Concern:

Independent CASA Grande runs generated results that appear to be inconsistent with the February 4 STP presentation in two areas: (i) the critical fiber (LDFG fines) threshold of 191.78 lb, used to determine whether the amount of LDFG fines on the strainer is within the tested range of conditions; and (ii) the number of welds that could generate fines in exceedance of the critical threshold.

The independent analysis provided below is consistent with the use of a critical threshold of 191.78 kg (not 191.78 lb) in the STP presentation.

The independent analysis provided below suggests that a LOCA event at total of 68 welds could generate a LDFB load exceeding the critical threshold of 191.78 kg, rather than the 45 welds identified in the STP presentation.

Independent approach:

A CASA Grande run of case 1 (all trains functional) was executed. To keep the number of realizations constrained, the following input values were employed

```
% max # LHS bins in LLOCA for max DEGB (DEGB counts as 1)
% Nmaxbrk =  2 => 2044 total breaks
% Nmaxbrk =  3 => 2100 total breaks
% Nmaxbrk =  5 => 2250 total breaks
% Nmaxbrk = 10 => 3070 total breaks
5

% # LHS replicates (batches) for each frequency CCDF
5

% # epistemic freq envelope samples
% current models process ~110 cases per minute
5
```

A total of 56,150 CASA Grande realizations were executed. The CASA Grande code was modified to output the maximum (pool+bed) debris mass for the 36-hour simulation time, itemized by debris type, and the weld location for each realization.

The weld locations that can produce large breaks (>5.189 in) were identified. Of the 628 welds simulated in CASA Grande, only 377 can produce large breaks.

All of the realizations corresponding to a specific weld location were identified. The number of realizations per weld location ranged from 75 to 175. For this subset of realizations corresponding to the same weld location, the realizations were sorted by increasing break size. The sorted pairs of break and debris mass can be plotted to estimate the amount of debris as a function of the break size. Figure 1 is an example of debris mass (LDFG fines) versus break size curve constructed with 100 points or 100 realizations for weld location 10-RH-1108-BB1-1. In each realization, a different value of the break size was sampled by CASA Grande. It is recognized that other stochastic parameters vary from realization to realization. However, the approach implemented was only intended to derive an approximation of the debris mass as a function of the break size for each weld location.

Following the example from Figure 1, debris mass versus break size curves were constructed for each of the weld locations (377 weld locations) and each of the debris types. The results are included in Figures 2 and 3, grouped in plots for each debris type. Figure 2 shows fibrous debris types, and Figure 3 shows particulate debris types. Each plot includes a total of 377 curves. Each curve is constructed from a range of 75 to 175 realizations (i.e., 75 to 175 points joined by lines). Most of the plots in Figures 2 and 3 are provided only to show results itemized by debris type, to allow for checking of trends. In the discussion that follows, only the low-density fiber glass (LDFG) fines versus break size plot is used in the analysis.

The source data to re-create the plots, output by a modified version of the CASA Grande code (Version 1.6 dated March 13, 2014) is included in the attached file OP_DebrisMass.xlsx.

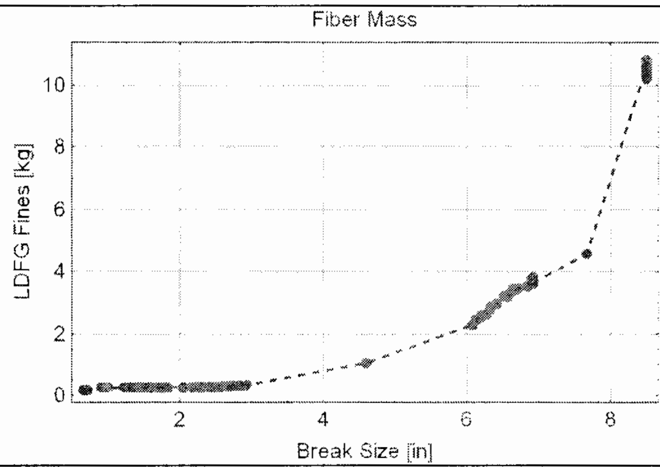


Figure 1. Example of debris mass versus break size for weld location 10-RH-1108-BB1-1.

