07	Cat. 4
472	105.5	12-RC-1112-BB1-2	10.126	9.75E-07	Cat. 4
473	112.0	12-RC-1112-BB1-3	10.126	9.75E-07	Cat. 4
474	116.1	12-RC-1112-BB1-4	10.126	9.75E-07	Cat. 4
475	118.2	12-RC-1112-BB1-5	10.126	9.75E-07	Cat. 4
476	114.8	12-RC-1112-BB1-6	10.126	9.75E-07	Cat. 4
477	112.5	12-RC-1112-BB1-7	10.126	9.75E-07	Cat. 4
478	113.5	12-RC-1112-BB1-8	10.126	9.75E-07	Cat. 4
479	123.3	12-RC-1112-BB1-9	10.126	9.75E-07	Cat. 4
480	143.3	12-RC-1125-BB1-1	10.126	9.75E-07	Cat. 4
481	63.4	12-RC-1125-BB1-10	10.126	9.75E-07	Cat. 4
482	60.1	12-RC-1125-BB1-11	10.126	9.75E-07	Cat. 4
483	65.9	12-RC-1125-BB1-12	10.126	9.75E-07	Cat. 4
484	90.7	12-RC-1125-BB1-13	10.126	9.75E-07	Cat. 4

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
485	144.6	12-RC-1125-BB1-2	10.126	9.75E-07	Cat. 4
486	144.8	12-RC-1125-BB1-3	10.126	9.75E-07	Cat. 4
487	145.1	12-RC-1125-BB1-4	10.126	9.75E-07	Cat. 4
488	145.1	12-RC-1125-BB1-5	10.126	9.75E-07	Cat. 4
489	142.4	12-RC-1125-BB1-6	10.126	9.75E-07	Cat. 4
490	140.8	12-RC-1125-BB1-7	10.126	9.75E-07	Cat. 4
491	95.7	12-RC-1125-BB1-8	10.126	9.75E-07	Cat. 4
492	67.7	12-RC-1125-BB1-9	10.126	9.75E-07	Cat. 4
493	100.2	12-RC-1212-BB1-1	10.126	9.75E-07	Cat. 4
494	108.6	12-RC-1212-BB1-2	10.126	9.75E-07	Cat. 4
495	112.9	12-RC-1212-BB1-3	10.126	9.75E-07	Cat. 4
496	118.6	12-RC-1212-BB1-4	10.126	9.75E-07	Cat. 4
497	120.0	12-RC-1212-BB1-5	10.126	9.75E-07	Cat. 4
498	115.5	12-RC-1212-BB1-6	10.126	9.75E-07	Cat. 4
499	113.6	12-RC-1212-BB1-7	10.126	9.75E-07	Cat. 4
500	107.8	12-RC-1212-BB1-8	10.126	9.75E-07	Cat. 4
501	146.4	12-RC-1221-BB1-1	10.126	9.75E-07	Cat. 4
502	64.1	12-RC-1221-BB1-10	10.126	9.75E-07	Cat. 4
503	54.5	12-RC-1221-BB1-11	10.126	9.75E-07	Cat. 4
504	62.7	12-RC-1221-BB1-12	10.126	9.75E-07	Cat. 4
505	68.5	12-RC-1221-BB1-13	10.126	9.75E-07	Cat. 4
506	94.2	12-RC-1221-BB1-14	10.126	9.75E-07	Cat. 4
507	147.3	12-RC-1221-BB1-2	10.126	9.75E-07	Cat. 4
508	146.9	12-RC-1221-BB1-3	10.126	9.75E-07	Cat. 4
509	145.8	12-RC-1221-BB1-4	10.126	9.75E-07	Cat. 4
510	144.3	12-RC-1221-BB1-5	10.126	9.75E-07	Cat. 4
511	142.3	12-RC-1221-BB1-6	10.126	9.75E-07	Cat. 4
512	141.0	12-RC-1221-BB1-7	10.126	9.75E-07	Cat. 4
513	100.5	12-RC-1221-BB1-8	10.126	9.75E-07	Cat. 4
514	67.8	12-RC-1221-BB1-9	10.126	9.75E-07	Cat. 4
515	99.9	12-RC-1312-BB1-1	10.126	9.75E-07	Cat. 4
516	119.3	12-RC-1312-BB1-10	10.126	9.75E-07	Cat. 4
517	120.0	12-RC-1312-BB1-11	10.126	9.75E-07	Cat. 4
518	108.1	12-RC-1312-BB1-2	10.126	9.75E-07	Cat. 4
519	112.5	12-RC-1312-BB1-3	10.126	9.75E-07	Cat. 4
520	118.1	12-RC-1312-BB1-4	10.126	9.75E-07	Cat. 4
521	119.6	12-RC-1312-BB1-5	10.126	9.75E-07	Cat. 4
522	115.0	12-RC-1312-BB1-6	10.126	9.75E-07	Cat. 4
523	113.4	12-RC-1312-BB1-7	10.126	9.75E-07	Cat. 4
524	103.4	12-RC-1312-BB1-8	10.126	9.75E-07	Cat. 4
525	117.5	12-RC-1312-BB1-9	10.126	9.75E-07	Cat. 4
526	61.0	12-RC-1322-BB1-1	10.126	9.75E-07	Cat. 4
527	61.1	12-RC-1322-BB1-1A	10.126	9.75E-07	Cat. 4
528	65.4	12-RC-1322-BB1-2	10.126	9.75E-07	Cat. 4
529	70.3	12-RC-1322-BB1-3	10.126	9.75E-07	Cat. 4
530	94.6	12-RC-1322-BB1-4	10.126	9.75E-07	Cat. 4

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
531	125.4	12-RH-1101-BB1-1	10.126	9.75E-07	Cat. 4
532	147.3	12-RH-1101-BB1-10	10.126	9.75E-07	Cat. 4
533	148.4	12-RH-1101-BB1-11	10.126	9.75E-07	Cat. 4
534	152.6	12-RH-1101-BB1-12	10.126	9.75E-07	Cat. 4
535	148.8	12-RH-1101-BB1-13	10.126	9.75E-07	Cat. 4
536	151.7	12-RH-1101-BB1-14	10.126	9.75E-07	Cat. 4
537	151.9	12-RH-1101-BB1-15	10.126	9.75E-07	Cat. 4
538	150.9	12-RH-1101-BB1-16	10.126	9.75E-07	Cat. 4
539	128.7	12-RH-1101-BB1-2	10.126	9.75E-07	Cat. 4
540	127.5	12-RH-1101-BB1-3	10.126	9.75E-07	Cat. 4
541	109.5	12-RH-1101-BB1-3A	10.126	9.75E-07	Cat. 4
542	112.3	12-RH-1101-BB1-4	10.126	9.75E-07	Cat. 4
543	121.2	12-RH-1101-BB1-5	10.126	9.75E-07	Cat. 4
544	122.0	12-RH-1101-BB1-6	10.126	9.75E-07	Cat. 4
545	121.5	12-RH-1101-BB1-7	10.126	9.75E-07	Cat. 4
546	127.8	12-RH-1101-BB1-8	10.126	9.75E-07	Cat. 4
547	148.7	12-RH-1101-BB1-9	10.126	9.75E-07	Cat. 4
548	113.8	12-RH-1201-BB1-1	10.126	9.75E-07	Cat. 4
549	124.0	12-RH-1201-BB1-10	10.126	9.75E-07	Cat. 4
550	145.9	12-RH-1201-BB1-11	10.126	9.75E-07	Cat. 4
551	147.7	12-RH-1201-BB1-12	10.126	9.75E-07	Cat. 4
552	148.1	12-RH-1201-BB1-13	10.126	9.75E-07	Cat. 4
553	151.0	12-RH-1201-BB1-14	10.126	9.75E-07	Cat. 4
554	153.7	12-RH-1201-BB1-15	10.126	9.75E-07	Cat. 4
555	153.4	12-RH-1201-BB1-16	10.126	9.75E-07	Cat. 4
556	152.8	12-RH-1201-BB1-17	10.126	9.75E-07	Cat. 4
557	118.7	12-RH-1201-BB1-2	10.126	9.75E-07	Cat. 4
558	122.5	12-RH-1201-BB1-3	10.126	9.75E-07	Cat. 4
559	123.1	12-RH-1201-BB1-4	10.126	9.75E-07	Cat. 4
560	122.6	12-RH-1201-BB1-5	10.126	9.75E-07	Cat. 4
561	108.3	12-RH-1201-BB1-6	10.126	9.75E-07	Cat. 4
562	117.8	12-RH-1201-BB1-7	10.126	9.75E-07	Cat. 4
563	118.5	12-RH-1201-BB1-8	10.126	9.75E-07	Cat. 4
564	117.3	12-RH-1201-BB1-9	10.126	9.75E-07	Cat. 4
565	123.3	12-RH-1301-BB1-1	10.126	9.75E-07	Cat. 4
566	150.8	12-RH-1301-BB1-10	10.126	9.75E-07	Cat. 4
567	125.6	12-RH-1301-BB1-2	10.126	9.75E-07	Cat. 4
568	125.8	12-RH-1301-BB1-3	10.126	9.75E-07	Cat. 4
569	123.5	12-RH-1301-BB1-4	10.126	9.75E-07	Cat. 4
570	127.4	12-RH-1301-BB1-5	10.126	9.75E-07	Cat. 4
571	149.1	12-RH-1301-BB1-5A	10.126	9.75E-07	Cat. 4
572	148.8	12-RH-1301-BB1-6	10.126	9.75E-07	Cat. 4
573	148.9	12-RH-1301-BB1-7	10.126	9.75E-07	Cat. 4
574	150.4	12-RH-1301-BB1-8	10.126	9.75E-07	Cat. 4
575	150.8	12-RH-1301-BB1-9	10.126	9.75E-07	Cat. 4
576	146.8	12-SI-1125-BB1-1	10.126	9.75E-07	Cat. 4

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
577	144.5	12-SI-1125-BB1-2	10.126	9.75E-07	Cat. 4
578	144.0	12-SI-1125-BB1-3	10.126	9.75E-07	Cat. 4
579	143.9	12-SI-1125-BB1-4	10.126	9.75E-07	Cat. 4
580	149.3	12-SI-1218-BB1-1	10.126	9.75E-07	Cat. 4
581	147.2	12-SI-1218-BB1-2	10.126	9.75E-07	Cat. 4
582	146.6	12-SI-1218-BB1-3	10.126	9.75E-07	Cat. 4
583	146.4	12-SI-1218-BB1-4	10.126	9.75E-07	Cat. 4
584	156.3	12-SI-1315-BB1-1	10.126	9.75E-07	Cat. 4
585	70.7	12-SI-1315-BB1-10	10.126	9.75E-07	Cat. 4
586	155.8	12-SI-1315-BB1-2	10.126	9.75E-07	Cat. 4
587	155.2	12-SI-1315-BB1-3	10.126	9.75E-07	Cat. 4
588	155.3	12-SI-1315-BB1-4	10.126	9.75E-07	Cat. 4
589	155.5	12-SI-1315-BB1-5	10.126	9.75E-07	Cat. 4
590	117.8	12-SI-1315-BB1-6	10.126	9.75E-07	Cat. 4
591	91.1	12-SI-1315-BB1-7	10.126	9.75E-07	Cat. 4
592	79.2	12-SI-1315-BB1-8	10.126	9.75E-07	Cat. 4
593	74.7	12-SI-1315-BB1-9	10.126	9.75E-07	Cat. 4
594	116.2	27.5-RC-1103-NSS-4	10.126	9.75E-07	Cat. 4
595	105.5	27.5-RC-1203-NSS-3	10.126	9.75E-07	Cat. 4
596	104.6	27.5-RC-1303-NSS-3	10.126	9.75E-07	Cat. 4
597	93.4	29-RC-1101-NSS-3	10.126	9.75E-07	Cat. 4
598	95.8	29-RC-1201-NSS-3	10.126	9.75E-07	Cat. 4
599	96.4	29-RC-1301-NSS-3	10.126	9.75E-07	Cat. 4
600	97.4	16-RC-1412-NSS-1	12.814	4.37E-07	Cat. 4
601	147.9	16-RC-1412-NSS-3	12.814	4.37E-07	Cat. 4
602	150.9	16-RC-1412-NSS-4	12.814	4.37E-07	Cat. 4
603	77.8	16-RC-1412-NSS-5	12.814	4.37E-07	Cat. 4
604	59.0	16-RC-1412-NSS-6	12.814	4.37E-07	Cat. 4
605	48.3	16-RC-1412-NSS-7	12.814	4.37E-07	Cat. 4
606	21.4	16-RC-1412-NSS-9	12.814	4.37E-07	Cat. 4
607	96.5	16-RC-1412-NSS-PRZ-1-N1-SE	12.814	4.37E-07	Cat. 4
608	22.6	29-RC-1401-NSS-2	12.814	4.37E-07	Cat. 4
609	49.4	27.5-RC-1103-NSS-6	27.500	6.42E-08	Cat. 5
610	50.4	27.5-RC-1103-NSS-7	27.500	6.42E-08	Cat. 5
611	48.3	27.5-RC-1103-NSS-RPV1-N2ASE	27.500	6.42E-08	Cat. 5
612	50.6	27.5-RC-1203-NSS-4	27.500	6.42E-08	Cat. 5
613	51.1	27.5-RC-1203-NSS-5	27.500	6.42E-08	Cat. 5
614	50.5	27.5-RC-1203-NSS-RPV1-N2BSE	27.500	6.42E-08	Cat. 5
615	67.0	27.5-RC-1303-NSS-5	27.500	6.42E-08	Cat. 5
616	64.2	27.5-RC-1303-NSS-6	27.500	6.42E-08	Cat. 5
617	63.6	27.5-RC-1303-NSS-RPV1-N2CSE	27.500	6.42E-08	Cat. 5
618	74.3	27.5-RC-1403-NSS-5	27.500	6.42E-08	Cat. 5
619	69.4	27.5-RC-1403-NSS-6	27.500	6.42E-08	Cat. 5
620	68.3	27.5-RC-1403-NSS-RPV1-N2DSE	27.500	6.42E-08	Cat. 5
621	25.2	29-RC-1101-NSS-1	29.000	4.91E-08	Cat. 5
622	23.6	29-RC-1101-NSS-RPV1-N1ASE	29.000	4.91E-08	Cat. 5

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
623	22.3	29-RC-1201-NSS-1	29.000	4.91E-08	Cat. 5
624	19.3	29-RC-1201-RPV1-N1BSE	29.000	4.91E-08	Cat. 5
625	23.8	29-RC-1301-NSS-1	29.000	4.91E-08	Cat. 5
626	21.5	29-RC-1301-RPV1-N1CSE	29.000	4.91E-08	Cat. 5
627	23.8	29-RC-1401-NSS-1	29.000	4.91E-08	Cat. 5
628	20.9	29-RC-1401-NSS-RPV1-N1DSE	29.000	4.91E-08	Cat. 5

Table 14: Single train data for weld locations in the risk-informed category listing the i^{th} weld number, mass of fiber in the sump for the scenario (lbm), location name (ID), Break size (Size), scenario frequency, f_i (mean quantile, geometric aggregation), and NUREG 1829 data category

No.	Amount (lbm)	Location	Size (in)	f_i	NUREG 1829 Cat.
1	95.96	29-RC-1301-RSG-1C-IN-SE	9.28	1.14E-06	Cat. 4
2	96.13	29-RC-1101-NSS-5.1	9.31	1.14E-06	Cat. 4
3	96.83	29-RC-1101-NSS-RSG-1A-IN-SE	9.33	1.13E-06	Cat. 4
4	96.17	29-RC-1201-RSG-1B-IN-SE	9.35	1.13E-06	Cat. 4
5	96.74	29-RC-1301-NSS-5.1	9.35	1.13E-06	Cat. 4
6	95.99	29-RC-1201-NSS-5.1	9.35	1.13E-06	Cat. 4
7	96.34	29-RC-1401-NSS-RSG-1D-IN-SE	9.38	1.12E-06	Cat. 4
8	96.55	29-RC-1401-NSS-4.1	9.41	1.12E-06	Cat. 4
9	95.96	31-RC-1102-NSS-RSG-1A-ON-SE	9.81	1.04E-06	Cat. 4
10	96.35	31-RC-1202-NSS-1.1	9.86	1.03E-06	Cat. 4
11	96.66	31-RC-1102-NSS-1.1	9.86	1.03E-06	Cat. 4
12	96.48	31-RC-1202-NSS-RSG-1B-ON-SE	9.87	1.03E-06	Cat. 4
13	96.13	31-RC-1202-NSS-2	10.03	9.94E-07	Cat. 4
14	95.97	31-RC-1302-NSS-1.1	10.10	9.80E-07	Cat. 4
15	96.07	31-RC-1302-NSS-RSG-1C-ON-SE	10.11	9.79E-07	Cat. 4
17	96.26	12-RC-1112-BB1-1	10.13	9.75E-07	Cat. 4
18	96.96	12-RC-1125-BB1-10	10.13	9.75E-07	Cat. 4
19	128.39	12-RC-1125-BB1-11	10.13	9.75E-07	Cat. 4
20	131.64	12-RC-1125-BB1-12	10.13	9.75E-07	Cat. 4
21	125.93	12-RC-1125-BB1-13	10.13	9.75E-07	Cat. 4
22	101.10	12-RC-1125-BB1-8	10.13	9.75E-07	Cat. 4
23	96.07	12-RC-1125-BB1-9	10.13	9.75E-07	Cat. 4
24	124.08	12-RC-1221-BB1-10	10.13	9.75E-07	Cat. 4
25	127.70	12-RC-1221-BB1-11	10.13	9.75E-07	Cat. 4
26	137.30	12-RC-1221-BB1-12	10.13	9.75E-07	Cat. 4
27	129.09	12-RC-1221-BB1-13	10.13	9.75E-07	Cat. 4
28	123.32	12-RC-1221-BB1-14	10.13	9.75E-07	Cat. 4
29	97.57	12-RC-1221-BB1-9	10.13	9.75E-07	Cat. 4
30	123.96	12-RC-1322-BB1-1	10.13	9.75E-07	Cat. 4
31	130.82	12-RC-1322-BB1-1A	10.13	9.75E-07	Cat. 4
32	130.73	12-RC-1322-BB1-2	10.13	9.75E-07	Cat. 4
33	126.33	12-RC-1322-BB1-3	10.13	9.75E-07	Cat. 4
34	121.46	12-RC-1322-BB1-4	10.13	9.75E-07	Cat. 4

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No.	Amount (lbm)	Location	Size (in)	f_i	NUREG 1829 Cat.
35	97.21	12-SI-1315-BB1-10	10.13	9.75E-07	Cat. 4
36	121.12	12-SI-1315-BB1-7	10.13	9.75E-07	Cat. 4
37	100.67	12-SI-1315-BB1-8	10.13	9.75E-07	Cat. 4
38	112.56	12-SI-1315-BB1-9	10.13	9.75E-07	Cat. 4
39	117.11	29-RC-1101-NSS-3	10.13	9.75E-07	Cat. 4
40	98.43	29-RC-1201-NSS-3	10.13	9.75E-07	Cat. 4
16	96.01	31-RC-1102-NSS-2	10.13	9.75E-07	Cat. 4
41	96.35	16-RC-1412-NSS-8	10.21	9.59E-07	Cat. 4
42	96.44	31-RC-1302-NSS-2	10.30	9.40E-07	Cat. 4
43	95.90	29-RC-1101-NSS-4	10.45	9.10E-07	Cat. 4
44	96.00	31-RC-1402-NSS-1.1	10.50	9.00E-07	Cat. 4
45	96.14	31-RC-1402-NSS-RSG-1D-ON-SE	10.51	8.98E-07	Cat. 4
46	96.07	29-RC-1401-NSS-3	10.63	8.75E-07	Cat. 4
47	96.14	29-RC-1301-NSS-4	10.63	8.74E-07	Cat. 4
48	96.38	29-RC-1201-NSS-4	10.67	8.67E-07	Cat. 4
49	96.05	31-RC-1402-NSS-2	11.08	7.83E-07	Cat. 4
50	95.97	31-RC-1202-NSS-3	11.15	7.71E-07	Cat. 4
51	96.37	16-RC-1412-NSS-9	11.17	7.66E-07	Cat. 4
52	95.99	29-RC-1401-NSS-2	11.17	7.66E-07	Cat. 4
53	95.90	31-RC-1302-NSS-3	11.31	7.38E-07	Cat. 4
54	96.15	31-RC-1102-NSS-3	11.39	7.22E-07	Cat. 4
55	95.98	31-RC-1202-NSS-4	11.50	7.00E-07	Cat. 4
56	95.90	31-RC-1102-NSS-4	11.62	6.76E-07	Cat. 4
57	95.93	31-RC-1302-NSS-4	11.74	6.52E-07	Cat. 4
58	96.08	31-RC-1202-NSS-8	11.76	6.49E-07	Cat. 4
59	95.91	31-RC-1102-NSS-8	11.90	6.19E-07	Cat. 4
60	95.92	31-RC-1302-NSS-8	12.30	5.40E-07	Cat. 4
61	96.05	31-RC-1402-NSS-3	12.43	5.14E-07	Cat. 4
62	95.92	31-RC-1202-NSS-9	12.56	4.88E-07	Cat. 4
63	95.95	27.5-RC-1103-NSS-1	12.75	4.50E-07	Cat. 4
64	113.96	16-RC-1412-NSS-5	12.81	4.37E-07	Cat. 4
65	132.76	16-RC-1412-NSS-6	12.81	4.37E-07	Cat. 4
66	143.52	16-RC-1412-NSS-7	12.81	4.37E-07	Cat. 4
67	95.90	27.5-RC-1203-NSS-1	12.82	4.36E-07	Cat. 4
68	95.94	31-RC-1102-NSS-9	12.83	4.34E-07	Cat. 4
69	96.03	31-RC-1402-NSS-4	13.26	3.48E-07	Cat. 4
70	95.95	27.5-RC-1303-NSS-1	13.68	2.64E-07	Cat. 4
71	95.93	31-RC-1302-NSS-9	13.95	2.10E-07	Cat. 4
72	97.33	31-RC-1402-NSS-8	14.45	1.10E-07	Cat. 4
73	96.02	27.5-RC-1403-NSS-1	14.72	5.62E-08	Cat. 4
74	97.16	31-RC-1402-NSS-9	16.33	1.77E-07	Cat. 5
75	142.33	27.5-RC-1103-NSS-6	27.50	6.42E-08	Cat. 5
76	141.38	27.5-RC-1103-NSS-7	27.50	6.42E-08	Cat. 5
77	143.44	27.5-RC-1103-NSS-RPV1-N2ASE	27.50	6.42E-08	Cat. 5
78	141.23	27.5-RC-1203-NSS-4	27.50	6.42E-08	Cat. 5
79	140.65	27.5-RC-1203-NSS-5	27.50	6.42E-08	Cat. 5
80	141.24	27.5-RC-1203-NSS-RPV1-N2BSE	27.50	6.42E-08	Cat. 5

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No.	Amount (lbm)	Location	Size (in)	f_i	NUREG 1829 Cat.
81	124.75	27.5-RC-1303-NSS-5	27.50	6.42E-08	Cat. 5
82	127.56	27.5-RC-1303-NSS-6	27.50	6.42E-08	Cat. 5
83	128.16	27.5-RC-1303-NSS-RPV1-N2CSE	27.50	6.42E-08	Cat. 5
84	117.48	27.5-RC-1403-NSS-5	27.50	6.42E-08	Cat. 5
85	122.40	27.5-RC-1403-NSS-6	27.50	6.42E-08	Cat. 5
86	123.45	27.5-RC-1403-NSS-RPV1-N2DSE	27.50	6.42E-08	Cat. 5
87	166.58	29-RC-1101-NSS-1	29.00	4.91E-08	Cat. 5
88	168.16	29-RC-1101-NSS-RPV1-N1ASE	29.00	4.91E-08	Cat. 5
89	169.49	29-RC-1201-NSS-1	29.00	4.91E-08	Cat. 5
90	172.48	29-RC-1201-RPV1-N1BSE	29.00	4.91E-08	Cat. 5
91	167.99	29-RC-1301-NSS-1	29.00	4.91E-08	Cat. 5
92	170.23	29-RC-1301-RPV1-N1CSE	29.00	4.91E-08	Cat. 5
93	168.01	29-RC-1401-NSS-1	29.00	4.91E-08	Cat. 5
94	170.85	29-RC-1401-NSS-RPV1-N1DSE	29.00	4.91E-08	Cat. 5

Table 15: Single train DEGB data (largest break size) for weld locations in the deterministic category showing listing the i^{th} weld number, the margin to the mass of fiber in the sump produced to the tested amount (lbm), location name, Break size (Size), scenario DEGB frequency, f_i (mean quantile, geometric aggregation), and NUREG 1829 data category

No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
95	67.3	0.75-CV-1122-BB1-1	0.614	1.75E-03	Cat. 1
96	67.3	0.75-CV-1122-BB1-2	0.614	1.75E-03	Cat. 1
97	67.4	0.75-CV-1124-BB1-1	0.614	1.75E-03	Cat. 1
98	67.4	0.75-CV-1124-BB1-2	0.614	1.75E-03	Cat. 1
99	67.4	0.75-CV-1126-BB1-1	0.614	1.75E-03	Cat. 1
100	67.2	0.75-CV-1126-BB1-2	0.614	1.75E-03	Cat. 1
101	67.4	0.75-CV-1128-BB1-1	0.614	1.75E-03	Cat. 1
102	67.4	0.75-CV-1128-BB1-2	0.614	1.75E-03	Cat. 1
103	67.2	0.75-RC-1001-BB1-1	0.614	1.75E-03	Cat. 1
104	67.1	0.75-RC-1002-BB2-1	0.614	1.75E-03	Cat. 1
105	67.1	0.75-RC-1112-BB1-1	0.614	1.75E-03	Cat. 1
106	67.0	0.75-RC-1114-BB1-1	0.614	1.75E-03	Cat. 1
107	67.1	0.75-RC-1125-BB1-1	0.614	1.75E-03	Cat. 1
108	67.0	0.75-RC-1125-BB1-2	0.614	1.75E-03	Cat. 1
109	67.1	0.75-RC-1126-BB1-1	0.614	1.75E-03	Cat. 1
110	67.1	0.75-RC-1212-BB1-1	0.614	1.75E-03	Cat. 1
111	67.0	0.75-RC-1214-BB1-1	0.614	1.75E-03	Cat. 1
112	67.1	0.75-RC-1221-BB1-1	0.614	1.75E-03	Cat. 1
113	67.1	0.75-RC-1221-BB1-2	0.614	1.75E-03	Cat. 1
114	67.1	0.75-RC-1312-BB1-1	0.614	1.75E-03	Cat. 1
115	67.0	0.75-RC-1324-BB1-1	0.614	1.75E-03	Cat. 1
116	67.1	0.75-RC-1423-BB1-1	0.614	1.75E-03	Cat. 1
117	67.2	0.75-SI-1130-BB2-1	0.614	1.75E-03	Cat. 1
118	67.2	0.75-SI-1132-BB1-1	0.614	1.75E-03	Cat. 1

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
119	67.2	0.75-SI-1218-BB1-1	0.614	1.75E-03	Cat. 1
120	67.2	0.75-SI-1223-BB2-1	0.614	1.75E-03	Cat. 1
121	67.0	0.75-SI-1315-BB1-1	0.614	1.75E-03	Cat. 1
122	67.3	0.75-SI-1323-BB1-1	0.614	1.75E-03	Cat. 1
123	67.2	0.75-SI-1327-BB1-1	0.614	1.75E-03	Cat. 1
124	67.2	0.75-SI-1327-BB1-2	0.614	1.75E-03	Cat. 1
125	67.2	0.75-SI-1327-BB1-3	0.614	1.75E-03	Cat. 1
126	67.2	0.75-SI-1328-BB2-1	0.614	1.75E-03	Cat. 1
127	66.8	1-RC-1003-BB1-1	0.815	1.49E-03	Cat. 1
128	67.1	1-RC-1123-BB1-1	0.815	1.49E-03	Cat. 1
129	67.0	1-RC-1422-BB1-1	0.815	1.49E-03	Cat. 1
130	65.7	1.5-RC-1412-NSS-1	1.338	7.98E-04	Cat. 1
131	67.3	2(1.5)-CV-1122-BB1-1	1.338	7.98E-04	Cat. 1
132	67.1	2(1.5)-CV-1122-BB1-2	1.338	7.98E-04	Cat. 1
133	67.3	2(1.5)-CV-1124-BB1-1	1.338	7.98E-04	Cat. 1
134	67.0	2(1.5)-CV-1124-BB1-2	1.338	7.98E-04	Cat. 1
135	66.9	2(1.5)-CV-1126-BB1-1	1.338	7.98E-04	Cat. 1
136	66.9	2(1.5)-CV-1126-BB1-2	1.338	7.98E-04	Cat. 1
137	67.1	2(1.5)-CV-1128-BB1-1	1.338	7.98E-04	Cat. 1
138	66.9	2(1.5)-CV-1128-BB1-2	1.338	7.98E-04	Cat. 1
139	67.2	2-CV-1121-BB1-1	1.689	4.01E-04	Cat. 2
140	66.9	2-CV-1121-BB1-2	1.689	4.01E-04	Cat. 2
141	66.8	2-CV-1121-BB1-3	1.689	4.01E-04	Cat. 2
142	66.6	2-CV-1122-BB1-1	1.689	4.01E-04	Cat. 2
143	66.7	2-CV-1122-BB1-2	1.689	4.01E-04	Cat. 2
144	66.7	2-CV-1122-BB1-3	1.689	4.01E-04	Cat. 2
145	66.7	2-CV-1122-BB1-4	1.689	4.01E-04	Cat. 2
146	66.7	2-CV-1122-BB1-5	1.689	4.01E-04	Cat. 2
147	67.0	2-CV-1122-BB1-6	1.689	4.01E-04	Cat. 2
148	66.7	2-CV-1124-BB1-1	1.689	4.01E-04	Cat. 2
149	66.6	2-CV-1124-BB1-10	1.689	4.01E-04	Cat. 2
150	66.6	2-CV-1124-BB1-11	1.689	4.01E-04	Cat. 2
151	67.1	2-CV-1124-BB1-12	1.689	4.01E-04	Cat. 2
152	67.0	2-CV-1124-BB1-13	1.689	4.01E-04	Cat. 2
153	66.7	2-CV-1124-BB1-2	1.689	4.01E-04	Cat. 2
154	66.7	2-CV-1124-BB1-3	1.689	4.01E-04	Cat. 2
155	66.6	2-CV-1124-BB1-4	1.689	4.01E-04	Cat. 2
156	66.6	2-CV-1124-BB1-5	1.689	4.01E-04	Cat. 2
157	66.7	2-CV-1124-BB1-6	1.689	4.01E-04	Cat. 2
158	66.8	2-CV-1124-BB1-7	1.689	4.01E-04	Cat. 2
159	66.7	2-CV-1124-BB1-8	1.689	4.01E-04	Cat. 2
160	66.7	2-CV-1124-BB1-9	1.689	4.01E-04	Cat. 2
161	67.2	2-CV-1126-BB1-1	1.689	4.01E-04	Cat. 2
162	66.5	2-CV-1126-BB1-10	1.689	4.01E-04	Cat. 2
163	66.6	2-CV-1126-BB1-11	1.689	4.01E-04	Cat. 2
164	67.2	2-CV-1126-BB1-2	1.689	4.01E-04	Cat. 2

