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MASTER

DISSOLUTION OF FFTF VENDOR FUEL

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DISSOLUTION OF FFTF VENDOR FUEL

1.0 INTRODUCTION

The primary core fuel material for the Fast Flux Test Facility (FFTF) in Richland, Washington is a mixed plutonium oxide-uranium oxide fuel pellet containing nominally 22-25 wt% plutonium oxide. Fuel cores I and II for the FFTF were fabricated by private industry in the United States. Two processes were used: a mechanical mixing process and a coprecipitation process. The fuel pellets were fabricated into fuel pins and sent to Westinghouse Hanford Company* for subsequent analysis and acceptance testing. Westinghouse Hanford Co., then fabricated them into fuel assemblies for use in the FFTF.

During 1974-1976, a fuel dissolution program was performed on selected pellet lots representative of the initial fuel pellets. The purpose of the dissolution program was to obtain as much background information as possible on the initial fuel for the FFTF and how the fuel might be expected to perform during subsequent fuel reprocessing. The dissolution data might also be useful in providing information for the early design effort for a fast reactor fuel reprocessing facility. For example, could complete dissolution of fuel be assured in nitric acid alone or would a two-step dissolution process be required using a mixture of nitric and hydrofluoric acid to dissolve any fuel residue remaining after the nitric acid alone dissolution step?

The dissolution data were collected for the individual years 1974, 1975, and 1976 and will be reported as such in order to show a general improvement in fuel dissolution characteristics. No dissolution data have been collected at HEDL since 1976.

2.0 SUMMARY

Dissolution experiments were performed on FFTF vendor fuel (both mechanically mixed and coprecipitated) during 1974, 1975, and 1976. A marked improvement was noted in the completeness of fuel dissolution from 1974 to 1976. The reason for this is unknown but may have been attributable to slight changes in fuel fabrication conditions. In general, the bulk of the fuel pellets tested dissolved to greater than 99.9% in nitric acid alone.

3.0 EXPERIMENTAL

The dissolution data were accumulated by dissolving individual FFTF pellets in 25 ml of boiling 12M nitric acid for two six-hour periods. At the end of

*Westinghouse Hanford Company operates the Hanford Engineering Development Laboratory in Richland, Washington for the U.S. Department of Energy and is the prime contractor for construction and operation of the FFTF.

the second six-hour period, the solutions were filtered through fine porosity, pre-weighed filters and the residues were collected, dried and weighed. The residues collected were calculated as weight percent of original pellet. The high nitric acid to metal mole ratio (~60 to 1) was selected to minimize depletion effects during dissolution; 12M nitric acid was used since the objective was to determine what fraction of the fuel would not dissolve using extreme conditions.

The apparatus used in the dissolution experiment is shown in Figure 1. It consisted of specially fabricated glass five finger condensers fit with 24/40 ⅄ dissolution tubes such that multiple pellets could be dissolved simultaneously.

4.0 RESULTS AND DISCUSSION

Two fuel fabrication processes were used for fabrication of the initial two cores of FFTF fuel: coprecipitation and mechnically mixed. A comparison of the two fabrication processes is shown schematically in Figure 2. Results of dissolution studies for each type of fuel will be discussed separately.

Studies have shown that both fabrication and irradiation histories of mixed oxide fuel can have a significant effect on both the dissolution rate and the dissolubility of the fuel during reprocessing. Previous investigations[1-5] have shown that certain fabrication conditions (e.g., high sintering temperature) can have a beneficial effect on dissolution of mixed oxide fuel. In general, irradiation also has a beneficial effect on dissolution of mixed oxide fuel.[6-10]

Fabrication conditions for the initial FFTF fuel pellets were set by the vendor to meet established acceptability criteria on the final pellets (e.g., sintered density, oxygen-to-metal ratio, plutonium content, etc.). Typical fabrication conditions used during fabrication of six batches of mechanically mixed pellets are shown in Table 1. The table illustrates the range of variables used by the vendor. Note that sintering temperature, which has previously been shown to have a major effect on completeness of fuel dissolution, varied from a low of 1580°C to a high of 1675°C. Such a difference would be expected to produce a measurable effect on dissolution. A continuous sintering furnace was used during the sintering process. Typical temperature profiles for the furnace are shown in Figures 3-5.

Exact fuel fabrication conditions for the coprecipitated fuel were not determined since, traditionally, fabrication conditions for coprecipitated fuel have less effect on dissolution of mixed oxide fuel provided the fabrication conditions are such that solid solution formation takes place.

