4.3.2 Results

(4.1a) to (4.1c) were integrated in FIDOE using well-known ordinary differential equation solvers[2] implemented in a Python application to obtain $M_c(t)$ (See Listing 11.1). 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 11.1 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 may be based on data with uncertainty (Figure 4.4) or can be set to an arbitrary linear function with slope

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 minimum amount of LDFG fines in all the risk-informed scenarios is approximately 192 lbm Table 10.1 (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.

Table 4.2: Core mass (grams total) 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

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

[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).'

Section 4.3.1) a version of FIDOE was created to investigate fixed fiber penetration values. The updated version of FIDOE uses (4.1) for mass conservation but $f()$ is a constant value set by the user in input. The updated version of FIDOE is provided in Section 11.3 along with input and output files.

Three levels of fixed filtration, 0.4, 0.5 0.6, an 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 4.4 is roughly 0.65. Results of the fixed filtration study are summarized in Table 4.3. 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 4.3: 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

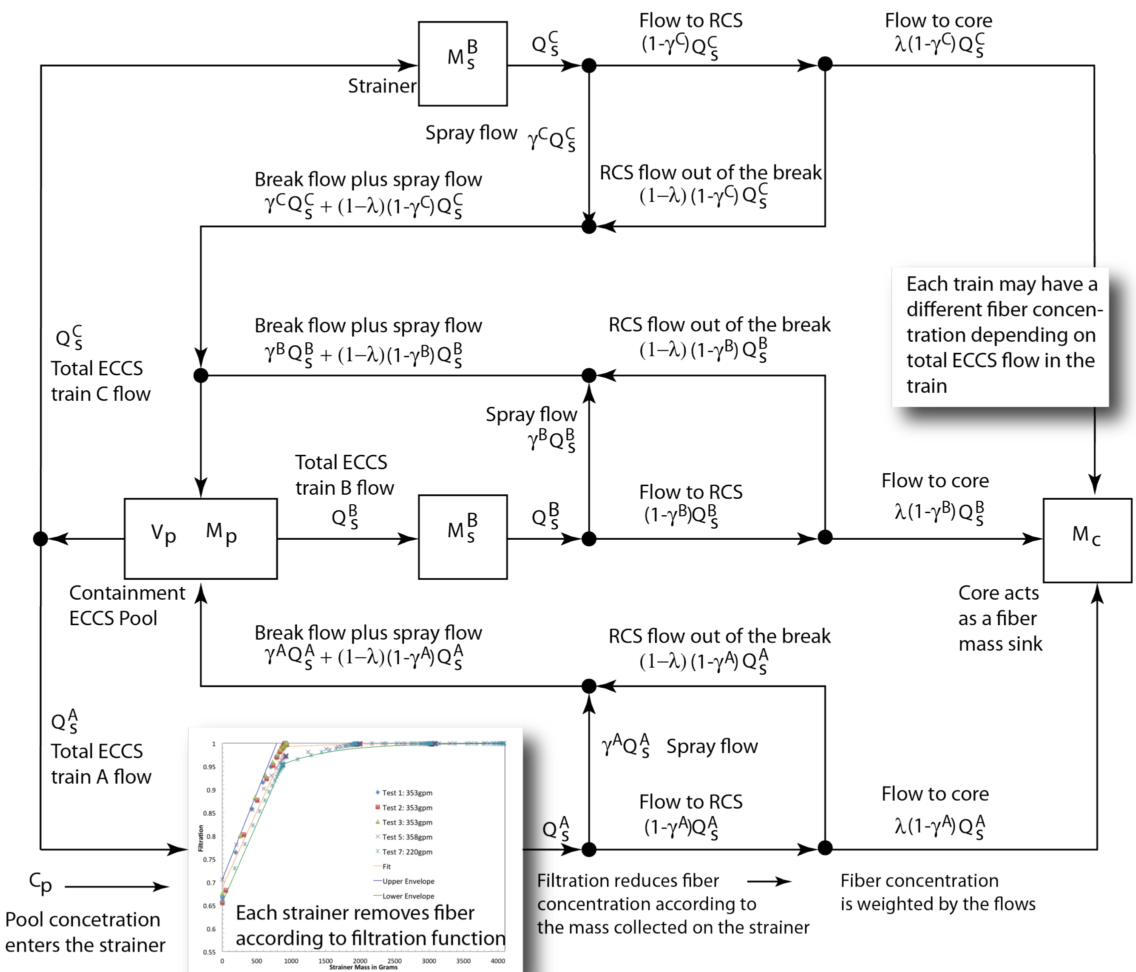

Figure 4.3: Flow network for the three STP ECCS and CSS trains showing the three places debris is caught: the pool, the strainer, and the core during a CLB scenario. Shown as well are the various flow splits that take place between the places debris is caught. The flow split λ is defined by the amount of flow demanded by the core to remove decay heat.

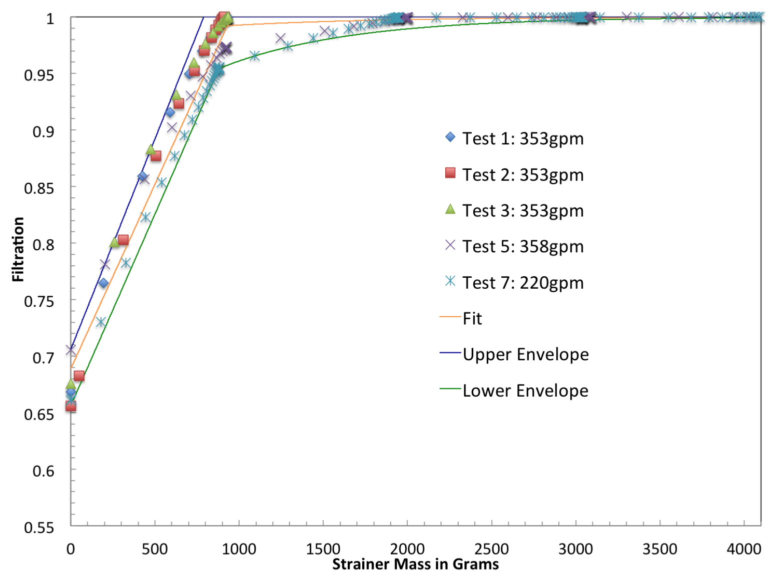

Figure 4.4: Filtration efficiency fits as a function of mass compared to measured data for the STP ECCS strainer modules. Efficiency fits obtained for the upper, central, and lower limits of the measurements are compared to the measured data.

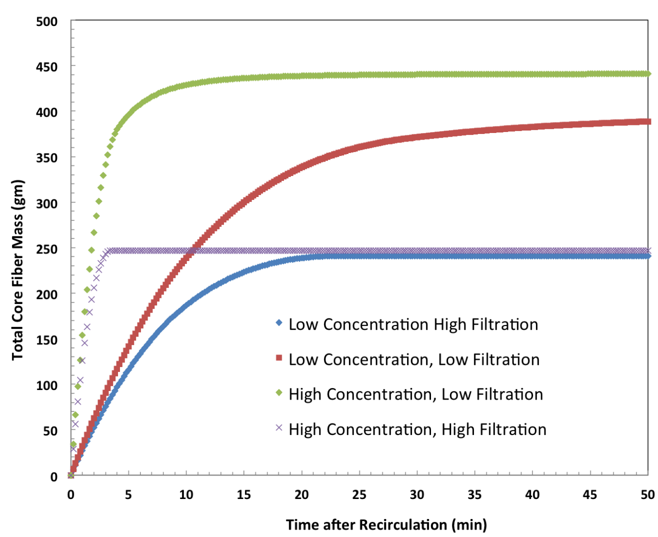

Figure 4.5: Comparison of bounding cases for core LDFG accumulation after start of ECCS recirculation. The mass accumulation should be divided by 193 to obtain gm/FA.