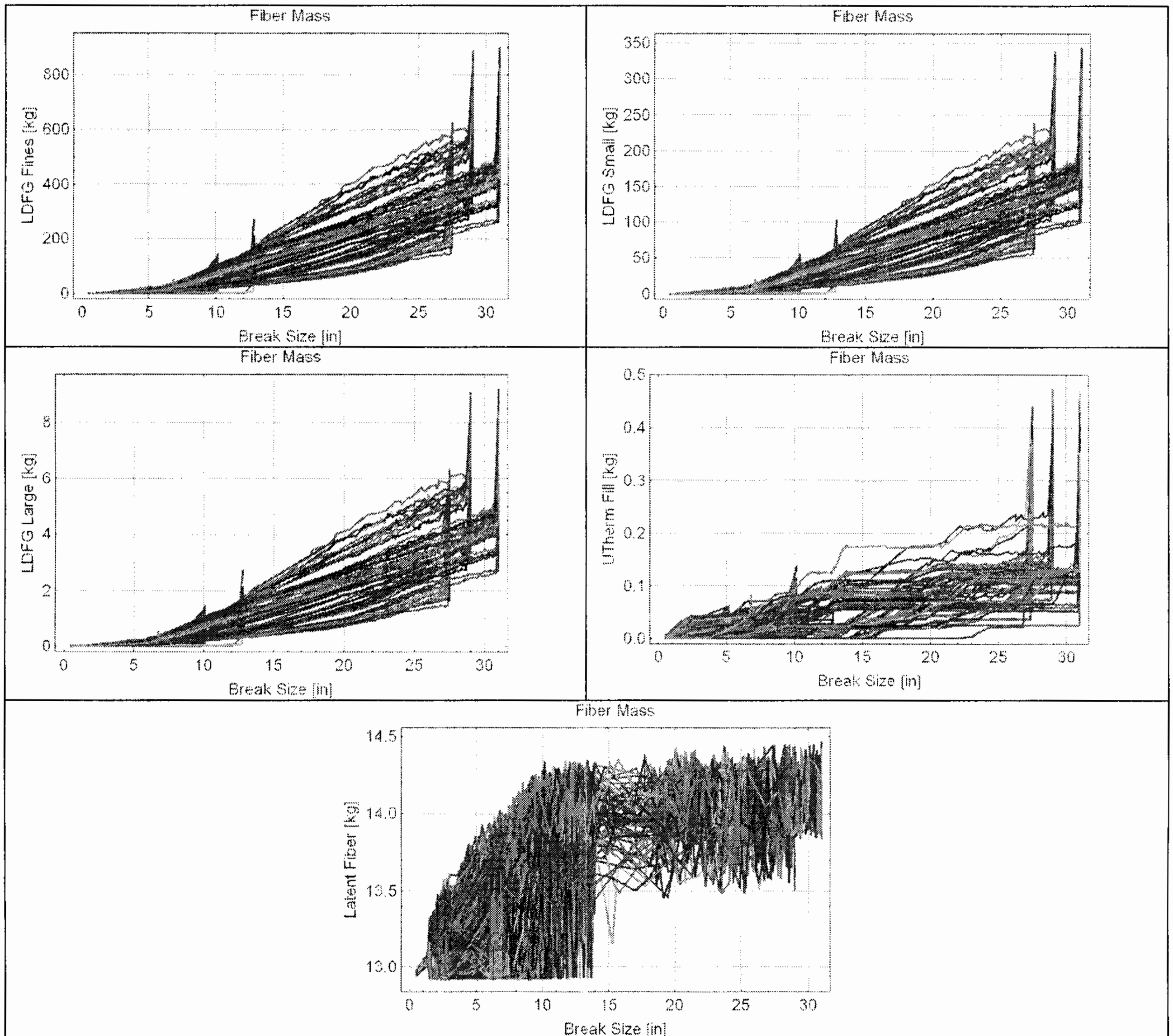
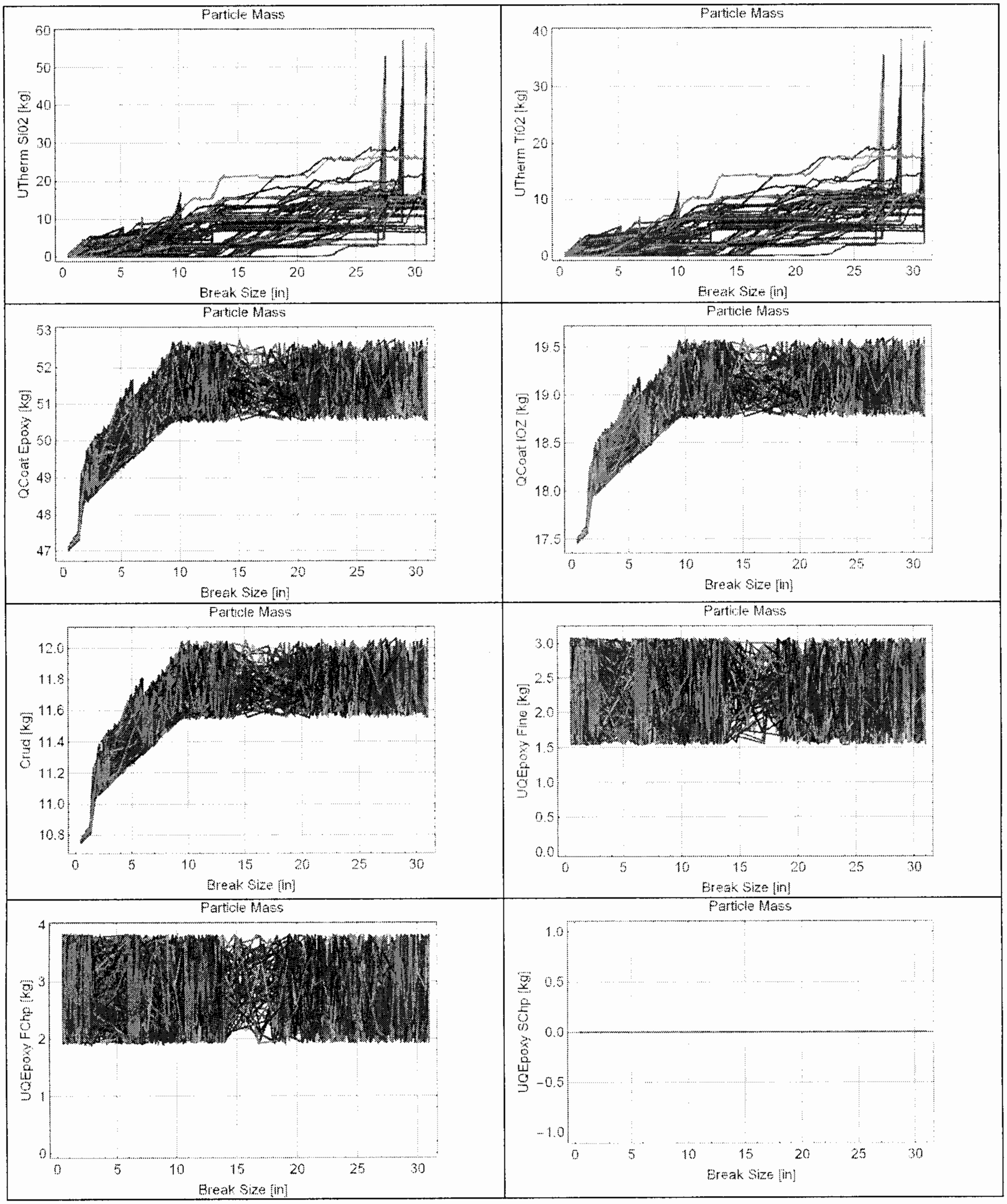