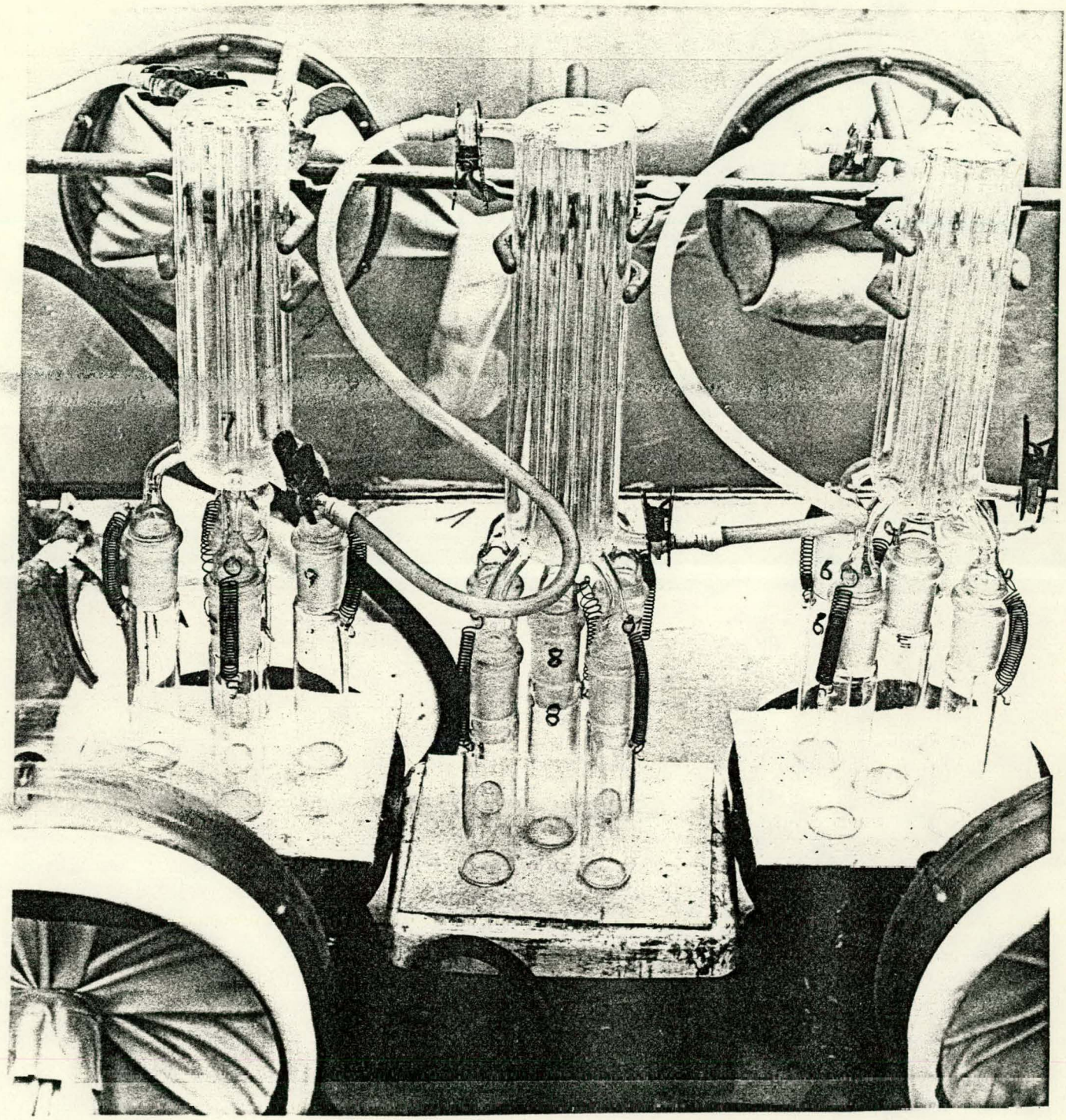


Figure 1: Apparatus Used for Dissolution Experiments (Neg. No. 704805-3)