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
165	67.1	2-CV-1126-BB1-3	1.689	4.01E-04	Cat. 2
166	67.0	2-CV-1126-BB1-4	1.689	4.01E-04	Cat. 2
167	67.0	2-CV-1126-BB1-5	1.689	4.01E-04	Cat. 2
168	67.0	2-CV-1126-BB1-6	1.689	4.01E-04	Cat. 2
169	66.9	2-CV-1126-BB1-7	1.689	4.01E-04	Cat. 2
170	66.0	2-CV-1126-BB1-8	1.689	4.01E-04	Cat. 2
171	65.9	2-CV-1126-BB1-9	1.689	4.01E-04	Cat. 2
172	67.4	2-CV-1128-BB1-1	1.689	4.01E-04	Cat. 2
173	67.2	2-CV-1128-BB1-2	1.689	4.01E-04	Cat. 2
174	67.1	2-CV-1128-BB1-3	1.689	4.01E-04	Cat. 2
175	67.1	2-CV-1128-BB1-3A	1.689	4.01E-04	Cat. 2
176	67.0	2-CV-1128-BB1-3B	1.689	4.01E-04	Cat. 2
177	67.0	2-CV-1128-BB1-4	1.689	4.01E-04	Cat. 2
178	67.0	2-CV-1128-BB1-5	1.689	4.01E-04	Cat. 2
179	67.1	2-CV-1128-BB1-6	1.689	4.01E-04	Cat. 2
180	66.9	2-CV-1128-BB1-7	1.689	4.01E-04	Cat. 2
181	66.9	2-CV-1141-BB1-1	1.689	4.01E-04	Cat. 2
182	67.1	2-CV-1141-BB1-2	1.689	4.01E-04	Cat. 2
183	66.8	2-RC-1003-BB1-1	1.689	4.01E-04	Cat. 2
184	66.5	2-RC-1003-BB1-2	1.689	4.01E-04	Cat. 2
185	66.1	2-RC-1120-BB1-1	1.689	4.01E-04	Cat. 2
186	66.3	2-RC-1120-BB1-2	1.689	4.01E-04	Cat. 2
187	65.7	2-RC-1121-BB1-1	1.689	4.01E-04	Cat. 2
188	66.8	2-RC-1121-BB1-2	1.689	4.01E-04	Cat. 2
189	66.8	2-RC-1121-BB1-3	1.689	4.01E-04	Cat. 2
190	66.8	2-RC-1121-BB1-3A	1.689	4.01E-04	Cat. 2
191	66.9	2-RC-1121-BB1-3B	1.689	4.01E-04	Cat. 2
192	67.0	2-RC-1121-BB1-4	1.689	4.01E-04	Cat. 2
193	66.0	2-RC-1219-BB1-1	1.689	4.01E-04	Cat. 2
194	66.2	2-RC-1219-BB1-2	1.689	4.01E-04	Cat. 2
195	65.7	2-RC-1220-BB1-1	1.689	4.01E-04	Cat. 2
196	66.9	2-RC-1220-BB1-2	1.689	4.01E-04	Cat. 2
197	66.9	2-RC-1220-BB1-3	1.689	4.01E-04	Cat. 2
198	67.0	2-RC-1220-BB1-4	1.689	4.01E-04	Cat. 2
199	65.9	2-RC-1319-BB1-1	1.689	4.01E-04	Cat. 2
200	66.3	2-RC-1319-BB1-2	1.689	4.01E-04	Cat. 2
201	66.3	2-RC-1321-BB1-1	1.689	4.01E-04	Cat. 2
202	66.5	2-RC-1321-BB1-4	1.689	4.01E-04	Cat. 2
203	66.5	2-RC-1321-BB1-5	1.689	4.01E-04	Cat. 2
204	66.6	2-RC-1321-BB1-6	1.689	4.01E-04	Cat. 2
205	66.1	2-RC-1417-BB1-1	1.689	4.01E-04	Cat. 2
206	66.3	2-RC-1417-BB1-2	1.689	4.01E-04	Cat. 2
207	65.7	2-RC-1418-BB1-1	1.689	4.01E-04	Cat. 2
208	66.3	2-RC-1418-BB1-2	1.689	4.01E-04	Cat. 2
209	66.4	2-RC-1418-BB1-3	1.689	4.01E-04	Cat. 2
210	66.4	2-RC-1418-BB1-4	1.689	4.01E-04	Cat. 2

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
211	66.6	2-RC-1418-BB1-5	1.689	4.01E-04	Cat. 2
212	66.7	2-RC-1418-BB1-6	1.689	4.01E-04	Cat. 2
213	66.4	2-RC-1419-BB1-1	1.689	4.01E-04	Cat. 2
214	66.6	2-RC-1419-BB1-2	1.689	4.01E-04	Cat. 2
215	66.6	2-RC-1419-BB1-3	1.689	4.01E-04	Cat. 2
216	66.9	2-RC-1419-BB1-4	1.689	4.01E-04	Cat. 2
217	65.9	31-RC-1102-NSS-5	1.689	4.01E-04	Cat. 2
218	65.6	31-RC-1102-NSS-6	1.689	4.01E-04	Cat. 2
219	65.9	31-RC-1202-NSS-5	1.689	4.01E-04	Cat. 2
220	65.5	31-RC-1202-NSS-7	1.689	4.01E-04	Cat. 2
221	65.8	31-RC-1302-NSS-5	1.689	4.01E-04	Cat. 2
222	65.9	31-RC-1402-NSS-5	1.689	4.01E-04	Cat. 2
223	65.6	31-RC-1402-NSS-7	1.689	4.01E-04	Cat. 2
224	65.5	2.5-RC-1003-BB1-1	2.125	2.73E-04	Cat. 2
225	65.6	2.5-RC-1003-BB1-2	2.125	2.73E-04	Cat. 2
226	65.7	2.5-RC-1003-BB1-3	2.125	2.73E-04	Cat. 2
227	65.7	2.5-RC-1003-BB1-4	2.125	2.73E-04	Cat. 2
228	65.7	2.5-RC-1003-BB1-5	2.125	2.73E-04	Cat. 2
229	65.8	2.5-RC-1003-BB1-6	2.125	2.73E-04	Cat. 2
230	63.0	31-RC-1102-NSS-7	2.626	1.26E-04	Cat. 2
231	63.0	31-RC-1202-NSS-6	2.626	1.26E-04	Cat. 2
232	63.0	31-RC-1302-NSS-6	2.626	1.26E-04	Cat. 2
233	63.0	31-RC-1402-NSS-6	2.626	1.26E-04	Cat. 2
234	65.2	3-RC-1003-BB1-1	2.626	1.26E-04	Cat. 2
235	65.3	3-RC-1003-BB1-2	2.626	1.26E-04	Cat. 2
236	65.3	3-RC-1015-NSS-1	2.626	1.26E-04	Cat. 2
237	64.7	3-RC-1015-NSS-10	2.626	1.26E-04	Cat. 2
238	64.8	3-RC-1015-NSS-11	2.626	1.26E-04	Cat. 2
239	65.3	3-RC-1015-NSS-12	2.626	1.26E-04	Cat. 2
240	66.0	3-RC-1015-NSS-13	2.626	1.26E-04	Cat. 2
241	67.1	3-RC-1015-NSS-14	2.626	1.26E-04	Cat. 2
242	67.2	3-RC-1015-NSS-15	2.626	1.26E-04	Cat. 2
243	66.2	3-RC-1015-NSS-16	2.626	1.26E-04	Cat. 2
244	65.5	3-RC-1015-NSS-2	2.626	1.26E-04	Cat. 2
245	65.7	3-RC-1015-NSS-3	2.626	1.26E-04	Cat. 2
246	66.3	3-RC-1015-NSS-4	2.626	1.26E-04	Cat. 2
247	66.8	3-RC-1015-NSS-5	2.626	1.26E-04	Cat. 2
248	67.3	3-RC-1015-NSS-6	2.626	1.26E-04	Cat. 2
249	67.4	3-RC-1015-NSS-7	2.626	1.26E-04	Cat. 2
250	67.4	3-RC-1015-NSS-8	2.626	1.26E-04	Cat. 2
251	64.7	3-RC-1015-NSS-9	2.626	1.26E-04	Cat. 2
252	63.7	3-RC-1106-BB1-25	2.626	1.26E-04	Cat. 2
253	63.7	3-RC-1206-BB1-28	2.626	1.26E-04	Cat. 2
254	63.7	3-RC-1306-BB1-28	2.626	1.26E-04	Cat. 2
255	63.8	3-RC-1406-BB1-25	2.626	1.26E-04	Cat. 2
256	57.9	27.5-RC-1103-NSS-3	3.438	1.44E-05	Cat. 3

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
257	59.7	27.5-RC-1103-NSS-5	3.438	1.44E-05	Cat. 3
258	60.3	27.5-RC-1303-NSS-4	3.438	1.44E-05	Cat. 3
259	59.3	27.5-RC-1403-NSS-3	3.438	1.44E-05	Cat. 3
260	59.6	27.5-RC-1403-NSS-4	3.438	1.44E-05	Cat. 3
261	59.3	31-RC-1302-NSS-7	3.438	1.44E-05	Cat. 3
262	65.9	4-CV-1001-BB1-1	3.438	1.44E-05	Cat. 3
263	66.4	4-CV-1001-BB1-2	3.438	1.44E-05	Cat. 3
264	66.4	4-CV-1118-BB1-1	3.438	1.44E-05	Cat. 3
265	65.6	4-CV-1118-BB1-2	3.438	1.44E-05	Cat. 3
266	64.4	4-CV-1120-BB1-1	3.438	1.44E-05	Cat. 3
267	64.0	4-CV-1120-BB1-2	3.438	1.44E-05	Cat. 3
268	63.1	4-RC-1000-BB1-1	3.438	1.44E-05	Cat. 3
269	63.8	4-RC-1000-BB1-2	3.438	1.44E-05	Cat. 3
270	63.8	4-RC-1000-BB1-3	3.438	1.44E-05	Cat. 3
271	64.2	4-RC-1000-BB1-4	3.438	1.44E-05	Cat. 3
272	64.2	4-RC-1000-BB1-5	3.438	1.44E-05	Cat. 3
273	64.0	4-RC-1000-BB1-6	3.438	1.44E-05	Cat. 3
274	63.9	4-RC-1000-BB1-7	3.438	1.44E-05	Cat. 3
275	62.7	4-RC-1000-BB1-8	3.438	1.44E-05	Cat. 3
276	63.2	4-RC-1003-BB1-1	3.438	1.44E-05	Cat. 3
277	63.3	4-RC-1003-BB1-2	3.438	1.44E-05	Cat. 3
278	63.2	4-RC-1003-BB1-3	3.438	1.44E-05	Cat. 3
279	62.8	4-RC-1003-BB1-4	3.438	1.44E-05	Cat. 3
280	58.4	4-RC-1123-BB1-1	3.438	1.44E-05	Cat. 3
281	64.7	4-RC-1123-BB1-10	3.438	1.44E-05	Cat. 3
282	65.6	4-RC-1123-BB1-11	3.438	1.44E-05	Cat. 3
283	65.9	4-RC-1123-BB1-12	3.438	1.44E-05	Cat. 3
284	65.9	4-RC-1123-BB1-13	3.438	1.44E-05	Cat. 3
285	66.1	4-RC-1123-BB1-14	3.438	1.44E-05	Cat. 3
286	65.9	4-RC-1123-BB1-15	3.438	1.44E-05	Cat. 3
287	63.9	4-RC-1123-BB1-16	3.438	1.44E-05	Cat. 3
288	63.2	4-RC-1123-BB1-17	3.438	1.44E-05	Cat. 3
289	61.8	4-RC-1123-BB1-18	3.438	1.44E-05	Cat. 3
290	61.9	4-RC-1123-BB1-19	3.438	1.44E-05	Cat. 3
291	65.9	4-RC-1123-BB1-2	3.438	1.44E-05	Cat. 3
292	62.8	4-RC-1123-BB1-20	3.438	1.44E-05	Cat. 3
293	65.9	4-RC-1123-BB1-3	3.438	1.44E-05	Cat. 3
294	65.9	4-RC-1123-BB1-4	3.438	1.44E-05	Cat. 3
295	66.0	4-RC-1123-BB1-5	3.438	1.44E-05	Cat. 3
296	66.0	4-RC-1123-BB1-6	3.438	1.44E-05	Cat. 3
297	65.9	4-RC-1123-BB1-7	3.438	1.44E-05	Cat. 3
298	66.0	4-RC-1123-BB1-8	3.438	1.44E-05	Cat. 3
299	64.2	4-RC-1123-BB1-9	3.438	1.44E-05	Cat. 3
300	65.3	4-RC-1126-BB1-1	3.438	1.44E-05	Cat. 3
301	64.3	4-RC-1126-BB1-2	3.438	1.44E-05	Cat. 3
302	64.0	4-RC-1126-BB1-3	3.438	1.44E-05	Cat. 3

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
303	64.1	4-RC-1126-BB1-4	3.438	1.44E-05	Cat. 3
304	63.4	4-RC-1126-BB1-5	3.438	1.44E-05	Cat. 3
305	60.1	4-RC-1126-BB1-6	3.438	1.44E-05	Cat. 3
306	59.5	4-RC-1320-BB1-1	3.438	1.44E-05	Cat. 3
307	65.5	4-RC-1320-BB1-10	3.438	1.44E-05	Cat. 3
308	65.6	4-RC-1320-BB1-11	3.438	1.44E-05	Cat. 3
309	65.6	4-RC-1320-BB1-12	3.438	1.44E-05	Cat. 3
310	60.1	4-RC-1320-BB1-2	3.438	1.44E-05	Cat. 3
311	60.8	4-RC-1320-BB1-3	3.438	1.44E-05	Cat. 3
312	62.9	4-RC-1320-BB1-4	3.438	1.44E-05	Cat. 3
313	63.4	4-RC-1320-BB1-5	3.438	1.44E-05	Cat. 3
314	63.7	4-RC-1320-BB1-6	3.438	1.44E-05	Cat. 3
315	64.0	4-RC-1320-BB1-7	3.438	1.44E-05	Cat. 3
316	64.4	4-RC-1320-BB1-8	3.438	1.44E-05	Cat. 3
317	65.2	4-RC-1320-BB1-9	3.438	1.44E-05	Cat. 3
318	64.9	4-RC-1323-BB1-1	3.438	1.44E-05	Cat. 3
319	65.1	4-RC-1323-BB1-2	3.438	1.44E-05	Cat. 3
320	65.6	4-RC-1323-BB1-3	3.438	1.44E-05	Cat. 3
321	60.7	4-RC-1323-BB1-4	3.438	1.44E-05	Cat. 3
322	60.2	4-RC-1420-BB1-1	3.438	1.44E-05	Cat. 3
323	60.0	4-RC-1422-BB1-1	3.438	1.44E-05	Cat. 3
324	65.9	4-RC-1422-BB1-10	3.438	1.44E-05	Cat. 3
325	65.9	4-RC-1422-BB1-11	3.438	1.44E-05	Cat. 3
326	63.9	4-RC-1422-BB1-12	3.438	1.44E-05	Cat. 3
327	64.7	4-RC-1422-BB1-13	3.438	1.44E-05	Cat. 3
328	64.9	4-RC-1422-BB1-14	3.438	1.44E-05	Cat. 3
329	65.3	4-RC-1422-BB1-15	3.438	1.44E-05	Cat. 3
330	65.9	4-RC-1422-BB1-16	3.438	1.44E-05	Cat. 3
331	66.1	4-RC-1422-BB1-17	3.438	1.44E-05	Cat. 3
332	65.9	4-RC-1422-BB1-18	3.438	1.44E-05	Cat. 3
333	66.1	4-RC-1422-BB1-19	3.438	1.44E-05	Cat. 3
334	60.8	4-RC-1422-BB1-2	3.438	1.44E-05	Cat. 3
335	66.2	4-RC-1422-BB1-20	3.438	1.44E-05	Cat. 3
336	64.4	4-RC-1422-BB1-21	3.438	1.44E-05	Cat. 3
337	63.9	4-RC-1422-BB1-22	3.438	1.44E-05	Cat. 3
338	63.7	4-RC-1422-BB1-23	3.438	1.44E-05	Cat. 3
339	61.5	4-RC-1422-BB1-3	3.438	1.44E-05	Cat. 3
340	61.0	4-RC-1422-BB1-4	3.438	1.44E-05	Cat. 3
341	61.5	4-RC-1422-BB1-5	3.438	1.44E-05	Cat. 3
342	65.7	4-RC-1422-BB1-6	3.438	1.44E-05	Cat. 3
343	65.7	4-RC-1422-BB1-7	3.438	1.44E-05	Cat. 3
344	65.7	4-RC-1422-BB1-8	3.438	1.44E-05	Cat. 3
345	65.7	4-RC-1422-BB1-9	3.438	1.44E-05	Cat. 3
346	53.1	6-RC-1003-BB1-1	5.189	8.12E-06	Cat. 3
347	54.5	6-RC-1003-BB1-10	5.189	8.12E-06	Cat. 3
348	54.3	6-RC-1003-BB1-11	5.189	8.12E-06	Cat. 3

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
349	51.7	6-RC-1003-BB1-11A	5.189	8.12E-06	Cat. 3
350	50.1	6-RC-1003-BB1-11B	5.189	8.12E-06	Cat. 3
351	46.7	6-RC-1003-BB1-12	5.189	8.12E-06	Cat. 3
352	42.9	6-RC-1003-BB1-13	5.189	8.12E-06	Cat. 3
353	37.8	6-RC-1003-BB1-13A	5.189	8.12E-06	Cat. 3
354	33.7	6-RC-1003-BB1-14	5.189	8.12E-06	Cat. 3
355	53.0	6-RC-1003-BB1-2	5.189	8.12E-06	Cat. 3
356	53.0	6-RC-1003-BB1-3	5.189	8.12E-06	Cat. 3
357	53.3	6-RC-1003-BB1-4	5.189	8.12E-06	Cat. 3
358	53.5	6-RC-1003-BB1-5	5.189	8.12E-06	Cat. 3
359	54.1	6-RC-1003-BB1-6	5.189	8.12E-06	Cat. 3
360	52.4	6-RC-1003-BB1-7	5.189	8.12E-06	Cat. 3
361	48.5	6-RC-1003-BB1-8	5.189	8.12E-06	Cat. 3
362	48.1	6-RC-1003-BB1-9	5.189	8.12E-06	Cat. 3
363	48.0	6-RC-1003-BB1-9A	5.189	8.12E-06	Cat. 3
364	48.0	6-RC-1003-BB1-9B	5.189	8.12E-06	Cat. 3
365	33.8	6-RC-1003-BB1-PRZ-1-N2-SE	5.189	8.12E-06	Cat. 3
366	40.7	6-RC-1004-NSS-1	5.189	8.12E-06	Cat. 3
367	42.6	6-RC-1004-NSS-2	5.189	8.12E-06	Cat. 3
368	46.2	6-RC-1004-NSS-3	5.189	8.12E-06	Cat. 3
369	41.4	6-RC-1004-NSS-4	5.189	8.12E-06	Cat. 3
370	40.2	6-RC-1004-NSS-5	5.189	8.12E-06	Cat. 3
371	47.0	6-RC-1004-NSS-6	5.189	8.12E-06	Cat. 3
372	49.4	6-RC-1004-NSS-7	5.189	8.12E-06	Cat. 3
373	40.7	6-RC-1004-NSS-PRZ-1-N3-SE	5.189	8.12E-06	Cat. 3
374	38.5	6-RC-1009-NSS-1	5.189	8.12E-06	Cat. 3
375	40.2	6-RC-1009-NSS-2	5.189	8.12E-06	Cat. 3
376	44.8	6-RC-1009-NSS-3	5.189	8.12E-06	Cat. 3
377	40.9	6-RC-1009-NSS-4	5.189	8.12E-06	Cat. 3
378	37.8	6-RC-1009-NSS-5	5.189	8.12E-06	Cat. 3
379	36.7	6-RC-1009-NSS-6	5.189	8.12E-06	Cat. 3
380	38.3	6-RC-1009-NSS-7	5.189	8.12E-06	Cat. 3
381	41.4	6-RC-1009-NSS-8	5.189	8.12E-06	Cat. 3
382	44.1	6-RC-1009-NSS-9	5.189	8.12E-06	Cat. 3
383	38.7	6-RC-1009-NSS-PRZ-1-N4C-SE	5.189	8.12E-06	Cat. 3
384	35.6	6-RC-1012-NSS-1	5.189	8.12E-06	Cat. 3
385	43.2	6-RC-1012-NSS-10	5.189	8.12E-06	Cat. 3
386	43.7	6-RC-1012-NSS-11	5.189	8.12E-06	Cat. 3
387	37.1	6-RC-1012-NSS-2	5.189	8.12E-06	Cat. 3
388	38.1	6-RC-1012-NSS-3	5.189	8.12E-06	Cat. 3
389	38.4	6-RC-1012-NSS-4	5.189	8.12E-06	Cat. 3
390	41.0	6-RC-1012-NSS-5	5.189	8.12E-06	Cat. 3
391	41.8	6-RC-1012-NSS-6	5.189	8.12E-06	Cat. 3
392	43.1	6-RC-1012-NSS-7	5.189	8.12E-06	Cat. 3
393	42.6	6-RC-1012-NSS-8	5.189	8.12E-06	Cat. 3
394	39.9	6-RC-1012-NSS-9	5.189	8.12E-06	Cat. 3

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
395	35.5	6-RC-1012-NSS-PRZ-1-N4B-SE	5.189	8.12E-06	Cat. 3
396	36.2	6-RC-1015-NSS-1	5.189	8.12E-06	Cat. 3
397	43.8	6-RC-1015-NSS-10	5.189	8.12E-06	Cat. 3
398	54.8	6-RC-1015-NSS-11	5.189	8.12E-06	Cat. 3
399	56.7	6-RC-1015-NSS-12	5.189	8.12E-06	Cat. 3
400	56.9	6-RC-1015-NSS-13	5.189	8.12E-06	Cat. 3
401	56.0	6-RC-1015-NSS-14	5.189	8.12E-06	Cat. 3
402	56.0	6-RC-1015-NSS-15	5.189	8.12E-06	Cat. 3
403	38.1	6-RC-1015-NSS-2	5.189	8.12E-06	Cat. 3
404	39.4	6-RC-1015-NSS-3	5.189	8.12E-06	Cat. 3
405	38.3	6-RC-1015-NSS-4	5.189	8.12E-06	Cat. 3
406	36.2	6-RC-1015-NSS-5	5.189	8.12E-06	Cat. 3
407	35.4	6-RC-1015-NSS-6	5.189	8.12E-06	Cat. 3
408	35.3	6-RC-1015-NSS-7	5.189	8.12E-06	Cat. 3
409	38.3	6-RC-1015-NSS-8	5.189	8.12E-06	Cat. 3
410	40.7	6-RC-1015-NSS-9	5.189	8.12E-06	Cat. 3
411	66.8	6-SI-1108-BB1-1	5.189	8.12E-06	Cat. 3
412	66.7	6-SI-1108-BB1-2	5.189	8.12E-06	Cat. 3
413	66.1	6-SI-1108-BB1-3	5.189	8.12E-06	Cat. 3
414	58.7	6-SI-1108-BB1-4	5.189	8.12E-06	Cat. 3
415	64.0	6-SI-1111-BB1-1	5.189	8.12E-06	Cat. 3
416	63.9	6-SI-1111-BB1-2	5.189	8.12E-06	Cat. 3
417	66.9	6-SI-1208-BB1-1	5.189	8.12E-06	Cat. 3
418	66.8	6-SI-1208-BB1-2	5.189	8.12E-06	Cat. 3
419	66.1	6-SI-1208-BB1-3	5.189	8.12E-06	Cat. 3
420	59.8	6-SI-1208-BB1-4	5.189	8.12E-06	Cat. 3
421	64.7	6-SI-1211-BB1-1	5.189	8.12E-06	Cat. 3
422	64.5	6-SI-1211-BB1-2	5.189	8.12E-06	Cat. 3
423	63.8	6-SI-1308-BB1-1	5.189	8.12E-06	Cat. 3
424	65.0	6-SI-1308-BB1-2	5.189	8.12E-06	Cat. 3
425	65.3	6-SI-1308-BB1-3	5.189	8.12E-06	Cat. 3
426	64.2	6-SI-1308-BB1-4	5.189	8.12E-06	Cat. 3
427	53.1	6-SI-1327-BB1-1	5.189	8.12E-06	Cat. 3
428	53.6	6-SI-1327-BB1-2	5.189	8.12E-06	Cat. 3
429	54.1	6-SI-1327-BB1-3	5.189	8.12E-06	Cat. 3
430	53.6	6-SI-1327-BB1-4	5.189	8.12E-06	Cat. 3
431	54.5	6-SI-1327-BB1-5	5.189	8.12E-06	Cat. 3
432	55.3	6-SI-1327-BB1-6	5.189	8.12E-06	Cat. 3
433	56.3	6-SI-1327-BB1-7	5.189	8.12E-06	Cat. 3
434	35.9	29-RC-1101-NSS-2	6.813	2.27E-06	Cat. 3
435	36.0	29-RC-1201-NSS-2	6.813	2.27E-06	Cat. 3
436	35.5	29-RC-1301-NSS-2	6.813	2.27E-06	Cat. 3
437	46.2	8-RC-1114-BB1-1	6.813	2.27E-06	Cat. 3
438	47.8	8-RC-1114-BB1-2	6.813	2.27E-06	Cat. 3
439	46.2	8-RC-1114-BB1-3	6.813	2.27E-06	Cat. 3
440	43.3	8-RC-1114-BB1-4	6.813	2.27E-06	Cat. 3

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
441	39.6	8-RC-1114-BB1-5	6.813	2.27E-06	Cat. 3
442	36.3	8-RC-1114-BB1-6	6.813	2.27E-06	Cat. 3
443	46.5	8-RC-1214-BB1-1	6.813	2.27E-06	Cat. 3
444	48.0	8-RC-1214-BB1-2	6.813	2.27E-06	Cat. 3
445	46.7	8-RC-1214-BB1-3	6.813	2.27E-06	Cat. 3
446	43.7	8-RC-1214-BB1-4	6.813	2.27E-06	Cat. 3
447	40.1	8-RC-1214-BB1-5	6.813	2.27E-06	Cat. 3
448	37.1	8-RC-1214-BB1-6	6.813	2.27E-06	Cat. 3
449	45.0	8-RC-1324-BB1-1	6.813	2.27E-06	Cat. 3
450	46.6	8-RC-1324-BB1-2	6.813	2.27E-06	Cat. 3
451	45.6	8-RC-1324-BB1-3	6.813	2.27E-06	Cat. 3
452	44.5	8-RC-1324-BB1-4	6.813	2.27E-06	Cat. 3
453	40.3	8-RC-1324-BB1-5	6.813	2.27E-06	Cat. 3
454	37.0	8-RC-1324-BB1-6	6.813	2.27E-06	Cat. 3
455	63.2	8-RH-1108-BB1-1	6.813	2.27E-06	Cat. 3
456	62.9	8-RH-1108-BB1-2	6.813	2.27E-06	Cat. 3
457	45.8	8-RH-1112-BB1-1	6.813	2.27E-06	Cat. 3
458	47.3	8-RH-1112-BB1-1A	6.813	2.27E-06	Cat. 3
459	46.9	8-RH-1112-BB1-2	6.813	2.27E-06	Cat. 3
460	64.2	8-RH-1208-BB1-1	6.813	2.27E-06	Cat. 3
461	63.9	8-RH-1208-BB1-2	6.813	2.27E-06	Cat. 3
462	45.1	8-RH-1212-BB1-1	6.813	2.27E-06	Cat. 3
463	48.1	8-RH-1212-BB1-2	6.813	2.27E-06	Cat. 3
464	57.2	8-RH-1308-BB1-1	6.813	2.27E-06	Cat. 3
465	58.9	8-RH-1308-BB1-2	6.813	2.27E-06	Cat. 3
466	46.9	8-RH-1315-BB1-1	6.813	2.27E-06	Cat. 3
467	52.1	8-SI-1108-BB1-1	6.813	2.27E-06	Cat. 3
468	48.8	8-SI-1108-BB1-2	6.813	2.27E-06	Cat. 3
469	45.1	8-SI-1108-BB1-3	6.813	2.27E-06	Cat. 3
470	41.2	8-SI-1108-BB1-4	6.813	2.27E-06	Cat. 3
471	43.9	8-SI-1108-BB1-5	6.813	2.27E-06	Cat. 3
472	52.4	8-SI-1208-BB1-1	6.813	2.27E-06	Cat. 3
473	50.5	8-SI-1208-BB1-2	6.813	2.27E-06	Cat. 3
474	45.9	8-SI-1208-BB1-3	6.813	2.27E-06	Cat. 3
475	41.9	8-SI-1208-BB1-3A	6.813	2.27E-06	Cat. 3
476	45.0	8-SI-1208-BB1-4	6.813	2.27E-06	Cat. 3
477	48.2	8-SI-1327-BB1-1	6.813	2.27E-06	Cat. 3
478	35.4	8-SI-1327-BB1-10	6.813	2.27E-06	Cat. 3
479	41.1	8-SI-1327-BB1-11	6.813	2.27E-06	Cat. 3
480	48.8	8-SI-1327-BB1-2	6.813	2.27E-06	Cat. 3
481	49.2	8-SI-1327-BB1-3	6.813	2.27E-06	Cat. 3
482	49.9	8-SI-1327-BB1-4	6.813	2.27E-06	Cat. 3
483	51.6	8-SI-1327-BB1-5	6.813	2.27E-06	Cat. 3
484	49.7	8-SI-1327-BB1-6	6.813	2.27E-06	Cat. 3
485	45.1	8-SI-1327-BB1-7	6.813	2.27E-06	Cat. 3
486	40.3	8-SI-1327-BB1-8	6.813	2.27E-06	Cat. 3