Figure 2: Mass of fibrous debris as a function of the break size computed by CASA Grande for welds that yield large breaks. For each realization, the mass was computed as the maximum(pool+bed) within a 36-hour simulation time. Each single-color curve in any plot represents a single weld location. There are 377 curves (i.e., weld locations) in each plot. Each curve is comprised of a range of 75 to 175 points. Each point is a different CASA Grande realization.


Particle Mass
UTherm Si02 [kg]
Break Size [in]
Particle Mass
UTherm Ti02 [kg]
Break Size [in]
Particle Mass
QCoat Epoxy [kg]
Break Size [in]
Particle Mass
QCoat IOZ [kg]
Break Size [in]
Particle Mass
Crud [kg]
Break Size [in]
Particle Mass
UQEpoxy Fine [kg]
Break Size [in]
Particle Mass
UQEpoxy FChp [kg]
Break Size [in]
Particle Mass
UQEpoxy SChp [kg]
Break Size [in]

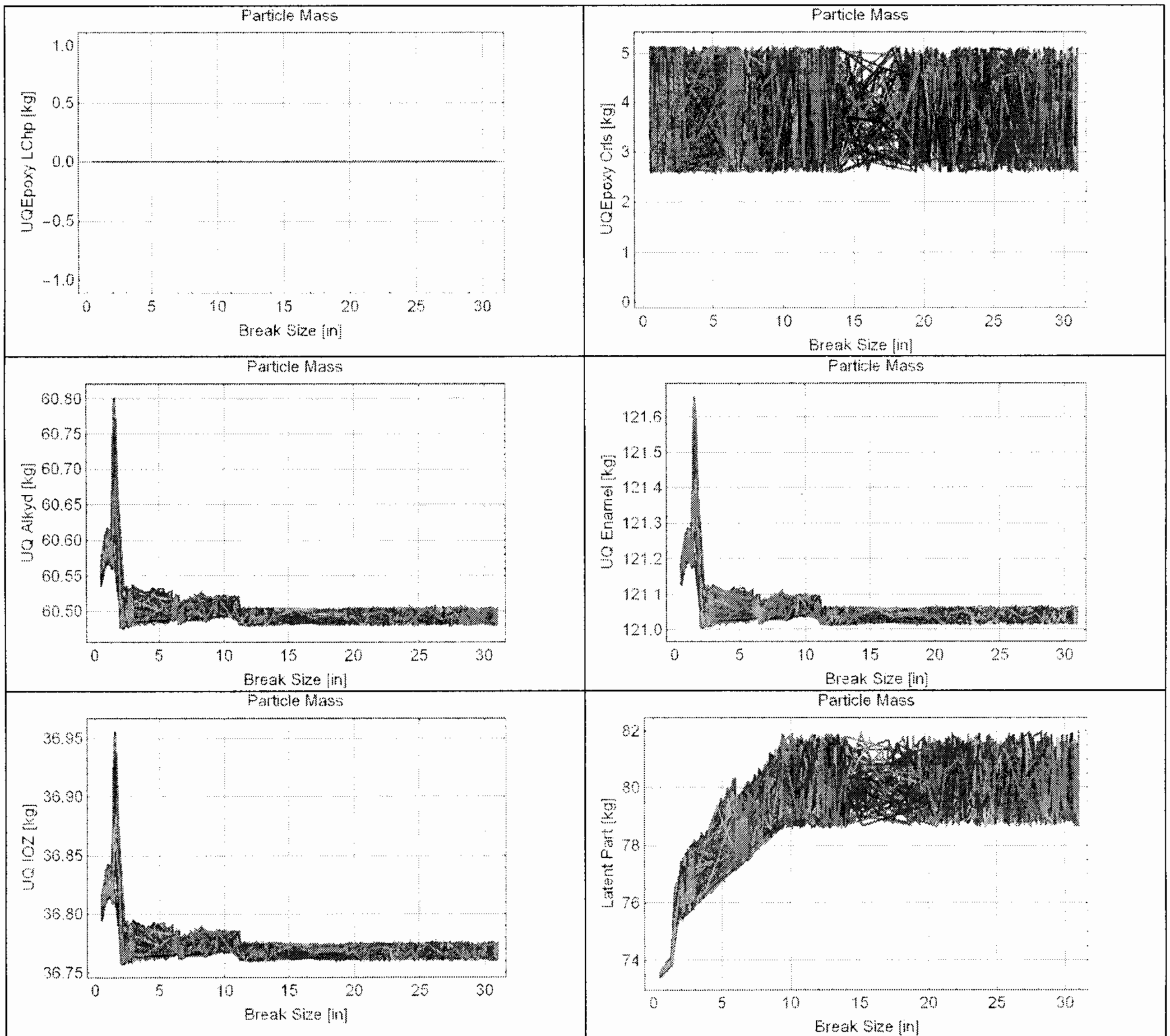


Figure 3: Mass of particulate debris as a function of the break size computed by CASA Grande for welds that yield large breaks. For each realization, the mass was computed as the maximum(pool+bed) within a 36-hour simulation time. Each curve single-color in any plot represents a single weld location. There are 377 curves (i.e., weld locations) in each plot. Each curve is comprised of a range of 75 to 175 points. Each point is a different CASA Grande realization.

The User Guide for Version 1.6, page 93 (see the units for the files Time History – Particulate.txt and Time History – Fiber.txt) implies that CASA Grande internally tracks mass in units of kg. According to the internal code documentation, the Matlab module computing the head loss, headloss.m, requires quantities in International System (SI) units, as does the module computing mass balances, debris_calc.m. The following is an extract of the debris_calc.m module:

```
mperft = 0.3048006;
kgperlbm = 0.4535924;

Aclean = Aclean*mperft^2;                              % clean area (m2)
Dfill(iparts) = Dfill(iparts)*kgperlbm;                % particles (kg)
Dfill(ifiber) = Dfill(ifiber)*mperft^3;                % fiber (m^3)
Dpool(iparts) = Dpool(iparts)*kgperlbm;                % particles (kg)
Dpool(ifiber) = Dpool(ifiber)*mperft^3;                % fiber (m^3)