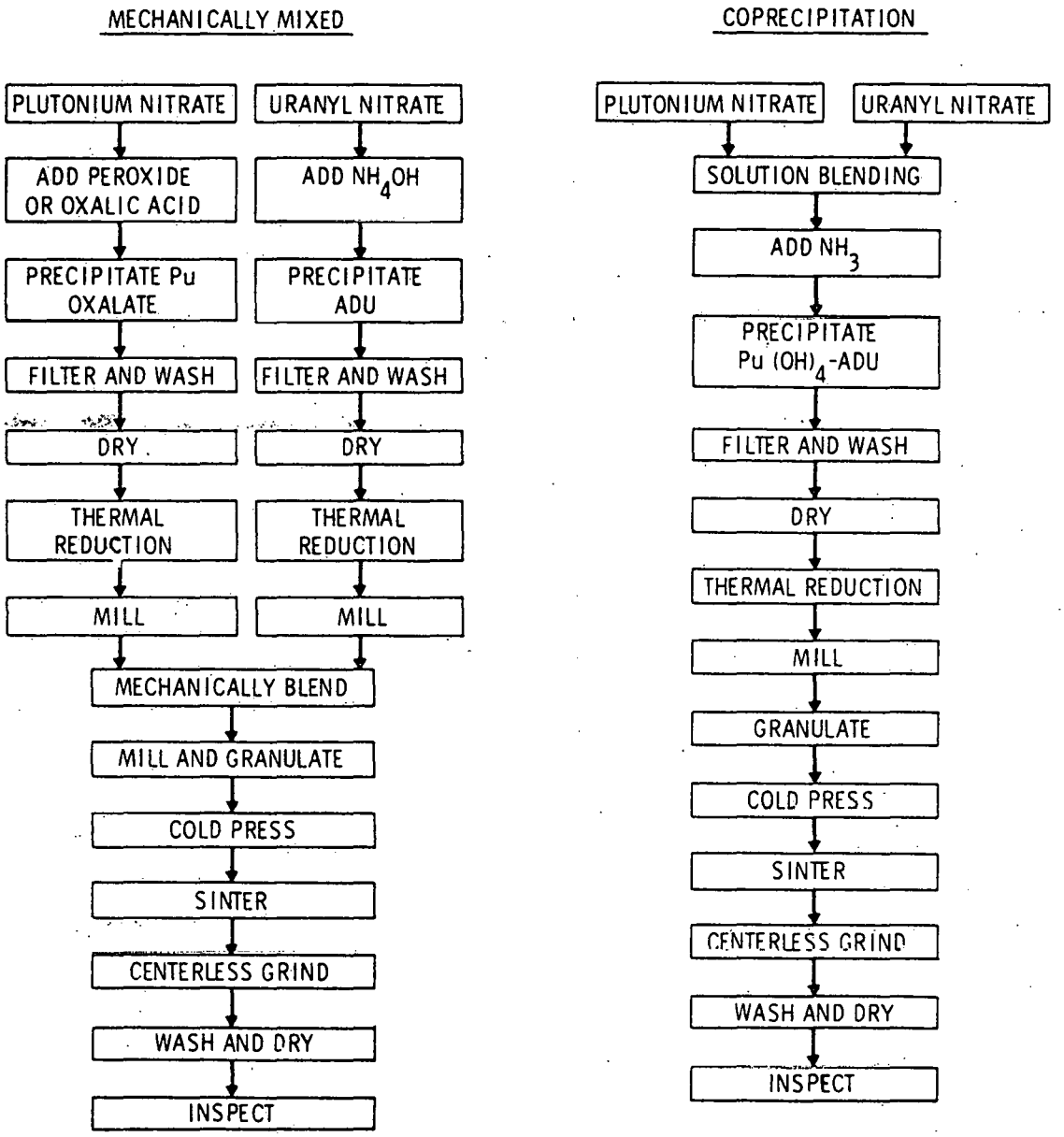


Figure 2: Flowsheets for (U, Pu) O_2 Pellet Fabrication Using Mechanically Mixed and Coprecipitation Processes

TABLE 1

FABRICATION CONDITIONS FOR MECHANICALLY MIXED FFTF PELLETS

PELLET LOT NUMBER	5	6	7	8	9	10
PRESSING:						
Pressure, recorded tons/0.232" Dia.	3.8-4.8	1.1-5.2	2.5-2.7	1.4-2.5	1.9-2.6	1.3-1.6
Pressure Kpsi	90-114	26-123	59-64	33-59	45-61.5	31-38
Green Density, % TD	56.5	56.5	56	54	55	54.5
PRESINTERING:						
Heatup and Soaking Atm.	CO_2	CO_2	CO_2	CO_2	CO_2	CO_2
Cooling Atmosphere	Ar-8%H_2	Ar-8%H_2	Ar-8%H_2	Ar-8%H_2	Ar-8%H_2	N_2-H_2
Time at Temperature, hrs.	2	2	2-2.4	2-2.33	2	2-2.33
Temperature, °C	850	850	850	835-850	850	830-850
Heatup Rate, °C/m	200	200	200	126-202	130-185	125-225
Cooling Rate, °C/m	200	200	200	92-137	138-200	91-256
SINTERING:						
Atmosphere	Ar-8%H	Ar-8%H	Ar-8%H	Ar-8%H	Ar-8%H	Ar-8%H
Furnace Profile Curve	10/14/72	10/14/72	12/12/72	1/13/73	12/12/72	1/13/73
Temperature, °C	1650	1580°	1675	1675	1675	1675
Time, hrs.	1	1	1	1	1	1
Heatup Rate, °C/hr	~ 156	~ 156	~ 183	~ 108	~ 183	~ 108
Cooling Rate, °C/hr	~ 210	~ 210	~ 137	~ 200	~ 137	~ 200
FINAL PELLETS:						
Pu Content, %	19.84	19.84	19.82	19.916	19.87	19.916
O/M	1.958	1.960	1.957	1.960	1.960	1.961