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
487	39.0	8-SI-1327-BB1-9	6.813	2.27E-06	Cat. 3
488	61.4	10-RH-1108-BB1-1	8.5	1.30E-06	Cat. 4
489	49.7	10-RH-1108-BB1-10	8.5	1.30E-06	Cat. 4
490	61.1	10-RH-1108-BB1-1A	8.5	1.30E-06	Cat. 4
491	61.0	10-RH-1108-BB1-2	8.5	1.30E-06	Cat. 4
492	60.9	10-RH-1108-BB1-3	8.5	1.30E-06	Cat. 4
493	60.7	10-RH-1108-BB1-4	8.5	1.30E-06	Cat. 4
494	60.7	10-RH-1108-BB1-5	8.5	1.30E-06	Cat. 4
495	60.8	10-RH-1108-BB1-6	8.5	1.30E-06	Cat. 4
496	60.2	10-RH-1108-BB1-7	8.5	1.30E-06	Cat. 4
497	49.0	10-RH-1108-BB1-8	8.5	1.30E-06	Cat. 4
498	49.2	10-RH-1108-BB1-9	8.5	1.30E-06	Cat. 4
499	62.6	10-RH-1208-BB1-1	8.5	1.30E-06	Cat. 4
500	51.1	10-RH-1208-BB1-10	8.5	1.30E-06	Cat. 4
501	52.0	10-RH-1208-BB1-11	8.5	1.30E-06	Cat. 4
502	62.3	10-RH-1208-BB1-2	8.5	1.30E-06	Cat. 4
503	62.2	10-RH-1208-BB1-3	8.5	1.30E-06	Cat. 4
504	61.6	10-RH-1208-BB1-4	8.5	1.30E-06	Cat. 4
505	61.3	10-RH-1208-BB1-5	8.5	1.30E-06	Cat. 4
506	61.4	10-RH-1208-BB1-6	8.5	1.30E-06	Cat. 4
507	60.6	10-RH-1208-BB1-7	8.5	1.30E-06	Cat. 4
508	50.9	10-RH-1208-BB1-8	8.5	1.30E-06	Cat. 4
509	50.6	10-RH-1208-BB1-9	8.5	1.30E-06	Cat. 4
510	57.0	10-RH-1308-BB1-1	8.5	1.30E-06	Cat. 4
511	62.5	10-RH-1308-BB1-2	8.5	1.30E-06	Cat. 4
512	62.6	10-RH-1308-BB1-3	8.5	1.30E-06	Cat. 4
513	62.5	10-RH-1308-BB1-4	8.5	1.30E-06	Cat. 4
514	62.8	10-RH-1308-BB1-5	8.5	1.30E-06	Cat. 4
515	61.9	10-RH-1308-BB1-6	8.5	1.30E-06	Cat. 4
516	61.8	10-RH-1308-BB1-7	8.5	1.30E-06	Cat. 4
517	61.4	10-RH-1308-BB1-8	8.5	1.30E-06	Cat. 4
518	30.4	12-RC-1112-BB1-10	10.126	9.75E-07	Cat. 4
519	30.3	12-RC-1112-BB1-11	10.126	9.75E-07	Cat. 4
520	9.6	12-RC-1112-BB1-2	10.126	9.75E-07	Cat. 4
521	16.1	12-RC-1112-BB1-3	10.126	9.75E-07	Cat. 4
522	20.2	12-RC-1112-BB1-4	10.126	9.75E-07	Cat. 4
523	22.3	12-RC-1112-BB1-5	10.126	9.75E-07	Cat. 4
524	18.9	12-RC-1112-BB1-6	10.126	9.75E-07	Cat. 4
525	16.6	12-RC-1112-BB1-7	10.126	9.75E-07	Cat. 4
526	17.6	12-RC-1112-BB1-8	10.126	9.75E-07	Cat. 4
527	27.4	12-RC-1112-BB1-9	10.126	9.75E-07	Cat. 4
528	47.4	12-RC-1125-BB1-1	10.126	9.75E-07	Cat. 4
529	48.7	12-RC-1125-BB1-2	10.126	9.75E-07	Cat. 4
530	48.9	12-RC-1125-BB1-3	10.126	9.75E-07	Cat. 4
531	49.2	12-RC-1125-BB1-4	10.126	9.75E-07	Cat. 4
532	49.2	12-RC-1125-BB1-5	10.126	9.75E-07	Cat. 4

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
533	46.5	12-RC-1125-BB1-6	10.126	9.75E-07	Cat. 4
534	44.9	12-RC-1125-BB1-7	10.126	9.75E-07	Cat. 4
535	4.4	12-RC-1212-BB1-1	10.126	9.75E-07	Cat. 4
536	12.7	12-RC-1212-BB1-2	10.126	9.75E-07	Cat. 4
537	17.0	12-RC-1212-BB1-3	10.126	9.75E-07	Cat. 4
538	22.7	12-RC-1212-BB1-4	10.126	9.75E-07	Cat. 4
539	24.1	12-RC-1212-BB1-5	10.126	9.75E-07	Cat. 4
540	19.6	12-RC-1212-BB1-6	10.126	9.75E-07	Cat. 4
541	17.7	12-RC-1212-BB1-7	10.126	9.75E-07	Cat. 4
542	11.9	12-RC-1212-BB1-8	10.126	9.75E-07	Cat. 4
543	50.5	12-RC-1221-BB1-1	10.126	9.75E-07	Cat. 4
544	51.4	12-RC-1221-BB1-2	10.126	9.75E-07	Cat. 4
545	51.0	12-RC-1221-BB1-3	10.126	9.75E-07	Cat. 4
546	49.9	12-RC-1221-BB1-4	10.126	9.75E-07	Cat. 4
547	48.4	12-RC-1221-BB1-5	10.126	9.75E-07	Cat. 4
548	46.4	12-RC-1221-BB1-6	10.126	9.75E-07	Cat. 4
549	45.1	12-RC-1221-BB1-7	10.126	9.75E-07	Cat. 4
550	4.6	12-RC-1221-BB1-8	10.126	9.75E-07	Cat. 4
551	4.0	12-RC-1312-BB1-1	10.126	9.75E-07	Cat. 4
552	23.4	12-RC-1312-BB1-10	10.126	9.75E-07	Cat. 4
553	24.1	12-RC-1312-BB1-11	10.126	9.75E-07	Cat. 4
554	12.2	12-RC-1312-BB1-2	10.126	9.75E-07	Cat. 4
555	16.6	12-RC-1312-BB1-3	10.126	9.75E-07	Cat. 4
556	22.2	12-RC-1312-BB1-4	10.126	9.75E-07	Cat. 4
557	23.7	12-RC-1312-BB1-5	10.126	9.75E-07	Cat. 4
558	19.1	12-RC-1312-BB1-6	10.126	9.75E-07	Cat. 4
559	17.5	12-RC-1312-BB1-7	10.126	9.75E-07	Cat. 4
560	7.5	12-RC-1312-BB1-8	10.126	9.75E-07	Cat. 4
561	21.6	12-RC-1312-BB1-9	10.126	9.75E-07	Cat. 4
562	29.5	12-RH-1101-BB1-1	10.126	9.75E-07	Cat. 4
563	51.4	12-RH-1101-BB1-10	10.126	9.75E-07	Cat. 4
564	52.5	12-RH-1101-BB1-11	10.126	9.75E-07	Cat. 4
565	56.7	12-RH-1101-BB1-12	10.126	9.75E-07	Cat. 4
566	52.9	12-RH-1101-BB1-13	10.126	9.75E-07	Cat. 4
567	55.8	12-RH-1101-BB1-14	10.126	9.75E-07	Cat. 4
568	56.0	12-RH-1101-BB1-15	10.126	9.75E-07	Cat. 4
569	55.0	12-RH-1101-BB1-16	10.126	9.75E-07	Cat. 4
570	32.8	12-RH-1101-BB1-2	10.126	9.75E-07	Cat. 4
571	31.6	12-RH-1101-BB1-3	10.126	9.75E-07	Cat. 4
572	13.6	12-RH-1101-BB1-3A	10.126	9.75E-07	Cat. 4
573	16.4	12-RH-1101-BB1-4	10.126	9.75E-07	Cat. 4
574	25.3	12-RH-1101-BB1-5	10.126	9.75E-07	Cat. 4
575	26.1	12-RH-1101-BB1-6	10.126	9.75E-07	Cat. 4
576	25.7	12-RH-1101-BB1-7	10.126	9.75E-07	Cat. 4
577	32.0	12-RH-1101-BB1-8	10.126	9.75E-07	Cat. 4
578	52.8	12-RH-1101-BB1-9	10.126	9.75E-07	Cat. 4

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
579	17.9	12-RH-1201-BB1-1	10.126	9.75E-07	Cat. 4
580	28.1	12-RH-1201-BB1-10	10.126	9.75E-07	Cat. 4
581	50.0	12-RH-1201-BB1-11	10.126	9.75E-07	Cat. 4
582	51.8	12-RH-1201-BB1-12	10.126	9.75E-07	Cat. 4
583	52.2	12-RH-1201-BB1-13	10.126	9.75E-07	Cat. 4
584	55.2	12-RH-1201-BB1-14	10.126	9.75E-07	Cat. 4
585	57.8	12-RH-1201-BB1-15	10.126	9.75E-07	Cat. 4
586	57.5	12-RH-1201-BB1-16	10.126	9.75E-07	Cat. 4
587	56.9	12-RH-1201-BB1-17	10.126	9.75E-07	Cat. 4
588	22.8	12-RH-1201-BB1-2	10.126	9.75E-07	Cat. 4
589	26.6	12-RH-1201-BB1-3	10.126	9.75E-07	Cat. 4
590	27.2	12-RH-1201-BB1-4	10.126	9.75E-07	Cat. 4
591	26.7	12-RH-1201-BB1-5	10.126	9.75E-07	Cat. 4
592	12.4	12-RH-1201-BB1-6	10.126	9.75E-07	Cat. 4
593	21.9	12-RH-1201-BB1-7	10.126	9.75E-07	Cat. 4
594	22.6	12-RH-1201-BB1-8	10.126	9.75E-07	Cat. 4
595	21.5	12-RH-1201-BB1-9	10.126	9.75E-07	Cat. 4
596	27.4	12-RH-1301-BB1-1	10.126	9.75E-07	Cat. 4
597	54.9	12-RH-1301-BB1-10	10.126	9.75E-07	Cat. 4
598	29.8	12-RH-1301-BB1-2	10.126	9.75E-07	Cat. 4
599	29.9	12-RH-1301-BB1-3	10.126	9.75E-07	Cat. 4
600	27.6	12-RH-1301-BB1-4	10.126	9.75E-07	Cat. 4
601	31.5	12-RH-1301-BB1-5	10.126	9.75E-07	Cat. 4
602	53.2	12-RH-1301-BB1-5A	10.126	9.75E-07	Cat. 4
603	52.9	12-RH-1301-BB1-6	10.126	9.75E-07	Cat. 4
604	53.0	12-RH-1301-BB1-7	10.126	9.75E-07	Cat. 4
605	54.5	12-RH-1301-BB1-8	10.126	9.75E-07	Cat. 4
606	55.0	12-RH-1301-BB1-9	10.126	9.75E-07	Cat. 4
607	50.9	12-SI-1125-BB1-1	10.126	9.75E-07	Cat. 4
608	48.6	12-SI-1125-BB1-2	10.126	9.75E-07	Cat. 4
609	48.1	12-SI-1125-BB1-3	10.126	9.75E-07	Cat. 4
610	48.0	12-SI-1125-BB1-4	10.126	9.75E-07	Cat. 4
611	53.5	12-SI-1218-BB1-1	10.126	9.75E-07	Cat. 4
612	51.3	12-SI-1218-BB1-2	10.126	9.75E-07	Cat. 4
613	50.7	12-SI-1218-BB1-3	10.126	9.75E-07	Cat. 4
614	50.5	12-SI-1218-BB1-4	10.126	9.75E-07	Cat. 4
615	60.4	12-SI-1315-BB1-1	10.126	9.75E-07	Cat. 4
616	59.9	12-SI-1315-BB1-2	10.126	9.75E-07	Cat. 4
617	59.3	12-SI-1315-BB1-3	10.126	9.75E-07	Cat. 4
618	59.4	12-SI-1315-BB1-4	10.126	9.75E-07	Cat. 4
619	59.6	12-SI-1315-BB1-5	10.126	9.75E-07	Cat. 4
620	21.9	12-SI-1315-BB1-6	10.126	9.75E-07	Cat. 4
621	20.3	27.5-RC-1103-NSS-4	10.126	9.75E-07	Cat. 4
622	9.6	27.5-RC-1203-NSS-3	10.126	9.75E-07	Cat. 4
623	8.7	27.5-RC-1303-NSS-3	10.126	9.75E-07	Cat. 4
624	0.5	29-RC-1301-NSS-3	10.126	9.75E-07	Cat. 4

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No.	Margin (lbm)	Location	DEGB Size (in)	f_i	NUREG 1829 Cat.
625	1.5	16-RC-1412-NSS-1	12.814	4.37E-07	Cat. 4
626	52.1	16-RC-1412-NSS-3	12.814	4.37E-07	Cat. 4
627	55.0	16-RC-1412-NSS-4	12.814	4.37E-07	Cat. 4
628	0.6	16-RC-1412-NSS-PRZ-1-N1-SE	12.814	4.37E-07	Cat. 4

Acknowledgements and primary contributions

Work presented in this article was developed by YK.risk, LLC funded by STPNOC contract BO5657, Revision 0 and Revision 1, and by Alion Science and Technology through contract BO4461, Revision 5. Reduction of CASA Grande results was performed by Jeremy Tejada under the direction of John Hasenbein and funded by STPNOC grant BO4425. Development of the strainer mass conservation equations was supported by Alex Zolan under the direction of John Hasenbein and funded by STPNOC grant BO4425, Revision 4. Seyed Reihani contributed to developing the mass conservation equations at UIUC under STPNOC grant BO5270, Revision 3. The top down frequency methodology was originally developed by Elmira Popova at UT Austin, funded by STPNOC grant BO4425, Revision 0. Further development for implementation RoverD was supported by David Johnson and Don Wakefield at ABS Consulting under STPNOC contract BO5760, Revision 1 and Bruce Letellier at Alionscience and Technology under STPNOC contract BO4461, Revision 6. Work contributed by Ernie Kee is funded by STPNOC under YK.risk, LLC contract BO5657, Revision 1.

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9 Acronyms

CAD Computer Aided Design

CASA Grande Containment Accident Stochastic Analysis (CASA) Grande

CDF Core Damage Frequency

CFD Computational fluid dynamics

ΔCDF Change in core damage frequency above a baseline level

ΔLERF Change in large early release frequency above a baseline level

CLB Cold Leg Break

CSS Containment Spray System

DEGB Double-Ended Guillotine Break

ECCS Emergency Core Cooling System

FA Fuel Assembly. Several fuel assemblies are loaded in the reactor vessel to form the reactor core

FIDOE FIber Diffusion Operations Engine; application that solves fiber mass conservation

GSI-191 Generic Safety Issue 191 - the NRC Generic Safety Issue number 191

HLB Hot Leg Break

HLSO Hot Leg Switch Over

LDFG Low Density Fiberglass (such as NUKON™)

LERF Large Early Release Frequency

LLOCA Large Break Loss of Coolant Accident

LOCA Loss of Coolant Accident

MLOCA Medium Break Loss of Coolant Accident

PCT Peak Cladding Temperature

PRA Probabilistic Risk Assessment

PWROG Pressurized Water Reactor Owners Group

RCB Reactor Containment Building

RCFC The Reactor Containment Fan Coolers

RCP Reactor Coolant Pump

RCS Reactor Coolant System

RoverD Risk-informed Over Deterministic

SLOCA Small Break Loss of Coolant Accident

STP South Texas Project

STL stereolithography file format

ZOI Zone of Influence

D_i The break size at any particular location (locations indexed by $i = 1, 2, \ldots, N$)

D_i^{small} corresponds to the smallest break size at any particular location that produces more fines in the ECCS sump than the tested amount

10 LDFG mass conservation solution implementation

The following listings are Python source code and the inputs used to generate the results in Section 3.6. Five input files are required for the analysis performed summarized in Table 5. The input files are in the ".CSV" text format (comma separated variables) and can be imported into (for example) the Microsoft application, EXCEL for ease of editing.

The Python source code is in Listing 13. The following lists the inputs used in the mass conservation study summarized in Section 3.6:

1. The time-dependent flow inputs are listed in Listing 3.
2. Constants for high pool concentration, high filtration efficiency are listed in Listing 4.
3. Constants for high pool concentration, low filtration efficiency are listed in Listing 5.
4. Constants for low pool concentration, low filtration efficiency are listed in Listing 6.
5. Constants for low pool concentration, high filtration efficiency are listed in Listing 7.

Listing 2: Source listing for (1c) solution, Alex Zolan, UT Austin, 02 March, 2015

```
"""
Recirculation / Core Debris Tracking Tool
System of Differential Equations Solver
Alex Zolan
Updated March 2, 2015

The purpose of the program is to simulate debris moving through
a recirculating pool from which strainers can filter out some
debris, and some of the debris that passes through the strainers
may attach itself to the core.
"""

import time
import scipy
import scipy.integrate
import matplotlib
matplotlib.use('Agg')
import matplotlib.pyplot as plt
import pandas
import csv

class MassCalculator(object):
    """Note that in initialization, we allow for inputs to be left
    out of the input file and still allow the program to run using
    default values in their place. When a default value is used,
    a note is printed to the console to inform the user."""
    def __init__(self, params):
        #pool volume (gallons) and initial mass in pool (grams)
        if "M_p_0" in params.keys(): self.M_p_0 = params["M_p_0"]
        else:
            self.M_p_0 = 3000.0
            print "M_p_0␣not␣in␣inputs.␣␣Default␣value␣of␣3000␣used."
        if "V_p" in params.keys(): self.V_p = params["V_p"]
        else:
            self.V_p = 50000.0
            print "V_p␣not␣in␣inputs.␣␣Default␣value␣of␣50000␣used."

        #Initial mass on strainers
```

```
if "M_s_a_0" in params.keys(): self.M_s_a_0 = params["M_s_a_0"]
else:
    self.M_s_a_0 = 0.0
    print "M_s_a_0␣not␣in␣inputs.␣␣Default␣value␣of␣0␣used."
if "M_s_b_0" in params.keys(): self.M_s_b_0 = params["M_s_b_0"]
else:
    self.M_s_b_0 = 0.0
    print "M_s_b_0␣not␣in␣inputs.␣␣Default␣value␣of␣0␣used."
if "M_s_c_0" in params.keys(): self.M_s_c_0 = params["M_s_c_0"]
else:
    self.M_s_c_0 = 0.0
    print "M_s_c_0␣not␣in␣inputs.␣␣Default␣value␣of␣0␣used."
#initial mass on core
if "M_c_0" in params.keys(): self.M_c_0 = params["M_c_0"]
else:
    self.M_c_0 = 0.0
    print "M_c_0␣not␣in␣inputs.␣␣Default␣value␣of␣0.0␣used."

#gamma, the percentage of water flowing back to the strainers
if "gamma_a" in params.keys(): self.gamma_a = params["gamma_a"]
else:
    self.gamma_a = 0.0
    print "gamma_a␣not␣in␣inputs.␣␣Default␣value␣of␣0.0␣used."
if "gamma_b" in params.keys(): self.gamma_b = params["gamma_b"]
else:
    self.gamma_b = 0.0
    print "gamma_b␣not␣in␣inputs.␣␣Default␣value␣of␣0.0␣used."
if "gamma_c" in params.keys(): self.gamma_c = params["gamma_c"]
else:
    self.gamma_c = 0.0
    print "gamma_c␣not␣in␣inputs.␣␣Default␣value␣of␣0.0␣used."

#strainer flow rates in gallons per minute (gpm)
if "Q_s_a" in params.keys(): self.Q_s_a = params["Q_s_a"]
else:
    self.Q_s_a = 1000.0
    print "Q_s_a␣not␣in␣inputs.␣␣Default␣value␣of␣1000.0␣used."
if "Q_s_b" in params.keys(): self.Q_s_b = params["Q_s_b"]
else:
    self.Q_s_b = 1000.0
    print "Q_s_b␣not␣in␣inputs.␣␣Default␣value␣of␣1000.0␣used."
```

```
        if "Q_s_c" in params.keys(): self.Q_s_c = params["Q_s_c"]
        else:
            self.Q_s_c = 1000.0
            print "Q_s_c␣not␣in␣inputs.␣␣Default␣value␣of␣1000.0␣used."

        #core flow rate in gpm
        if "Q_c" in params.keys(): self.Q_c = params["Q_c"]
        else:
            self.Q_c = 1600.0
            print "Q_c␣not␣in␣inputs.␣␣Default␣value␣of␣1600.0␣used."

        #filtration rate (function of mass)
        if "m" in params.keys(): self.m = params["m"]
        else:
            self.m = 0.0003391 #lower envelope
            print "m␣(filtration␣function)␣not␣in␣inputs.␣␣Default␣of␣0.0003391␣used."
        if "b" in params.keys(): self.b = params["b"]
        else:
            self.b = 0.6560 #lower envelope
            print "b␣(filtration␣function)␣not␣in␣inputs.␣␣Default␣of␣0.6560␣used."
        if "M_c" in params.keys(): self.threshold = params["M_c"]
        else:
            self.threshold = 880 #lower envelope
            print "M_c␣(filtration␣function)␣not␣in␣inputs.␣␣Default␣of␣880␣used."
        if "delta" in params.keys(): self.delta = params["delta"]
        else:
            self.delta = 0.0013 #lower envelope
            print "delta␣(filtration␣function)␣not␣in␣inputs.␣␣Default␣of␣0.0013␣used."
        if "a" in params.keys(): self.a = params["a"]
        else:
            self.a = 1.0 #lower envelope
            #this upper bound is not expected to be used in most cases, so it is not
            #called out in the console.,
            #print "a (filtration function) not in inputs. Default of 1.0 used."

    def getFlowRateStrainerA(self,t):
        """returns the flow rate out of strainer A, in gallons per minute.
        This function is assumed to be known with respect to time,
        but currently has only a constant."""
```

```
        if type(self.Q__s__a) == float: return self.Q__s__a
        else:
            #if not a constant, use the flow rate just before the time
            #period that exceeds the input t. otherwise, use the
            #last flow rate given
            if self.Q__s__a["t"][0] > t: return 0
            for i in range(1,len(self.Q__s__a["t"])):
                if self.Q__s__a["t"][i] > t:
                    return self.Q__s__a["vals"][i-1]
            return self.Q__s__a["vals"][-1]

    def getFlowRateStrainerB(self,t):
        """returns the flow rate out of strainer B, in gallons per minute.
        This function is assumed to be known with respect to time,
        but currently has only a constant."""
        if type(self.Q__s__b) == float: return self.Q__s__b #if the input is a constant, just report that.
        else:
            #if not a constant, use the flow rate just before the time
            #period that exceeds the input t. otherwise, use the
            #last flow rate given
            if self.Q__s__b["t"][0] > t: return 0
            for i in range(1,len(self.Q__s__b["t"])):
                if self.Q__s__b["t"][i] > t:
                    return self.Q__s__b["vals"][i-1]
            return self.Q__s__b["vals"][-1]

    def getFlowRateStrainerC(self,t):
        """returns the flow rate out of strainer C, in gallons per minute.
        This function is assumed to be known with respect to time,
        but currently has only a constant."""
        if type(self.Q__s__c) == float: return self.Q__s__c
        else:
            #if not a constant, use the flow rate just before the time
            #period that exceeds the input t. otherwise, use the
            #last flow rate given
            if self.Q__s__c["t"][0] > t: return 0
            for i in range(1,len(self.Q__s__c["t"])):
                if self.Q__s__c["t"][i] > t:
                    return self.Q__s__c["vals"][i-1]
            return self.Q__s__c["vals"][-1]
```

```
def getFlowRateCore(self, t):
    """returns the flow rate through the core, in gallons per minute.
    This function is assumed to be known with respect to time."""
    if type(self.Q__c) == float: return self.Q__c
    else:
        #if not a constant, use the flow rate just before the time
        #period that exceeds the input t. otherwise, use the
        #last flow rate given
        if self.Q__c["t"][0] > t: return 0
        for i in range(1,len(self.Q__c["t"])):
            if self.Q__c["t"][i] > t:
                return self.Q__c["vals"][i-1]
        return self.Q__c["vals"][-1]


def getFiltrationRate(self,mass):
    """returns the filtration rate (fraction between 0 and 1)
    of debris through the strainer. (Note the mass is total for
    a strainer, and there are 20 modules, with the filtration
    function relating to the per module mass - so we divide
    by 20 to get the per-module mass.
    mass -- amount of debris currently on the strainer (grams)
    retval - fraction between 0 and 1 indicating how the
    proportion of mass that is caught and added to the strainer
    """
    if (mass/20.0) <= self.threshold:
        return (mass/20.0)*self.m + self.b
    else:
        return (self.threshold*self.m + self.b) + (self.a - self.threshold*self.m -
            self.b) * (1-scipy.exp(-self.delta * ((mass/20.0)-self.threshold) ) )

def getDeltaMassStrainerA(self, masses, t):
    """Calculates the rate of change of mass on strainer A.
    masses -- mass of debris in the different parts of the
    recirculation system:
        masses[0] = Pool (M__p)
        masses[1] = Strainer A (M__s__A)
        masses[2] = Strainer B (M__s__B)
        masses[3] = Strainer C (M__s__C)
        masses[4] = Core (M__c)
```

```
        t -- time
        retval -- rate of change of mass on Strainer A."""
        return self.getFlowRateStrainerA(t) * (masses[0] / self.V_p) * self.
            getFiltrationRate(masses[1])

    def getDeltaMassStrainerB(self, masses, t):
        """Calculates the rate of change of mass on strainer B.
        masses -- mass of debris in the different parts of the
        recirculation system:
            masses[0] = Pool (M_p)
            masses[1] = Strainer A (M_s_A)
            masses[2] = Strainer B (M_s_B)
            masses[3] = Strainer C (M_s_C)
            masses[4] = Core (M_c)
        t -- time
        retval -- rate of change of mass on Strainer B."""
        return self.getFlowRateStrainerB(t) * (masses[0] / self.V_p) * self.
            getFiltrationRate(masses[2])

    def getDeltaMassStrainerC(self, masses, t):
        """Calculates the rate of change of mass on strainer C.
        masses -- mass of debris in the different parts of the
        recirculation system:
            masses[0] = Pool (M_p)
            masses[1] = Strainer A (M_s_A)
            masses[2] = Strainer B (M_s_B)
            masses[3] = Strainer C (M_s_C)
            masses[4] = Core (M_c)
        t -- time
        retval -- rate of change of mass on Strainer C."""
        return self.getFlowRateStrainerC(t) * (masses[0] / self.V_p) * self.
            getFiltrationRate(masses[3])

    def getNetPassThroughRate(self,masses,t):
        """Calculates the weighted average pass-through rate of debris through the
            strainers and to the core.
        result is weighted by flow rate to the core (given by the gamma term and
            flow rate).
        masses -- mass of debris in the different parts of the system:
            recirculation system:
            masses[0] = Pool (M_p)
```

```
        masses[1] = Strainer A (M_s_A)
        masses[2] = Strainer B (M_s_B)
        masses[3] = Strainer C (M_s_C)
        masses[4] = Core (M_c)
    t -- time
    retval -- weighted average of debris filtered by the strainers"""
    if self.getFlowRateStrainerA(t) + self.getFlowRateStrainerB(t) + self.
        getFlowRateStrainerC(t) == 0: return 1.0
    else: return ( self.getFlowRateStrainerA(t) * (1-self.getFiltrationRate(masses
        [1])) * (1-self.gamma_a)
            + self.getFlowRateStrainerB(t) * (1-self.getFiltrationRate(masses
                [2])) * (1-self.gamma_b)
            + self.getFlowRateStrainerC(t) * (1-self.getFiltrationRate(masses
                [3])) * (1-self.gamma_c) ) / \
            ( self.getFlowRateStrainerA(t) * (1-self.gamma_a) +
              self.getFlowRateStrainerB(t) * (1-self.gamma_b) +
              self.getFlowRateStrainerC(t) * (1-self.gamma_c) )

def getDeltaMassCore(self, masses, t):
    """Calculates the rate of change of debris on the core."""
    return self.getFlowRateCore(t) * (masses[0] / self.V_p) * (self.
        getNetPassThroughRate(masses,t))

def getDeltaMassPool(self,masses,t):
    """Calculates the rate of change of debris in the pool."""
    return -1.0*( self.getDeltaMassCore(masses,t)
                + self.getDeltaMassStrainerA(masses, t)
                + self.getDeltaMassStrainerB(masses, t)
                + self.getDeltaMassStrainerC(masses, t) )

def getAllDeltas(self, masses, t):
    """Gets the rate of change of debris in all locations."""
    return scipy.array( [ self.getDeltaMassPool(masses,t),
                          self.getDeltaMassStrainerA(masses,t),
                          self.getDeltaMassStrainerB(masses,t),
                          self.getDeltaMassStrainerC(masses,t),
                          self.getDeltaMassCore(masses,t) ] )


def solveForCoreMass(self, t):
    """Runs the ODE integrator from Python's ODE library,
```

```
        with the delta functions and initial values arranged in
        order: pool, strainer A, B, C, and Core.
        Note: We use the library's default solver, LSODA,
        for this set of differential equations."""
        return scipy.integrate.odeint(self.getAllDeltas,
                                      scipy.array([self.M_p_0,
                                                   self.M_s_a_0,
                                                   self.M_s_b_0,
                                                   self.M_s_c_0,
                                                   self.M_c_0]
                                                   ),
                                      t, mxstep=10000000 )

    def printEchoIn(self,filename = "echoin.csv"):
        """Prints all model parameters to file. Used for debugging
        and I/O checking."""
        outfile = open(filename,'w')
        outfile.write("Model parameters used:\n\n")
        outfile.write("Filtration Function Parameter Values:\n")
        outfile.write("m,%s\n" % self.m)
        outfile.write("b,%s\n" % self.b)
        outfile.write("M_c,%s\n" % self.threshold)
        outfile.write("delta,%s\n" % self.delta)
        outfile.write("a,%s\n\n" % self.a)
        outfile.write("Initial Masses and Strainer Values:\n")
        outfile.write("M_p_0,%s\n" % self.M_p_0)
        outfile.write("V_p,%s\n" % self.V_p)
        outfile.write("M_s_a_0,%s\n" % self.M_s_a_0)
        outfile.write("M_s_b_0,%s\n" % self.M_s_b_0)
        outfile.write("M_s_c_0,%s\n" % self.M_s_c_0)
        outfile.write("Flow Rates over time:\n")
        if type(self.Q_s_a) == float: outfile.write("Q_s_a,%s\n" % self.Q_s_a)
        else:
            outfile.write("t,Q_s_a\n")
            for idx in range(len(self.Q_s_a["t"])):
                outfile.write("%s,%s\n" % (self.Q_s_a["t"][idx],self.Q_s_a["vals"][
                    idx]))
        outfile.write("\n")
        if type(self.Q_s_b) == float: outfile.write("Q_s_b,%s\n" % self.Q_s_b)
        else:
            outfile.write("t,Q_s_b\n")
```

```
            for idx in range(len(self.Q_s_b["t"])):
                outfile.write("%s,%s\n" % (self.Q_s_b["t"][idx],self.Q_s_b["vals"][
                    idx]))
        outfile.write("\n")
        if type(self.Q_s_c) == float: outfile.write("Q_s_c,%s\n" % self.Q_s_c)
        else:
            outfile.write("t,Q_s_c\n")
            for idx in range(len(self.Q_s_c["t"])):
                outfile.write("%s,%s\n" % (self.Q_s_c["t"][idx],self.Q_s_c["vals"][
                    idx]))
        outfile.write("\n")
        if type(self.Q_c) == float: outfile.write("Q_c,%s\n" % self.Q_c)
        else:
            outfile.write("t,Q_c\n")
            for idx in range(len(self.Q_c["t"])):
                outfile.write("%s,%s\n" % (self.Q_c["t"][idx],self.Q_c["vals"][idx]))
        outfile.write("\n")

def ReadParams(time_filename, initials_filename):
    """Serves as the input reader for this model. Assumes there
    is one file that reads as a table of time-based inputs and
    another file with initial and model values. the output is a
    dictionary that is used to initialize the MassCalculator class.
    """
    params = {}
    #read in initials and constants file
    initials_file = csv.reader(open(initials_filename, 'rU'))
    for line in initials_file:
        if len(line) > 1:
            try: params[line[0]] = float(line[1])
            except ValueError: pass
    #read in time-based inputs file
    time_df = pandas.read_csv(time_filename)
    #print time_df
    params["Q_s_a"] = {}
    params["Q_s_a"]["t"] = time_df.t.values
    params["Q_s_a"]["vals"] = time_df.Q_s_a.values
    params["Q_s_b"] = {}
    params["Q_s_b"]["t"] = time_df.t.values
    params["Q_s_b"]["vals"] = time_df.Q_s_b.values
    params["Q_s_c"] = {}
```

```
    params["Q_s_c"]["t"] = time_df.t.values
    params["Q_s_c"]["vals"] = time_df.Q_s_c.values
    params["Q_c"] = {}
    params["Q_c"]["t"] = time_df.t.values
    params["Q_c"]["vals"] = time_df.Q_c.values
    return params


if __name__ == "__main__":
    time_filename = raw_input("Please␣enter␣the␣name␣of␣the␣time-indexed␣inputs␣file:␣␣")
    #time_filename = "time.csv"
    initials_filename = raw_input("Please␣enter␣the␣name␣of␣the␣constant␣inputs␣file:␣␣")
    #initials_filename = "const.csv"
    solver = MassCalculator(ReadParams(time_filename, initials_filename))
    timespan = float(raw_input("Please␣enter␣the␣desired␣timespan␣(minutes):␣␣"))
    #timespan = 1000
    outfile = raw_input("Please␣enter␣the␣results␣filename␣(no␣extension):␣␣")
    #outfile = "DEMO"
    #create_png = raw_input("Create graph summary of output (y/n)? ")
    clock = time.time()
    t = scipy.linspace(0,timespan,1001)
    sol = solver.solveForCoreMass(t).T
    elapsed = time.time() - clock
    print "Calculations␣completed␣in␣"+str(elapsed)+"␣seconds.␣␣Creating␣output␣files."
    #Creating csv table
    output = open(outfile+".csv",'w')
    output.write("t,M_p,M_s_a,M_s_b,M_s_c,M_c\n")
    for idx in range(len(sol[0])):
        output.write(str(t[idx])+","+str(sol[0][idx])+","+str(sol[1][idx])+","+str(sol[2][idx])+","+str(sol[3][idx])+","+str(sol[4][idx])+"\n")
    output.close()
    #Creating 2x2 figure of plots of debris levels over time.
    #If plotting can't be done here, skip this step.
    try:
        fig, axes = plt.subplots(2,2)
        axes[0, 0].plot(t,sol[1])
        axes[0, 0].set_title('Debris␣on␣strainer␣A␣over␣time')
        axes[0, 1].plot(t,sol[2])
```

```
        axes[0, 1].set_title('Debris␣on␣strainer␣B␣over␣time')
        axes[1, 0].plot(t,sol[3])
        axes[1, 0].set_title('Debris␣on␣strainer␣C␣over␣time')
        axes[1, 1].plot(t,sol[4])
        axes[1, 1].set_title('Debris␣on␣core␣over␣time')
        plt.savefig(outfile+".png")
    except TypeError: pass
    #print model parameters
    solver.printEchoIn()
```