Ddiam = Ddiam*1e-6;                                    % diam (m)
Drhomat = Drhomat*kgperlbm/mperft^3;                   % rho matl (kg/m^3)
Drhomfc = Drhomfc*kgperlbm/mperft^3;                   % rho manf (kg/m^3)
Vgeom = Vgeom*mperft^3;                                % vol. interp vector (m^3)
xgeom = xgeom/12*mperft;                               % thick. interp vector (m)
Dpool(ifiber) = Dpool(ifiber).*Drhomfc(ifiber);        % fiber (kg)
Dfill(ifiber) = Dfill(ifiber).*Drhomfc(ifiber);        % fiber (kg)
```

Figures 1 through 3 use the kg unit to report CASA Grande output because masses are internally tracked in CASA Grande in kg units, and are not converted on output to a different unit such as lb.

Slide 11 of the presentation for the public meeting on February 4 reports a critical fiber (LDFB fines) threshold of 191.78 lb. Fiber loads below this critical limit are considered within testing conditions and are therefore regarded as safe. For the sake of the risk assessment, STP will consider LDFG loads on the strainer exceeding the critical fiber threshold to be strainer-failed conditions.

The following analysis identifies weld locations that can yield LDFB fines in excess of 191.78 lb (=87 kg) and in excess of 191.78 kg. The higher limit results in values and weld locations that are consistent with the tabulated data in Slides 17-19 of the February 4 presentation. Therefore, we suggest that there may be a kg to lb conversion error either in the CASA Grande or in the results presented at the February 4 meeting.

Figure 4 superimposes the 191.78 lb and 191.78 kg thresholds on the curves of LDFG fines versus break size from Figure 2. The exceedance breaks are computed, by interpolation, by determining the point at which the LDFG fines mass versus break size crosses the dotted lines, for each weld location. Table 1 shows the 191.78 lb exceedance breaks (i.e. the break at which the produced LDFG fines would exceed 191.78 lb). A total of 109 weld locations were identified that could exceed 191.78 lb of LDFG fines. Each of the 45 exceedance breaks reported in Slides 17-19 of the February 4 presentation is larger than the interpolated break size for the same weld (ranging from 9.2 in to 21.5 in) using a threshold of 191.78 lb.