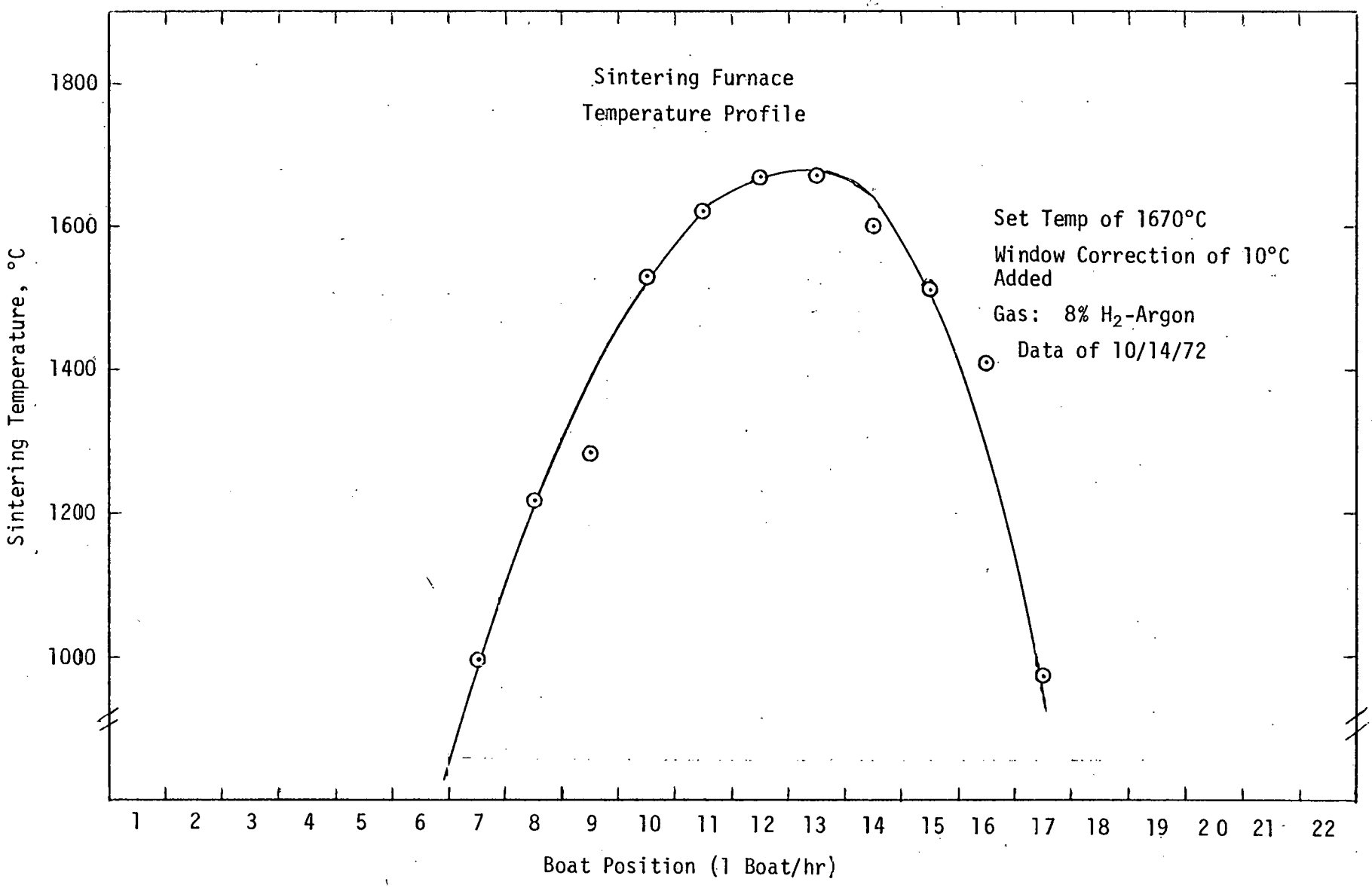


Figure 3: Sintering Furnace Temperature Profile for Mechanically Mixed Fuel Pellets - Lots 5 and 6

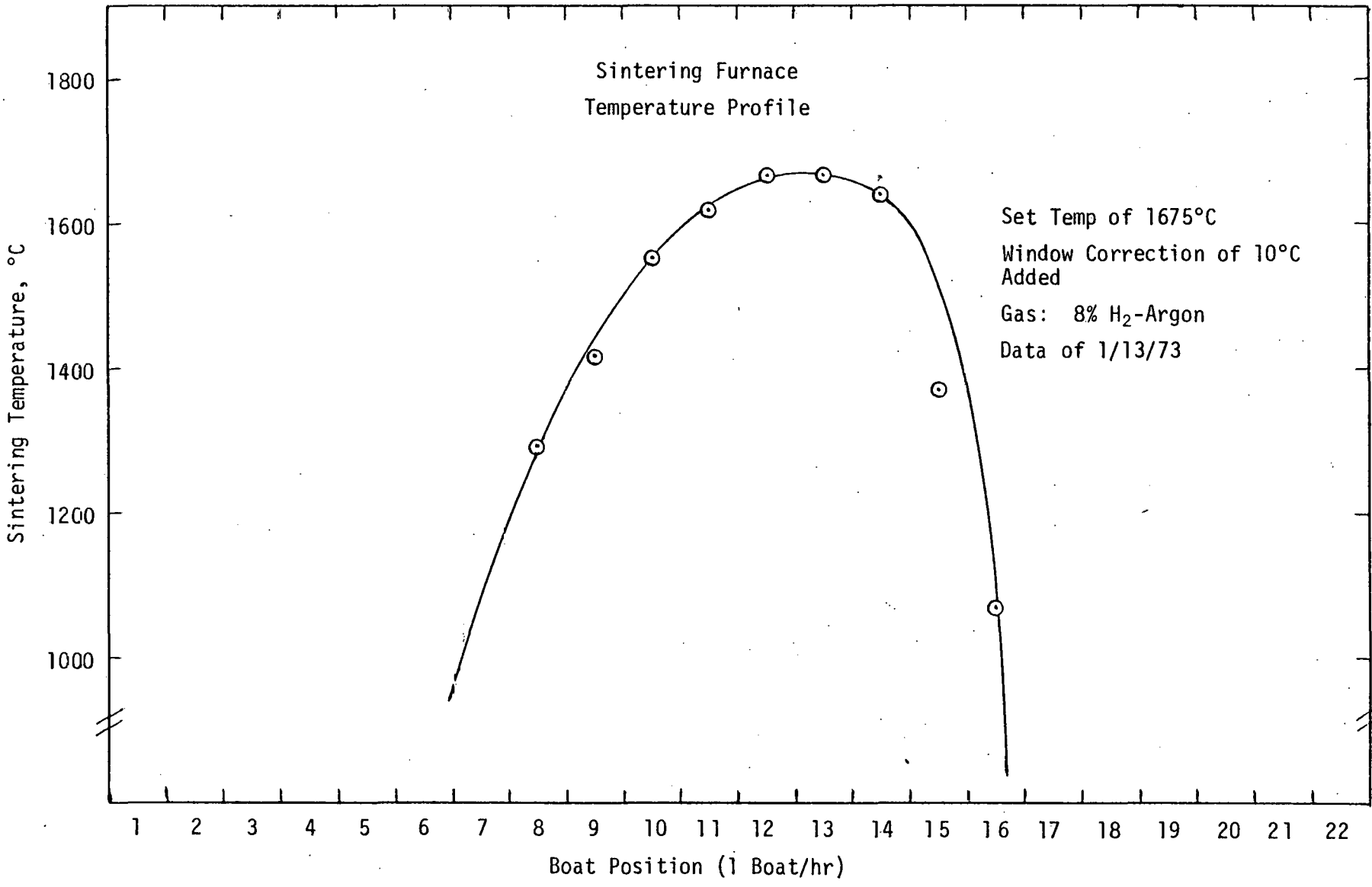


Figure 4: Sintering Furnace Temperature Profile for Mechanically Mixed Fuel Pellets - Lots 8 and 10

