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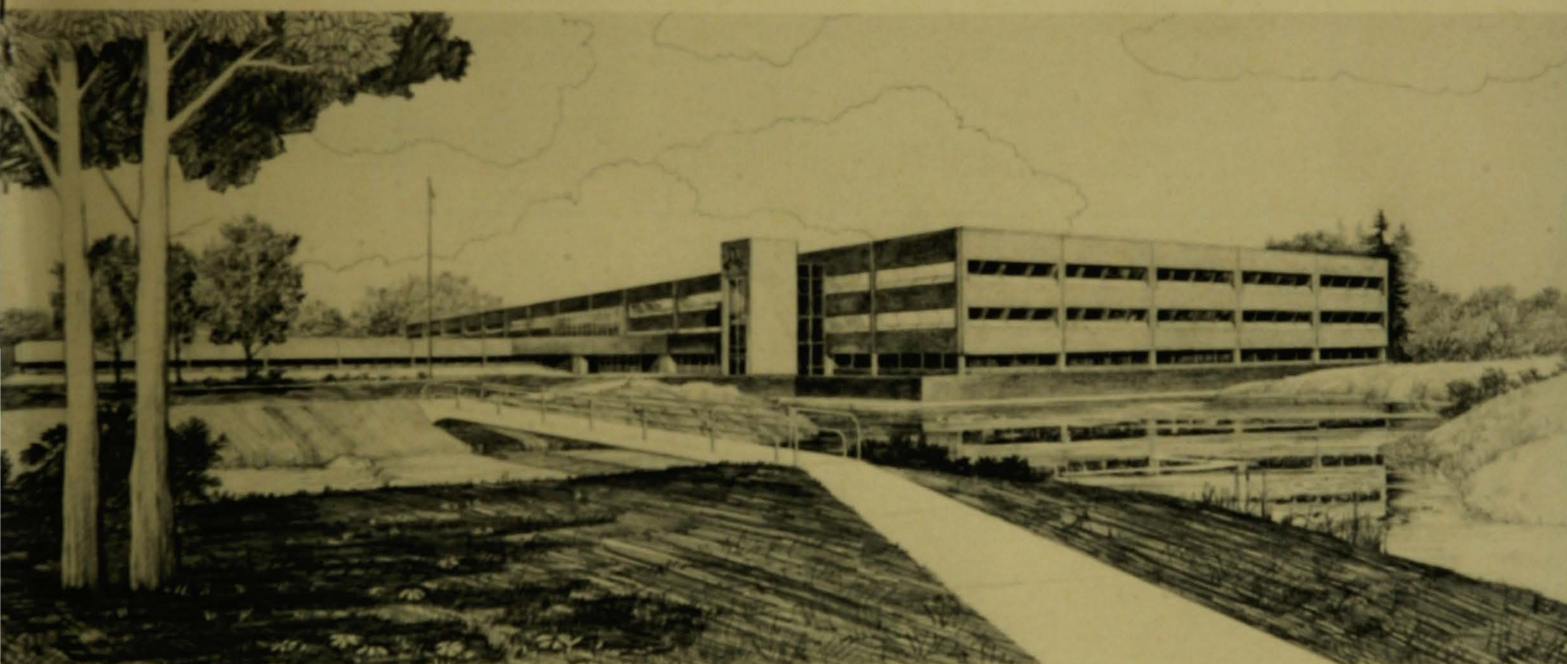
DRAFT REPORT:

TMI-2 CORE DEBRIS-CESIUM RELEASE/SETTLING TEST

Douglas W. Akers
Delbert A. Johnson

Idaho National Engineering Laboratory
Operated by the U.S. Department of Energy

Informal Report



Prepared for the
U.S. DEPARTMENT OF ENERGY
Under DOE Contract No. DE-AC07-76ID01570

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Douglas W. Akers
Delbert A. Johnson

EG&G Idaho, Inc.
Idaho Falls, Idaho 83415

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ACKNOWLEDGMENT

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ABSTRACT

Cesium release, turbidity and airborne potential tests were conducted on 50 grams of TMI-2 core debris materials. The tests were performed on the debris in two stages: (1) undisturbed, without fracturing the debris particles, and (2) disturbed, after crushing the debris particles. Data from the tests will assist the GPU Nuclear defueling task.

A brief summary of the analysis results are as follows.

1. Crushing the debris has minimal impact on turbidity. In general, the opacity of both solutions decreased at about the same rate (within a factor of 2).

2. Crushing the debris increased the soluble ^{137}Cs concentrations a factor of 4 to 5.

3. Most of the airborne activity occurred near the end of the evaporation process, just prior to dry out. The increase in airborne concentration at this time is two to three orders of magnitude higher than at any other time.

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1. INTRODUCTION

The cesium release and settling tests were incorporated into the core debris examination program to support data requirements of General Public Utilities (GPU) Nuclear for reactor recovery. Reactor recovery issues that are addressed by these tests are:

- o What are the release rates of radioisotopes from existing and freshly created surfaces?
- o Does the core debris present any unanticipated defueling concerns? (Filtration properties and settling rate).
- o What is the airborne potential for radioactive particles?

These data requirements are necessary to aid TMI defueling planning. The physical and radiological characteristics of the core debris which provide information concerning these issues have been evalutated and the results of these evaluations are presented in this report.

2. MATERIALS AND METHODS

Approximately 50 grams of debris taken from Sample Number 6 (E9-22 in. into the debris bed) were used for the tests. Three types of tests were conducted as summarized below:

- Minor Disturbance Test--Approximately 50 grams of debris were mixed in a simulated reactor coolant solution and allowed to settle. Samples were removed at specified intervals and turbidimetry and radionuclide analysis were performed. The samples were filtered and analyses performed on both solid and liquid sample fractions.

- Major Disturbance Test--This test was similar to the minor disturbance test except that the core debris were crushed to expose freshly fractured surface areas before mixing it in the simulated reactor coolant solution. The 50 grams of debris used in the minor disturbance test were also used for this test.

- Airborne Evaporation Test--The airborne evaporation test was performed on the simulated reactor coolant solution remaining from both the minor and major disturbance tests. The minor and major disturbance test solutions (~500 ml each) were transferred to an enclosed evaporation chamber where an air-stream of 3048 cm/min (100 linear ft/min) was passed over the surface of the solution. The air-stream was passed through a 0.45 μm HEPA filter which was analyzed for radionuclide content.

3. DESCRIPTION OF MATERIALS AND EXPERIMENTAL PROCEDURES

3.1 Minor Disturbance Test

3.1.1 Materials and Equipment

- Core debris--48.75-grams of material taken from Sample 6 (core position E9, 22-in. into the debris bed). Approximately 35% of the sample was used (see Table 1).