Listing 3: Mass conservation solver, time-dependent inputs

```
t,Q_s_a,Q_s_b,Q_s_c,Q_c
0.00,7200,7200,7200,610.00
8.33,7200,7200,7200,565.81
41.67,7200,7200,7200,520.19
75.00,7200,7200,7200,419.82
108.33,7200,7200,7200,370.37
141.67,7200,7200,7200,340.83
225.00,7200,7200,7200,319.87
308.33,7200,7200,7200,286.78
641.67,7200,7200,7200,265.56
975.00,7200,7200,7200,220.91
1308.33,7200,7200,7200,197.62
1641.67,7200,7200,7200,182.46
2475.00,7200,7200,7200,171.01
6641.67,7200,7200,7200,151.19
9975.00,7200,7200,7200,107.08
13308.33,7200,7200,7200,90.92
16641.67,7200,7200,7200,80.49
```

Listing 4: Input listing for the mass conservation solver: constants for High Pool Concentration, High Filtration Efficiency

```
Initial Mass:
M_p_0,249700
M_s_a_0,0
M_s_b_0,0
M_s_c_0,0
M_c_0,0
Pool Volume:
V_p,300000
Strainer Recirculation Rates::
gamma_a,0
gamma_b,0.33
gamma_c,0.33
Filtration Function Parameters (see Ogden Tejada and Morton STP-RIGSI1913V03
    .06):
m,0.0003723
b,0.7059
M_c,790
delta,0.0318
```

Listing 5: Input listing for the mass conservation solver: constants for High Pool Concentration, Low Filtration Efficiency

```
Initial Mass:
M_p_0,249700
M_s_a_0,0
M_s_b_0,0
M_s_c_0,0
M_c_0,0
Pool Volume:
V_p,300000,,,,
Strainer Recirculation Rates::
gamma_a,0
gamma_b,0.33
gamma_c,0.33
Filtration Function Parameters (see Ogden Tejada and Morton STP-RIGSI1913V03
    .06):
m,0.0003391
b,0.656
M_c,880
delta,0.0013
```

Listing 6: Input listing for the mass conservation solver: constants for Low Pool Concentration, Low Filtration Efficiency

```
Initial Mass:
M_p_0,87068.12
M_s_a_0,0
M_s_b_0,0
M_s_c_0,0
M_c_0,0
Pool Volume:
V_p,550000
Strainer Recirculation Rates::
gamma_a,0
gamma_b,0.33
gamma_c,0.33
Filtration Function Parameters (see Ogden Tejada and Morton STP-RIGSI1913V03
    .06):
m,0.0003391
b,0.656
M_c,880
delta,0.0013
```

Listing 7: Input listing for the mass conservation solver: constants for Low Pool Concentration, Low Filtration Efficiency

```
Initial Mass:
M_p_0,87068.12
M_s_a_0,0
M_s_b_0,0
M_s_c_0,0
M_c_0,0
Pool Volume:
V_p,550000
Strainer Recirculation Rates::
gamma_a,0
gamma_b,0.33
gamma_c,0.33
Filtration Function Parameters (see Ogden Tejada and Morton STP-RIGSI1913V03
    .06):
m,0.0003723
b,0.7059
M_c,790
delta,0.0318
```

11 Top-down LOCA frequency solution implementation

The following listings are Python source code and the inputs used to generate the results in Section 4.4 (Results). The output of the frequency application is directed to the screen via a ‘print’ statement (see last four lines of Listing 8). Input files are required for the exceedence frequency quantiles at different break sizes, a weld list that has the number and inside diameter of welds in the plant within the GSI-191 scope, and a list of the D_i^{small} from the RoverD *f*etch stage. The input files are in the “.CSV” text format (comma separated variables) and can be imported into (for example) the Microsoft application, EXCEL for ease of editing.
NOTE: The frequency results in Table 12, Table 13, Table 14, and Table 15 were not from the Python application but rather a spreadsheet implementation of the top-down method.

In the following, input files for computing the results shown in Table 8 are listed:

1. The arithmetic mean frequency table (from Tregoning et al. (2008)) input is Listing 9.
2. The geometric mean frequency table (from Tregoning et al. (2008)) input is Listing 10.
3. The weld list (ID and count) input is shown in Listing 11.
4. The pipe break table from RoverD fetch is listed in Listing 12.

Listing 8: Source listing for (5) solution, Alex Zolan, UT Austin, 27 February, 2015

```
"""
LOCA Frequency Calculator
Alex Zolan
Updated February 27, 2015

The purpose of the program is to estimate the frequency of critical
breaks that can occur We assume that any pipe that has a diameter
as large or larger than any critical break size could experience
such a break, and that each possible pipe has the same chance of
having such a break.
"""
import pandas
import scipy

class NUREG_1829_Freqs(object):
    """This class manages the NUREG-1829 frequencies as given
    by an input file, which has the the break size, mean, and
    5th, 50th and 95th exceedance break frequencies for a set
    number of categories."""
```

```
def __init__(self,nureg_file):
    """
    We start with a dataframe and take the break sizes and
    each sumimary statistic as their own independent list.
    """
    df = pandas.read_csv(nureg_file)
    #self.categories = df.Category.values
    self.sizes = df.Break_Size.values
    self.means = df.Mean.values
    self.P5 = df.P5.values
    self.P50 = df.P50.values
    self.P95 = df.P95.values

def findFirstExceedingIndex(self,size):
    """Finds the index of the first size that is larger
    than the given size.

    size -- break size, in inches
    retval - index from sizes object"""
    assert size >= self.sizes[0], "Size outside of NUREG found.  Aborting."
    for idx, s in enumerate(self.sizes):
        if s >= size: return idx
    return -1
def getFrequency(self,size,stat):
    """Returns the exceedance frequency of a given break size
    uses NUREG 1829 values and linear interpolation to find
    the best .

    size -- break size, in inches
    stat -- desired summary statistic
    retval - summary statistic frequency for break size"""
    idx = self.findFirstExceedingIndex(size)
    assert idx >= 0, "Size outside of NUREG Found.  Aborting."
    if idx == 0: return self.getStat(0,stat)
    lower = self.getStat(idx-1,stat)
    upper = self.getStat(idx,stat)
    frac = (size-self.sizes[idx-1])/(self.sizes[idx]-self.sizes[idx-1])
    #print "Frac Calc",size,lower,upper,self.sizes[idx-1],self.sizes[idx]
    return lower + (upper-lower)*frac

def getStat(self,idx,stat):
```

```
        """Returns a summary statistic based on the object desired.

        idx -- index of the desire list to return
        stat -- desired summary statistic
        retval - summary statistic frequency from NUREG-1829"""
        if stat == "P5": return self.P5[idx]
        if stat == "P50": return self.P50[idx]
        if stat == "P95": return self.P95[idx]
        if stat == "Mean": return self.means[idx]

class LOCAEventCalculator(object):
    """This class acts as the calculator for LOCA Events. It calls
    frequencies from the NUREG_1829_Freqs object, and determines
    the probability of a particular pipe breaking by finding the
    number of pipes that could handle such a break.

    breaksFile -- location of the file that contains all pipes and
    the weld break sizes that would cause a significant event
    weldsFile -- location of the file that contains a summary of
    the number of welds of each size/type
    """
    def __init__(self,breaksFile,weldsFile):
        self.breaks_df = pandas.read_csv(breaksFile)
        self.welds_df = pandas.read_csv(weldsFile)
    def getPipesOfExceedingSize(self,breakSize):
        """returns the number of pipes in from the welds dataframe
        that have a diameter that meets or exceeds a given break
        size, given the input breakSize."""
        return scipy.sum(self.welds_df[self.welds_df.pipe_type
                         >= breakSize].number_of_welds.values)
    def getSumOfAllBreaks(self,stat,nuregFile):
        """calculates the expected frequency of LOCA events based
        on calculating the exceedance frequency of the break size
        and then dividing by the number of pipes that could have
        a break of that size in the plant (as given by the welds
        file). This term is calculated for each pipe in the
        pipebreaks file (when a nonzero break size is included)
        and then summed to get the result.

        nuregFile -- table of NUREG-1829 frequencies.
        retval -- expected frequency of LOCA events/CY."""
```

```
        nureg = NUREG_1829_Freqs(nuregFile)
        sum_freqs = 0.0
        for i,rowdata in self.breaks_df.iterrows():
            if self.breaks_df.Break_size[i] == 0: continue
            breakFreq = nureg.getFrequency(self.breaks_df.Break_size[i],stat)
            numPipes = self.getPipesOfExceedingSize(self.breaks_df.Break_size[i])
            sum_freqs += breakFreq / numPipes
            #print self.breaks_df.Break_size[i],breakFreq,numPipes
        return sum_freqs

if __name__ == "__main__":
    weldsFile = raw_input("Please enter the name of the welds inputs file:  ")
    #weldsFile = "welds.csv"
    breaksFile = raw_input("Please enter the name of the pipe/break sizes file:  ")
    #breaksFile = "pipebreaks.csv"
    nuregFile = raw_input("Please enter the name of the NUREG frequencies file:  ")
    #nuregFile = "NUREG_GM.csv"
    locas = LOCAEventCalculator(breaksFile,weldsFile)
    #print locas.breaks_df[locas.breaks_df.Break_size > 0]
    #print locas.welds_df
    P5Freq = locas.getSumOfAllBreaks("P5",nuregFile)
    P50Freq = locas.getSumOfAllBreaks("P50",nuregFile)
    P95Freq = locas.getSumOfAllBreaks("P95",nuregFile)
    meanFreq = locas.getSumOfAllBreaks("Mean",nuregFile)
    print "Total expected frequency of events at P5:  "+str(P5Freq)+" events/CY"
    print "Total expected frequency of events at P50:  "+str(P50Freq)+" events/CY"
    print "Total expected frequency of events at P95:  "+str(P95Freq)+" events/CY"
    print "Total expected frequency of events at Mean:  "+str(meanFreq)+" events/CY"
```


Listing 9: Input listing for the Arithmetic Means quantiles. Taken from NUREG-1829, Table 13

```
Category,Break_Size,P5,P50,Mean,P95
Cat1,0.5,8.10E-04,4.80E-03,1.00E-02,3.60E-02
Cat2,1.625,4.20E-05,7.00E-04,3.00E-03,1.20E-02
```

```
Cat3,3,1.30E-06,1.90E-05,7.30E-05,2.90E-04
Cat4,7,6.90E-08,1.30E-06,9.40E-06,3.00E-05
Cat5,14,9.90E-09,2.60E-07,2.40E-06,7.20E-06
Cat6,31,5.90E-09,1.50E-07,1.50E-06,5.20E-06
```

Listing 10: Input listing for the Geometric Means quantiles. Taken from NUREG-1829, Table 19

```
        Category,Break_Size,P5,P50,P95,Mean
Cat1,0.5,6.80E-05,6.30E-04,7.10E-03,1.90E-03
Cat2,1.625,5.00E-06,8.90E-05,1.60E-03,4.20E-04
Cat3,3,2.14E-07,3.40E-06,6.10E-05,1.60E-05
Cat4,7,1.40E-08,3.10E-07,6.10E-06,1.60E-06
Cat5,14,4.10E-10,1.20E-08,5.80E-07,2.00E-07
Cat6,31,3.49E-11,1.19E-09,8.00E-08,2.90E-08
```

Listing 11: Input listing for the welds in the scope of GSI-191

```
pipe_type,number_of_welds,,Pipe size (stainless schedule 160),
0.612,32,,0.75,
0.815,3,,1,
1.338,9,,1.5,
1.687,85,,2,
2.125,6,,2.5,
2.624,26,,3,
3.438,90,,4,
5.187,88,,6,
6.813,54,,8,
8.5,30,,10,
10.126,131,,12,
12.814,10,,16,
27.5,16,,27.5,Spool/forged
29,20,,29,Spool/forged
31,28,,31,Spool/forged
```

Listing 12: Input listing from the RoverD fetch stage for the welds in the scope of GSI-191

```
Number,Line_Number,Location_Name,System,Category,Pipe_ID,Break_size
1,2-CV-1122-BB1,0.75-CV-1122-BB1-1,CV Small Bore,6B-1,0.614,0
2,2-CV-1122-BB1,0.75-CV-1122-BB1-2,CV Small Bore,6B-1,0.614,0
3,2-CV-1124-BB1,0.75-CV-1124-BB1-1,CV Small Bore,6B-1,0.614,0
```

4,2-CV-1124-BB1,0.75-CV-1124-BB1-2,CV Small Bore,6B-1,0.614,0
5,2-CV-1126-BB1,0.75-CV-1126-BB1-1,CV Small Bore,6B-1,0.614,0
6,2-CV-1126-BB1,0.75-CV-1126-BB1-2,CV Small Bore,6B-1,0.614,0
7,2-CV-1128-BB1,0.75-CV-1128-BB1-1,CV Small Bore,6B-1,0.614,0
8,2-CV-1128-BB1,0.75-CV-1128-BB1-2,CV Small Bore,6B-1,0.614,0
9,4-RC-1003-BB1,0.75-RC-1001-BB1-1,RC Small Bore,6B-1,0.614,0
10,4-RC-1000-BB1,0.75-RC-1002-BB2-1,RC Small Bore,6B-1,0.614,0
11,12-RC-1112-BB1,0.75-RC-1112-BB1-1,RC Small Bore,6B-1,0.614,0
12,8-RC-1114-BB1,0.75-RC-1114-BB1-1,RC Small Bore,6B-1,0.614,0
13,12-RC-1125-BB1,0.75-RC-1125-BB1-1,SI-ACC-CL1 Small Bore,6B-1,0.614,0
14,12-RC-1125-BB1,0.75-RC-1125-BB1-2,SI-ACC-CL1 Small Bore,6B-1,0.614,0
15,4-RC-1126-BB1,0.75-RC-1126-BB1-1,RC Small Bore,6B-1,0.614,0
16,12-RC-1212-BB1,0.75-RC-1212-BB1-1,RC Small Bore,6B-1,0.614,0
17,8-RC-1214-BB1,0.75-RC-1214-BB1-1,RC Small Bore,6B-1,0.614,0
18,12-RC-1221-BB1,0.75-RC-1221-BB1-1,SI-ACC-CL2 Small Bore,6B-1,0.614,0
19,12-RC-1221-BB1,0.75-RC-1221-BB1-2,SI-ACC-CL2 Small Bore,6B-1,0.614,0
20,12-RC-1312-BB1,0.75-RC-1312-BB1-1,RC Small Bore,6B-1,0.614,0
21,8-RC-1324-BB1,0.75-RC-1324-BB1-1,RC Small Bore,6B-1,0.614,0
22,4-RC-1422-BB1,0.75-RC-1423-BB1-1,RC Small Bore,6B-1,0.614,0
23,8-SI-1108-BB1,0.75-SI-1130-BB2-1,RC Small Bore,6B-1,0.614,0
24,12-SI-1125-BB1,0.75-SI-1132-BB1-1,RC Small Bore,6B-1,0.614,0
25,12-SI-1218-BB1,0.75-SI-1218-BB1-1,SI Small Bore,6B-1,0.614,0
26,8-SI-1208-BB1,0.75-SI-1223-BB2-1,RC Small Bore,6B-1,0.614,0
27,12-SI-1315-BB1,0.75-SI-1315-BB1-1,SI-ACC Small Bore,6B-1,0.614,0
28,12-SI-1315-BB1,0.75-SI-1323-BB1-1,SI-ACC Small Bore,6B-1,0.614,0
29,6-SI-1327-BB1,0.75-SI-1327-BB1-1,SI Small Bore,6B-1,0.614,0
30,8-SI-1327-BB1,0.75-SI-1327-BB1-2,SI Small Bore,6B-1,0.614,0
31,8-SI-1327-BB1,0.75-SI-1327-BB1-3,SI Small Bore,6B-1,0.614,0
32,8-SI-1327-BB1,0.75-SI-1328-BB2-1,SI Small Bore,6B-1,0.614,0
33,6-RC-1003-BB1,1-RC-1003-BB1-1,RC Small Bore,6B-2,0.815,0
34,4-RC-1123-BB1,1-RC-1123-BB1-1,RC Small Bore,6B-2,0.815,0
35,4-RC-1422-BB1,1-RC-1422-BB1-1,RC Small Bore,6B-2,0.815,0
36,16-RC-1412-NSS,1.5-RC-1412-NSS-1,RC,6A-1,1.338,0
37,2(1.5)-CV-1122-BB1,2(1.5)-CV-1122-BB1-1,CV - RCP1A,8C-1,1.338,0
38,2(1.5)-CV-1122-BB1,2(1.5)-CV-1122-BB1-2,CV - RCP1A,8C-1,1.338,0
39,2(1.5)-CV-1124-BB1,2(1.5)-CV-1124-BB1-1,CV - RCP1B,8C-1,1.338,0
40,2(1.5)-CV-1124-BB1,2(1.5)-CV-1124-BB1-2,CV - RCP1B,8C-1,1.338,0
41,2(1.5)-CV-1126-BB1,2(1.5)-CV-1126-BB1-1,CV - RCP1C,8C-1,1.338,0
42,2(1.5)-CV-1126-BB1,2(1.5)-CV-1126-BB1-2,CV - RCP1C,8C-1,1.338,0
43,2(1.5)-CV-1128-BB1,2(1.5)-CV-1128-BB1-1,CV - RCP1D,8C-1,1.338,0
44,2(1.5)-CV-1128-BB1,2(1.5)-CV-1128-BB1-2,CV - RCP1D,8C-1,1.338,0

45,2-CV-1121-BB1,2-CV-1121-BB1-1,CV - PZR Auxiliary Spray Line,8A,1.689,0
46,2-CV-1121-BB1,2-CV-1121-BB1-2,CV - PZR Auxiliary Spray Line,8A,1.689,0
47,2-CV-1121-BB1,2-CV-1121-BB1-3,CV - PZR Auxiliary Spray Line,8A,1.689,0
48,2-CV-1122-BB1,2-CV-1122-BB1-1,CV - RCP1A,8C-2,1.689,0
49,2-CV-1122-BB1,2-CV-1122-BB1-2,CV - RCP1A,8C-2,1.689,0
50,2-CV-1122-BB1,2-CV-1122-BB1-3,CV - RCP1A,8C-2,1.689,0
51,2-CV-1122-BB1,2-CV-1122-BB1-4,CV - RCP1A,8C-2,1.689,0
52,2-CV-1122-BB1,2-CV-1122-BB1-5,CV - RCP1A,8C-2,1.689,0
53,2-CV-1122-BB1,2-CV-1122-BB1-6,CV - RCP1A,8C-2,1.689,0
54,2-CV-1124-BB1,2-CV-1124-BB1-1,CV - RCP1B,8C-2,1.689,0
55,2-CV-1124-BB1,2-CV-1124-BB1-2,CV - RCP1B,8C-2,1.689,0
56,2-CV-1124-BB1,2-CV-1124-BB1-3,CV - RCP1B,8C-2,1.689,0
57,2-CV-1124-BB1,2-CV-1124-BB1-4,CV - RCP1B,8C-2,1.689,0
58,2-CV-1124-BB1,2-CV-1124-BB1-5,CV - RCP1B,8C-2,1.689,0
59,2-CV-1124-BB1,2-CV-1124-BB1-6,CV - RCP1B,8C-2,1.689,0
60,2-CV-1124-BB1,2-CV-1124-BB1-7,CV - RCP1B,8C-2,1.689,0
61,2-CV-1124-BB1,2-CV-1124-BB1-8,CV - RCP1B,8C-2,1.689,0
62,2-CV-1124-BB1,2-CV-1124-BB1-9,CV - RCP1B,8C-2,1.689,0
63,2-CV-1124-BB1,2-CV-1124-BB1-10,CV - RCP1B,8C-2,1.689,0
64,2-CV-1124-BB1,2-CV-1124-BB1-11,CV - RCP1B,8C-2,1.689,0
65,2-CV-1124-BB1,2-CV-1124-BB1-12,CV - RCP1B,8C-2,1.689,0
66,2-CV-1124-BB1,2-CV-1124-BB1-13,CV - RCP1B,8C-2,1.689,0
67,2-CV-1126-BB1,2-CV-1126-BB1-1,CV - RCP1C,8C-2,1.689,0
68,2-CV-1126-BB1,2-CV-1126-BB1-2,CV - RCP1C,8C-2,1.689,0
69,2-CV-1126-BB1,2-CV-1126-BB1-3,CV - RCP1C,8C-2,1.689,0
70,2-CV-1126-BB1,2-CV-1126-BB1-4,CV - RCP1C,8C-2,1.689,0
71,2-CV-1126-BB1,2-CV-1126-BB1-5,CV - RCP1C,8C-2,1.689,0
72,2-CV-1126-BB1,2-CV-1126-BB1-6,CV - RCP1C,8C-2,1.689,0
73,2-CV-1126-BB1,2-CV-1126-BB1-7,CV - RCP1C,8C-2,1.689,0
74,2-CV-1126-BB1,2-CV-1126-BB1-8,CV - RCP1C,8C-2,1.689,0
75,2-CV-1126-BB1,2-CV-1126-BB1-9,CV - RCP1C,8C-2,1.689,0
76,2-CV-1126-BB1,2-CV-1126-BB1-10,CV - RCP1C,8C-2,1.689,0
77,2-CV-1126-BB1,2-CV-1126-BB1-11,CV - RCP1C,8C-2,1.689,0
78,2-CV-1128-BB1,2-CV-1128-BB1-1,CV - RCP1D,8C-2,1.689,0
79,2-CV-1128-BB1,2-CV-1128-BB1-2,CV - RCP1D,8C-2,1.689,0
80,2-CV-1128-BB1,2-CV-1128-BB1-3,CV - RCP1D,8C-2,1.689,0
81,2-CV-1128-BB1,2-CV-1128-BB1-3A,CV - RCP1D,8C-2,1.689,0
82,2-CV-1128-BB1,2-CV-1128-BB1-3B,CV - RCP1D,8C-2,1.689,0
83,2-CV-1128-BB1,2-CV-1128-BB1-4,CV - RCP1D,8C-2,1.689,0
84,2-CV-1128-BB1,2-CV-1128-BB1-5,CV - RCP1D,8C-2,1.689,0
85,2-CV-1128-BB1,2-CV-1128-BB1-6,CV - RCP1D,8C-2,1.689,0