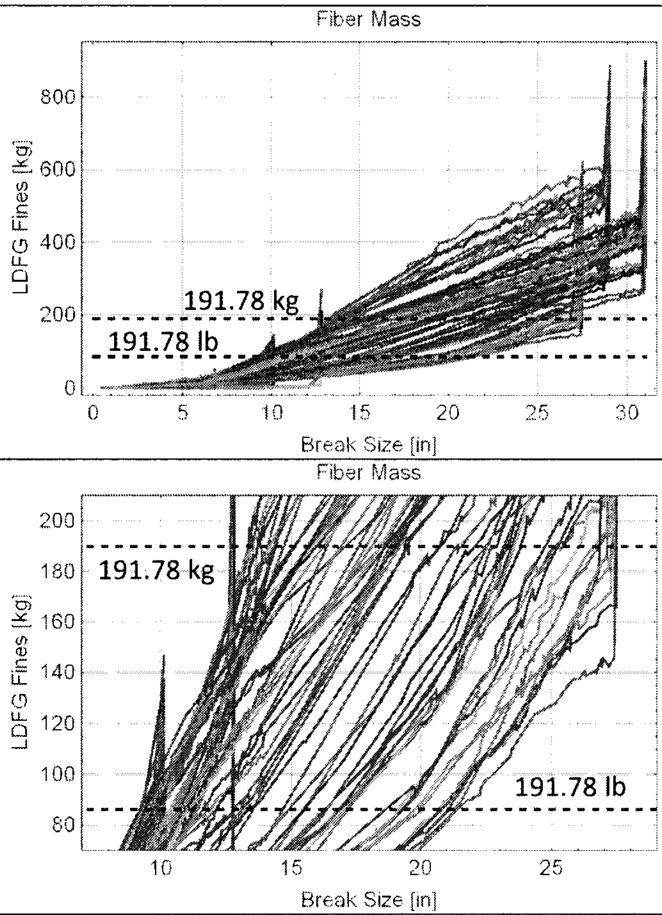


Figure 4: LDFG Fiber versus break size. The intersection of the fiber versus break size curves with the dotted lines is used to estimate the exceedance break.

Table 1: Estimated break size at which the produced LDFG fines could exceed 191.78 lb.

Location	Cold Leg?	Identified in Slides 17-19	Exceedance Break Size [in] CNWRA	Exceedance Break Size [in] in Slides 17-19	Difference [in]
12-RC-1112-BB1-1	0	FALSE	10.02	NA	NA
12-RC-1112-BB1-2	0	FALSE	9.83	NA	NA
12-RC-1125-BB1-10	1	FALSE	10.02	NA	NA
12-RC-1125-BB1-11	1	FALSE	9.94	NA	NA
12-RC-1125-BB1-12	1	FALSE	10.00	NA	NA
12-RC-1125-BB1-13	1	FALSE	10.10	NA	NA
12-RC-1125-BB1-8	1	FALSE	10.12	NA	NA
12-RC-1125-BB1-9	1	FALSE	9.87	NA	NA
12-RC-1212-BB1-1	0	FALSE	10.05	NA	NA
12-RC-1212-BB1-2	0	FALSE	10.05	NA	NA
12-RC-1212-BB1-8	0	FALSE	10.00	NA	NA
12-RC-1221-BB1-10	1	FALSE	9.94	NA	NA
12-RC-1221-BB1-11	1	FALSE	9.68	NA	NA
12-RC-1221-BB1-12	1	FALSE	10.03	NA	NA
12-RC-1221-BB1-13	1	FALSE	9.94	NA	NA
12-RC-1221-BB1-14	1	FALSE	10.11	NA	NA
12-RC-1221-BB1-8	1	FALSE	9.96	NA	NA
12-RC-1221-BB1-9	1	FALSE	9.87	NA	NA
12-RC-1312-BB1-1	0	FALSE	10.05	NA	NA
12-RC-1312-BB1-2	0	FALSE	10.08	NA	NA
12-RC-1312-BB1-3	0	FALSE	10.10	NA	NA
12-RC-1312-BB1-7	0	FALSE	10.13	NA	NA
12-RC-1312-BB1-8	0	FALSE	10.02	NA	NA
12-RC-1312-BB1-9	0	FALSE	10.13	NA	NA
12-RC-1322-BB1-1	1	FALSE	10.12	NA	NA
12-RC-1322-BB1-1A	1	FALSE	9.34	NA	NA
12-RC-1322-BB1-2	1	FALSE	9.83	NA	NA
12-RC-1322-BB1-3	1	FALSE	10.08	NA	NA
12-RC-1322-BB1-4	1	FALSE	10.09	NA	NA
12-RH-1201-BB1-1	0	FALSE	9.93	NA	NA
12-RH-1201-BB1-6	0	FALSE	10.12	NA	NA
12-SI-1315-BB1-10	1	FALSE	10.04	NA	NA
12-SI-1315-BB1-7	1	FALSE	10.08	NA	NA
12-SI-1315-BB1-8	1	FALSE	10.01	NA	NA
12-SI-1315-BB1-9	1	FALSE	9.32	NA	NA
16-RC-1412-NSS-5	0	FALSE	12.77	NA	NA
16-RC-1412-NSS-6	0	FALSE	12.77	NA	NA