- Simulated reactor coolant water containing 5000 ppm boron, 1500 ppm sodium at a pH of 7.6.

- One liter plastic bottle.

- 25 ml high volume syringe.

- Glass curvettes, 25 ml.

- Turbidimeter, H.F. Instruments Co., Model DRT-1000.

- High volume filtration sysem with a HEPA filter, 0.45 μm size.

3.1.2 Procedure

The core debris (48.75 grams) and 1 liter of liquid (simulated reactor coolant) were placed into a 1 liter plastic bottle. The bottle was inverted several times to mix the contents. At predetermined time intervals, 25 ml samples of the solution were withdrawn from a specific depth (~5 cm) near the top surface of the solution using a syringe. Each sample was then transferred into a 25 ml glass curvette which was placed in the turbidimeter and the opacity of the solution measured.

Following turbidimetry measurements, each sample was filtered to separate the solid and liquid sample fractions. Both fractions were analyzed for radionuclide content using a calibrated Ge(Li) gamma spectrometer system. The measurements continued for approximately six days until the turbidity of the solution stabilized and the radionuclide concentrations leached onto the filtrate portion of the sample fraction had stabilized.

3.2 Airborne Evaporation Test (uncrushed debris)

3.2.1 Materials and Equipment

- Solution--∿500 ml of the core debris simulated reactor coolant solution.
- Evaporation Chamber--1.85 in. high x 4 in. wide x 18 in. long with controlled airflow of 100 linear ft/min (see Figure 1).
- Air sampling system with 0.45 μm HEPA filters.
- Graduated cylinder, 500 ml.

3.2.2 Procedure

Following the minor disturbance test ∿500 ml of the simulated reactor coolant was decanted from the solid core debris material and transferred to an enclosed chamber with air inlet and outlet tubes (see Figure 1). The solution was evaporated by passing air over the solution surface at a controlled velocity of 3048 cm/min (100 linear ft/min) at a total flow of 8.49 (+4) cm^3/min (∿3.0 ft^3/min). The 0.45 μm HEPA filters were replaced at intervals during the evaporation process to measure the radionuclide airborne concentrations at different times during the evaporation process.

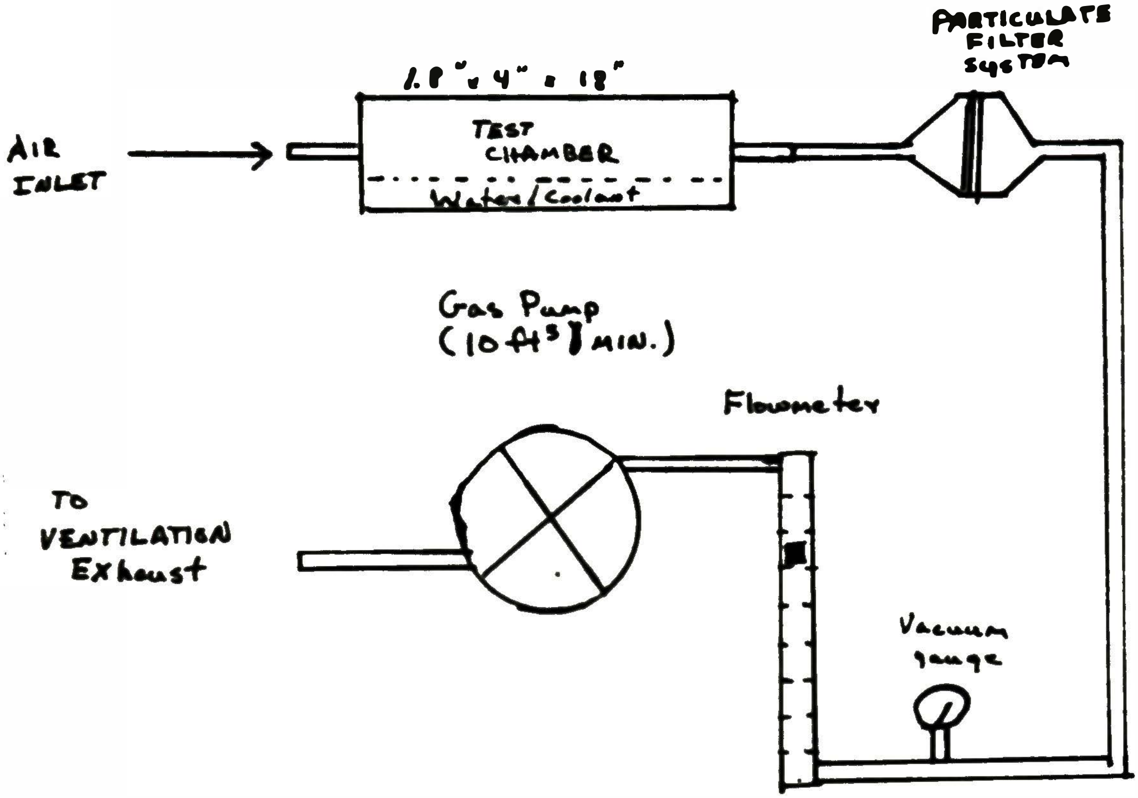

Figure 1. Schematic of the evaporation chamber measurement system

Each filter was analyzed in a calibrated geometry by gamma ray spectrometry and the radionuclide content on the filters converted to microcuries (μCi) of individual radionuclides evaporated per cm^3 of air.

During the evaporation process the solution was intermittently poured from the evaporation chamber and measured to determine the unevaporated volume remaining.

3.3 Major Disturbance Test

3.3.1 Materials and Equipment

- Core Debris--The debris collected from the minor disturbance test (42.75 grams) was dried and weighed.
- Crusher--A small cylinder and cup apparatus combined with a 2-ton hydraulic jack (see Figure 2).
- All equipment previously used in the minor disturbance test.
- SST sieves, W. S. Tyler, mesh sizes 5, 10, 16, 24, 48, 100, 200, and 325. Sieving was performed using a freon wash.

3.3.2 Procedure

The steps listed for the minor disturbance test were repeated using the same core debris sample with the following exceptions:

- The core debris material was first crushed using the crushing device shown in Figure 2 to generate freshly fractured surfaces.
- The crushed debris was sieved and weighed to determine the new particle size distribution.