86,2-CV-1128-BB1,2-CV-1128-BB1-7,CV - RCP1D,8C-2,1.689,0
87,2-CV-1141-BB1,2-CV-1141-BB1-1,CV - RC Crossover-4,8A,1.689,0
88,2-CV-1141-BB1,2-CV-1141-BB1-2,CV - RC Crossover-4,8A,1.689,0
89,2-RC-1003-BB1,2-RC-1003-BB1-1,PZR Auxiliary Spray Line,5J,1.689,0
90,2-RC-1003-BB1,2-RC-1003-BB1-2,PZR Auxiliary Spray Line,5J,1.689,0
91,2-RC-1120-BB1,2-RC-1120-BB1-1,RC,7K,1.689,0
92,2-RC-1120-BB1,2-RC-1120-BB1-2,RC,6A-2,1.689,0
93,2-RC-1121-BB1,2-RC-1121-BB1-1,RC,6A-2,1.689,0
94,2-RC-1121-BB1,2-RC-1121-BB1-2,RC,6A-2,1.689,0
95,2-RC-1121-BB1,2-RC-1121-BB1-3,RC,6A-2,1.689,0
96,2-RC-1121-BB1,2-RC-1121-BB1-3A,RC Drain,6A-2,1.689,0
97,2-RC-1121-BB1,2-RC-1121-BB1-3B,RC Drain,6A-2,1.689,0
98,2-RC-1121-BB1,2-RC-1121-BB1-4,RC,6A-2,1.689,0
99,2-RC-1219-BB1,2-RC-1219-BB1-1,RC,7K,1.689,0
100,2-RC-1219-BB1,2-RC-1219-BB1-2,RC,6A-2,1.689,0
101,2-RC-1220-BB1,2-RC-1220-BB1-1,RC,6A-2,1.689,0
102,2-RC-1220-BB1,2-RC-1220-BB1-2,RC,6A-2,1.689,0
103,2-RC-1220-BB1,2-RC-1220-BB1-3,RC,6A-2,1.689,0
104,2-RC-1220-BB1,2-RC-1220-BB1-4,RC,6A-2,1.689,0
105,2-RC-1319-BB1,2-RC-1319-BB1-1,RC,7K,1.689,0
106,2-RC-1319-BB1,2-RC-1319-BB1-2,RC,6A-2,1.689,0
107,2-RC-1321-BB1,2-RC-1321-BB1-1,RC,6A-2,1.689,0
108,2-RC-1321-BB1,2-RC-1321-BB1-4,RC,6A-2,1.689,0
109,2-RC-1321-BB1,2-RC-1321-BB1-5,RC,6A-2,1.689,0
110,2-RC-1321-BB1,2-RC-1321-BB1-6,RC,6A-2,1.689,0
111,2-RC-1417-BB1,2-RC-1417-BB1-1,RC,7K,1.689,0
112,2-RC-1417-BB1,2-RC-1417-BB1-2,RC,6A-2,1.689,0
113,2-RC-1418-BB1,2-RC-1418-BB1-1,RC,6A-2,1.689,0
114,2-RC-1418-BB1,2-RC-1418-BB1-2,CV - RC Crossover-4,8A,1.689,0
115,2-RC-1418-BB1,2-RC-1418-BB1-3,CV - RC Crossover-4,8A,1.689,0
116,2-RC-1418-BB1,2-RC-1418-BB1-4,RC,6A-2,1.689,0
117,2-RC-1418-BB1,2-RC-1418-BB1-5,RC,6A-2,1.689,0
118,2-RC-1418-BB1,2-RC-1418-BB1-6,RC,6A-2,1.689,0
119,2-RC-1419-BB1,2-RC-1419-BB1-1,CV - RC Crossover-4,8A,1.689,0
120,2-RC-1419-BB1,2-RC-1419-BB1-2,CV - RC Crossover-4,8A,1.689,0
121,2-RC-1419-BB1,2-RC-1419-BB1-3,CV - RC Crossover-4,8A,1.689,0
122,2-RC-1419-BB1,2-RC-1419-BB1-4,RC,6A-2,1.689,0
123,31-RC-1102-NSS - LOOP 1,31-RC-1102-NSS-5,RC,7K,1.689,0
124,31-RC-1102-NSS - LOOP 1,31-RC-1102-NSS-6,RC,7K,1.689,0
125,31-RC-1202-NSS - LOOP 2,31-RC-1202-NSS-5,RC,7K,1.689,0
126,31-RC-1202-NSS - LOOP 2,31-RC-1202-NSS-7,RC,7K,1.689,0

127,31-RC-1302-NSS - LOOP 3,31-RC-1302-NSS-5,RC,7K,1.689,0
128,31-RC-1402-NSS - LOOP 4,31-RC-1402-NSS-5,RC,7K,1.689,0
129,31-RC-1402-NSS - LOOP 4,31-RC-1402-NSS-7,RC,7K,1.689,0
130,2.5-RC-1003-BB1,2.5-RC-1003-BB1-1,Pressurizer Surge Line,4D,2.125,0
131,2.5-RC-1003-BB1,2.5-RC-1003-BB1-2,Pressurizer Surge Line,4D,2.125,0
132,2.5-RC-1003-BB1,2.5-RC-1003-BB1-3,Pressurizer Surge Line,4D,2.125,0
133,2.5-RC-1003-BB1,2.5-RC-1003-BB1-4,Pressurizer Surge Line,4D,2.125,0
134,2.5-RC-1003-BB1,2.5-RC-1003-BB1-5,Pressurizer Surge Line,4D,2.125,0
135,2.5-RC-1003-BB1,2.5-RC-1003-BB1-6,Pressurizer Surge Line,4D,2.125,0
136,3-RC-1003-BB1,3-RC-1003-BB1-1,PZR Auxiliary Spray Line,5B,2.626,0
137,3-RC-1003-BB1,3-RC-1003-BB1-2,PZR Auxiliary Spray Line,5B,2.626,0
138,3-RC-1015-NSS,3-RC-1015-NSS-1,Pressurizer PORV Line,5D,2.626,0
139,3-RC-1015-NSS,3-RC-1015-NSS-2,Pressurizer PORV Line,5D,2.626,0
140,3-RC-1015-NSS,3-RC-1015-NSS-3,Pressurizer PORV Line,5B,2.626,0
141,3-RC-1015-NSS,3-RC-1015-NSS-4,Pressurizer PORV Line,5B,2.626,0
142,3-RC-1015-NSS,3-RC-1015-NSS-5,Pressurizer PORV Line,5B,2.626,0
143,3-RC-1015-NSS,3-RC-1015-NSS-6,Pressurizer PORV Line,5B,2.626,0
144,3-RC-1015-NSS,3-RC-1015-NSS-7,Pressurizer PORV Line,5B,2.626,0
145,3-RC-1015-NSS,3-RC-1015-NSS-8,Pressurizer PORV Line,5B,2.626,0
146,3-RC-1015-NSS,3-RC-1015-NSS-9,Pressurizer PORV Line,5D,2.626,0
147,3-RC-1015-NSS,3-RC-1015-NSS-10,Pressurizer PORV Line,5D,2.626,0
148,3-RC-1015-NSS,3-RC-1015-NSS-11,Pressurizer PORV Line,5B,2.626,0
149,3-RC-1015-NSS,3-RC-1015-NSS-12,Pressurizer PORV Line,5B,2.626,0
150,3-RC-1015-NSS,3-RC-1015-NSS-13,Pressurizer PORV Line,5B,2.626,0
151,3-RC-1015-NSS,3-RC-1015-NSS-14,Pressurizer PORV Line,5B,2.626,0
152,3-RC-1015-NSS,3-RC-1015-NSS-15,Pressurizer PORV Line,5B,2.626,0
153,3-RC-1015-NSS,3-RC-1015-NSS-16,Pressurizer PORV Line,5B,2.626,0
154,3-RC-1106-BB1,3-RC-1106-BB1-25,SI - Capped,7J,2.626,0
155,3-RC-1206-BB1,3-RC-1206-BB1-28,SI - Capped,7J,2.626,0
156,3-RC-1306-BB1,3-RC-1306-BB1-28,SI - Capped,7J,2.626,0
157,3-RC-1406-BB1,3-RC-1406-BB1-25,SI - Capped,7J,2.626,0
158,31-RC-1102-NSS - LOOP 1,31-RC-1102-NSS-7,RC,7J,2.626,0
159,31-RC-1202-NSS - LOOP 2,31-RC-1202-NSS-6,RC,7J,2.626,0
160,31-RC-1302-NSS - LOOP 3,31-RC-1302-NSS-6,RC,7J,2.626,0
161,31-RC-1402-NSS - LOOP 4,31-RC-1402-NSS-6,RC,7J,2.626,0
162,4-CV-1001-BB1,4-CV-1001-BB1-1,CV - RC Crossover-3,8B,3.438,0
163,4-CV-1001-BB1,4-CV-1001-BB1-2,CV - RC Crossover-3,8B,3.438,0
164,4-CV-1118-BB1,4-CV-1118-BB1-1,CV - RC Coldleg 1,8B,3.438,0
165,4-CV-1118-BB1,4-CV-1118-BB1-2,CV - RC Coldleg 1,8B,3.438,0
166,4-CV-1120-BB1,4-CV-1120-BB1-1,CV - RC Coldleg 3,8B,3.438,0
167,4-CV-1120-BB1,4-CV-1120-BB1-2,CV - RC Coldleg 3,8B,3.438,0

168,4-RC-1000-BB1,4-RC-1000-BB1-1,Pressurizer Spray,5C,3.438,0
169,4-RC-1000-BB1,4-RC-1000-BB1-2,Pressurizer Spray,5C,3.438,0
170,4-RC-1000-BB1,4-RC-1000-BB1-3,Pressurizer Spray,5C,3.438,0
171,4-RC-1000-BB1,4-RC-1000-BB1-4,Pressurizer Spray,5C,3.438,0
172,4-RC-1000-BB1,4-RC-1000-BB1-5,Pressurizer Spray,5C,3.438,0
173,4-RC-1000-BB1,4-RC-1000-BB1-6,Pressurizer Spray,5C,3.438,0
174,4-RC-1000-BB1,4-RC-1000-BB1-7,Pressurizer Spray,5C,3.438,0
175,4-RC-1000-BB1,4-RC-1000-BB1-8,Pressurizer Spray,5C,3.438,0
176,4-RC-1003-BB1,4-RC-1003-BB1-1,Pressurizer Spray,5C,3.438,0
177,4-RC-1003-BB1,4-RC-1003-BB1-2,Pressurizer Spray,5C,3.438,0
178,4-RC-1003-BB1,4-RC-1003-BB1-3,Pressurizer Spray,5C,3.438,0
179,4-RC-1003-BB1,4-RC-1003-BB1-4,Pressurizer Spray,5C,3.438,0
180,4-RC-1123-BB1,4-RC-1123-BB1-1,Pressurizer Spray,5I,3.438,0
181,4-RC-1123-BB1,4-RC-1123-BB1-2,Pressurizer Spray,5C,3.438,0
182,4-RC-1123-BB1,4-RC-1123-BB1-3,Pressurizer Spray,5C,3.438,0
183,4-RC-1123-BB1,4-RC-1123-BB1-4,Pressurizer Spray,5C,3.438,0
184,4-RC-1123-BB1,4-RC-1123-BB1-5,Pressurizer Spray,5C,3.438,0
185,4-RC-1123-BB1,4-RC-1123-BB1-6,Pressurizer Spray,5C,3.438,0
186,4-RC-1123-BB1,4-RC-1123-BB1-7,Pressurizer Spray,5C,3.438,0
187,4-RC-1123-BB1,4-RC-1123-BB1-8,Pressurizer Spray,5C,3.438,0
188,4-RC-1123-BB1,4-RC-1123-BB1-9,Pressurizer Spray,5C,3.438,0
189,4-RC-1123-BB1,4-RC-1123-BB1-10,Pressurizer Spray,5C,3.438,0
190,4-RC-1123-BB1,4-RC-1123-BB1-11,Pressurizer Spray,5C,3.438,0
191,4-RC-1123-BB1,4-RC-1123-BB1-12,Pressurizer Spray,5C,3.438,0
192,4-RC-1123-BB1,4-RC-1123-BB1-13,Pressurizer Spray,5C,3.438,0
193,4-RC-1123-BB1,4-RC-1123-BB1-14,Pressurizer Spray,5C,3.438,0
194,4-RC-1123-BB1,4-RC-1123-BB1-15,Pressurizer Spray,5C,3.438,0
195,4-RC-1123-BB1,4-RC-1123-BB1-16,Pressurizer Spray,5C,3.438,0
196,4-RC-1123-BB1,4-RC-1123-BB1-17,Pressurizer Spray,5C,3.438,0
197,4-RC-1123-BB1,4-RC-1123-BB1-18,Pressurizer Spray,5C,3.438,0
198,4-RC-1123-BB1,4-RC-1123-BB1-19,Pressurizer Spray,5C,3.438,0
199,4-RC-1123-BB1,4-RC-1123-BB1-20,Pressurizer Spray,5C,3.438,0
200,4-RC-1126-BB1,4-RC-1126-BB1-1,CV - RC Coldleg 1,8B,3.438,0
201,4-RC-1126-BB1,4-RC-1126-BB1-2,CV - RC Coldleg 1,8B,3.438,0
202,4-RC-1126-BB1,4-RC-1126-BB1-3,CV - RC Coldleg 1,8B,3.438,0
203,4-RC-1126-BB1,4-RC-1126-BB1-4,CV - RC Coldleg 1,8B,3.438,0
204,4-RC-1126-BB1,4-RC-1126-BB1-5,CV - RC Coldleg 1,8B,3.438,0
205,4-RC-1126-BB1,4-RC-1126-BB1-6,CV - RC Coldleg 1,8E,3.438,0
206,4-RC-1320-BB1,4-RC-1320-BB1-1,CV - RC Crossover-3,8F,3.438,0
207,4-RC-1320-BB1,4-RC-1320-BB1-2,CV - RC Crossover-3,8D,3.438,0
208,4-RC-1320-BB1,4-RC-1320-BB1-3,CV - RC Crossover-3,8D,3.438,0

209,4-RC-1320-BB1,4-RC-1320-BB1-4,CV - RC Crossover-3,8D,3.438,0
210,4-RC-1320-BB1,4-RC-1320-BB1-5,CV - RC Crossover-3,8D,3.438,0
211,4-RC-1320-BB1,4-RC-1320-BB1-6,CV - RC Crossover-3,8D,3.438,0
212,4-RC-1320-BB1,4-RC-1320-BB1-7,CV - RC Crossover-3,8D,3.438,0
213,4-RC-1320-BB1,4-RC-1320-BB1-8,CV - RC Crossover-3,8B,3.438,0
214,4-RC-1320-BB1,4-RC-1320-BB1-9,CV - RC Crossover-3,8B,3.438,0
215,4-RC-1320-BB1,4-RC-1320-BB1-10,CV - RC Crossover-3,8B,3.438,0
216,4-RC-1320-BB1,4-RC-1320-BB1-11,CV - RC Crossover-3,8B,3.438,0
217,4-RC-1320-BB1,4-RC-1320-BB1-12,CV - RC Crossover-3,8B,3.438,0
218,4-RC-1323-BB1,4-RC-1323-BB1-1,CV - RC Coldleg 3,8B,3.438,0
219,4-RC-1323-BB1,4-RC-1323-BB1-2,CV - RC Coldleg 3,8B,3.438,0
220,4-RC-1323-BB1,4-RC-1323-BB1-3,CV - RC Coldleg 3,8B,3.438,0
221,4-RC-1323-BB1,4-RC-1323-BB1-4,CV - RC Coldleg 3,8E,3.438,0
222,4-RC-1420-BB1,4-RC-1420-BB1-1,SI,7I,3.438,0
223,4-RC-1422-BB1,4-RC-1422-BB1-1,Pressurizer Spray,5I,3.438,0
224,4-RC-1422-BB1,4-RC-1422-BB1-2,Pressurizer Spray,5C,3.438,0
225,4-RC-1422-BB1,4-RC-1422-BB1-3,Pressurizer Spray,5C,3.438,0
226,4-RC-1422-BB1,4-RC-1422-BB1-4,Pressurizer Spray,5C,3.438,0
227,4-RC-1422-BB1,4-RC-1422-BB1-5,Pressurizer Spray,5C,3.438,0
228,4-RC-1422-BB1,4-RC-1422-BB1-6,Pressurizer Spray,5C,3.438,0
229,4-RC-1422-BB1,4-RC-1422-BB1-7,Pressurizer Spray,5C,3.438,0
230,4-RC-1422-BB1,4-RC-1422-BB1-8,Pressurizer Spray,5C,3.438,0
231,4-RC-1422-BB1,4-RC-1422-BB1-9,Pressurizer Spray,5C,3.438,0
232,4-RC-1422-BB1,4-RC-1422-BB1-10,Pressurizer Spray,5C,3.438,0
233,4-RC-1422-BB1,4-RC-1422-BB1-11,Pressurizer Spray,5C,3.438,0
234,4-RC-1422-BB1,4-RC-1422-BB1-12,Pressurizer Spray,5C,3.438,0
235,4-RC-1422-BB1,4-RC-1422-BB1-13,Pressurizer Spray,5C,3.438,0
236,4-RC-1422-BB1,4-RC-1422-BB1-14,Pressurizer Spray,5C,3.438,0
237,4-RC-1422-BB1,4-RC-1422-BB1-15,Pressurizer Spray,5C,3.438,0
238,4-RC-1422-BB1,4-RC-1422-BB1-16,Pressurizer Spray,5C,3.438,0
239,4-RC-1422-BB1,4-RC-1422-BB1-17,Pressurizer Spray,5C,3.438,0
240,4-RC-1422-BB1,4-RC-1422-BB1-18,Pressurizer Spray,5C,3.438,0
241,4-RC-1422-BB1,4-RC-1422-BB1-19,Pressurizer Spray,5C,3.438,0
242,4-RC-1422-BB1,4-RC-1422-BB1-20,Pressurizer Spray,5C,3.438,0
243,4-RC-1422-BB1,4-RC-1422-BB1-21,Pressurizer Spray,5C,3.438,0
244,4-RC-1422-BB1,4-RC-1422-BB1-22,Pressurizer Spray,5C,3.438,0
245,4-RC-1422-BB1,4-RC-1422-BB1-23,Pressurizer Spray,5C,3.438,0
246,27.5-RC-1103-NSS - LOOP 1,27.5-RC-1103-NSS-3,RC,7I,3.438,0
247,27.5-RC-1103-NSS - LOOP 1,27.5-RC-1103-NSS-5,CV,8E,3.438,0
248,27.5-RC-1303-NSS - LOOP 3,27.5-RC-1303-NSS-4,CV,8E,3.438,0
249,27.5-RC-1403-NSS - LOOP 4,27.5-RC-1403-NSS-3,RC,7I,3.438,0

250,27.5-RC-1403-NSS - LOOP 4,27.5-RC-1403-NSS-4,RC,7I,3.438,0
251,31-RC-1302-NSS - LOOP 3,31-RC-1302-NSS-7,RC,7I,3.438,0
252,6-RC-1003-BB1,6-RC-1003-BB1-1,Pressurizer Spray,5E,5.189,0
253,6-RC-1003-BB1,6-RC-1003-BB1-2,Pressurizer Spray,5E,5.189,0
254,6-RC-1003-BB1,6-RC-1003-BB1-3,Pressurizer Spray,5E,5.189,0
255,6-RC-1003-BB1,6-RC-1003-BB1-4,Pressurizer Spray,5A,5.189,0
256,6-RC-1003-BB1,6-RC-1003-BB1-5,Pressurizer Spray,5A,5.189,0
257,6-RC-1003-BB1,6-RC-1003-BB1-6,Pressurizer Spray,5A,5.189,0
258,6-RC-1003-BB1,6-RC-1003-BB1-7,Pressurizer Spray,5A,5.189,0
259,6-RC-1003-BB1,6-RC-1003-BB1-8,Pressurizer Spray,5A,5.189,0
260,6-RC-1003-BB1,6-RC-1003-BB1-9,Pressurizer Spray,5A,5.189,0
261,6-RC-1003-BB1,6-RC-1003-BB1-9A,Pressurizer Spray,5A,5.189,0
262,6-RC-1003-BB1,6-RC-1003-BB1-9B,Pressurizer Spray,5A,5.189,0
263,6-RC-1003-BB1,6-RC-1003-BB1-10,Pressurizer Spray,5A,5.189,0
264,6-RC-1003-BB1,6-RC-1003-BB1-11,Pressurizer Spray,5A,5.189,0
265,6-RC-1003-BB1,6-RC-1003-BB1-11A,Pressurizer Spray,5A,5.189,0
266,6-RC-1003-BB1,6-RC-1003-BB1-11B,Pressurizer Spray,5A,5.189,0
267,6-RC-1003-BB1,6-RC-1003-BB1-12,Pressurizer Spray,5A,5.189,0
268,6-RC-1003-BB1,6-RC-1003-BB1-13,Pressurizer Spray,5A,5.189,0
269,6-RC-1003-BB1,6-RC-1003-BB1-13A,Pressurizer Spray,5A,5.189,0
270,6-RC-1003-BB1,6-RC-1003-BB1-14,Pressurizer Spray,5H,5.189,0
271,6-RC-1003-BB1,6-RC-1003-BB1-PRZ-1-N2-SE,Pressurizer Spray,5F,5.189,0
272,6-RC-1004-NSS,6-RC-1004-NSS-1,Pressurizer SRV Line,5H,5.189,0
273,6-RC-1004-NSS,6-RC-1004-NSS-2,Pressurizer SRV Line,5E,5.189,0
274,6-RC-1004-NSS,6-RC-1004-NSS-3,Pressurizer SRV Line,5E,5.189,0
275,6-RC-1004-NSS,6-RC-1004-NSS-4,Pressurizer SRV Line,5E,5.189,0
276,6-RC-1004-NSS,6-RC-1004-NSS-5,Pressurizer SRV Line,5A,5.189,0
277,6-RC-1004-NSS,6-RC-1004-NSS-6,Pressurizer SRV Line,5A,5.189,0
278,6-RC-1004-NSS,6-RC-1004-NSS-7,Pressurizer SRV Line,5A,5.189,0
279,6-RC-1004-NSS,6-RC-1004-NSS-PRZ-1-N3-SE,Pressurizer SRV Line,5F,5.189,0
280,6-RC-1009-NSS,6-RC-1009-NSS-1,Pressurizer SRV Line,5H,5.189,0
281,6-RC-1009-NSS,6-RC-1009-NSS-2,Pressurizer SRV Line,5E,5.189,0
282,6-RC-1009-NSS,6-RC-1009-NSS-3,Pressurizer SRV Line,5E,5.189,0
283,6-RC-1009-NSS,6-RC-1009-NSS-4,Pressurizer SRV Line,5E,5.189,0
284,6-RC-1009-NSS,6-RC-1009-NSS-5,Pressurizer SRV Line,5A,5.189,0
285,6-RC-1009-NSS,6-RC-1009-NSS-6,Pressurizer SRV Line,5A,5.189,0
286,6-RC-1009-NSS,6-RC-1009-NSS-7,Pressurizer SRV Line,5A,5.189,0
287,6-RC-1009-NSS,6-RC-1009-NSS-8,Pressurizer SRV Line,5A,5.189,0
288,6-RC-1009-NSS,6-RC-1009-NSS-9,Pressurizer SRV Line,5A,5.189,0
289,6-RC-1009-NSS,6-RC-1009-NSS-PRZ-1-N4C-SE,Pressurizer SRV Line,5F,5.189,0
290,6-RC-1012-NSS,6-RC-1012-NSS-1,Pressurizer SRV Line,5H,5.189,0

291,6-RC-1012-NSS,6-RC-1012-NSS-2,Pressurizer SRV Line,5E,5.189,0
292,6-RC-1012-NSS,6-RC-1012-NSS-3,Pressurizer SRV Line,5E,5.189,0
293,6-RC-1012-NSS,6-RC-1012-NSS-4,Pressurizer SRV Line,5E,5.189,0
294,6-RC-1012-NSS,6-RC-1012-NSS-5,Pressurizer SRV Line,5E,5.189,0
295,6-RC-1012-NSS,6-RC-1012-NSS-6,Pressurizer SRV Line,5E,5.189,0
296,6-RC-1012-NSS,6-RC-1012-NSS-7,Pressurizer SRV Line,5A,5.189,0
297,6-RC-1012-NSS,6-RC-1012-NSS-8,Pressurizer SRV Line,5A,5.189,0
298,6-RC-1012-NSS,6-RC-1012-NSS-9,Pressurizer SRV Line,5A,5.189,0
299,6-RC-1012-NSS,6-RC-1012-NSS-10,Pressurizer SRV Line,5A,5.189,0
300,6-RC-1012-NSS,6-RC-1012-NSS-11,Pressurizer SRV Line,5A,5.189,0
301,6-RC-1012-NSS,6-RC-1012-NSS-PRZ-1-N4B-SE,Pressurizer SRV Line,5F,5.189,0
302,6-RC-1015-NSS,6-RC-1015-NSS-1,Pressurizer PORV Line,5E,5.189,0
303,6-RC-1015-NSS,6-RC-1015-NSS-2,Pressurizer PORV Line,5E,5.189,0
304,6-RC-1015-NSS,6-RC-1015-NSS-3,Pressurizer PORV Line,5E,5.189,0
305,6-RC-1015-NSS,6-RC-1015-NSS-4,Pressurizer PORV Line,5E,5.189,0
306,6-RC-1015-NSS,6-RC-1015-NSS-5,Pressurizer PORV Line,5E,5.189,0
307,6-RC-1015-NSS,6-RC-1015-NSS-6,Pressurizer PORV Line,5E,5.189,0
308,6-RC-1015-NSS,6-RC-1015-NSS-7,Pressurizer PORV Line,5E,5.189,0
309,6-RC-1015-NSS,6-RC-1015-NSS-8,Pressurizer PORV Line,5E,5.189,0
310,6-RC-1015-NSS,6-RC-1015-NSS-9,Pressurizer PORV Line,5E,5.189,0
311,6-RC-1015-NSS,6-RC-1015-NSS-10,Pressurizer PORV Line,5E,5.189,0
312,6-RC-1015-NSS,6-RC-1015-NSS-11,Pressurizer PORV Line,5E,5.189,0
313,6-RC-1015-NSS,6-RC-1015-NSS-12,Pressurizer PORV Line,5E,5.189,0
314,6-RC-1015-NSS,6-RC-1015-NSS-13,Pressurizer PORV Line,5E,5.189,0
315,6-RC-1015-NSS,6-RC-1015-NSS-14,Pressurizer PORV Line,5E,5.189,0
316,6-RC-1015-NSS,6-RC-1015-NSS-15,Pressurizer PORV Line,5E,5.189,0
317,6-SI-1108-BB1,6-SI-1108-BB1-1,SI,7H,5.189,0
318,6-SI-1108-BB1,6-SI-1108-BB1-2,SI,7H,5.189,0
319,6-SI-1108-BB1,6-SI-1108-BB1-3,SI,7H,5.189,0
320,6-SI-1108-BB1,6-SI-1108-BB1-4,SI,7H,5.189,0
321,6-SI-1111-BB1,6-SI-1111-BB1-1,SI,7H,5.189,0
322,6-SI-1111-BB1,6-SI-1111-BB1-2,SI,7H,5.189,0
323,6-SI-1208-BB1,6-SI-1208-BB1-1,SI,7H,5.189,0
324,6-SI-1208-BB1,6-SI-1208-BB1-2,SI,7H,5.189,0
325,6-SI-1208-BB1,6-SI-1208-BB1-3,SI,7H,5.189,0
326,6-SI-1208-BB1,6-SI-1208-BB1-4,SI,7H,5.189,0
327,6-SI-1211-BB1,6-SI-1211-BB1-1,SI,7H,5.189,0
328,6-SI-1211-BB1,6-SI-1211-BB1-2,SI,7H,5.189,0
329,6-SI-1308-BB1,6-SI-1308-BB1-1,RH,7H,5.189,0
330,6-SI-1308-BB1,6-SI-1308-BB1-2,RH,7H,5.189,0
331,6-SI-1308-BB1,6-SI-1308-BB1-3,RH,7H,5.189,0