16-RC-1412-NSS-7	0	FALSE	12.75	NA	NA
16-RC-1412-NSS-8	0	TRUE	9.43	12.81	3.39
16-RC-1412-NSS-9	0	FALSE	11.23	NA	NA
27.5-RC-1103-NSS-1	1	TRUE	13.24	19.46	6.22
27.5-RC-1103-NSS-6	1	FALSE	20.76	NA	NA
27.5-RC-1103-NSS-7	1	FALSE	19.41	NA	NA
27.5-RC-1103-NSS-RPV1-N2A5E	1	FALSE	19.37	NA	NA
27.5-RC-1203-NSS-1	1	TRUE	13.19	19.57	6.38
27.5-RC-1203-NSS-4	1	FALSE	21.47	NA	NA
27.5-RC-1203-NSS-5	1	FALSE	19.20	NA	NA
27.5-RC-1203-NSS-RPV1-N2BSE	1	FALSE	19.00	NA	NA
27.5-RC-1303-NSS-1	1	TRUE	14.60	21.05	6.46
27.5-RC-1303-NSS-3	1	FALSE	10.13	NA	NA
27.5-RC-1303-NSS-5	1	FALSE	21.50	NA	NA
27.5-RC-1303-NSS-6	1	FALSE	20.85	NA	NA
27.5-RC-1303-NSS-RPV1-N2CSE	1	FALSE	20.84	NA	NA
27.5-RC-1403-NSS-1	1	TRUE	15.5S	22.05	6.50
27.5-RC-1403-NSS-5	1	FALSE	21.10	NA	NA
27.5-RC-1403-NSS-6	1	FALSE	19.86	NA	NA
27.5-RC-1403-NSS-RPV1-N2DSE	1	FALSE	20.07	NA	NA
29-RC-1101-NSS-1	0	FALSE	16.36	NA	NA
29-RC-1101-NSS-3	0	FALSE	9.94	NA	NA
29-RC-1101-NSS-4	0	TRUE	10.74	15.05	4.32
29-RC-1101-NSS-5.1	0	TRUE	9.80	13.94	4.15
29-RC-1101-NSS-RPV1-N1ASE	0	FALSE	16.43	NA	NA
29-RC-1101-NSS-RSG-1A-IN-SE	0	TRUE	9.85	13.92	4.08
29-RC-1201-NSS-1	0	FALSE	17.23	NA	NA
29-RC-1201-NSS-3	0	FALSE	9.94	NA	NA
29-RC-1201-NSS-4	0	TRUE	11.09	15.09	4.00
29-RC-1201-NSS-5.1	0	TRUE	10.01	14.43	4.42
29-RC-1201-RPV1-N1BSE	0	FALSE	16.99	NA	NA
29-RC-1201-RSG-1B-IN-SE	0	TRUE	9.97	14.54	4.57
29-RC-1301-NSS-1	0	FALSE	17.17	NA	NA
29-RC-1301-NSS-3	0	FALSE	9.93	NA	NA
29-RC-1301-NSS-4	0	TRUE	11.06	15.50	4.44
29-RC-1301-NSS-5.1	0	TRUE	9.80	14.43	4.63
29-RC-1301-RPV1-N1CSE	0	FALSE	17.22	NA	NA
29-RC-1301-RSG-1C-IN-SE	0	TRUE	9.79	14.37	4.57
29-RC-1401-NSS-1	0	FALSE	16.40	NA	NA
29-RC-1401-NSS-2	0	FALSE	11.27	NA	NA
29-RC-1401-NSS-3	0	TRUE	10.98	15.29	4.32

29-RC-1401-NSS-4.1	0	TRUE	9.97	14.43	4.46
29-RC-1401-NSS-RPV1-N1DSE	0	FALSE	16.95	NA	NA
29-RC-1401-NSS-RSG-1D-IN-SE	0	TRUE	10.00	14.40	4.41
31-RC-1102-NSS-1.1	1	TRUE	9.47	17.07	7.60
31-RC-1102-NSS-2	1	TRUE	9.62	16.41	6.79
31-RC-1102-NSS-3	1	TRUE	10.49	17.37	6.89
31-RC-1102-NSS-4	1	TRUE	11.39	18.18	6.79
31-RC-1102-NSS-8	1	TRUE	12.22	19.62	7.39
31-RC-1102-NSS-9	1	TRUE	13.50	21.28	7.78
31-RC-1102-NSS-RSG-1A-ON-SE	1	TRUE	9.63	17.20	7.57
31-RC-1202-NSS-1.1	1	TRUE	9.37	16.98	7.61
31-RC-1202-NSS-2	1	TRUE	9.26	16.78	7.51
31-RC-1202-NSS-3	1	TRUE	9.93	17.24	7.31
31-RC-1202-NSS-4	1	TRUE	10.80	17.84	7.04
31-RC-1202-NSS-8	1	TRUE	11.71	19.24	7.53
31-RC-1202-NSS-9	1	TRUE	11.77	21.12	9.34
31-RC-1202-NSS-RSG-1B-ON-SE	1	TRUE	9.42	16.93	7.50
31-RC-1302-NSS-1.1	1	TRUE	10.01	17.64	7.63
31-RC-1302-NSS-2	1	TRUE	9.81	17.35	7.54
31-RC-1302-NSS-3	1	TRUE	10.40	17.92	7.52
31-RC-1302-NSS-4	1	TRUE	11.45	18.34	6.89
31-RC-1302-NSS-8	1	TRUE	12.82	20.35	7.53
31-RC-1302-NSS-9	1	TRUE	14.92	23.17	8.25
31-RC-1302-NSS-RSG-1C-ON-SE	1	TRUE	9.90	18.11	8.20
31-RC-1402-NSS-1.1	1	TRUE	10.78	18.14	7.35
31-RC-1402-NSS-2	1	TRUE	11.14	18.31	7.17
31-RC-1402-NSS-3	1	TRUE	12.18	19.25	7.07
31-RC-1402-NSS-4	1	TRUE	13.58	20.24	6.66
31-RC-1402-NSS-8	1	TRUE	15.55	22.17	6.62
31-RC-1402-NSS-9	1	TRUE	17.36	25.34	7.98
31-RC-1402-NSS-RSG-1D-ON-SE	1	TRUE	10.80	18.20	7.40