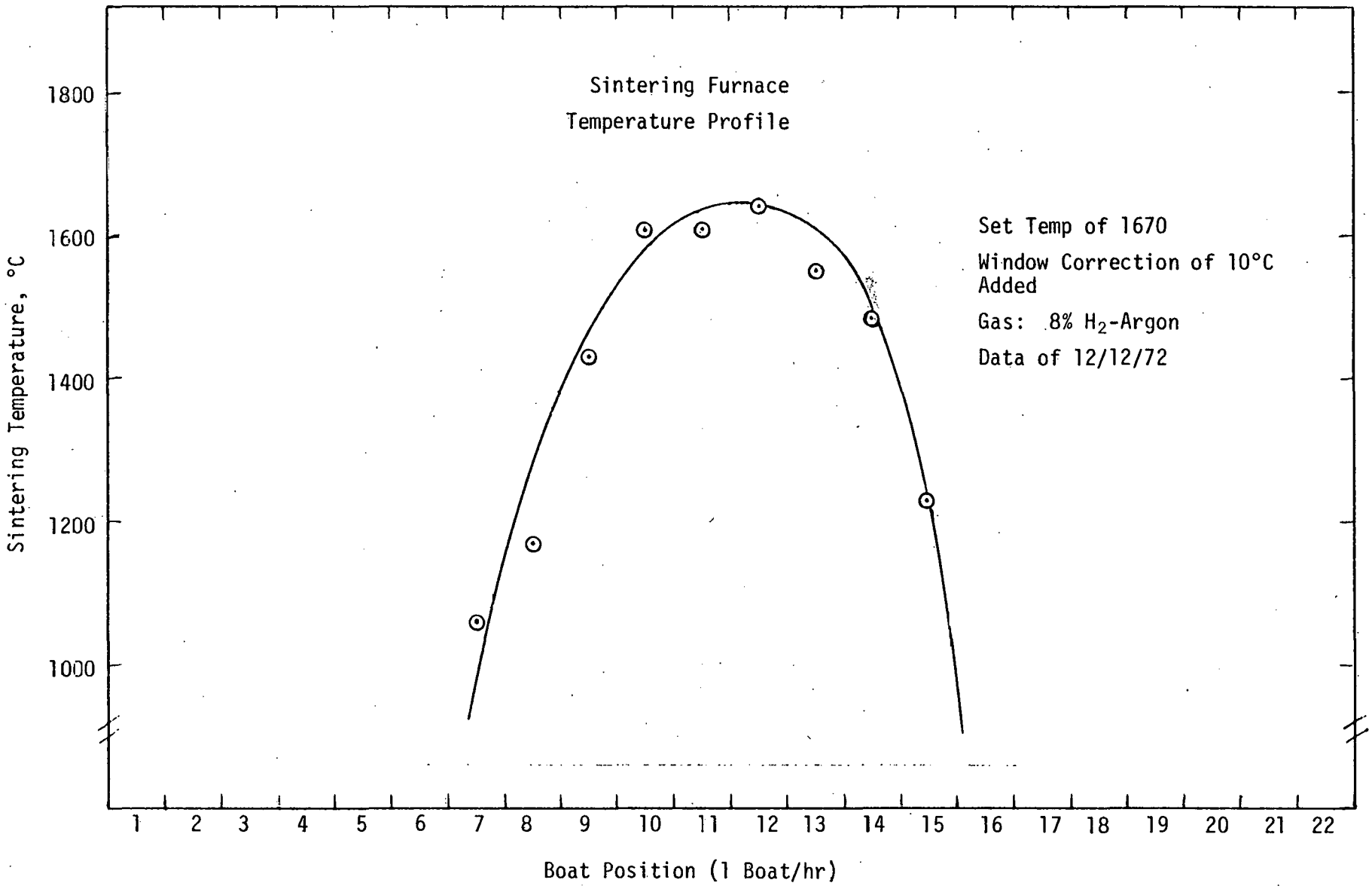


Figure 5: Sintering Furnace Temperature Profile for Mechanically Mixed Fuel Pellets - Lots 7 and 9

Dissolution experiments were run on selected samples of the FFTF vendor fuel pellets during each of 1974, 1975, and 1976; the results will be reported separately to show the general improvement noted for the fuel from 1974 to 1976.

4.1 Dissolution of FFTF Fuel Pellets - 1974

4.1.1 Mechanically Mixed Pellets

Pellet samples from 16 different mechanically mixed fuel pellet lots were dissolved. Dissolution data, calculated as weight percent of the original pellet undissolved, are shown in Table 2. The 16 pellet lots had residues averaging 0.42 weight percent of the original pellet. The largest and smallest residues were 1.18 and 0.025 weight percent of the original pellet, respectively. Completeness of pellet dissolution was close to that predicted from earlier HEDL dissolution data,[1] the average predicted value being 0.98 weight percent of the original pellet. Some of the variation in dissolution data noted from fuel lot-to-lot was predictable based on fabrication differences. For example, the largest pellet residue (1.18 w/o) corresponded to the pellet lot with the lowest sintering temperature (1660°C for pellet lot N-56) while the smallest pellet residue (0.025 w/o) corresponded to the pellet lot with the highest sintering temperature (1700°C for lot N-48). In general, other fabrication differences (e.g. soak time at temperature, rate of temperature rise during sintering, etc.) were not known precisely enough to allow correlation with completeness of dissolution.

Another dissolution difference noted was apparently due to resintering of a pellet lot. Fabrication conditions for fuel lots N-67 and N-67-A were exactly the same except that lot N-67-A was resintered at 1675°C (the original sintering temperatures). Perhaps as a direct result of resintering, samples from lot N-67-A had residues averaging only 0.06 w/o while the original pellet lot had residues averaging 0.46 w/o.