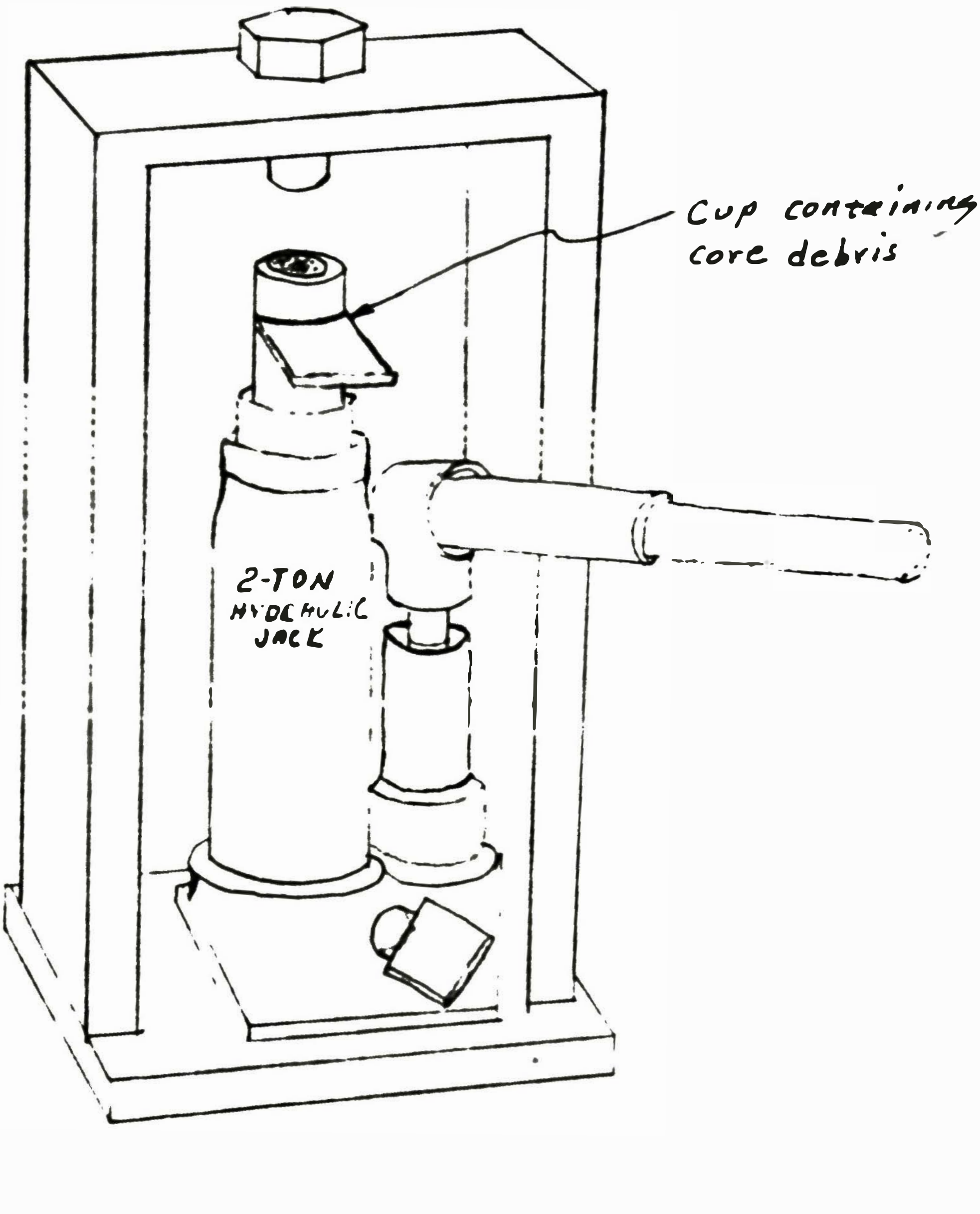

Figure 2 Core debris Crushing device

3.4 Airborne Evaporation Test (crushed debris)

3.4.1 Materials and Equipment

Same as for the uncrushed airborne evaporation test except that the solution was decanted from the major disturbance test solution.

3.4.2 Procedure

Following the major disturbance test, the decanted solution was transferred to the evaporation chamber and the test described in Section 2.2 repeated.

4. RESULTS AND DISCUSSION

4.1 Minor and Major Disturbance Tests

4.1.1 Turbidity Measurements[a]

The analytical results for the minor and major disturbance tests are discussed jointly to evaluate the effects of crushing the core debris for the major disturbance test. Following crushing, the debris was sieved and weighed to determine the particle size distribution. Table 1 lists the particle size distribution for (a) the original bulk sample, (b) the sample removed for analysis (~35% of the original sample), and (c) the crushed sample. A significant reduction in the quantity of the large particle size core debris with a corresponding increase in the weights of the smaller sized fractions resulted from the crushing process.

Table 2 lists the results of the turbidity measurements. It includes sample removal times and associated turbidity measurements. The simulated reactor coolant solution had a turbidity reading of 1.4 NTU before adding the core debris material.

Figure 3 shows the turbidity analysis results listed in Table 2. The data indicate that concentration of suspended material decreased fastest during the first hour for both minor and major tests. The reduction in turbidity is a logarithmic function based on time for both the minor and major disturbance tests. The major disturbance solution was more turbid initially, but was equal to the minor disturbance solution after about 60 minutes. It then became less turbid. In general, the opacity of both solutions decreased at about the same rate. Crushing the debris had minimal impact on turbidity (within a factor of 2).

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a. Turbidity is reported in terms of Nepholometric Turbidity Units (NTU) which is a measure of the light scattering ability of a solution. It is affected by both particle size and particle concentration. By definition, a formazin polymer solution of a specific concentration is equivalent to one NTU.