332,6-SI-1308-BB1,6-SI-1308-BB1-4,RH,7H,5.189,0
333,6-SI-1327-BB1,6-SI-1327-BB1-1,SI,7H,5.189,0
334,6-SI-1327-BB1,6-SI-1327-BB1-2,SI,7H,5.189,0
335,6-SI-1327-BB1,6-SI-1327-BB1-3,SI,7H,5.189,0
336,6-SI-1327-BB1,6-SI-1327-BB1-4,SI,7H,5.189,0
337,6-SI-1327-BB1,6-SI-1327-BB1-5,SI,7H,5.189,0
338,6-SI-1327-BB1,6-SI-1327-BB1-6,SI,7H,5.189,0
339,6-SI-1327-BB1,6-SI-1327-BB1-7,SI,7H,5.189,0
340,8-RC-1114-BB1,8-RC-1114-BB1-1,SI,7B,6.813,0
341,8-RC-1114-BB1,8-RC-1114-BB1-2,SI,7B,6.813,0
342,8-RC-1114-BB1,8-RC-1114-BB1-3,SI,7B,6.813,0
343,8-RC-1114-BB1,8-RC-1114-BB1-4,SI,7G,6.813,0
344,8-RC-1114-BB1,8-RC-1114-BB1-5,SI,7G,6.813,0
345,8-RC-1114-BB1,8-RC-1114-BB1-6,SI,7G,6.813,0
346,8-RC-1214-BB1,8-RC-1214-BB1-1,SI,7B,6.813,0
347,8-RC-1214-BB1,8-RC-1214-BB1-2,SI,7B,6.813,0
348,8-RC-1214-BB1,8-RC-1214-BB1-3,SI,7B,6.813,0
349,8-RC-1214-BB1,8-RC-1214-BB1-4,SI,7G,6.813,0
350,8-RC-1214-BB1,8-RC-1214-BB1-5,SI,7G,6.813,0
351,8-RC-1214-BB1,8-RC-1214-BB1-6,SI,7G,6.813,0
352,8-RC-1324-BB1,8-RC-1324-BB1-1,SI,7B,6.813,0
353,8-RC-1324-BB1,8-RC-1324-BB1-2,SI,7B,6.813,0
354,8-RC-1324-BB1,8-RC-1324-BB1-3,SI,7B,6.813,0
355,8-RC-1324-BB1,8-RC-1324-BB1-4,SI,7G,6.813,0
356,8-RC-1324-BB1,8-RC-1324-BB1-5,SI,7G,6.813,0
357,8-RC-1324-BB1,8-RC-1324-BB1-6,SI,7G,6.813,0
358,8-RH-1108-BB1,8-RH-1108-BB1-1,RH,7G,6.813,0
359,8-RH-1108-BB1,8-RH-1108-BB1-2,RH,7G,6.813,0
360,8-RH-1112-BB1,8-RH-1112-BB1-1,RH,7G,6.813,0
361,8-RH-1112-BB1,8-RH-1112-BB1-1A,RH,7G,6.813,0
362,8-RH-1112-BB1,8-RH-1112-BB1-2,RH,7G,6.813,0
363,8-RH-1208-BB1,8-RH-1208-BB1-1,RH,7G,6.813,0
364,8-RH-1208-BB1,8-RH-1208-BB1-2,RH,7G,6.813,0
365,8-RH-1212-BB1,8-RH-1212-BB1-1,RH,7G,6.813,0
366,8-RH-1212-BB1,8-RH-1212-BB1-2,RH,7G,6.813,0
367,8-RH-1308-BB1,8-RH-1308-BB1-1,RH,7G,6.813,0
368,8-RH-1308-BB1,8-RH-1308-BB1-2,RH,7G,6.813,0
369,8-RH-1315-BB1,8-RH-1315-BB1-1,RH,7G,6.813,0
370,8-SI-1108-BB1,8-SI-1108-BB1-1,SI,7G,6.813,0
371,8-SI-1108-BB1,8-SI-1108-BB1-2,SI,7G,6.813,0
372,8-SI-1108-BB1,8-SI-1108-BB1-3,SI,7G,6.813,0

373,8-SI-1108-BB1,8-SI-1108-BB1-4,SI,7G,6.813,0
374,8-SI-1108-BB1,8-SI-1108-BB1-5,SI,7C,6.813,0
375,8-SI-1208-BB1,8-SI-1208-BB1-1,SI,7G,6.813,0
376,8-SI-1208-BB1,8-SI-1208-BB1-2,SI,7G,6.813,0
377,8-SI-1208-BB1,8-SI-1208-BB1-3,SI,7G,6.813,0
378,8-SI-1208-BB1,8-SI-1208-BB1-3A,SI,7G,6.813,0
379,8-SI-1208-BB1,8-SI-1208-BB1-4,SI,7C,6.813,0
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381,8-SI-1327-BB1,8-SI-1327-BB1-2,SI,7G,6.813,0
382,8-SI-1327-BB1,8-SI-1327-BB1-3,SI,7G,6.813,0
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388,8-SI-1327-BB1,8-SI-1327-BB1-9,SI,7G,6.813,0
389,8-SI-1327-BB1,8-SI-1327-BB1-10,SI,7G,6.813,0
390,8-SI-1327-BB1,8-SI-1327-BB1-11,SI,7C,6.813,0
391,29-RC-1101-NSS - LOOP 1,29-RC-1101-NSS-2,SI,7G,6.813,0
392,29-RC-1201-NSS - LOOP 2,29-RC-1201-NSS-2,SI,7G,6.813,0
393,29-RC-1301-NSS - LOOP 3,29-RC-1301-NSS-2,SI,7G,6.813,0
394,10-RH-1108-BB1,10-RH-1108-BB1-1,RH,7F,8.5,0
395,10-RH-1108-BB1,10-RH-1108-BB1-1A,RH,7F,8.5,0
396,10-RH-1108-BB1,10-RH-1108-BB1-2,RH,7F,8.5,0
397,10-RH-1108-BB1,10-RH-1108-BB1-3,RH,7F,8.5,0
398,10-RH-1108-BB1,10-RH-1108-BB1-4,RH,7F,8.5,0
399,10-RH-1108-BB1,10-RH-1108-BB1-5,RH,7F,8.5,0
400,10-RH-1108-BB1,10-RH-1108-BB1-6,RH,7F,8.5,0
401,10-RH-1108-BB1,10-RH-1108-BB1-7,RH,7F,8.5,0
402,10-RH-1108-BB1,10-RH-1108-BB1-8,RH,7F,8.5,0
403,10-RH-1108-BB1,10-RH-1108-BB1-9,RH,7F,8.5,0
404,10-RH-1108-BB1,10-RH-1108-BB1-10,RH,7F,8.5,0
405,10-RH-1208-BB1,10-RH-1208-BB1-1,RH,7F,8.5,0
406,10-RH-1208-BB1,10-RH-1208-BB1-2,RH,7F,8.5,0
407,10-RH-1208-BB1,10-RH-1208-BB1-3,RH,7F,8.5,0
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409,10-RH-1208-BB1,10-RH-1208-BB1-5,RH,7F,8.5,0
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412,10-RH-1208-BB1,10-RH-1208-BB1-8,RH,7F,8.5,0
413,10-RH-1208-BB1,10-RH-1208-BB1-9,RH,7F,8.5,0

414,10-RH-1208-BB1,10-RH-1208-BB1-10,RH,7F,8.5,0
415,10-RH-1208-BB1,10-RH-1208-BB1-11,RH,7F,8.5,0
416,10-RH-1308-BB1,10-RH-1308-BB1-1,RH,7F,8.5,0
417,10-RH-1308-BB1,10-RH-1308-BB1-2,RH,7F,8.5,0
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419,10-RH-1308-BB1,10-RH-1308-BB1-4,RH,7F,8.5,0
420,10-RH-1308-BB1,10-RH-1308-BB1-5,RH,7F,8.5,0
421,10-RH-1308-BB1,10-RH-1308-BB1-6,RH,7F,8.5,0
422,10-RH-1308-BB1,10-RH-1308-BB1-7,RH,7F,8.5,0
423,10-RH-1308-BB1,10-RH-1308-BB1-8,RH,7F,8.5,0
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425,12-RC-1112-BB1,12-RC-1112-BB1-2,RHR-Suction,7A,10.126,0
426,12-RC-1112-BB1,12-RC-1112-BB1-3,RHR-Suction,7A,10.126,0
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428,12-RC-1112-BB1,12-RC-1112-BB1-5,RHR-Suction,7A,10.126,0
429,12-RC-1112-BB1,12-RC-1112-BB1-6,RHR-Suction,7A,10.126,0
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431,12-RC-1112-BB1,12-RC-1112-BB1-8,RHR-Suction,7A,10.126,0
432,12-RC-1112-BB1,12-RC-1112-BB1-9,RHR-Suction,7E,10.126,0
433,12-RC-1112-BB1,12-RC-1112-BB1-10,RHR-Suction,7E,10.126,0
434,12-RC-1112-BB1,12-RC-1112-BB1-11,RHR-Suction,7E,10.126,0
435,12-RC-1125-BB1,12-RC-1125-BB1-1,SI-ACC-CL1,7N,10.126,0
436,12-RC-1125-BB1,12-RC-1125-BB1-2,SI-ACC-CL1,7N,10.126,0
437,12-RC-1125-BB1,12-RC-1125-BB1-3,SI-ACC-CL1,7N,10.126,0
438,12-RC-1125-BB1,12-RC-1125-BB1-4,SI-ACC-CL1,7N,10.126,0
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441,12-RC-1125-BB1,12-RC-1125-BB1-7,SI-ACC-CL1,7N,10.126,0
442,12-RC-1125-BB1,12-RC-1125-BB1-8,SI-ACC-CL1,7N,10.126,0
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447,12-RC-1125-BB1,12-RC-1125-BB1-13,SI-ACC-CL1,7N,10.126,0
448,12-RC-1212-BB1,12-RC-1212-BB1-1,RHR-Suction,7E,10.126,0
449,12-RC-1212-BB1,12-RC-1212-BB1-2,RHR-Suction,7A,10.126,0
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453,12-RC-1212-BB1,12-RC-1212-BB1-6,RHR-Suction,7A,10.126,0
454,12-RC-1212-BB1,12-RC-1212-BB1-7,RHR-Suction,7A,10.126,0

455,12-RC-1212-BB1,12-RC-1212-BB1-8,RHR-Suction,7A,10.126,0
456,12-RC-1221-BB1,12-RC-1221-BB1-1,SI-ACC-CL2,7N,10.126,0
457,12-RC-1221-BB1,12-RC-1221-BB1-2,SI-ACC-CL2,7N,10.126,0
458,12-RC-1221-BB1,12-RC-1221-BB1-3,SI-ACC-CL2,7N,10.126,0
459,12-RC-1221-BB1,12-RC-1221-BB1-4,SI-ACC-CL2,7N,10.126,0
460,12-RC-1221-BB1,12-RC-1221-BB1-5,SI-ACC-CL2,7N,10.126,0
461,12-RC-1221-BB1,12-RC-1221-BB1-6,SI-ACC-CL2,7N,10.126,0
462,12-RC-1221-BB1,12-RC-1221-BB1-7,SI-ACC-CL2,7N,10.126,0
463,12-RC-1221-BB1,12-RC-1221-BB1-8,SI-ACC-CL2,7N,10.126,0
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465,12-RC-1221-BB1,12-RC-1221-BB1-10,SI-ACC-CL2,7N,10.126,0
466,12-RC-1221-BB1,12-RC-1221-BB1-11,SI-ACC-CL2,7N,10.126,0
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468,12-RC-1221-BB1,12-RC-1221-BB1-13,SI-ACC-CL2,7N,10.126,0
469,12-RC-1221-BB1,12-RC-1221-BB1-14,SI-ACC-CL2,7N,10.126,0
470,12-RC-1312-BB1,12-RC-1312-BB1-1,RH,7E,10.126,0
471,12-RC-1312-BB1,12-RC-1312-BB1-2,RH,7A,10.126,0
472,12-RC-1312-BB1,12-RC-1312-BB1-3,RH,7A,10.126,0
473,12-RC-1312-BB1,12-RC-1312-BB1-4,RH,7A,10.126,0
474,12-RC-1312-BB1,12-RC-1312-BB1-5,RH,7A,10.126,0
475,12-RC-1312-BB1,12-RC-1312-BB1-6,RH,7A,10.126,0
476,12-RC-1312-BB1,12-RC-1312-BB1-7,RH,7A,10.126,0
477,12-RC-1312-BB1,12-RC-1312-BB1-8,RH,7A,10.126,0
478,12-RC-1312-BB1,12-RC-1312-BB1-9,RH,7E,10.126,0
479,12-RC-1312-BB1,12-RC-1312-BB1-10,RH,7E,10.126,0
480,12-RC-1312-BB1,12-RC-1312-BB1-11,RH,7E,10.126,0
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482,12-RC-1322-BB1,12-RC-1322-BB1-1A,SI-ACC-CL3,7N,10.126,0
483,12-RC-1322-BB1,12-RC-1322-BB1-2,SI-ACC-CL3,7N,10.126,0
484,12-RC-1322-BB1,12-RC-1322-BB1-3,SI-ACC-CL3,7N,10.126,0
485,12-RC-1322-BB1,12-RC-1322-BB1-4,SI-ACC-CL3,7N,10.126,0
486,12-RH-1101-BB1,12-RH-1101-BB1-1,RH,7E,10.126,0
487,12-RH-1101-BB1,12-RH-1101-BB1-2,RH,7E,10.126,0
488,12-RH-1101-BB1,12-RH-1101-BB1-3,RH,7E,10.126,0
489,12-RH-1101-BB1,12-RH-1101-BB1-3A,RH,7E,10.126,0
490,12-RH-1101-BB1,12-RH-1101-BB1-4,RH,7E,10.126,0
491,12-RH-1101-BB1,12-RH-1101-BB1-5,RH,7E,10.126,0
492,12-RH-1101-BB1,12-RH-1101-BB1-6,RH,7E,10.126,0
493,12-RH-1101-BB1,12-RH-1101-BB1-7,RH,7E,10.126,0
494,12-RH-1101-BB1,12-RH-1101-BB1-8,RH,7E,10.126,0
495,12-RH-1101-BB1,12-RH-1101-BB1-9,RH,7E,10.126,0

496,12-RH-1101-BB1,12-RH-1101-BB1-10,RH,7E,10.126,0
497,12-RH-1101-BB1,12-RH-1101-BB1-11,RH,7E,10.126,0
498,12-RH-1101-BB1,12-RH-1101-BB1-12,RH,7E,10.126,0
499,12-RH-1101-BB1,12-RH-1101-BB1-13,RH,7E,10.126,0
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501,12-RH-1101-BB1,12-RH-1101-BB1-15,RH,7E,10.126,0
502,12-RH-1101-BB1,12-RH-1101-BB1-16,RH,7E,10.126,0
503,12-RH-1201-BB1,12-RH-1201-BB1-1,RH,7E,10.126,0
504,12-RH-1201-BB1,12-RH-1201-BB1-2,RH,7E,10.126,0
505,12-RH-1201-BB1,12-RH-1201-BB1-3,RH,7E,10.126,0
506,12-RH-1201-BB1,12-RH-1201-BB1-4,RH,7E,10.126,0
507,12-RH-1201-BB1,12-RH-1201-BB1-5,RH,7E,10.126,0
508,12-RH-1201-BB1,12-RH-1201-BB1-6,RH,7E,10.126,0
509,12-RH-1201-BB1,12-RH-1201-BB1-7,RH,7E,10.126,0
510,12-RH-1201-BB1,12-RH-1201-BB1-8,RH,7E,10.126,0
511,12-RH-1201-BB1,12-RH-1201-BB1-9,RH,7E,10.126,0
512,12-RH-1201-BB1,12-RH-1201-BB1-10,RH,7E,10.126,0
513,12-RH-1201-BB1,12-RH-1201-BB1-11,RH,7E,10.126,0
514,12-RH-1201-BB1,12-RH-1201-BB1-12,RH,7E,10.126,0
515,12-RH-1201-BB1,12-RH-1201-BB1-13,RH,7E,10.126,0
516,12-RH-1201-BB1,12-RH-1201-BB1-14,RH,7E,10.126,0
517,12-RH-1201-BB1,12-RH-1201-BB1-15,RH,7E,10.126,0
518,12-RH-1201-BB1,12-RH-1201-BB1-16,RH,7E,10.126,0
519,12-RH-1201-BB1,12-RH-1201-BB1-17,RH,7E,10.126,0
520,12-RH-1301-BB1,12-RH-1301-BB1-1,RH,7E,10.126,0
521,12-RH-1301-BB1,12-RH-1301-BB1-2,RH,7E,10.126,0
522,12-RH-1301-BB1,12-RH-1301-BB1-3,RH,7E,10.126,0
523,12-RH-1301-BB1,12-RH-1301-BB1-4,RH,7E,10.126,0
524,12-RH-1301-BB1,12-RH-1301-BB1-5,RH,7E,10.126,0
525,12-RH-1301-BB1,12-RH-1301-BB1-5A,RH,7E,10.126,0
526,12-RH-1301-BB1,12-RH-1301-BB1-6,RH,7E,10.126,0
527,12-RH-1301-BB1,12-RH-1301-BB1-7,RH,7E,10.126,0
528,12-RH-1301-BB1,12-RH-1301-BB1-8,RH,7E,10.126,0
529,12-RH-1301-BB1,12-RH-1301-BB1-9,RH,7E,10.126,0
530,12-RH-1301-BB1,12-RH-1301-BB1-10,RH,7E,10.126,0
531,12-SI-1125-BB1,12-SI-1125-BB1-1,SI-ACC-CL1,7O,10.126,0
532,12-SI-1125-BB1,12-SI-1125-BB1-2,SI-ACC-CL1,7O,10.126,0
533,12-SI-1125-BB1,12-SI-1125-BB1-3,SI-ACC-CL1,7O,10.126,0
534,12-SI-1125-BB1,12-SI-1125-BB1-4,SI-ACC-CL1,7O,10.126,0
535,12-SI-1218-BB1,12-SI-1218-BB1-1,SI-ACC-CL2,7O,10.126,0
536,12-SI-1218-BB1,12-SI-1218-BB1-2,SI-ACC-CL2,7O,10.126,0

537,12-SI-1218-BB1,12-SI-1218-BB1-3,SI-ACC-CL2,7O,10.126,0
538,12-SI-1218-BB1,12-SI-1218-BB1-4,SI-ACC-CL2,7O,10.126,0
539,12-SI-1315-BB1,12-SI-1315-BB1-1,SI-ACC-CL4,7O,10.126,0
540,12-SI-1315-BB1,12-SI-1315-BB1-2,SI-ACC-CL4,7O,10.126,0
541,12-SI-1315-BB1,12-SI-1315-BB1-3,SI-ACC-CL4,7O,10.126,0
542,12-SI-1315-BB1,12-SI-1315-BB1-4,SI-ACC-CL4,7O,10.126,0
543,12-SI-1315-BB1,12-SI-1315-BB1-5,SI-ACC-CL1,7O,10.126,0
544,12-SI-1315-BB1,12-SI-1315-BB1-6,SI-ACC-CL4,7O,10.126,0
545,12-SI-1315-BB1,12-SI-1315-BB1-7,SI-ACC-CL4,7O,10.126,0
546,12-SI-1315-BB1,12-SI-1315-BB1-8,SI-ACC-CL4,7D,10.126,0
547,12-SI-1315-BB1,12-SI-1315-BB1-9,SI-ACC-CL4,7D,10.126,0
548,12-SI-1315-BB1,12-SI-1315-BB1-10,SI-ACC-CL4,7D,10.126,0
549,27.5-RC-1103-NSS - LOOP 1,27.5-RC-1103-NSS-4,SI-ACC-CL1,7N,10.126,0
550,27.5-RC-1203-NSS - LOOP 2,27.5-RC-1203-NSS-3,SI-ACC-CL2,7N,10.126,0
551,27.5-RC-1303-NSS - LOOP 3,27.5-RC-1303-NSS-3,SI-ACC-CL3,7N,10.126,0
552,29-RC-1101-NSS - LOOP 1,29-RC-1101-NSS-3,RHR-Suction,7E,10.126,0
553,29-RC-1201-NSS - LOOP 2,29-RC-1201-NSS-3,RC,7E,10.126,0
554,29-RC-1301-NSS - LOOP 3,29-RC-1301-NSS-3,RC,7E,10.126,0
555,16-RC-1412-NSS,16-RC-1412-NSS-1,Pressurizer Surge Line,4B,12.814,12.814
556,16-RC-1412-NSS,16-RC-1412-NSS-3,Pressurizer Surge Line,4B,12.814,0
557,16-RC-1412-NSS,16-RC-1412-NSS-4,Pressurizer Surge Line,4B,12.814,0
558,16-RC-1412-NSS,16-RC-1412-NSS-5,Pressurizer Surge Line,4B,12.814,0
559,16-RC-1412-NSS,16-RC-1412-NSS-6,Pressurizer Surge Line,4B,12.814,0
560,16-RC-1412-NSS,16-RC-1412-NSS-7,Pressurizer Surge Line,4B,12.814,0
561,16-RC-1412-NSS,16-RC-1412-NSS-8,Pressurizer Surge Line,4B,12.814,0
562,16-RC-1412-NSS,16-RC-1412-NSS-9,Pressurizer Surge Line,4C,12.814,0
563,16-RC-1412-NSS,16-RC-1412-NSS-PRZ-1-N1-SE,Pressurizer Surge Line,4A ,12.814,0
564,29-RC-1401-NSS - LOOP 4,29-RC-1401-NSS-2,Pressurizer Surge Line,4C ,12.814,0
565,27.5-RC-1103-NSS - LOOP 1,27.5-RC-1103-NSS-1,RC Cold Leg 1,3C ,27.5,19.4606
566,27.5-RC-1103-NSS - LOOP 1,27.5-RC-1103-NSS-6,RC Cold Leg 1,3C ,27.5,19.5657
567,27.5-RC-1103-NSS - LOOP 1,27.5-RC-1103-NSS-7,RC Cold Leg 1,3C ,27.5,21.0532
568,27.5-RC-1103-NSS - LOOP 1,27.5-RC-1103-NSS-RPV1-N2ASE,RC Cold Leg 1,3 A,27.5,22.047
569,27.5-RC-1203-NSS - LOOP 2,27.5-RC-1203-NSS-1,RC Cold Leg 2,3C,27.5,0
570,27.5-RC-1203-NSS - LOOP 2,27.5-RC-1203-NSS-4,RC Cold Leg 2,3C,27.5,0
571,27.5-RC-1203-NSS - LOOP 2,27.5-RC-1203-NSS-5,RC Cold Leg 2,3C,27.5,0

572,27.5-RC-1203-NSS - LOOP 2,27.5-RC-1203-NSS-RPV1-N2BSE,RC Cold Leg 2,3 A,27.5,0
573,27.5-RC-1303-NSS - LOOP 3,27.5-RC-1303-NSS-1,RC Cold Leg 3,3C,27.5,0
574,27.5-RC-1303-NSS - LOOP 3,27.5-RC-1303-NSS-5,RC Cold Leg 3,3C,27.5,0
575,27.5-RC-1303-NSS - LOOP 3,27.5-RC-1303-NSS-6,RC Cold Leg 3,3C,27.5,0
576,27.5-RC-1303-NSS - LOOP 3,27.5-RC-1303-NSS-RPV1-N2CSE,RC Cold Leg 3,3 A,27.5,0
577,27.5-RC-1403-NSS - LOOP 4,27.5-RC-1403-NSS-1,RC Cold Leg 4,3C,27.5,0
578,27.5-RC-1403-NSS - LOOP 4,27.5-RC-1403-NSS-5,RC Cold Leg 4,3C,27.5,0
579,27.5-RC-1403-NSS - LOOP 4,27.5-RC-1403-NSS-6,RC Cold Leg 4,3C,27.5,0
580,27.5-RC-1403-NSS - LOOP 4,27.5-RC-1403-NSS-RPV1-N2DSE,RC Cold Leg 4,3 A,27.5,0
581,29-RC-1101-NSS - LOOP 1,29-RC-1101-NSS-1,RC-Hot Leg 1,1B,29,13.9236
582,29-RC-1101-NSS - LOOP 1,29-RC-1101-NSS-4,RC-Hot Leg 1,1B,29,13.9411
583,29-RC-1101-NSS - LOOP 1,29-RC-1101-NSS-5.1,RC-Hot Leg 1,1B,29,14.3682
584,29-RC-1101-NSS - LOOP 1,29-RC-1101-NSS-RPV1-N1ASE,RC-Hot Leg 1,1A ,29,14.404
585,29-RC-1101-NSS - LOOP 1,29-RC-1101-NSS-RSG-1A-IN-SE,RC-Hot Leg 1,2,29,14.4278
586,29-RC-1201-NSS - LOOP 2,29-RC-1201-NSS-1,RC-Hot Leg 2,1B,29,14.4279
587,29-RC-1201-NSS - LOOP 2,29-RC-1201-NSS-4,RC-Hot Leg 2,1B,29,14.4336
588,29-RC-1201-NSS - LOOP 2,29-RC-1201-NSS-5.1,RC-Hot Leg 2,1B,29,14.5424
589,29-RC-1201-NSS - LOOP 2,29-RC-1201-RPV1-N1BSE,RC-Hot Leg 2,1A ,29,15.0515
590,29-RC-1201-NSS - LOOP 2,29-RC-1201-RSG-1B-IN-SE,RC-Hot Leg 2,2,29,15.0866
591,29-RC-1301-NSS - LOOP 3,29-RC-1301-NSS-1,RC-Hot Leg 3,1B,29,15.2938
592,29-RC-1301-NSS - LOOP 3,29-RC-1301-NSS-4,RC-Hot Leg 3,1B,29,15.4956
593,29-RC-1301-NSS - LOOP 3,29-RC-1301-NSS-5.1,RC-Hot Leg 3,1B,29,0
594,29-RC-1301-NSS - LOOP 3,29-RC-1301-RPV1-N1CSE,RC-Hot Leg 3,1A,29,0
595,29-RC-1301-NSS - LOOP 3,29-RC-1301-RSG-1C-IN-SE,RC-Hot Leg 3,2,29,0
596,29-RC-1401-NSS - LOOP 4,29-RC-1401-NSS-1,RC-Hot Leg 4,1B,29,0
597,29-RC-1401-NSS - LOOP 4,29-RC-1401-NSS-3,RC-Hot Leg 4,1C,29,0
598,29-RC-1401-NSS - LOOP 4,29-RC-1401-NSS-4.1,RC-Hot Leg 4,1B,29,0
599,29-RC-1401-NSS - LOOP 4,29-RC-1401-NSS-RPV1-N1DSE,RC-Hot Leg 4,1A ,29,0
600,29-RC-1401-NSS - LOOP 4,29-RC-1401-NSS-RSG-1D-IN-SE,RC-Hot Leg 4,2,29,0
601,31-RC-1102-NSS - LOOP 1,31-RC-1102-NSS-1.1,RC Cold Leg 1,3D,31,19.6171
602,31-RC-1102-NSS - LOOP 1,31-RC-1102-NSS-2,RC Cold Leg 1,3D,31,20.2358
603,31-RC-1102-NSS - LOOP 1,31-RC-1102-NSS-3,RC Cold Leg 1,3D,31,20.35
604,31-RC-1102-NSS - LOOP 1,31-RC-1102-NSS-4,RC Cold Leg 1,3D,31,21.1162

605,31-RC-1102-NSS - LOOP 1,31-RC-1102-NSS-8,RC Cold Leg 1,3D,31,21.2781
606,31-RC-1102-NSS - LOOP 1,31-RC-1102-NSS-9,RC Cold Leg 1,3D,31,22.174
607,31-RC-1102-NSS - LOOP 1,31-RC-1102-NSS-RSG-1A-ON-SE,RC Cold Leg 1,3B ,31,23.169
608,31-RC-1202-NSS - LOOP 2,31-RC-1202-NSS-1.1,RC Cold Leg 2,3D,31,25.3351
609,31-RC-1202-NSS - LOOP 2,31-RC-1202-NSS-2,RC Cold Leg 2,3D,31,16.4079
610,31-RC-1202-NSS - LOOP 2,31-RC-1202-NSS-3,RC Cold Leg 2,3D,31,16.7765
611,31-RC-1202-NSS - LOOP 2,31-RC-1202-NSS-4,RC Cold Leg 2,3D,31,16.9282
612,31-RC-1202-NSS - LOOP 2,31-RC-1202-NSS-8,RC Cold Leg 2,3D,31,16.9813
613,31-RC-1202-NSS - LOOP 2,31-RC-1202-NSS-9,RC Cold Leg 2,3D,31,17.0714
614,31-RC-1202-NSS - LOOP 2,31-RC-1202-NSS-RSG-1B-ON-SE,RC Cold Leg 2,3B ,31,17.2001
615,31-RC-1302-NSS - LOOP 3,31-RC-1302-NSS-1.1,RC Cold Leg 3,3D,31,17.2398
616,31-RC-1302-NSS - LOOP 3,31-RC-1302-NSS-2,RC Cold Leg 3,3D,31,17.3454
617,31-RC-1302-NSS - LOOP 3,31-RC-1302-NSS-3,RC Cold Leg 3,3D,31,17.3737
618,31-RC-1302-NSS - LOOP 3,31-RC-1302-NSS-4,RC Cold Leg 3,3D,31,17.6362
619,31-RC-1302-NSS - LOOP 3,31-RC-1302-NSS-8,RC Cold Leg 3,3D,31,17.8428
620,31-RC-1302-NSS - LOOP 3,31-RC-1302-NSS-9,RC Cold Leg 3,3D,31,17.9194
621,31-RC-1302-NSS - LOOP 3,31-RC-1302-NSS-RSG-1C-ON-SE,RC Cold Leg 3,3B ,31,18.1077
622,31-RC-1402-NSS - LOOP 4,31-RC-1402-NSS-1.1,RC Cold Leg 4,3D,31,18.1367
623,31-RC-1402-NSS - LOOP 4,31-RC-1402-NSS-2,RC Cold Leg 4,3D,31,18.1794
624,31-RC-1402-NSS - LOOP 4,31-RC-1402-NSS-3,RC Cold Leg 4,3D,31,18.1976
625,31-RC-1402-NSS - LOOP 4,31-RC-1402-NSS-4,RC Cold Leg 4,3D,31,18.3113
626,31-RC-1402-NSS - LOOP 4,31-RC-1402-NSS-8,RC Cold Leg 4,3D,31,18.3429
627,31-RC-1402-NSS - LOOP 4,31-RC-1402-NSS-9,RC Cold Leg 4,3D,31,19.235
628,31-RC-1402-NSS - LOOP 4,31-RC-1402-NSS-RSG-1D-ON-SE,RC Cold Leg 4,3B ,31,19.2473

12 FIDOE sensitivity study, fixed filtration

A sensitivity study using fixed filtration values is performed in a updated version of FIDOE designed to accommodate a linear (increase rate, constant rate). The update is effected in the class `MassCalculator`. In the update, a fixed filtration can can be obtained by adding the appropriate keyword in the input file (the c file) with a zero slope parameter. If a non-zero slope parameter is entered, the filtration will increase linearly until 1.0 is reached. The default filtration fit function will be used in all other cases.

Several cases were developed and run in FIDOE for low, normal, and high initial pool concentrations and low, normal, and high flows. The assumed flow levels for the sensitivity are summarized in Table 16. Each of these cases is further examined at four levels of filtration, 0.4, 0.5, 0.6 and 0.7.