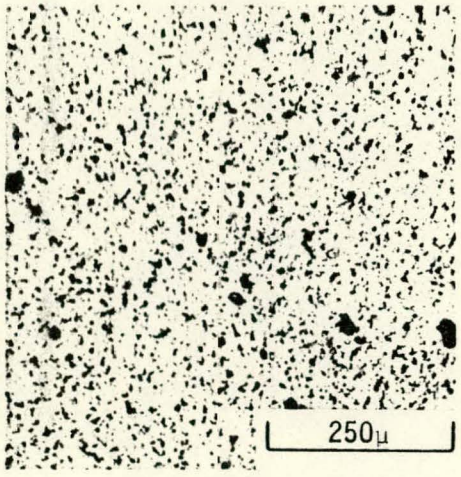
In general, duplication of dissolution results within pellet lots was very good indicating general consistency during fabrication of the various pellet lots.

Particle size of the undissolved residue was determined for residues from four lots of the mechanically mixed fuel pellets by making a glass slide of the residue and photographing different areas of the residue at 100X. The pictures, shown in Figure 6, indicate that the residues were very fine with few particles larger than 50μ in size.

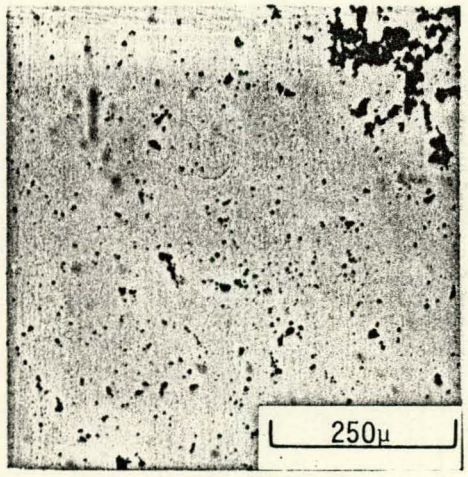
TABLE 2

FFTF VENDOR FUEL DISSOLUTION DATA - 1974

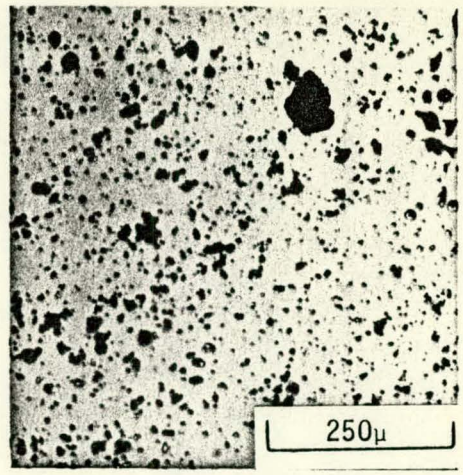
Lot Number	Pellet wt% Undissolved						Average Wt% Undissolved	Standard Deviation ±
	1	2	3	4	5	6		
N-15	1.19	1.13					1.16	0.04
N-43	0.80	0.70					0.75	0.07
N-46	0.25	0.25					0.25	0.00
N-48	0.04	0.01					0.025	0.02
N-49	0.45	0.66					0.55	0.15
N-50	0.22	0.22					0.22	0.00
N-53	0.72	0.83					0.77	0.08
N-56	1.27	1.09					1.18	0.13
N-58	0.42	0.41					0.41	0.007
N-61	0.13	0.06	0.03				0.07	0.05
N-64	0.32	0.15	0.19				0.22	0.09
N-65	0.52	0.42					0.47	0.07
N-66	0.61	0.46					0.54	0.11
N-67	0.49	0.55	0.33				0.46	0.11
N-67A	0.07	0.04					0.055	0.02
N-70	0.92	0.85	0.44				0.74	0.26
K-14	0.01	0.02	0.06	0.08	0.05	0.15	0.04	0.03
K-15	0.61	0.39	0.06	0.08	0.05		0.26	0.24
K-16	0.09	0.13	0.29	0.22			0.18	0.09
K-17	0.13	0.10	0.15				0.13	0.03
K-18	0.31	0.01	0.10	0.19	0.15	0.48	0.21	0.17
K-19	0.06	0.43	0.53	0.51	0.20	0.56	0.38	0.20



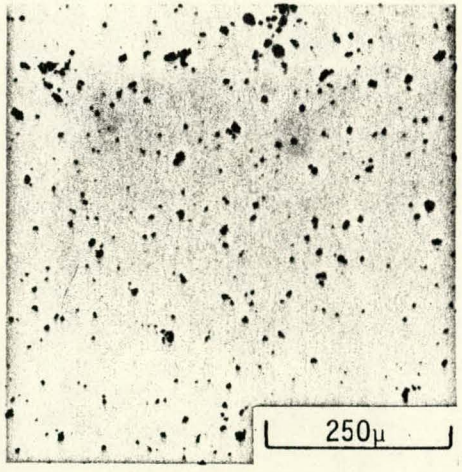
Pellet Lot N-15



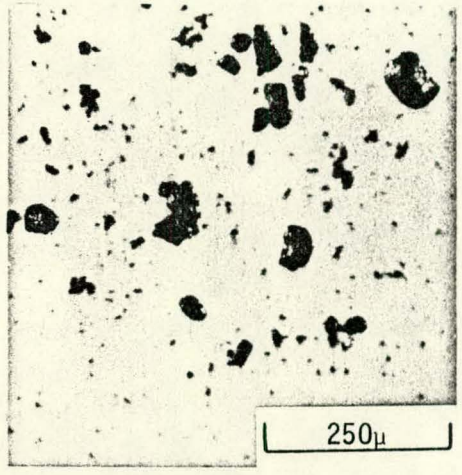
Pellet Lot N-43



Pellet Lot N-56



Pellet Lot N-70 Area A



Pellet Lot N-70 Area B

Figure 6: Dissolution Residues from Mechanically Mixed Fuel Pellets (Neg. No. 744681-1)

4.1.2 Coprecipitated Pellets

Pellets from six different coprecipitated fuel pellet fabrication lots were dissolved. Results are shown in Table 2. Average residue for the six lots was 0.20 weight percent of the original pellet. The largest and smallest residues were 0.38 and 0.04 weight percent, respectively. Based on earlier HEDL dissolution data,[1] one would expect from 0.01 to 0.02 weight percent to be undissolved.