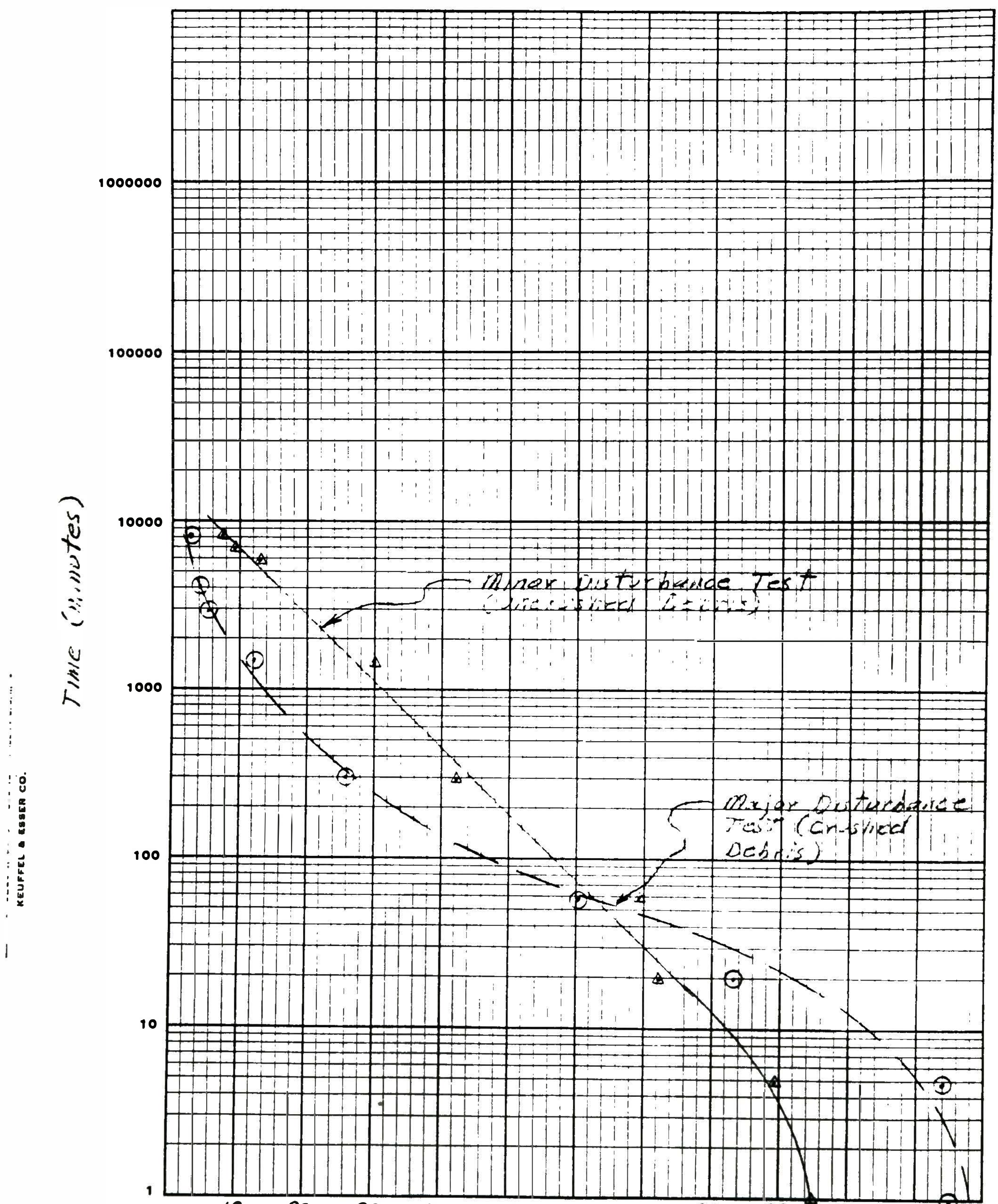

Figure 1. Minor and Major disturbance Turbidity results

4.1.2 Suspended Solids Concentration

The weights of solid materials suspended in the simulated reactor coolant solutions were calculated as a function of time. The data are listed in Table 3. The data range from 49 μ grams/ml at one minute for the major disturbance test to 0.17 μ grams/ml at 144 hours for the minor disturbance test. Extremely small concentrations of solids were present even immediately following agitation of the solution.

The concentration of solid materials suspended in the simulated reactor coolant solution was calculated by ratioing the measured radionuclide solids content on the filters (μCi) to the radionuclide concentrations from the smaller particle size fractions of core debris Sample 6. Listed in Table 3 is the number of grams of solid material present in each 25 ml of solution. The uncertainty in this analysis is at least a factor of 2 resulting from the uncertainties in the radionuclide concentrations of the particles deposited on the surface of the filter and/or the possible presence of particles smaller than 0.45 μm.

4.1.3 Radionuclide Concentrations

Tables 4 and 5 list the radionuclide concentrations (μCi/sample) for the solid and liquid portions of the minor and major disturbance tests. The data show the radionuclide content of the suspended solid fractions decreased at a relatively constant rate for all radionuclides measured in the minor disturbance test. The major disturbance test radionuclide concentrations followed a similar pattern.

Figure 4 shows the ^{137}Cs radionuclide content for the suspended solids. The data are plotted in total μCi per 25 ml of sample. The scale is expanded during the first hour of the test to highlight the reductions in concentration during that period of time. The explanation for the high concentration at the one hour time period in the minor disturbance test is not known. However, after the first hour, the solid