When a FIDOE calculation is executed, the first file generated is an "echo in" file which is a print out of each of the parameters read into memory. Note that at the end of the flow input, there are entries that read "nan". "nan" refers to additional rows that are blank lines that are additional rows in the MS EXCEL .csv file (not visible during input development).

Table 16: ECCS and CSS train flow rates assumed for the low, normal, and high sensitivities in FIDOE.

Train	Low	Normal	High
A	3300	4400	5500
B	5062.5	6750	8437.5
C	5062.5	6750	8437.5

Listing 13: Source listing for (1c) solution, Alex Zolan, UT Austin, 02 March, 2015

```
"""
Fiber Diffusion Operations Engine (FIDOE)
System of Differential Equations Solver
Alex Zolan
Updated March 24, 2015

The purpose of the program is to simulate debris moving through
a recirculating pool from which strainers can filter out some
debris, and some of the debris that passes through the strainers
may attach itself to the core.
"""

import time
import scipy
```

```
import scipy.integrate
import matplotlib
matplotlib.use('Agg')
import matplotlib.pyplot as plt
import pandas
import csv

class MassCalculator(object):
    """Note that in initialization, we allow for inputs to be left
    out of the input file and still allow the program to run using
    default values in their place. When a default value is used,
    a note is printed to the console to inform the user."""
    def __init__(self, params):
        #pool volume (gallons) and initial mass in pool (grams)
        if "M_p_0" in params.keys(): self.M_p_0 = params["M_p_0"]
        else:
            self.M_p_0 = 3000.0
            print "M_p_0 not in inputs.  Default value of 3000 used."
        if "V_p" in params.keys(): self.V_p = params["V_p"]
        else:
            self.V_p = 50000.0
            print "V_p not in inputs.  Default value of 50000 used."

        #Initial mass on strainers
        if "M_s_a_0" in params.keys(): self.M_s_a_0 = params["M_s_a_0"]
        else:
            self.M_s_a_0 = 0.0
            print "M_s_a_0 not in inputs.  Default value of 0 used."
        if "M_s_b_0" in params.keys(): self.M_s_b_0 = params["M_s_b_0"]
        else:
            self.M_s_b_0 = 0.0
            print "M_s_b_0 not in inputs.  Default value of 0 used."
        if "M_s_c_0" in params.keys(): self.M_s_c_0 = params["M_s_c_0"]
        else:
            self.M_s_c_0 = 0.0
            print "M_s_c_0 not in inputs.  Default value of 0 used."
        #initial mass on core
        if "M_c_0" in params.keys(): self.M_c_0 = params["M_c_0"]
        else:
            self.M_c_0 = 0.0
            print "M_c_0 not in inputs.  Default value of 0.0 used."
```

```
#gamma, the percentage of water flowing back to the strainers
if "gamma_a" in params.keys(): self.gamma_a = params["gamma_a"]
else:
    self.gamma_a = 0.0
    print "gamma_a␣not␣in␣inputs.␣␣Default␣value␣of␣0.0␣used."
if "gamma_b" in params.keys(): self.gamma_b = params["gamma_b"]
else:
    self.gamma_b = 0.0
    print "gamma_b␣not␣in␣inputs.␣␣Default␣value␣of␣0.0␣used."
if "gamma_c" in params.keys(): self.gamma_c = params["gamma_c"]
else:
    self.gamma_c = 0.0
    print "gamma_c␣not␣in␣inputs.␣␣Default␣value␣of␣0.0␣used."

#strainer flow rates in gallons per minute (gpm)
if "Q_s_a" in params.keys(): self.Q_s_a = params["Q_s_a"]
else:
    self.Q_s_a = 1000.0
    print "Q_s_a␣not␣in␣inputs.␣␣Default␣value␣of␣1000.0␣used."
if "Q_s_b" in params.keys(): self.Q_s_b = params["Q_s_b"]
else:
    self.Q_s_b = 1000.0
    print "Q_s_b␣not␣in␣inputs.␣␣Default␣value␣of␣1000.0␣used."
if "Q_s_c" in params.keys(): self.Q_s_c = params["Q_s_c"]
else:
    self.Q_s_c = 1000.0
    print "Q_s_c␣not␣in␣inputs.␣␣Default␣value␣of␣1000.0␣used."

#core flow rate in gpm
if "Q_c" in params.keys(): self.Q_c = params["Q_c"]
else:
    self.Q_c = 1600.0
    print "Q_c␣not␣in␣inputs.␣␣Default␣value␣of␣1600.0␣used."

#filtration function type definition = hybrid or linear function
if "function_type" in params.keys(): self.filtration_function = params["
    function_type"]
else:
    print "Filtration␣function␣type␣not␣specified.␣␣Default␣of␣hybrid␣
        equation␣used."
```

```
        self.filtration_function = "hybrid"

    #for a linear function, read in the slope and intercept.
    #if none provided, assume constant filtration factor of 0.75.
    if self.filtration_function == "linear":
        if "slope" in params.keys(): self.slope = params["slope"]
        else:
            self.slope = 0.0
            print "slope␣(filtration␣function)␣not␣in␣inputs.␣␣Default␣of␣0.0␣
                used."
        if "intercept" in params.keys(): self.intercept = params["intercept"]
        else:
            self.intercept = 0.75
            print "intercept␣(filtration␣function)␣not␣in␣inputs.␣␣Default␣of␣
                0.75␣used."
        self.m = "N/A"
        self.b = "N/A"
        self.threshold = "N/A"
        self.delta = "N/A"
        self.a = "N/A"

    # We assume the hybrid function if there's anything else specified,
    # whether it's "hybrid" or anything not "linear" or "hybrid".
    else:
        if self.filtration_function != "hybrid":
            print "Function␣not␣specified␣as␣hybrid␣or␣linear.␣␣Default␣of␣
                hybrid␣used."
        #filtration rate (function of mass)b
        if "m" in params.keys(): self.m = params["m"]
        else:
            self.m = 0.007741 #lower envelope
            print "m␣(filtration␣function)␣not␣in␣inputs.␣␣Default␣of␣0.007741␣
                used."
        if "b" in params.keys(): self.b = params["b"]
        else:
            self.b = 0.6560 #lower envelope
            print "b␣(filtration␣function)␣not␣in␣inputs.␣␣Default␣of␣0.6560␣
                used."
        if "M_c" in params.keys(): self.threshold = params["M_c"]
        else:
            self.threshold = 38.5 #lower envelope
```

```
                print "M__c␣(filtration␣function)␣not␣in␣inputs.␣␣Default␣of␣38.5␣
                    used."
            if "delta" in params.keys(): self.delta = params["delta"]
            else:
                self.delta = 0.02968 #lower envelope
                print "delta␣(filtration␣function)␣not␣in␣inputs.␣␣Default␣of␣
                    0.02968␣used."
            if "a" in params.keys(): self.a = params["a"]
            else:
                self.a = 1.0 #lower envelope
                #this upper bound is not expected to be used in most cases, so it is
                    not
                #called out in the console.,
                #print "a (filtration function) not in inputs. Default of 1.0 used."
            self.slope = "N/A"
            self.intercept = "N/A"

    def getFlowRateStrainerA(self,t):
        """returns the flow rate out of strainer A, in gallons per minute.
        This function is assumed to be known with respect to time,
        but currently has only a constant."""
        if type(self.Q__s__a) == float: return self.Q__s__a
        else:
            #if not a constant, use the flow rate just before the time
            #period that exceeds the input t. otherwise, use the
            #last flow rate given
            if self.Q__s__a["t"][0] > t: return 0
            for i in range(1,len(self.Q__s__a["t"])):
                if self.Q__s__a["t"][i] > t:
                    return self.Q__s__a["vals"][i-1]
            return self.Q__s__a["vals"][-1]

    def getFlowRateStrainerB(self,t):
        """returns the flow rate out of strainer B, in gallons per minute.
        This function is assumed to be known with respect to time,
        but currently has only a constant."""
        if type(self.Q__s__b) == float: return self.Q__s__b #if the input is a constant,
            just report that.
        else:
            #if not a constant, use the flow rate just before the time
            #period that exceeds the input t. otherwise, use the
```

```
            #last flow rate given
            if self.Q__s__b["t"][0] > t: return 0
            for i in range(1,len(self.Q__s__b["t"])):
                if self.Q__s__b["t"][i] > t:
                    return self.Q__s__b["vals"][i-1]
            return self.Q__s__b["vals"][-1]

    def getFlowRateStrainerC(self,t):
        """returns the flow rate out of strainer C, in gallons per minute.
        This function is assumed to be known with respect to time,
        but currently has only a constant."""
        if type(self.Q__s__c) == float: return self.Q__s__c
        else:
            #if not a constant, use the flow rate just before the time
            #period that exceeds the input t. otherwise, use the
            #last flow rate given
            if self.Q__s__c["t"][0] > t: return 0
            for i in range(1,len(self.Q__s__c["t"])):
                if self.Q__s__c["t"][i] > t:
                    return self.Q__s__c["vals"][i-1]
            return self.Q__s__c["vals"][-1]

    def getFlowRateCore(self, t):
        """returns the flow rate through the core, in gallons per minute.
        This function is assumed to be known with respect to time."""
        if type(self.Q__c) == float: return self.Q__c
        else:
            #if not a constant, use the flow rate just before the time
            #period that exceeds the input t. otherwise, use the
            #last flow rate given
            if self.Q__c["t"][0] > t: return 0
            for i in range(1,len(self.Q__c["t"])):
                if self.Q__c["t"][i] > t:
                    return self.Q__c["vals"][i-1]
            return self.Q__c["vals"][-1]

    def getFiltrationRate(self,mass):
        """returns the filtration rate (fraction between 0 and 1)
        of debris through the strainer. (Note the mass is total for
        a strainer, and there are 20 modules, with the filtration
        function relating to the per module mass - so we divide
```

```
        by 20 to get the per-module mass.
        mass -- amount of debris currently on the strainer (grams)
        retval - fraction between 0 and 1 indicating how the
        proportion of mass that is caught and added to the strainer
        """
        if self.filtration_function == "hybrid":
            if (mass/20.0) <= self.threshold:
                return (mass/20.0)*self.m + self.b
            else:
                return (self.threshold*self.m + self.b) + (self.a - self.threshold*self.m
                    - self.b) * (1-scipy.exp(-self.delta * ((mass/20.0)-self.threshold)
                    ) )
        else:
            return min(1.0,(mass/20.0)*self.slope + self.intercept)

    def getDeltaMassStrainerA(self, masses, t):
        """Calculates the rate of change of mass on strainer A.
        masses -- mass of debris in the different parts of the
        recirculation system:
            masses[0] = Pool (M_p)
            masses[1] = Strainer A (M_s_A)
            masses[2] = Strainer B (M_s_B)
            masses[3] = Strainer C (M_s_C)
            masses[4] = Core (M_c)
        t -- time
        retval -- rate of change of mass on Strainer A."""
        return self.getFlowRateStrainerA(t) * (masses[0] / self.V_p) * self.
            getFiltrationRate(masses[1])

    def getDeltaMassStrainerB(self, masses, t):
        """Calculates the rate of change of mass on strainer B.
        masses -- mass of debris in the different parts of the
        recirculation system:
            masses[0] = Pool (M_p)
            masses[1] = Strainer A (M_s_A)
            masses[2] = Strainer B (M_s_B)
            masses[3] = Strainer C (M_s_C)
            masses[4] = Core (M_c)
        t -- time
        retval -- rate of change of mass on Strainer B."""
        return self.getFlowRateStrainerB(t) * (masses[0] / self.V_p) * self.
```

```
            getFiltrationRate(masses[2])

    def getDeltaMassStrainerC(self, masses, t):
        """Calculates the rate of change of mass on strainer C.
        masses -- mass of debris in the different parts of the
        recirculation system:
            masses[0] = Pool (M_p)
            masses[1] = Strainer A (M_s_A)
            masses[2] = Strainer B (M_s_B)
            masses[3] = Strainer C (M_s_C)
            masses[4] = Core (M_c)
        t -- time
        retval -- rate of change of mass on Strainer C."""
        return self.getFlowRateStrainerC(t) * (masses[0] / self.V_p) * self.
            getFiltrationRate(masses[3])

    def getNetPassThroughRate(self,masses,t):
        """Calculates the weighted average pass-through rate of debris through the
            strainers and to the core.
        result is weighted by flow rate to the core (given by the gamma term and
            flow rate).
        masses -- mass of debris in the different parts of the system:
            recirculation system:
            masses[0] = Pool (M_p)
            masses[1] = Strainer A (M_s_A)
            masses[2] = Strainer B (M_s_B)
            masses[3] = Strainer C (M_s_C)
            masses[4] = Core (M_c)
        t -- time
        retval -- weighted average of debris filtered by the strainers"""
        if self.getFlowRateStrainerA(t) + self.getFlowRateStrainerB(t) + self.
            getFlowRateStrainerC(t) == 0: return 1.0
        else: return ( self.getFlowRateStrainerA(t) * (1-self.getFiltrationRate(masses
            [1])) * (1-self.gamma_a)
                  + self.getFlowRateStrainerB(t) * (1-self.getFiltrationRate(masses
                      [2])) * (1-self.gamma_b)
                  + self.getFlowRateStrainerC(t) * (1-self.getFiltrationRate(masses
                      [3])) * (1-self.gamma_c) ) / \
                  ( self.getFlowRateStrainerA(t) * (1-self.gamma_a) +
                    self.getFlowRateStrainerB(t) * (1-self.gamma_b) +
                    self.getFlowRateStrainerC(t) * (1-self.gamma_c) )
```

```
def getDeltaMassCore(self, masses, t):
    """Calculates the rate of change of debris on the core."""
    return self.getFlowRateCore(t) * (masses[0] / self.V_p) * (self.
        getNetPassThroughRate(masses,t))

def getDeltaMassPool(self,masses,t):
    """Calculates the rate of change of debris in the pool."""
    return -1.0*( self.getDeltaMassCore(masses,t)
                 + self.getDeltaMassStrainerA(masses, t)
                 + self.getDeltaMassStrainerB(masses, t)
                 + self.getDeltaMassStrainerC(masses, t) )

def getAllDeltas(self, masses, t):
    """Gets the rate of change of debris in all locations."""
    return scipy.array( [ self.getDeltaMassPool(masses,t),
                          self.getDeltaMassStrainerA(masses,t),
                          self.getDeltaMassStrainerB(masses,t),
                          self.getDeltaMassStrainerC(masses,t),
                          self.getDeltaMassCore(masses,t) ] )


def solveForCoreMass(self, t):
    """Runs the ODE integrator from Python's ODE library,
    with the delta functions and initial values arranged in
    order: pool, strainer A, B, C, and Core.
    Note: We use the library's default solver, LSODA,
    for this set of differential equations."""
    return scipy.integrate.odeint(self.getAllDeltas,
                                  scipy.array([self.M_p_0,
                                               self.M_s_a_0,
                                               self.M_s_b_0,
                                               self.M_s_c_0,
                                               self.M_c_0]
                                               ),
                                  t, mxstep=10000000 )

def printEchoIn(self,filename = "echoin.csv"):
    """Prints all model parameters to file. Used for debugging
    and I/O checking."""
    outfile = open(filename,'w')
```

```
outfile.write("Model␣parameters␣used:\n\n")
outfile.write("Filtration␣Function␣Type:␣␣%s\n" % self.filtration_function)
outfile.write("Filtration␣Function␣Parameter␣Values:\n")
outfile.write("m,%s\n" % self.m)
outfile.write("b,%s\n" % self.b)
outfile.write("M_c,%s\n" % self.threshold)
outfile.write("delta,%s\n" % self.delta)
outfile.write("a,%s\n\n" % self.a)
outfile.write("slope,%s\n\n" % self.slope)
outfile.write("intercept,%s\n\n" % self.intercept)
outfile.write("Initial␣Masses␣and␣Strainer␣Values:\n")
outfile.write("M_p_0,%s\n" % self.M_p_0)
outfile.write("V_p,%s\n" % self.V_p)
outfile.write("M_s_a_0,%s\n" % self.M_s_a_0)
outfile.write("M_s_b_0,%s\n" % self.M_s_b_0)
outfile.write("M_s_c_0,%s\n" % self.M_s_c_0)
outfile.write("Flow␣Rates␣over␣time:\n")
if type(self.Q_s_a) == float: outfile.write("Q_s_a,%s\n" % self.Q_s_a)
else:
    outfile.write("t,Q_s_a\n")
    for idx in range(len(self.Q_s_a["t"])):
        outfile.write("%s,%s\n" % (self.Q_s_a["t"][idx],self.Q_s_a["vals"][
            idx]))
outfile.write("\n")
if type(self.Q_s_b) == float: outfile.write("Q_s_b,%s\n" % self.Q_s_b)
else:
    outfile.write("t,Q_s_b\n")
    for idx in range(len(self.Q_s_b["t"])):
        outfile.write("%s,%s\n" % (self.Q_s_b["t"][idx],self.Q_s_b["vals"][
            idx]))
outfile.write("\n")
if type(self.Q_s_c) == float: outfile.write("Q_s_c,%s\n" % self.Q_s_c)
else:
    outfile.write("t,Q_s_c\n")
    for idx in range(len(self.Q_s_c["t"])):
        outfile.write("%s,%s\n" % (self.Q_s_c["t"][idx],self.Q_s_c["vals"][
            idx]))
outfile.write("\n")
if type(self.Q_c) == float: outfile.write("Q_c,%s\n" % self.Q_c)
else:
    outfile.write("t,Q_c\n")
```

```
            for idx in range(len(self.Q_c["t"])):
                outfile.write("%s,%s\n" % (self.Q_c["t"][idx],self.Q_c["vals"][idx]))
        outfile.write("\n")

def ReadParams(time_filename, initials_filename):
    """Serves as the input reader for this model. Assumes there
    is one file that reads as a table of time-based inputs and
    another file with initial and model values. the output is a
    dictionary that is used to initialize the MassCalculator class.
    """
    params = {}
    #read in initials and constants file
    initials_file = csv.reader(open(initials_filename, 'rU'))
    for line in initials_file:
        if len(line) > 1:
            try: params[line[0]] = float(line[1])
            except ValueError: params[line[0]] = line[1]
    #read in time-based inputs file
    time_df = pandas.read_csv(time_filename)
    #print time_df
    params["Q_s_a"] = {}
    params["Q_s_a"]["t"] = time_df.t.values
    params["Q_s_a"]["vals"] = time_df.Q_s_a.values
    params["Q_s_b"] = {}
    params["Q_s_b"]["t"] = time_df.t.values
    params["Q_s_b"]["vals"] = time_df.Q_s_b.values
    params["Q_s_c"] = {}
    params["Q_s_c"]["t"] = time_df.t.values
    params["Q_s_c"]["vals"] = time_df.Q_s_c.values
    params["Q_c"] = {}
    params["Q_c"]["t"] = time_df.t.values
    params["Q_c"]["vals"] = time_df.Q_c.values
    return params


if __name__ == "__main__":

    time_filename = raw_input("Please␣enter␣the␣name␣of␣the␣time-indexed␣
        inputs␣file:␣␣")
    initials_filename = raw_input("Please␣enter␣the␣name␣of␣the␣constant␣inputs␣
        file:␣␣")
```

```
timespan = float(raw_input("Please␣enter␣the␣desired␣timespan␣(minutes):␣␣"))
outfile = raw_input("Please␣enter␣the␣results␣filename␣(no␣extension):␣␣")
"""
time_filename = "time.csv"
initials_filename = "const.csv"
timespan = 1000
outfile = "DEMO"
"""
#create_png = raw_input("Create graph summary of output (y/n)? ")
solver = MassCalculator(ReadParams(time_filename, initials_filename))
clock = time.time()
t = scipy.linspace(0,timespan,1001)
sol = solver.solveForCoreMass(t).T
elapsed = time.time() - clock
print "Calculations␣completed␣in␣"+str(elapsed)+"␣seconds.␣␣Creating␣output␣
    files."
#Creating csv table
output = open(outfile+".csv",'w')
output.write("t,M_p,M_s_a,M_s_b,M_s_c,M_c\n")
for idx in range(len(sol[0])):
    output.write(str(t[idx])+","+str(sol[0][idx])+","+str(sol[1][idx])+","+str(sol
        [2][idx])+","+str(sol[3][idx])+","+str(sol[4][idx])+"\n")
output.close()
#Creating 2x2 figure of plots of debris levels over time.
#If plotting can't be done here, skip this step.
try:
    fig, axes = plt.subplots(2,2)
    axes[0, 0].plot(t,sol[1])
    axes[0, 0].set_title('Debris␣on␣strainer␣A␣over␣time')
    axes[0, 1].plot(t,sol[2])
    axes[0, 1].set_title('Debris␣on␣strainer␣B␣over␣time')
    axes[1, 0].plot(t,sol[3])
    axes[1, 0].set_title('Debris␣on␣strainer␣C␣over␣time')
    axes[1, 1].plot(t,sol[4])
    axes[1, 1].set_title('Debris␣on␣core␣over␣time')
    plt.savefig(outfile+".png")
except TypeError: pass
#print model parameters
solver.printEchoIn()
```

12.1 Low pool concentration

Low pool concentration is defined by an initial debris mass of 68181.8 gm and water volume of 600,000 gal. The category of low pool concentration includes the four levels of filtration and three levels of flow. The following listings correspond to the low pool concentration sensitivities.

12.1.1 Low ECCS flow

Listing 14: Low ECCS flow, 0.4 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.4

Initial Masses and Strainer Values:
M_p_0,68181.82
V_p,600000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,3300.0
8.33,3300.0
41.67,3300.0
75.0,3300.0
108.33,3300.0
141.67,3300.0
225.0,3300.0
308.33,3300.0
641.67,3300.0
975.0,3300.0
1308.33,3300.0
1641.67,3300.0
2475.0,3300.0
6641.67,3300.0
9975.0,3300.0
13308.33,3300.0
16641.67,3300.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
2475.0,5062.5
6641.67,5062.5
9975.0,5062.5
13308.33,5062.5
16641.67,5062.5
nan,nan
nan,nan
nan,nan
```

```
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
2475.0,5062.5
6641.67,5062.5
9975.0,5062.5
13308.33,5062.5
16641.67,5062.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 15: Low ECCS flow, 0.5 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.5

Initial Masses and Strainer Values:
M_p_0,68181.82
V_p,600000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,3300.0
```

```
8.33,3300.0
41.67,3300.0
75.0,3300.0
108.33,3300.0
141.67,3300.0
225.0,3300.0
308.33,3300.0
641.67,3300.0
975.0,3300.0
1308.33,3300.0
1641.67,3300.0
2475.0,3300.0
6641.67,3300.0
9975.0,3300.0
13308.33,3300.0
16641.67,3300.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
2475.0,5062.5
6641.67,5062.5
9975.0,5062.5
13308.33,5062.5
16641.67,5062.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
2475.0,5062.5
6641.67,5062.5
9975.0,5062.5
13308.33,5062.5
16641.67,5062.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
```

```
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 16: Low ECCS flow, 0.6 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.6

Initial Masses and Strainer Values:
M_p_0,68181.82
V_p,600000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,3300.0
8.33,3300.0
41.67,3300.0
75.0,3300.0
108.33,3300.0
141.67,3300.0
225.0,3300.0
308.33,3300.0
641.67,3300.0
975.0,3300.0
1308.33,3300.0
1641.67,3300.0
2475.0,3300.0
6641.67,3300.0
9975.0,3300.0
13308.33,3300.0
16641.67,3300.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
```

```
2475.0,5062.5
6641.67,5062.5
9975.0,5062.5
13308.33,5062.5
16641.67,5062.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
2475.0,5062.5
6641.67,5062.5
9975.0,5062.5
13308.33,5062.5
16641.67,5062.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 17: Low ECCS flow, 0.7 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.7

Initial Masses and Strainer Values:
```

```
M_p_0,68181.82
V_p,600000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,3300.0
8.33,3300.0
41.67,3300.0
75.0,3300.0
108.33,3300.0
141.67,3300.0
225.0,3300.0
308.33,3300.0
641.67,3300.0
975.0,3300.0
1308.33,3300.0
1641.67,3300.0
2475.0,3300.0
6641.67,3300.0
9975.0,3300.0
13308.33,3300.0
16641.67,3300.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
2475.0,5062.5
6641.67,5062.5
9975.0,5062.5
13308.33,5062.5
16641.67,5062.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
2475.0,5062.5
6641.67,5062.5
9975.0,5062.5
13308.33,5062.5
16641.67,5062.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

```
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

12.1.2 Normal ECCS flow

Listing 18: Normal ECCS flow, 0.4 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A
slope,0.0

intercept,0.4

Initial Masses and Strainer Values:
M_p_0,68181.82
V_p,600000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,4400
8.33,4400
41.67,4400
75.0,4400
108.33,4400
141.67,4400
225.0,4400
308.33,4400
641.67,4400
975.0,4400
1308.33,4400
1641.67,4400
2475.0,4400
6641.67,4400
9975.0,4400
13308.33,4400
16641.67,4400

t,Q_s_b
0.0,6750
8.33,6750
41.67,6750
75.0,6750
108.33,6750
141.67,6750
225.0,6750
308.33,6750
641.67,6750
```

```
975.0,6750
1308.33,6750
1641.67,6750
2475.0,6750
6641.67,6750
9975.0,6750
13308.33,6750
16641.67,6750

t,Q_s_c
0.0,6750
8.33,6750
41.67,6750
75.0,6750
108.33,6750
141.67,6750
225.0,6750
308.33,6750
641.67,6750
975.0,6750
1308.33,6750
1641.67,6750
2475.0,6750
6641.67,6750
9975.0,6750
13308.33,6750
16641.67,6750

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
```

Listing 19: Normal ECCS flow, 0.5 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.5

Initial Masses and Strainer Values:
M_p_0,68181.82
V_p,600000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,4400
8.33,4400
41.67,4400
75.0,4400
108.33,4400
141.67,4400
225.0,4400
308.33,4400
641.67,4400
975.0,4400
1308.33,4400
```

```
1641.67,4400
2475.0,4400
6641.67,4400
9975.0,4400
13308.33,4400
16641.67,4400

t,Q_s_b
0.0,6750
8.33,6750
41.67,6750
75.0,6750
108.33,6750
141.67,6750
225.0,6750
308.33,6750
641.67,6750
975.0,6750
1308.33,6750
1641.67,6750
2475.0,6750
6641.67,6750
9975.0,6750
13308.33,6750
16641.67,6750

t,Q_s_c
0.0,6750
8.33,6750
41.67,6750
75.0,6750
108.33,6750
141.67,6750
225.0,6750
308.33,6750
641.67,6750
975.0,6750
1308.33,6750
1641.67,6750
2475.0,6750
6641.67,6750
9975.0,6750
13308.33,6750
16641.67,6750

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
```

Listing 20: Normal ECCS flow, 0.6 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.6

Initial Masses and Strainer Values:
M_p_0,68181.82
```

```
V_p,600000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,4400
8.33,4400
41.67,4400
75.0,4400
108.33,4400
141.67,4400
225.0,4400
308.33,4400
641.67,4400
975.0,4400
1308.33,4400
1641.67,4400
2475.0,4400
6641.67,4400
9975.0,4400
13308.33,4400
16641.67,4400

t,Q_s_b
0.0,6750
8.33,6750
41.67,6750
75.0,6750
108.33,6750
141.67,6750
225.0,6750
308.33,6750
641.67,6750
975.0,6750
1308.33,6750
1641.67,6750
2475.0,6750
6641.67,6750
9975.0,6750
13308.33,6750
16641.67,6750

t,Q_s_c
0.0,6750
8.33,6750
41.67,6750
75.0,6750
108.33,6750
141.67,6750
225.0,6750
308.33,6750
641.67,6750
975.0,6750
1308.33,6750
1641.67,6750
2475.0,6750
6641.67,6750
9975.0,6750
13308.33,6750
16641.67,6750

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
```

Listing 21: Low ECCS flow, 0.7 filtration

Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.7

Initial Masses and Strainer Values:
M_p_0,68181.82
V_p,600000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,4400
8.33,4400
41.67,4400
75.0,4400
108.33,4400
141.67,4400
225.0,4400
308.33,4400
641.67,4400
975.0,4400
1308.33,4400
1641.67,4400
2475.0,4400
6641.67,4400
9975.0,4400
13308.33,4400
16641.67,4400

t,Q_s_b
0.0,6750
8.33,6750
41.67,6750
75.0,6750
108.33,6750
141.67,6750
225.0,6750
308.33,6750
641.67,6750
975.0,6750
1308.33,6750
1641.67,6750
2475.0,6750
6641.67,6750
9975.0,6750
13308.33,6750
16641.67,6750

t,Q_s_c
0.0,6750
8.33,6750
41.67,6750
75.0,6750
108.33,6750
141.67,6750
225.0,6750
308.33,6750
641.67,6750
975.0,6750
1308.33,6750
1641.67,6750
2475.0,6750
6641.67,6750
9975.0,6750
13308.33,6750
16641.67,6750

t,Q_c
0.0,610.0
8.33,565.81

```
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
```

12.1.3 High ECCS flow

Listing 22: High ECCS flow, 0.4 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.4

Initial Masses and Strainer Values:
M_p_0,68181.82
V_p,600000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,5500.0
8.33,5500.0
41.67,5500.0
75.0,5500.0
108.33,5500.0
141.67,5500.0
225.0,5500.0
308.33,5500.0
641.67,5500.0
975.0,5500.0
1308.33,5500.0
1641.67,5500.0
2475.0,5500.0
6641.67,5500.0
9975.0,5500.0
13308.33,5500.0
16641.67,5500.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,8437.5
8.33,8437.5
41.67,8437.5
75.0,8437.5
108.33,8437.5
141.67,8437.5
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
```

```
9975.0,8437.5
13308.33,8437.5
16641.67,8437.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,8437.5
8.33,8437.5
41.67,8437.5
75.0,8437.5
108.33,8437.5
141.67,8437.5
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
9975.0,8437.5
13308.33,8437.5
16641.67,8437.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 23: High ECCS flow, 0.5 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.5

Initial Masses and Strainer Values:
M_p_0,68181.82
V_p,600000.0
```

M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,5500.0
8.33,5500.0
41.67,5500.0
75.0,5500.0
108.33,5500.0
141.67,5500.0
225.0,5500.0
308.33,5500.0
641.67,5500.0
975.0,5500.0
1308.33,5500.0
1641.67,5500.0
2475.0,5500.0
6641.67,5500.0
9975.0,5500.0
13308.33,5500.0
16641.67,5500.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,8437.5
8.33,8437.5
41.67,8437.5
75.0,8437.5
108.33,8437.5
141.67,8437.5
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
9975.0,8437.5
13308.33,8437.5
16641.67,8437.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,8437.5
8.33,8437.5
41.67,8437.5
75.0,8437.5
108.33,8437.5
141.67,8437.5
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
9975.0,8437.5
13308.33,8437.5
16641.67,8437.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

```
t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 24: High ECCS flow, 0.6 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.6

Initial Masses and Strainer Values:
M_p_0,68181.82
V_p,600000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,5500.0
8.33,5500.0
41.67,5500.0
75.0,5500.0
108.33,5500.0
141.67,5500.0
225.0,5500.0
308.33,5500.0
641.67,5500.0
975.0,5500.0
1308.33,5500.0
1641.67,5500.0
2475.0,5500.0
6641.67,5500.0
9975.0,5500.0
13308.33,5500.0
16641.67,5500.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,8437.5
8.33,8437.5
41.67,8437.5
75.0,8437.5
108.33,8437.5
141.67,8437.5
```

```
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
9975.0,8437.5
13308.33,8437.5
16641.67,8437.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,8437.5
8.33,8437.5
41.67,8437.5
75.0,8437.5
108.33,8437.5
141.67,8437.5
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
9975.0,8437.5
13308.33,8437.5
16641.67,8437.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 25: High ECCS flow, 0.7 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A
```

slope,0.0

intercept,0.7

Initial Masses and Strainer Values:
M_p_0,68181.82
V_p,600000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,5500.0
8.33,5500.0
41.67,5500.0
75.0,5500.0
108.33,5500.0
141.67,5500.0
225.0,5500.0
308.33,5500.0
641.67,5500.0
975.0,5500.0
1308.33,5500.0
1641.67,5500.0
2475.0,5500.0
6641.67,5500.0
9975.0,5500.0
13308.33,5500.0
16641.67,5500.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,8437.5
8.33,8437.5
41.67,8437.5
75.0,8437.5
108.33,8437.5
141.67,8437.5
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
9975.0,8437.5
13308.33,8437.5
16641.67,8437.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,8437.5
8.33,8437.5
41.67,8437.5
75.0,8437.5
108.33,8437.5
141.67,8437.5
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
9975.0,8437.5
13308.33,8437.5
16641.67,8437.5

```
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

12.2 Normal pool concentration

Normal pool concentration is defined by an initial debris mass of 87273 gm and water volume of 500,000 gal. Within the category of normal pool concentration are the four levels of filtration and three levels of flow. The following listings correspond to the normal pool concentration sensitivities.