Table 2 lists the weld locations and break sizes that the independent analysis suggests could exceed 191.78 kg of LDFG fines. All of the 45 weld locations in Slides 17-19 of the February 4 presentation are included in this list, and the magnitude of the exceedance break is in agreement with the STP values. Figure 5 is included to demonstrate that the agreement of the two sets of results (the STP results and our independent results) is reasonable when the critical limit is assumed to be 191.78 kg. Figure 5(A) shows the exceedance breaks assuming a threshold limit of 191.78 lb versus exceedance breaks in Slides 17-19 (data from Table 1). Figure 5(B) displays the exceedance breaks assuming a threshold limit of 191.78 kg versus exceedance breaks in Slides 17-19 (data from Table 2). Figure 5 indicates that data in Table 2 is in better agreement with the STP values in Slides 17-19. Differences in the results are expected because only a limited number of CASA Grande realizations were executed in our independent analyses. However, the results are in such a reasonable agreement, that it is warranted to request STP to check whether it used 191.78 kg as threshold value in its computations, instead of 191.78 lb.

In the independent computations, a total of 68 weld locations were identified that could exceed the 191.78 lb threshold. Why did STP identify fewer locations (i.e., 45 locations)?

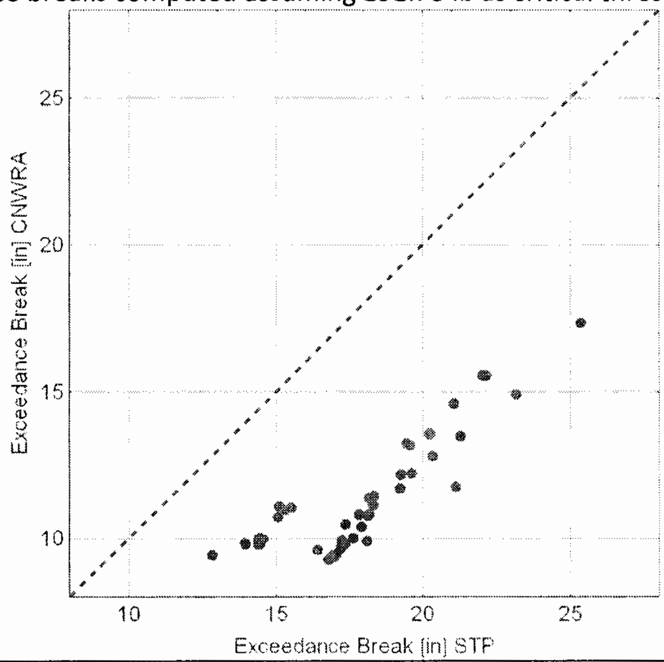
Table 2: Estimated break size at which the produced LDFG fines could exceed 191.78 kg.

Location	Cold Leg?	Identified in Slides 17-19	Exceedance Break Size [in] CNWRA	Exceedance Break Size [in] in Slides 17-19	Difference [in]
16-RC-1412-NSS-7	0	FALSE	12.81	NA	NA
16-RC-1412-NSS-8	0	TRUE	12.68	12.814	0.13
16-RC-1412-NSS-9	0	FALSE	12.79	NA	NA
27.5-RC-1103-NSS-1	1	TRUE	18.95	19.461	0.51
27.5-RC-1103-NSS-6	1	FALSE	26.75	NA	NA
27.5-RC-1103-NSS-7	1	FALSE	25.50	NA	NA
27.5-RC-1103-NSS-RPV1-N2ASE	1	FALSE	24.96	NA	NA
27.S-RC-1203-NSS-1	1	TRUE	19.06	19.566	0.50
27.5-RC-1203-NSS-4	1	FALSE	26.91	NA	NA
27.5-RC-1203-NSS-5	1	FALSE	26.12	NA	NA
27.5-RC-1203-NSS-RPV1-N2BSE	1	FALSE	25.32	NA	NA
27.5-RC-1303-NSS-1	1	TRUE	20.92	21.053	0.13
27.5-RC-1303-NSS-5	1	FALSE	27.05	NA	NA
27.5-RC-1303-NSS-6	1	FALSE	27.26	NA	NA
27.5-RC-1303-NSS-RPV1-N2CSE	1	FALSE	27.23	NA	NA
27.5-RC-1403-NSS-1	1	TRUE	21.55	22.047	0.49
27.5-RC-1403-NSS-5	1	FALSE	26.83	NA	NA
27.5-RC-1403-NSS-6	1	FALSE	27.35	NA	NA
27.5-RC-1403-NSS-RPV1-N2DSE	1	FALSE	27.12	NA	NA
29-RC-1101-NSS-1	0	FALSE	23.16	NA	NA
29-RC-1101-NSS-4	0	TRUE	14.07	15.052	0.98
29-RC-1101-NSS-5.1	0	TRUE	13.38	13.941	0.56
29-RC-1101-NSS-RPV1-N1ASE	0	FALSE	22.97	NA	NA
29-RC-1101-NSS-RSG-1A-IN-SE	0	TRUE	13.40	13.924	0.52
29-RC-1201-NSS-1	0	FALSE	23.88	NA	NA
29-RC-1201-NSS-4	0	TRUE	14.41	15.087	0.68
29-RC-1201-NSS-5.1	0	TRUE	13.56	14.428	0.87
29-RC-1201-RPV1-N1BSE	0	FALSE	23.54	NA	NA
29-RC-1201-RSG-1B-IN-SE	0	TRUE	13.57	14.542	0.97
29-RC-1301-NSS-1	0	FALSE	23.37	NA	NA
29-RC-1301-NSS-4	0	TRUE	14.45	15.496	1.04