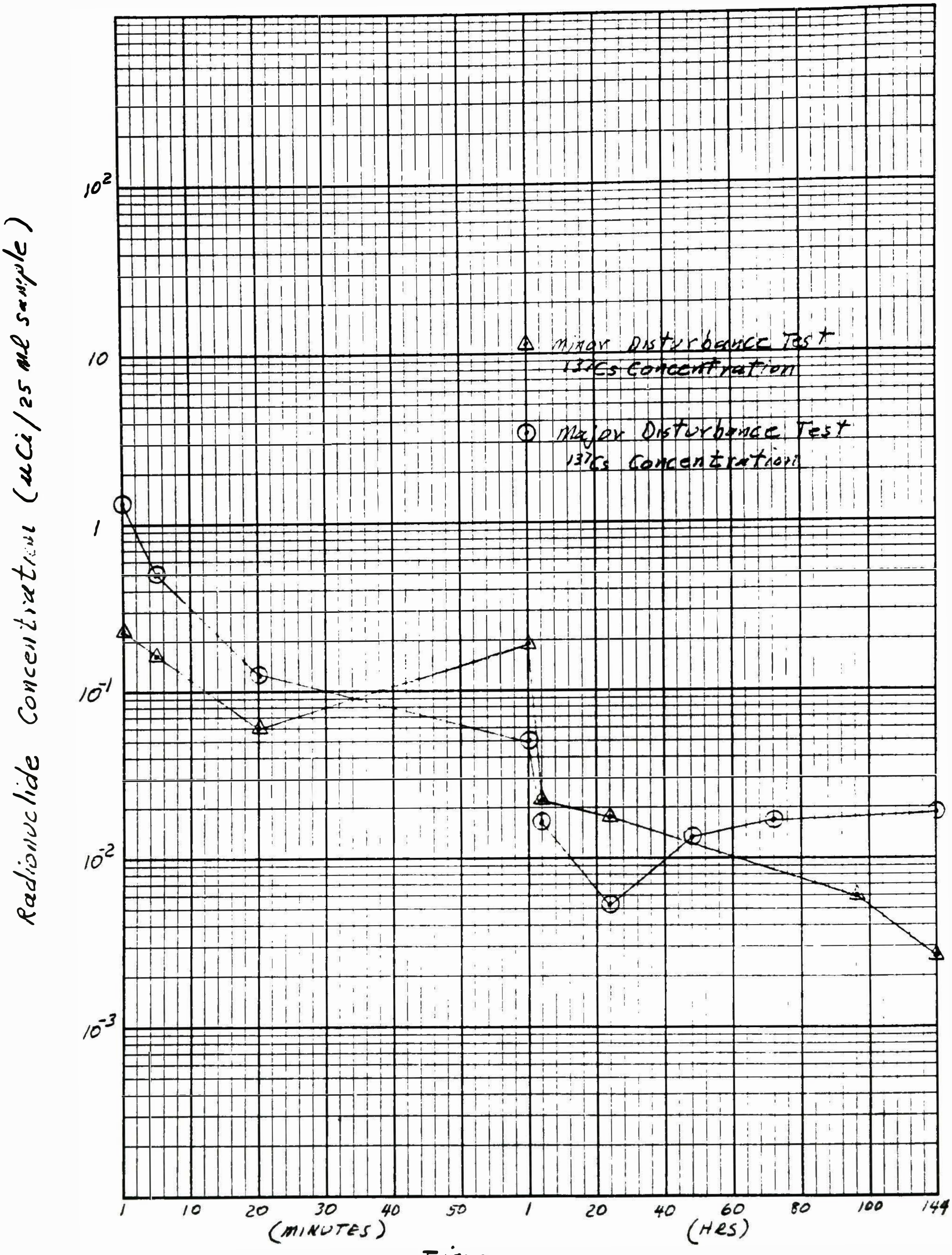

Figure 4. ^{137}Cs Concentration in the suspended solids (uCi/25 ml of solution)

radionuclide content is within a factor of 2 for both tests. Crushing appears to have little affect on radionuclide content present as suspended solids.

Figure 5 shows the total radionuclide concentrations in the 25 ml filtrate solution. The data indicate that soluble ^{137}Cs goes into solution within five minutes with little subsequent leaching. Crushing the minor disturbance sample resulted in a large release of ^{137}Cs ($\sim$ a factor of 10) which goes into solution immediately with little subsequent leaching into the solution.

3.2 Airborne Evaporation Tests

Tables 6 and 7 list the radionuclide concentrations resulting from the airborne evaporation tests conducted on the simulated reactor coolant solutions retained from the minor and major disturbance tests. Following are some general observations and comparisons.

- Most of the airborne activity occurred near the end of the evaporation process, just prior to dry out. The increase in airborne concentration at this time is 2 to 3 orders of magnitude higher than at any other time. This may be due to the increased wetted surface to volume ratio.

- Increased airborne concentrations occurred each time the solution volume was measured. By pouring the solution from and back into the chamber, some of the chamber surfaces were wetted. As these surfaces dried, airborne activity increased, perhaps as a result of the increased wetted surface to volume ratio.

- Airborne activities significantly decreased, almost to zero, as soon as all liquid had evaporated indicating the probable mode of transport is with the water droplets.

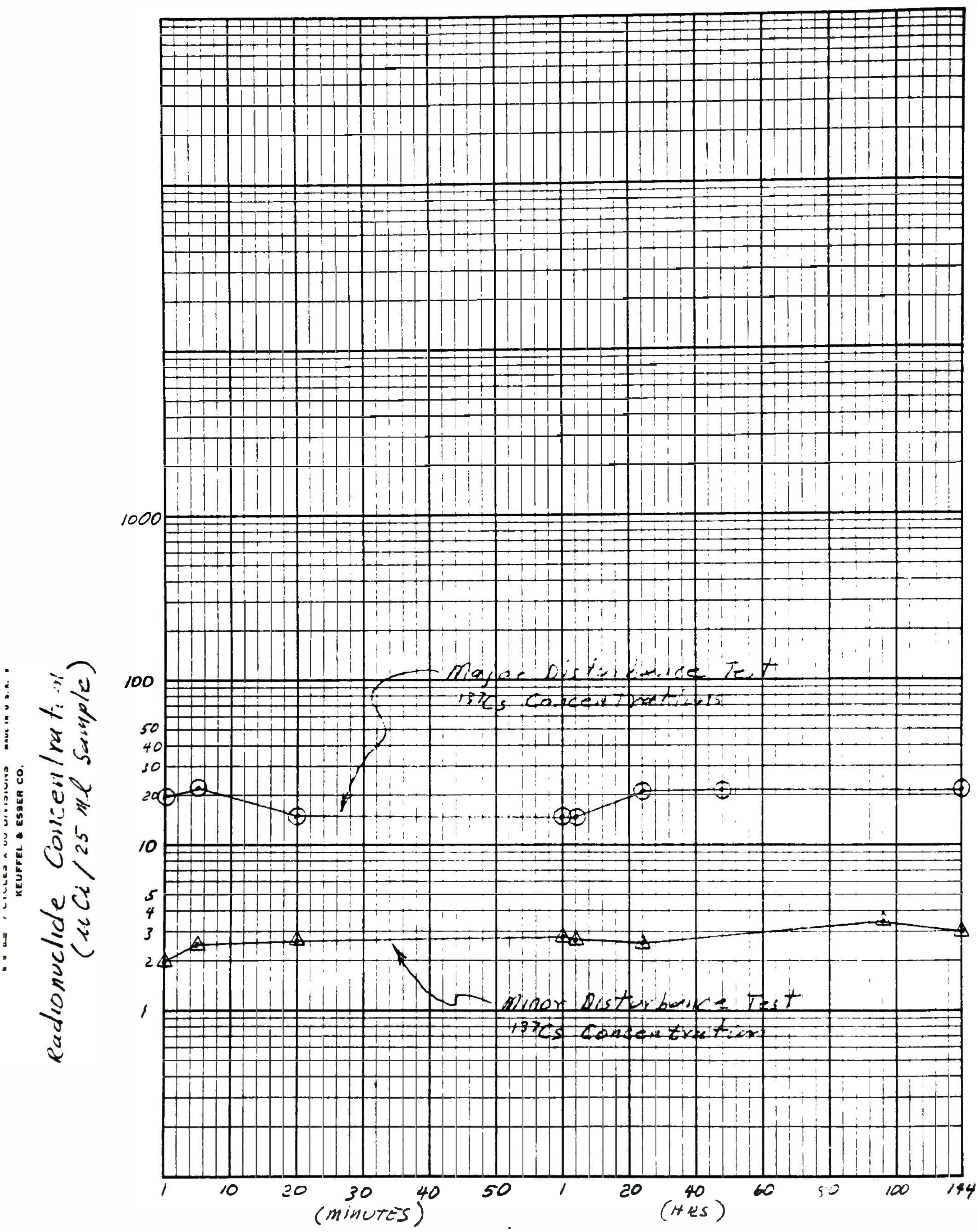

Figure 5. Filtrate ^{137}Cs Concentrations

- After drying, the ^{137}Cs airborne concentrations were a factor of 4 to 5 higher for the major disturbance test than for the minor disturbance test. The larger fractions of crushed, smaller particles present in the major disturbance test may be the cause of the higher airborne concentrations.