In general, dissolution differences within individual pellet lots were much larger than those noted for mechanically blended fuel pellets. This may be due in part to the much larger particle size of the final undissolved residue, as shown in Figure 7. Individual particles between 200μ and 500μ in length were noted in residue samples from all six coprecipitated fuel pellet lots.

4.1.3 Conclusions

Dissolution data on FFTF Vendor Fuel generally agree with results predicted from earlier HEDL dissolution data. The pellets dissolve rapidly in nitric acid alone although dissolution is not complete. Irradiation of the fuel is expected to render the fuel more completely dissolvable. Complete dissolution of the fuel is achievable if fluoride is added to the nitric acid, although addition of fluoride complicates the resulting reprocessing or refabrication operation.

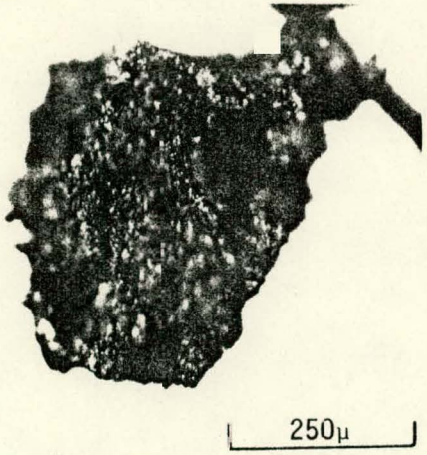
Pellet residues for the mechanically mixed and coprecipitated fuels, on the average, were 0.42 and 0.20 weight percent of the original pellet, respectively. (Corresponding plutonium numbers would be about 1.7 and 0.8 weight percent of the original plutonium, respectively, assuming preferential dissolution of the uranium and a Pu/U ratio of 4 in the residue.) The large residue size of coprecipitated fuel versus mechanically mixed fuel was puzzling and was not explainable without further work.

Because sintering temperature predominantly influences dissolvability, the dissolution test can serve as a secondary check on adequate sintering temperatures.

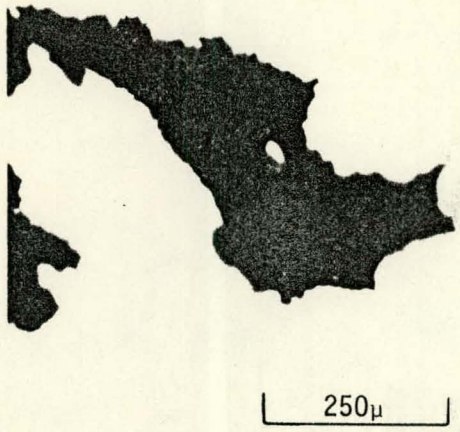
4.2 Dissolution of FFTF Fuel Pellets - 1975

4.2.1 Mechanically Mixed Pellets

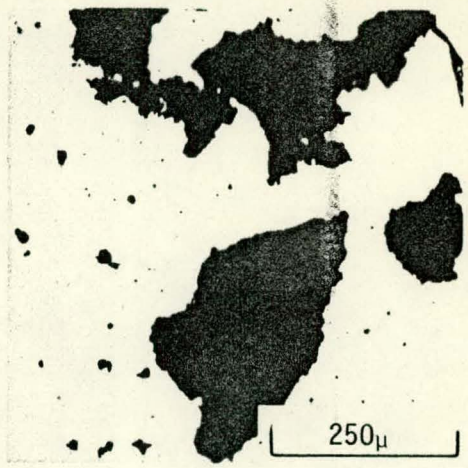
Pellet samples from 15 different mechanically mixed fuel pellet lots were dissolved. Dissolution data, calculated as weight percent of the