29-RC-1301-NSS-5.1	0	TRUE	13.77	14.434	0.66
29-RC-1301-RPV1-N1CSE	0	FALSE	23.63	NA	NA
29-RC-1301-RSG-1C-IN-SE	0	TRUE	13.82	14.368	0.55
29-RC-1401-NSS-1	0	FALSE	22.64	NA	NA
29-RC-1401-NSS-2	0	FALSE	12.81	NA	NA
29-RC-1401-NSS-3	0	TRUE	14.60	15.294	0.69
29-RC-1401-N5S-4.1	0	TRUE	14.13	14.428	0.29
29-RC-1401-NSS-RPV1-N1DSE	0	FALSE	23.41	NA	NA
29-RC-1401-NSS-RSG-1D-IN-SE	0	TRUE	14.18	14.404	0.22
31-RC-1102-NSS-1.1	1	TRUE	15.90	17.071	1.18
31-RC-1102-NSS-2	1	TRUE	15.76	16.408	0.65
31-RC-1102-NSS-3	1	TRUE	15.75	17.374	1.62
31-RC-1102-NSS-4	1	TRUE	16.46	18.179	1.72
31-RC-1102-NSS-8	1	TRUE	18.67	19.617	0.95
31-RC-1102-NSS-9	1	TRUE	20.90	21.278	0.37
31-RC-1102-NSS-RSG-1A-ON-SE	1	TRUE	15.96	17.2	1.24
31-RC-1202-NSS-1.1	1	TRUE	15.98	16.981	1.00
31-RC-1202-NSS-2	1	TRUE	15.25	16.777	1.52
31-RC-1202-NSS-3	1	TRUE	15.06	17.24	2.18
31-RC-1202-NSS-4	1	TRUE	15.71	17.843	2.13
31-RC-1202-NSS-8	1	TRUE	17.82	19.235	1.42
31-RC-1202-NSS-9	1	TRUE	19.31	21.116	1.81
31-RC-1202-NSS-RSG-1B-ON-SE	1	TRUE	16.14	16.928	0.79
31-RC-1302-NSS-1.1	1	TRUE	18.58	17.636	-0.95
31-RC-1302-NSS-2	1	TRUE	17.30	17.345	0.04
31-RC-1302-NSS-3	1	TRUE	16.48	17.919	1.44
31-RC-1302-NSS-4	1	TRUE	17.06	18.343	1.28
31-RC-1302-NSS-8	1	TRUE	19.42	20.35	0.93
31-RC-1302-NSS-9	1	TRUE	22.61	23.169	0.56
31-RC-1302-NSS-RSG-1C-ON-SE	1	TRUE	18.80	18.108	-0.69
31-RC-1402-NSS-1.1	1	TRUE	18.24	18.137	-0.10
31-RC-1402-NSS-2	1	TRUE	18.56	18.311	-0.25
31-RC-1402-NSS-3	1	TRUE	19.19	19.247	0.06
31-RC-1402-NSS-4	1	TRUE	19.54	20.236	0.69
31-RC-1402-NSS-8	1	TRUE	22.17	22.174	0.01
31-RC-1402-NSS-9	1	TRUE	25.52	25.335	-0.19
31-RC-1402-NSS-RSG-1D-ON-SE	1	TRUE	18.00	18.198	0.19

(A) Data from Table 1

CNWRA exceedance breaks computed assuming 191.78 lb as critical threshold for LDFG fines



(B) Data from Table 2

CNWRA exceedance breaks computed assuming 191.78 kg as critical threshold for LDFG fines

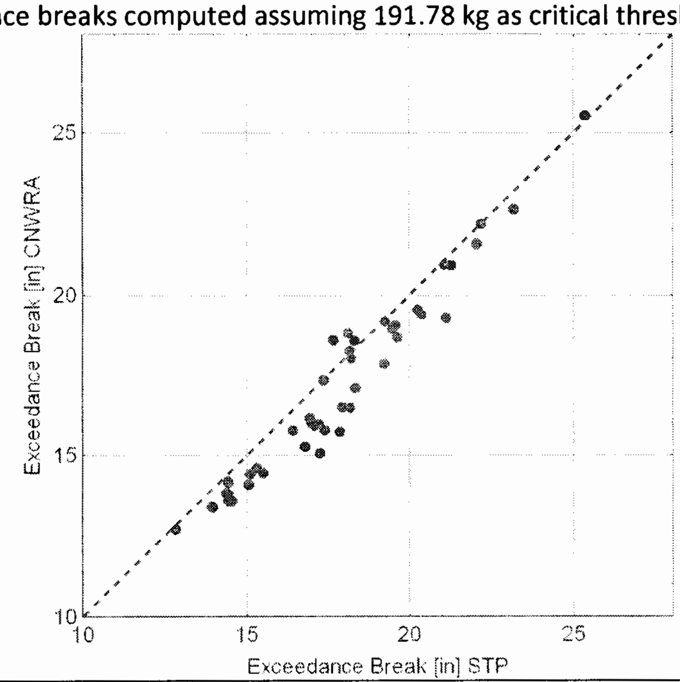


Figure 5. Exceedance break independently computed versus the exceedance break reported in Slides 17-19 of the February 4 presentation, for 45 weld locations. Values exactly falling on the dotted line indicate identical results in both methods.