The length of time between filter changes was increased during the major disturbance evaporation test as long evaporation periods were required to reduce the volume of the samples during the minor disturbance test and only low airborne concentrations were measured except during dryout. However, the solution evaporated more rapidly than expected and the evaporation chamber dried out during use of the second filter. An additional 100 ml of liquid was added to the chamber and the solution was again evaporated. The filters used during evaporation of the additional 100 ml of solution (3 through 5) were changed at shorter time intervals. The data indicate high radionuclide concentrations were produced after the dried surfaces were wetted and the airborne concentrations subsequently decreased following evaporation dryout by ~2 orders of magnitude.

TABLE 1. PARTICLE SIZE DISTRIBUTION FOR THE MINOR AND MAJOR DISTURBANCE TEST

Particle Size Range (μm)	Original Bulk Sample Size Distribution (grams)	Minor Disturbance Test[a] (grams)	Major Disturbance Test[b] (grams)
4000	57.99	20.25	0.30
1680-4000	49.39	17.26	10.99
1000-1680	13.88	4.94	10.44
707-1000	8.93	3.36	6.38
297-707	5.99	2.26	8.08
149-297	0.97	0.37	3.32
74-149	0.67	0.24	1.82
30-74	0.22	0.072	0.53
>30	0	0	0.87
Total	138.04	48.75[c]	42.75[c]

a. Amount removed from the various size fractions of Sample 6.

b. Quantities reflect the "after crushing" distribution. The same debris was used in the major disturbance test as for the minor disturbance test.

c. The difference of six grams between the minor and major disturbance tests was due to loss during the evaporation test or the crushing process.

TABLE 2. TURBIDITY ANALYSIS RESULTS[a]

Minor Disturbance Test[b]		Major Disturbance Test[b]	
Time After Shaking	Turbidity (NTU)	Time After Shaking	Turbidity (NTU)
1 min	94.7	1 min	115.6
5 min	89.0	5 min	114.0
20 min	72.4	20 min	83.6
1 hr	69.0	1 hr	60.0
4.90 hr	42.0	4.90 hr	25.4
24 hr	30.1	24 hr	12.2
96 hr	12.6	48 hr	5.5
120 hr	8.8	72 hr	4.1
144 hr	7.4	144 hr	2.5

a. Turbidity is listed in Nephelometric Turbidity Units (NTU) and is a measure of the light scattering ability of a solution. By definition a formazin polymer solution is equivalent to one NTU.

b. The measured background turbidity reading of the coolant simulant was 1.4 prior to mixing with the core debris material.

TABLE 3. CESIUM SETTLING TEST SUSPENDED SOLIDS CONCENTRATIONS[a]

Time	Minor Disturbance (grams/ml)	Major Disturbance (grams/ml)
1.0 minutes	8.6(-6)	4.9(-5)
5.0 minutes	6.05(-6)	1.9(-5)
20.0 minutes	2.4(-6)	4.9(6)
1.0 hours	7.0(-6)	2.0(-6)
4.9 hours	8.7(-7)	6.9(-7)
24 hours	6.9(-7)	2.24(-7)
48 hours	--[b]	5.0(-7)
72 hours	--[b]	8.8(-7)
96 hours	2.6(-7)	--[b]
120 hours	1.2(-7)	--[b]
144 hours	1.6(-7)	1.1(-6)

a. Calculation based on the ^{137}Cs concentrations of particles larger than 0.45 μm. The average ^{137}Cs concentration used for calculation purposes is 1.07(+3) μCi/gram.

b. Not measured.

TABLE 4. MINOR DISTURBANCE RADIONUCLIDE CONCENTRATIONS (μCi/sample)

Filtration Number	Time	Filter Number/ Filtrate	Radionuclide: ^{60}Co	^{125}Sb	^{134}Cs	^{137}Cs	^{144}Ce
1	1.0 min	Filter 1	5.1 ± 0.1(-3)	1.83 ± 0.02(-2)	8.6 ± 0.1(-3)	2.31 ± 0.01(-1)	1.14 ± 0.09(-1)
		Filter 2	3.8 ± 1.0(-5)	2.9 ± 0.3(-4)	3.9 ± 0.9(-5)	9.9 ± 0.4(-4)	--[a]
		Filtrate	3.9 ± 0.2(-2)	7.84 ± 0.08(-1)	6.2 ± 0.2(-2)	2.01 ± 0.01(0)	--[a]
2	5.0 min	Filter 1	4.2 ± 0.1(-3)	1.54 ± 0.03(-2)	6.2 ± 0.1(-3)	1.61 ± 0.01(-1)	8.2 ± 0.8(-2)
		Filter 2	2.3 ± 0.8(-5)	3.3 ± 0.3(-4)	4.2 ± 0.9(-5)	8.7 ± 0.4(-4)	--[a]
		Filtrate	6.9 ± 0.3(-2)	8.4 ± 0.1(-1)	9.9 ± 0.3(-2)	2.48 ± 0.01(0)	--[a]
3	20.0 min	Filter 1	2.3 ± 0.8(-3)	8.8 ± 0.2(-3)	2.46 ± 0.07(-3)	6.38 ± 0.03(-2)	4.1 ± 0.5(-2)
		Filter 2	2.4 ± 0.8(-5)	2.6 ± 0.3(-4)	2.7 ± 0.8(-5)	7.8 ± 0.4(-4)	--[a]
		Filtrate	7.3 ± 0.3(-2)	8.9 ± 0.1(-1)	1.39 ± 0.03(-1)	2.58 ± 0.01(0)	--[a]
4	1.0 hr	Filter 1	3.4 ± 0.1(-3)	1.34 ± 0.02(-2)	5.3 ± 0.4(-3)	1.86 ± 0.01(-1)	9.0 ± 0.8(-2)
		Filter 2	2.6 ± 0.8(-5)	3.0 ± 0.3(-4)	8.1 ± 0.7(-5)	8.1 ± 0.3(-4)	--[a]
		Filtrate	8.0 ± 0.3(-2)	9.7 ± 0.1(-2)	1.12 ± 0.03(-1)	2.81 ± 0.01(0)	--[a]
5	4.9 hrs	Filter 1	1.01 ± 0.05(-3)	4.8 ± 0.1(-3)	9.3 ± 0.4(-4)	2.24 ± 0.02(-2)	1.14 ± 0.03(-2)
		Filter 2	2.7 ± 0.7(-5)	3.2 ± 0.3(-4)	5.3 ± 0.7(-5)	8.0 ± 0.3(-4)	--[a]
		Filtrate	8.1 ± 0.3(-2)	9.5 ± 0.1(-1)	1.08 ± 0.03(-1)	2.70 ± 0.01(0)	--[a]
6	24.0 hrs	Filter 1	6.2 ± 0.4(-4)	3.4 ± 0.1(-3)	6.8 ± 0.4(-4)	1.77 ± 0.02(-2)	7.6 ± 0.2(-3)
		Filter 2	2.5 ± 0.7(-5)	3.7 ± 0.3(-4)	4.1 ± 0.9(-5)	8.8 ± 0.4(-4)	--[a]
		Filtrate	8.0 ± 0.3(-2)	9.9 ± 0.1(-1)	1.04 ± 0.03(-1)	2.54 ± 0.01(0)	--[a]
7	96 hrs	Filter 1	3.8 ± 0.3(-4)	1.49 ± 0.08(-3)	2.6 ± 0.2(-4)	6.1 ± 0.1(-3)	2.8 ± 0.8(-3)
		Filter 2	2.7 ± 0.8(-5)	4.5 ± 0.3(-4)	3.2 ± 0.8(-5)	8.9 ± 0.4(-4)	--[a]
		Filtrate	1.24 ± 0.04(-1)	1.70 ± 0.01(0)	1.41 ± 0.04(-1)	3.56 ± 0.01(0)	--[a]
8	120 hrs	Filter 1	1.75 ± 0.08(-4)	7.8 ± 0.2(-4)	1.05 ± 0.05(-4)	2.65 ± 0.02(-3)	6.2 ± 0.2(-4)
		Filter 2	5.1 ± 0.5(-5)	3.2 ± 0.1(-4)	2.6 ± 0.3(-5)	6.3 ± 0.1(-4)	--[a]
		Filtrate	1.15 ± 0.04(-1)	1.51 ± 0.01(0)	1.27 ± 0.03(-1)	3.13 ± 0.01(0)	--[a]
9	144 hrs	Filter 1	2.8 ± 0.3(-4)	1.20 ± 0.06(-3)	1.6 ± 0.2(-4)	3.72 ± 0.08(-3)	1.3 ± 0.5(-3)
		Filter 2	2.5 ± 0.3(-5)	3.2 ± 0.1(-4)	2.3 ± 0.3(-5)	6.1 ± 0.1(-4)	--[a]
		Filtrate	1.17 ± 0.04(-1)	1.60 ± 0.01(0)	1.24 ± 0.3(-1)	3.14 ± 0.01(0)	--[a]