12.2.1 Low ECCS flow

Listing 26: Low ECCS flow, 0.4 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.4

Initial Masses and Strainer Values:
M_p_0,87272.73
V_p,500000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,3300.0
8.33,3300.0
41.67,3300.0
75.0,3300.0
108.33,3300.0
141.67,3300.0
225.0,3300.0
308.33,3300.0
641.67,3300.0
975.0,3300.0
1308.33,3300.0
1641.67,3300.0
```

2475.0,3300.0
6641.67,3300.0
9975.0,3300.0
13308.33,3300.0
16641.67,3300.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
2475.0,5062.5
6641.67,5062.5
9975.0,5062.5
13308.33,5062.5
16641.67,5062.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
2475.0,5062.5
6641.67,5062.5
9975.0,5062.5
13308.33,5062.5
16641.67,5062.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92

```
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 27: Low ECCS flow, 0.5 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.5

Initial Masses and Strainer Values:
M_p_0,87272.73
V_p,500000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,3300.0
8.33,3300.0
41.67,3300.0
75.0,3300.0
108.33,3300.0
141.67,3300.0
225.0,3300.0
308.33,3300.0
641.67,3300.0
975.0,3300.0
1308.33,3300.0
1641.67,3300.0
2475.0,3300.0
6641.67,3300.0
9975.0,3300.0
13308.33,3300.0
16641.67,3300.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
2475.0,5062.5
6641.67,5062.5
9975.0,5062.5
13308.33,5062.5
16641.67,5062.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

```
nan,nan

t,Q__s__c
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
2475.0,5062.5
6641.67,5062.5
9975.0,5062.5
13308.33,5062.5
16641.67,5062.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q__c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 28: Low ECCS flow, 0.6 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M__c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.6

Initial Masses and Strainer Values:
M__p__0,87272.73
V__p,500000.0
M__s__a__0,0.0
M__s__b__0,0.0
M__s__c__0,0.0
Flow Rates over time:
t,Q__s__a
0.0,3300.0
8.33,3300.0
41.67,3300.0
75.0,3300.0
```

```
108.33,3300.0
141.67,3300.0
225.0,3300.0
308.33,3300.0
641.67,3300.0
975.0,3300.0
1308.33,3300.0
1641.67,3300.0
2475.0,3300.0
6641.67,3300.0
9975.0,3300.0
13308.33,3300.0
16641.67,3300.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
2475.0,5062.5
6641.67,5062.5
9975.0,5062.5
13308.33,5062.5
16641.67,5062.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
2475.0,5062.5
6641.67,5062.5
9975.0,5062.5
13308.33,5062.5
16641.67,5062.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
```

```
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 29: Low ECCS flow, 0.7 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.7

Initial Masses and Strainer Values:
M_p_0,87272.73
V_p,500000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,3300.0
8.33,3300.0
41.67,3300.0
75.0,3300.0
108.33,3300.0
141.67,3300.0
225.0,3300.0
308.33,3300.0
641.67,3300.0
975.0,3300.0
1308.33,3300.0
1641.67,3300.0
2475.0,3300.0
6641.67,3300.0
9975.0,3300.0
13308.33,3300.0
16641.67,3300.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
2475.0,5062.5
6641.67,5062.5
9975.0,5062.5
```

```
13308.33,5062.5
16641.67,5062.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
2475.0,5062.5
6641.67,5062.5
9975.0,5062.5
13308.33,5062.5
16641.67,5062.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

12.2.2 Normal ECCS flow

Listing 30: Normal ECCS flow, 0.4 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.4

Initial Masses and Strainer Values:
M_p_0,87272.73
```

```
V_p,500000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,4400.0
8.33,4400.0
41.67,4400.0
75.0,4400.0
108.33,4400.0
141.67,4400.0
225.0,4400.0
308.33,4400.0
641.67,4400.0
975.0,4400.0
1308.33,4400.0
1641.67,4400.0
2475.0,4400.0
6641.67,4400.0
9975.0,4400.0
13308.33,4400.0
16641.67,4400.0
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,6750.0
8.33,6750.0
41.67,6750.0
75.0,6750.0
108.33,6750.0
141.67,6750.0
225.0,6750.0
308.33,6750.0
641.67,6750.0
975.0,6750.0
1308.33,6750.0
1641.67,6750.0
2475.0,6750.0
6641.67,6750.0
9975.0,6750.0
13308.33,6750.0
16641.67,6750.0
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,6750.0
8.33,6750.0
41.67,6750.0
75.0,6750.0
108.33,6750.0
141.67,6750.0
225.0,6750.0
308.33,6750.0
641.67,6750.0
975.0,6750.0
1308.33,6750.0
1641.67,6750.0
2475.0,6750.0
6641.67,6750.0
9975.0,6750.0
13308.33,6750.0
16641.67,6750.0
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
```

```
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 31: Normal ECCS flow, 0.5 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.5

Initial Masses and Strainer Values:
M_p_0,87272.73
V_p,500000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,4400.0
8.33,4400.0
41.67,4400.0
75.0,4400.0
108.33,4400.0
141.67,4400.0
225.0,4400.0
308.33,4400.0
641.67,4400.0
975.0,4400.0
1308.33,4400.0
1641.67,4400.0
2475.0,4400.0
6641.67,4400.0
9975.0,4400.0
13308.33,4400.0
16641.67,4400.0
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,6750.0
8.33,6750.0
41.67,6750.0
75.0,6750.0
108.33,6750.0
141.67,6750.0
225.0,6750.0
308.33,6750.0
641.67,6750.0
975.0,6750.0
1308.33,6750.0
1641.67,6750.0
2475.0,6750.0
6641.67,6750.0
9975.0,6750.0
13308.33,6750.0
16641.67,6750.0
nan,nan
nan,nan
nan,nan
```

```
nan,nan

t,Q_s_c
0.0,6750.0
8.33,6750.0
41.67,6750.0
75.0,6750.0
108.33,6750.0
141.67,6750.0
225.0,6750.0
308.33,6750.0
641.67,6750.0
975.0,6750.0
1308.33,6750.0
1641.67,6750.0
2475.0,6750.0
6641.67,6750.0
9975.0,6750.0
13308.33,6750.0
16641.67,6750.0
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 32: Normal ECCS flow, 0.6 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.6

Initial Masses and Strainer Values:
M_p_0,87272.73
V_p,500000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,4400.0
8.33,4400.0
41.67,4400.0
75.0,4400.0
108.33,4400.0
141.67,4400.0
225.0,4400.0
308.33,4400.0
641.67,4400.0
975.0,4400.0
```

```
1308.33,4400.0
1641.67,4400.0
2475.0,4400.0
6641.67,4400.0
9975.0,4400.0
13308.33,4400.0
16641.67,4400.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,6750.0
8.33,6750.0
41.67,6750.0
75.0,6750.0
108.33,6750.0
141.67,6750.0
225.0,6750.0
308.33,6750.0
641.67,6750.0
975.0,6750.0
1308.33,6750.0
1641.67,6750.0
2475.0,6750.0
6641.67,6750.0
9975.0,6750.0
13308.33,6750.0
16641.67,6750.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,6750.0
8.33,6750.0
41.67,6750.0
75.0,6750.0
108.33,6750.0
141.67,6750.0
225.0,6750.0
308.33,6750.0
641.67,6750.0
975.0,6750.0
1308.33,6750.0
1641.67,6750.0
2475.0,6750.0
6641.67,6750.0
9975.0,6750.0
13308.33,6750.0
16641.67,6750.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
```

```
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 33: Normal ECCS flow, 0.7 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.7

Initial Masses and Strainer Values:
M_p_0,87272.73
V_p,500000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,4400.0
8.33,4400.0
41.67,4400.0
75.0,4400.0
108.33,4400.0
141.67,4400.0
225.0,4400.0
308.33,4400.0
641.67,4400.0
975.0,4400.0
1308.33,4400.0
1641.67,4400.0
2475.0,4400.0
6641.67,4400.0
9975.0,4400.0
13308.33,4400.0
16641.67,4400.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,6750.0
8.33,6750.0
41.67,6750.0
75.0,6750.0
108.33,6750.0
141.67,6750.0
225.0,6750.0
308.33,6750.0
641.67,6750.0
975.0,6750.0
1308.33,6750.0
1641.67,6750.0
2475.0,6750.0
6641.67,6750.0
9975.0,6750.0
13308.33,6750.0
16641.67,6750.0
nan,nan
nan,nan
nan,nan
nan,nan
```

```
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,6750.0
8.33,6750.0
41.67,6750.0
75.0,6750.0
108.33,6750.0
141.67,6750.0
225.0,6750.0
308.33,6750.0
641.67,6750.0
975.0,6750.0
1308.33,6750.0
1641.67,6750.0
2475.0,6750.0
6641.67,6750.0
9975.0,6750.0
13308.33,6750.0
16641.67,6750.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

12.2.3 High ECCS flow

Listing 34: High ECCS flow, 0.4 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.4

Initial Masses and Strainer Values:
M_p_0,87272.73
V_p,500000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
```

```
0.0,5500.0
8.33,5500.0
41.67,5500.0
75.0,5500.0
108.33,5500.0
141.67,5500.0
225.0,5500.0
308.33,5500.0
641.67,5500.0
975.0,5500.0
1308.33,5500.0
1641.67,5500.0
2475.0,5500.0
6641.67,5500.0
9975.0,5500.0
13308.33,5500.0
16641.67,5500.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,8437.5
8.33,8437.5
41.67,8437.5
75.0,8437.5
108.33,8437.5
141.67,8437.5
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
9975.0,8437.5
13308.33,8437.5
16641.67,8437.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,8437.5
8.33,8437.5
41.67,8437.5
75.0,8437.5
108.33,8437.5
141.67,8437.5
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
9975.0,8437.5
13308.33,8437.5
16641.67,8437.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
```

```
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 35: High ECCS flow, 0.5 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.5

Initial Masses and Strainer Values:
M_p_0,87272.73
V_p,500000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,5500.0
8.33,5500.0
41.67,5500.0
75.0,5500.0
108.33,5500.0
141.67,5500.0
225.0,5500.0
308.33,5500.0
641.67,5500.0
975.0,5500.0
1308.33,5500.0
1641.67,5500.0
2475.0,5500.0
6641.67,5500.0
9975.0,5500.0
13308.33,5500.0
16641.67,5500.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,8437.5
8.33,8437.5
41.67,8437.5
75.0,8437.5
108.33,8437.5
141.67,8437.5
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
```

```
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
9975.0,8437.5
13308.33,8437.5
16641.67,8437.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,8437.5
8.33,8437.5
41.67,8437.5
75.0,8437.5
108.33,8437.5
141.67,8437.5
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
9975.0,8437.5
13308.33,8437.5
16641.67,8437.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 36: High ECCS flow, 0.6 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.6
```

Initial Masses and Strainer Values:
M__p__0,87272.73
V__p,500000.0
M__s__a__0,0.0
M__s__b__0,0.0
M__s__c__0,0.0
Flow Rates over time:
t,Q__s__a
0.0,5500.0
8.33,5500.0
41.67,5500.0
75.0,5500.0
108.33,5500.0
141.67,5500.0
225.0,5500.0
308.33,5500.0
641.67,5500.0
975.0,5500.0
1308.33,5500.0
1641.67,5500.0
2475.0,5500.0
6641.67,5500.0
9975.0,5500.0
13308.33,5500.0
16641.67,5500.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q__s__b
0.0,8437.5
8.33,8437.5
41.67,8437.5
75.0,8437.5
108.33,8437.5
141.67,8437.5
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
9975.0,8437.5
13308.33,8437.5
16641.67,8437.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q__s__c
0.0,8437.5
8.33,8437.5
41.67,8437.5
75.0,8437.5
108.33,8437.5
141.67,8437.5
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
9975.0,8437.5
13308.33,8437.5
16641.67,8437.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

```
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 37: High ECCS flow, 0.7 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A
slope,0.0

intercept,0.7

Initial Masses and Strainer Values:
M_p_0,87272.73
V_p,500000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,5500.0
8.33,5500.0
41.67,5500.0
75.0,5500.0
108.33,5500.0
141.67,5500.0
225.0,5500.0
308.33,5500.0
641.67,5500.0
975.0,5500.0
1308.33,5500.0
1641.67,5500.0
2475.0,5500.0
6641.67,5500.0
9975.0,5500.0
13308.33,5500.0
16641.67,5500.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,8437.5
8.33,8437.5
41.67,8437.5
```

75.0,8437.5
108.33,8437.5
141.67,8437.5
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
9975.0,8437.5
13308.33,8437.5
16641.67,8437.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,8437.5
8.33,8437.5
41.67,8437.5
75.0,8437.5
108.33,8437.5
141.67,8437.5
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
9975.0,8437.5
13308.33,8437.5
16641.67,8437.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

12.3 High pool concentration sensitivity input

High pool concentration is defined by an initial debris mass of 113636 gm and water volume of 300,000 gal. The category of high pool concentration includes the four levels of filtration and three levels of flow. The following listings correspond to the low pool concentration sensitivities.

12.3.1 Low ECCS flow

Listing 38: Low ECCS flow, 0.4 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.4

Initial Masses and Strainer Values:
M_p_0,113636.36
V_p,300000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,3300.0
8.33,3300.0
41.67,3300.0
75.0,3300.0
108.33,3300.0
141.67,3300.0
225.0,3300.0
308.33,3300.0
641.67,3300.0
975.0,3300.0
1308.33,3300.0
1641.67,3300.0
2475.0,3300.0
6641.67,3300.0
9975.0,3300.0
13308.33,3300.0
16641.67,3300.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
2475.0,5062.5
6641.67,5062.5
```

```
9975.0,5062.5
13308.33,5062.5
16641.67,5062.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
2475.0,5062.5
6641.67,5062.5
9975.0,5062.5
13308.33,5062.5
16641.67,5062.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 39: Low ECCS flow, 0.5 filtration

Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.5

Initial Masses and Strainer Values:
M_p_0,113636.36
V_p,300000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,3300.0
8.33,3300.0
41.67,3300.0
75.0,3300.0
108.33,3300.0
141.67,3300.0
225.0,3300.0
308.33,3300.0
641.67,3300.0
975.0,3300.0
1308.33,3300.0
1641.67,3300.0
2475.0,3300.0
6641.67,3300.0
9975.0,3300.0
13308.33,3300.0
16641.67,3300.0
nan,nan
nan,nan
nan,nan
nan,nan

nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
2475.0,5062.5
6641.67,5062.5
9975.0,5062.5
13308.33,5062.5
16641.67,5062.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c

```
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
2475.0,5062.5
6641.67,5062.5
9975.0,5062.5
13308.33,5062.5
16641.67,5062.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 40: Low ECCS flow, 0.6 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.6

Initial Masses and Strainer Values:
M_p_0,113636.36
V_p,300000.0
M_s_a_0,0.0
M_s_b_0,0.0
```

M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,3300.0
8.33,3300.0
41.67,3300.0
75.0,3300.0
108.33,3300.0
141.67,3300.0
225.0,3300.0
308.33,3300.0
641.67,3300.0
975.0,3300.0
1308.33,3300.0
1641.67,3300.0
2475.0,3300.0
6641.67,3300.0
9975.0,3300.0
13308.33,3300.0
16641.67,3300.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
2475.0,5062.5
6641.67,5062.5
9975.0,5062.5
13308.33,5062.5
16641.67,5062.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
2475.0,5062.5
6641.67,5062.5
9975.0,5062.5
13308.33,5062.5
16641.67,5062.5

```
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 41: Low ECCS flow, 0.7 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.7

Initial Masses and Strainer Values:
M_p_0,113636.36
V_p,300000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,3300.0
8.33,3300.0
41.67,3300.0
75.0,3300.0
108.33,3300.0
141.67,3300.0
225.0,3300.0
308.33,3300.0
641.67,3300.0
975.0,3300.0
1308.33,3300.0
1641.67,3300.0
2475.0,3300.0
6641.67,3300.0
```

```
9975.0,3300.0
13308.33,3300.0
16641.67,3300.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
2475.0,5062.5
6641.67,5062.5
9975.0,5062.5
13308.33,5062.5
16641.67,5062.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,5062.5
8.33,5062.5
41.67,5062.5
75.0,5062.5
108.33,5062.5
141.67,5062.5
225.0,5062.5
308.33,5062.5
641.67,5062.5
975.0,5062.5
1308.33,5062.5
1641.67,5062.5
2475.0,5062.5
6641.67,5062.5
9975.0,5062.5
13308.33,5062.5
16641.67,5062.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
```

```
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

12.3.2 Normal ECCS flow

Listing 42: Normal ECCS flow, 0.4 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A
slope,0.0

intercept,0.4

Initial Masses and Strainer Values:
M_p_0,113636.36
V_p,300000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,4400.0
8.33,4400.0
41.67,4400.0
75.0,4400.0
108.33,4400.0
141.67,4400.0
225.0,4400.0
308.33,4400.0
641.67,4400.0
975.0,4400.0
1308.33,4400.0
1641.67,4400.0
2475.0,4400.0
6641.67,4400.0
9975.0,4400.0
13308.33,4400.0
16641.67,4400.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

```
t,Q_s_b
0.0,6750.0
8.33,6750.0
41.67,6750.0
75.0,6750.0
108.33,6750.0
141.67,6750.0
225.0,6750.0
308.33,6750.0
641.67,6750.0
975.0,6750.0
1308.33,6750.0
1641.67,6750.0
2475.0,6750.0
6641.67,6750.0
9975.0,6750.0
13308.33,6750.0
16641.67,6750.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,6750.0
8.33,6750.0
41.67,6750.0
75.0,6750.0
108.33,6750.0
141.67,6750.0
225.0,6750.0
308.33,6750.0
641.67,6750.0
975.0,6750.0
1308.33,6750.0
1641.67,6750.0
2475.0,6750.0
6641.67,6750.0
9975.0,6750.0
13308.33,6750.0
16641.67,6750.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
```

```
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 43: Normal ECCS flow, 0.5 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.5

Initial Masses and Strainer Values:
M_p_0,113636.36
V_p,300000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,4400.0
8.33,4400.0
41.67,4400.0
75.0,4400.0
108.33,4400.0
141.67,4400.0
225.0,4400.0
308.33,4400.0
641.67,4400.0
975.0,4400.0
1308.33,4400.0
1641.67,4400.0
2475.0,4400.0
6641.67,4400.0
9975.0,4400.0
13308.33,4400.0
16641.67,4400.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,6750.0
8.33,6750.0
41.67,6750.0
75.0,6750.0
108.33,6750.0
141.67,6750.0
225.0,6750.0
308.33,6750.0
641.67,6750.0
975.0,6750.0
1308.33,6750.0
1641.67,6750.0
2475.0,6750.0
6641.67,6750.0
9975.0,6750.0
```

```
13308.33,6750.0
16641.67,6750.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,6750.0
8.33,6750.0
41.67,6750.0
75.0,6750.0
108.33,6750.0
141.67,6750.0
225.0,6750.0
308.33,6750.0
641.67,6750.0
975.0,6750.0
1308.33,6750.0
1641.67,6750.0
2475.0,6750.0
6641.67,6750.0
9975.0,6750.0
13308.33,6750.0
16641.67,6750.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 44: Normal ECCS flow, 0.6 filtration

```
Model parameters used:

Filtration Function Type: linear
```

Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.6

Initial Masses and Strainer Values:
M_p_0,113636.36
V_p,300000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,4400.0
8.33,4400.0
41.67,4400.0
75.0,4400.0
108.33,4400.0
141.67,4400.0
225.0,4400.0
308.33,4400.0
641.67,4400.0
975.0,4400.0
1308.33,4400.0
1641.67,4400.0
2475.0,4400.0
6641.67,4400.0
9975.0,4400.0
13308.33,4400.0
16641.67,4400.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,6750.0
8.33,6750.0
41.67,6750.0
75.0,6750.0
108.33,6750.0
141.67,6750.0
225.0,6750.0
308.33,6750.0
641.67,6750.0
975.0,6750.0
1308.33,6750.0
1641.67,6750.0
2475.0,6750.0
6641.67,6750.0
9975.0,6750.0
13308.33,6750.0
16641.67,6750.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,6750.0

```
8.33,6750.0
41.67,6750.0
75.0,6750.0
108.33,6750.0
141.67,6750.0
225.0,6750.0
308.33,6750.0
641.67,6750.0
975.0,6750.0
1308.33,6750.0
1641.67,6750.0
2475.0,6750.0
6641.67,6750.0
9975.0,6750.0
13308.33,6750.0
16641.67,6750.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 45: Normal ECCS flow, 0.7 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.7

Initial Masses and Strainer Values:
M_p_0,113636.36
V_p,300000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
```

Flow Rates over time:

```
t,Q_s_a
0.0,4400.0
8.33,4400.0
41.67,4400.0
75.0,4400.0
108.33,4400.0
141.67,4400.0
225.0,4400.0
308.33,4400.0
641.67,4400.0
975.0,4400.0
1308.33,4400.0
1641.67,4400.0
2475.0,4400.0
6641.67,4400.0
9975.0,4400.0
13308.33,4400.0
16641.67,4400.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,6750.0
8.33,6750.0
41.67,6750.0
75.0,6750.0
108.33,6750.0
141.67,6750.0
225.0,6750.0
308.33,6750.0
641.67,6750.0
975.0,6750.0
1308.33,6750.0
1641.67,6750.0
2475.0,6750.0
6641.67,6750.0
9975.0,6750.0
13308.33,6750.0
16641.67,6750.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,6750.0
8.33,6750.0
41.67,6750.0
75.0,6750.0
108.33,6750.0
141.67,6750.0
225.0,6750.0
308.33,6750.0
641.67,6750.0
975.0,6750.0
1308.33,6750.0
1641.67,6750.0
2475.0,6750.0
6641.67,6750.0
9975.0,6750.0
13308.33,6750.0
16641.67,6750.0
nan,nan
```

```
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

12.3.3 High ECCS flow

Listing 46: High ECCS flow, 0.4 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.4

Initial Masses and Strainer Values:
M_p_0,113636.36
V_p,300000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,5500.0
8.33,5500.0
41.67,5500.0
75.0,5500.0
108.33,5500.0
141.67,5500.0
225.0,5500.0
308.33,5500.0
641.67,5500.0
975.0,5500.0
1308.33,5500.0
1641.67,5500.0
2475.0,5500.0
```

```
6641.67,5500.0
9975.0,5500.0
13308.33,5500.0
16641.67,5500.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,8437.5
8.33,8437.5
41.67,8437.5
75.0,8437.5
108.33,8437.5
141.67,8437.5
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
9975.0,8437.5
13308.33,8437.5
16641.67,8437.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,8437.5
8.33,8437.5
41.67,8437.5
75.0,8437.5
108.33,8437.5
141.67,8437.5
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
9975.0,8437.5
13308.33,8437.5
16641.67,8437.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
```

```
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 47: High ECCS flow, 0.5 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0
intercept,0.5

Initial Masses and Strainer Values:
M_p_0,68181.82
V_p,600000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,5500.0
8.33,5500.0
41.67,5500.0
75.0,5500.0
108.33,5500.0
141.67,5500.0
225.0,5500.0
308.33,5500.0
641.67,5500.0
975.0,5500.0
1308.33,5500.0
1641.67,5500.0
2475.0,5500.0
6641.67,5500.0
9975.0,5500.0
13308.33,5500.0
16641.67,5500.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,8437.5
8.33,8437.5
41.67,8437.5
75.0,8437.5
```

```
108.33,8437.5
141.67,8437.5
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
9975.0,8437.5
13308.33,8437.5
16641.67,8437.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,8437.5
8.33,8437.5
41.67,8437.5
75.0,8437.5
108.33,8437.5
141.67,8437.5
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
9975.0,8437.5
13308.33,8437.5
16641.67,8437.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 48: High ECCS flow, 0.6 filtration

```
Model parameters used:

Filtration Function Type: linear
Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
```

delta,N/A
a,N/A

slope,0.0

intercept,0.6

Initial Masses and Strainer Values:
M_p_0,68181.82
V_p,600000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,5500.0
8.33,5500.0
41.67,5500.0
75.0,5500.0
108.33,5500.0
141.67,5500.0
225.0,5500.0
308.33,5500.0
641.67,5500.0
975.0,5500.0
1308.33,5500.0
1641.67,5500.0
2475.0,5500.0
6641.67,5500.0
9975.0,5500.0
13308.33,5500.0
16641.67,5500.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_b
0.0,8437.5
8.33,8437.5
41.67,8437.5
75.0,8437.5
108.33,8437.5
141.67,8437.5
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
9975.0,8437.5
13308.33,8437.5
16641.67,8437.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_s_c
0.0,8437.5
8.33,8437.5
41.67,8437.5
75.0,8437.5
108.33,8437.5
141.67,8437.5
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
9975.0,8437.5

```
13308.33,8437.5
16641.67,8437.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q_c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

Listing 49: High ECCS flow, 0.7 filtration

```
Model parameters used:

Filtration Function Type: linear

Filtration Function Parameter Values:
m,N/A
b,N/A
M_c,N/A
delta,N/A
a,N/A

slope,0.0

intercept,0.7

Initial Masses and Strainer Values:
M_p_0,68181.82
V_p,600000.0
M_s_a_0,0.0
M_s_b_0,0.0
M_s_c_0,0.0
Flow Rates over time:
t,Q_s_a
0.0,5500.0
8.33,5500.0
41.67,5500.0
75.0,5500.0
108.33,5500.0
141.67,5500.0
225.0,5500.0
308.33,5500.0
641.67,5500.0
975.0,5500.0
1308.33,5500.0
1641.67,5500.0
2475.0,5500.0
6641.67,5500.0
9975.0,5500.0
13308.33,5500.0
16641.67,5500.0
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```

```
nan,nan
nan,nan

t,Q__s__b
0.0,8437.5
8.33,8437.5
41.67,8437.5
75.0,8437.5
108.33,8437.5
141.67,8437.5
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
9975.0,8437.5
13308.33,8437.5
16641.67,8437.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q__s__c
0.0,8437.5
8.33,8437.5
41.67,8437.5
75.0,8437.5
108.33,8437.5
141.67,8437.5
225.0,8437.5
308.33,8437.5
641.67,8437.5
975.0,8437.5
1308.33,8437.5
1641.67,8437.5
2475.0,8437.5
6641.67,8437.5
9975.0,8437.5
13308.33,8437.5
16641.67,8437.5
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan

t,Q__c
0.0,610.0
8.33,565.81
41.67,520.19
75.0,419.82
108.33,370.37
141.67,340.83
225.0,319.87
308.33,286.78
641.67,265.56
975.0,220.91
1308.33,197.62
1641.67,182.46
2475.0,171.01
6641.67,151.19
9975.0,107.08
13308.33,90.92
16641.67,80.49
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
nan,nan
```