TABLE 5. MAJOR DISTURBANCE RADIONUCLIDE CONCENTRATIONS (μCi/sample))

Filtration Number/Time[a]	Filter Number/Filtrate	^{60}Co	^{125}Sb	^{134}Cs	^{137}Cs	^{144}Ce
		Radionuclide				
1 1.0 min	Filter 1	9.1 ± 0.6(-3)	5.7 ± 0.2(-2)	4.4 ± 0.1(-2)	1.30 ± 0.05(0)	1.03 ± 0.09(0)
	Filter 2	--b	--b	2.3 ± 1.2(-4)	7.0 ± 0.1(-3)	--b
	Filtrate	9.6 ± 1.9(-3)	1.1 ± 0.2(-1)	6.4 ± 0.1(-1)	1.97 ± 0.08(+1)	--b
2 5 min	Filter 1	3.1 ± 0.2(-3)	4.3 ± 0.1(-1)	3.95 ± 0.04(-1)	5.09 ± 0.02(-1)	3.7 ± 0.3(-1)
	Filter 2	--b	--b	2.6 ± 0.2(-4)	7.8 ± 0.1(-3)	--b
	Filtrate	7.2 ± 1.2(-3)	5.5 ± 1.5(-2)	6.5 ± 0.1(-1)	2.05 ± 0.05(+1)	--b
3 20 min	Filter 1	1.26 ± 0.07(-3)	9.0 ± 0.2(-3)	4.3 ± 0.1(-3)	1.30 ± 0.01(-1)	1.2 ± 0.1(-1)
	Filter 2	--b	--b	1.8 ± 0.2(-4)	5.58 ± 0.09(-3)	--b
	Filtrate	6.3 ± 1.3(-3)	--b	5.09 ± 0.09(-1)	1.58 ± 0.05(+1)	--b
4 1 hr	Filter 1	6.72 ± 0.05(-4)	4.9 ± 0.2(-3)	1.58 ± 0.06(-3)	4.84 ± 0.03(-2)	4.9 ± 0.6(-2)
	Filter 2	--b	--b	1.7 ± 0.2(-4)	4.96 ± 0.09(-3)	--b
	Filtrate	4.3 ± 0.9(-3)	5.7 ± 1.5(-2)	5.06 ± 0.08(-1)	1.54 ± 0.04(+1)	--b
5 4.9 hrs	Filter 1	2.1 ± 0.3(-4)	1.5 ± 0.1(-3)	5.6 ± 0.4(-4)	1.71 ± 0.02(-2)	1.3 ± 0.3(-2)
	Filter 2	--b	--b	2.2 ± 0.2(-4)	6.6 ± 0.1(-3)	--b
	Filtrate	6.1 ± 1.3(-3)	5.2 ± 1.6(-2)	5.0 ± 0.1(-1)	1.54 ± 0.05(+1)	--b
6 24 hrs	Filter 1	6.9 ± 1.3(-5)	3.3 ± 0.4(-4)	1.9 ± 0.2(-4)	5.26 ± 0.09(-3)	2.4 ± 0.5(-3)
	Filter 2	--b	--b	2.4 ± 0.2(-4)	6.8 ± 0.1(-4)	--b
	Filtrate	8.3 ± 1.4(-3)	1.6 ± 0.2(-1)	6.7 ± 0.1(-1)	2.06 ± 0.05(+1)	--b
7 48 hrs	Filter 1	7.4 ± 1.5(-5)	6.0 ± 0.7(-4)	4.8 ± 0.3(-4)	1.32 ± 0.02(-2)	4.1 ± 0.8(-3)
	Filter 2	6.8 ± 2.5(-6)	--b	8.0 ± 0.1(-3)	2.5 ± 0.2(-4)	--b
	Filtrate	1.3 ± 0.2(-2)	2.7 ± 0.2(-1)	7.3 ± 0.1(-1)	2.24 ± 0.06(+1)	--b
8 72 hrs	Filter 1	8.9 ± 1.7(-5)	6.3 ± 0.8(-4)	5.1 ± 0.3(-4)	1.6 ± 0.2(-2)	5.4 ± 0.9(-3)
	Filter 2	--b	1.4 ± 0.4(-4)	2.4 ± 0.2(-4)	7.6 ± 0.1(-3)	--b
	Filtrate	1.5 ± 0.2(-2)	3.2 ± 0.3(-1)	7.6 ± 0.1(-1)	2.25 ± 0.07(+1)	--b
9 144 hrs	Filter 1	1.3 ± 0.2(-4)	6.9 ± 0.6(-4)	6.6 ± 0.3(-4)	2.00 ± 0.02(-2)	7.8 ± 1.0(-3)
	Filter 2	1.2 ± 0.5(-5)	1.9 ± 0.4(-4)	3.1 ± 0.2(-4)	9.0 ± 0.1(-3)	--b
	Filtrate	2.1 ± 0.4(-2)	4.2 ± 0.4(-1)	7.7 ± 0.2(-1)	2.27 ± 0.01(+1)	--b

a. Only 18 ml were recovered from filtration Samples 1 and 2, therefore, the data are extrapolated.

b. Not detected.

TABLE 6. AIRBORNE RADIONUCLIDE CONCENTRATIONS - MINOR DISTURBANCE TEST ($\mu Ci/cm^3$)

Radionuclide	Filter 1	Filter 2	Filter 3	Filter 4	Filter 5	Filter 6	Filter 7
	Time: 1 hour Total: 1 hour	Time: 1 hour Total: 2 hours	Time: 1 hour Total: 3 hours	Time: 1 hour Total: 4 hours	Time: 1 hour Total: 5 hours	Time: 1 hour Total: 6 hours	Time: 1 hour Total: 7 hours
^{60}Co	--[a]	--[a]	6.8 ± 1.5(-11)	--[a]	--[a]	8.9 ± 1.9(-11)	--[a]
^{125}Sb	--[a]	--[a]	1.04 ± 0.05(-9)	--[a]	--[a]	1.1 ± 0.4(-9)	--[a]
^{134}Cs	--[a]	--[a]	7.9 ± 1.2(-11)	--[a]	7.3 ± 4.3(-12)	8.9 ± 1.3(-11)	--[a]
^{137}Cs	9.4 ± 3.3(-12)	4.9 ± 2.7(-12)	2.31 ± 0.06(-9)	3.3 ± 0.6(-11)	2.2 ± 0.2(-10)	2.36 ± 0.08(-9)	4.6 ± 0.8(-11)
^{144}Ce	--[a]	--[a]	--[a]	--[a]	--[a]	1.1 ± 0.2(-10)	--[a]
Solution Volume (ml)	--[b]	470	--[b]	450	--[b]	400	--[b]

Radionuclide	Filter 8	Filter 9	Filter 10	Filter 11	Filter 12	Filter 13	Filter 14
	Time: 1 hour Total: 8 hour	Time: 1 hour Total: 9 hours	Time: 2 hours Total: 11 hours	Time: 2 hours Total: 13 hours	Time: 2 hours Total: 15 hours	Time: 2 hours Total: 17 hours	Time: 8 hours Total: 25 hours
^{60}Co	--[a]	--[a]	--[a]	--[a]	3.9 ± 0.6(-11)	--[a]	4.1 ± 0.3(-10)
^{125}Sb	--[a]	1.1 ± 0.7(-11)	1.1 ± 0.3(-11)	--[a]	5.6 ± 2.3(-10)	1.2 ± 0.7(-9)	5.7 ± 0.2(-9)
^{134}Cs	--[a]	--[a]	--[a]	--[a]	4.8 ± 0.6(-11)	--[a]	5.3 ± 0.4(-10)
^{137}Cs	2.2 ± 0.4(-11)	4.2 ± 1.0(-11)	4.6 ± 0.4(-11)	7.1 ± 0.7(-11)	1.15 ± 0.04(-9)	6.2 ± 0.7(-10)	1.28 ± 0.05(-8)
^{144}Ce	--[a]	--[a]	--[a]	--[a]	--[a]	--[a]	3.0 ± 0.8(-10)
Solution Volume (ml)	370	--[b]	--[b]	450	290	--[b]	150

TABLE 6. (continued)

Radionuclide	Filter 15 Time: 8 hour Total: 33 hours	Filter 16 Time: 4 hour Total: 37 hours	Filter 17 Time: 4 hours Total: 41 hours	Filter 18 Time: 4 hours Total: 45 hours	Filter 19 Time: 4 hours Total: 49 hours	Filter 20 Time: 4 hours Total: 53 hours	Filter 21 Time: 2 hours Total: 55 hours
^{60}Co	1.1 ± 0.7(-11)	--[a]	--[a]	--[a]	--[a]	--[a]	--[a]
^{125}Sb	1.4 ± 0.2(-10)	2.4 ± 0.2(-10)	3.4 ± 1.5(-11)	3.4 ± 1.3(-11)	4.0 ± 1.6(-11)	2.3 ± 1.3(-11)	--[a]
^{134}Cs	1.6 ± 0.5(-11)	1.8 ± 0.5(-11)	--[a]	--[a]	--[a]	--[a]	--[a]
^{137}Cs	3.2 ± 0.3(-10)	3.2 ± 0.3(-10)	5.2 ± 1.1(-11)	7.8 ± 1.2(-11)	9.1 ± 1.4(-11)	4.2 ± 0.9(-11)	7.1 ± 1.7(-12)
^{144}Ce	--[a]	--[a]	--[a]	--[a]	--[a]	--[a]	--[a]
Solution volume (ml)	--[b]	10	--[b]	No measurable solution	Dry	Dry	Dry

a. Not detected.

b. Not measured.

TABLE 7. AIRBORNE RADIONUCLIDE CONCENTRATIONS - MAJOR DISTURBANCE TEST ($\mu Ci/cm^3$)

Radionuclide	Filter 1 Time: 18 hours Total: 18 hours	Filter 2 Time: 24 hours Total: 42 hours	Filter 3[c] Time: 4 hours Total: 46 hours	Filter 4 Time: 2 hours Total: 48 hours	Filter 5 Time: 2 hours Total: 50 hours
^{60}Co	4.2 ± 1.9(-12)	--[a]	1.9 ± 0.3(-10)	5.3 ± 2.1(-11)	2.3 ± 1.8(-11)
^{125}Sb	1.4 ± 0.6(-11)	2.5 ± 1.5(-12)	3.2 ± 0.2(-9)	9.4 ± 4.3(-11)	--[a]
^{134}Cs	--[a]	--[a]	2.9 ± 0.1(-9)	--[a]	--[a]
^{137}Cs	9.9 ± 0.7(-11)	7.6 ± 1.5(-12)	9.23 ± 0.06(-8)	9.6 ± 1.1(-10)	4.9 ± 0.4(-10)
^{144}Ce	4.7 ± 0.6(-11)	--[a]	1.2 ± 0.21(-9)	2.0 ± 0.5(-10)	1.0 ± 0.5(-10)
Solution[b] Volume (ml)	220	-0-	30	Dried out	-0-

a. Not detected.

b. Initial volume (approximately 500 ml).

c. Reconstituted sample with 100 ml simulated reactor coolant.