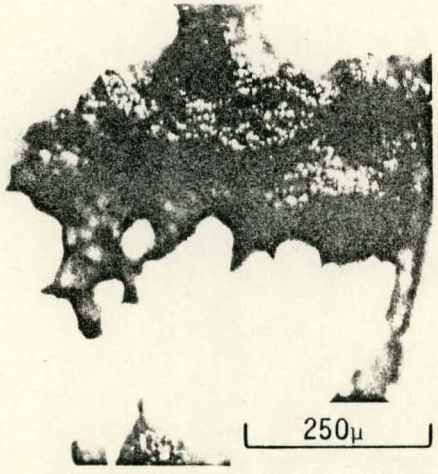
Pellet Lot K-14



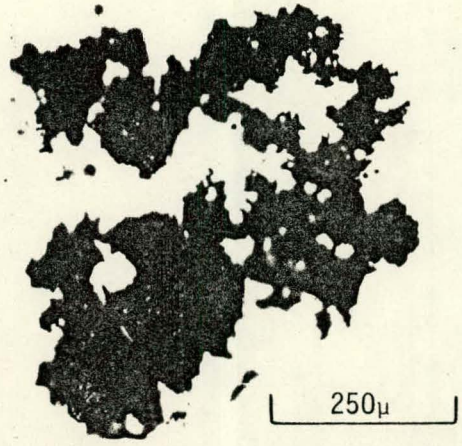
Pellet Lot K-15



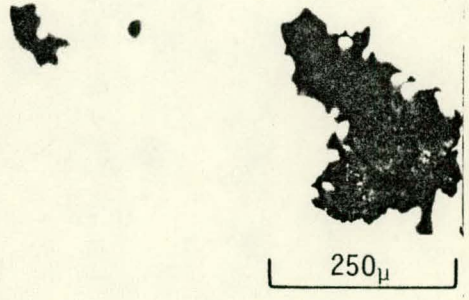
Pellet Lot K-16



Pellet Lot K-17



Pellet Lot K-18



Pellet Lot K-19

Figure 7: Dissolution Residues from Coprecipitated Fuel Pellets (Neg. No. 744681-2)

original pellet undissolved, are shown in Table 3. The 15 pellet lots had residues averaging only 0.014 weight percent. The largest and smallest residues were 0.048 and 0.000 weight percent, respectively. Some samples gave a negative weight percent undissolved due to weighing errors (i.e., the final weight of the filtering crucible and pellet residue was less than the original weight of the filtering crucible, usually by only 0.1 or 0.2 mg). These values were recorded as 0.000 to calculate the average residue; however, the actual negative value was used to calculate the standard deviation for the sample.

In general, duplication of dissolution results within pellet lots was very good indicating general consistency during fabrication of the various pellets.

Particle size measurements on the pellet residues were not attempted due to the very small amount of residue available (e.g., the maximum residue was only 0.8 mg).

All of the fuel lots investigated had very small residues following dissolution in nitric acid alone. Therefore, no attempt was made to explain the different fuel dissolution data as a function of fuel fabrication parameters.

Completeness of pellet dissolution (and, therefore, plutonium dissolution) was far superior for the 15 pellet lots evaluated in 1975 compared to the similarly fabricated fuel pellets evaluated in 1974. The average pellet residue was only 0.014 weight percent of the original pellet compared to an average value of 0.42 weight percent for pellets from 16 previous fuel fabrication lots, or a 30-fold increase in completeness of pellet dissolution. The reason for this was unknown, but it may have been due to a slight change in fabrication conditions which affects completeness of dissolution (e.g., higher pellet sintering temperature and/or longer sintering times).

4.2.2 Coprecipitated Pellets

Pellets from 15 different coprecipitated fuel pellet fabrication lots were dissolved in nitric acid alone. Results are shown in Table 3. Average residue for the 15 lots was only 0.011 weight percent of the original pellet. The largest and smallest residues were 0.060 and 0.000 weight percent, respectively. As with the mechanically blended fuel pellets, duplication of dissolution results within pellet lots was very good.

Completeness of pellet dissolution for the coprecipitated fuel pellets was greatly improved in 1975 compared to results in 1974. Dissolution of pellets from six previous fuel fabrication lots during 1974 gave an average

TABLE 3

FFTF VENDOR FUEL DISSOLUTION DATA - 1975

Fuel Lot Number	Pellet Wt% Undissolved			Average Wt% Undissolved	Standard Deviation ±
	1	2	3		
N-140	0.000	0.000*		0.000	0.006
N-159	0.016	0.000*	0.000	0.005	0.012
N-255	0.024	0.015		0.020	0.006
N-266	0.015	0.000		0.008	0.011
N-269	0.000	0.040	0.000	0.013	0.023
N-279	0.040	0.008	0.000*	0.016	0.031
N-292	0.024	0.016		0.020	0.006
N-322	0.015	0.063	0.032	0.037	0.024
N-400	0.000*	0.000*	0.000	0.000	0.006
N-469	0.064	0.032		0.048	0.023
N-523	0.000*	0.000		0.000	0.005
N-706	0.000*	0.000		0.000	0.006
N-922	0.000	0.000*	0.008	0.003	0.007
N-949	0.032	0.000*	0.064	0.032	0.037
N-972	0.040	0.000*	0.008	0.016	0.024
K-012	0.000	0.000*		0.000	0.006
K-057	0.033	0.000*	0.024	0.019	0.022
K-127	0.008	0.000		0.004	0.006
K-129	0.000*	0.000*		0.000	---
K-159	0.008	0.024		0.016	0.011
K-215	0.000*	0.000*		0.000	---
K-266	0.033	0.025		0.029	0.006
K-356	0.000*	0.000*		0.000	---
K-397	0.008	0.008		0.008	0.000
K-415	0.000*	0.000*		0.000	---
K-423	0.000*	0.000*		0.000	---
K-466	0.034	0.042		0.038	0.006
K-573	0.000*	0.000*		0.000	---
K-670	0.056	0.064		0.060	0.006
K-751	0.000*	0.000*		0.000	---

*Numbers were negative due to weighing differences; however, the actual value was used to calculate the standard deviation for the sample.

residue of 0.20 weight percent of the original pellet whereas the average for the 1975 samples was 0.011 weight percent, or an 18-fold improvement.

4.2.3 Conclusions

Completeness of dissolution was markedly improved for the 1975 mechanically mixed and coprecipitated FFTF pellets compared to pellets from 1974. Pellet residues on the average for the mechanically mixed and coprecipitated fuel were 0.014 and 0.011 weight percent of the original pellet, respectively. (Corresponding plutonium numbers would be about 0.06 and 0.04, respectively, assuming preferential dissolution of the uranium and a Pu/U ratio of 4 in the residue).

4.3 Dissolution of FFTF Fuel Pellets - 1976

4.3.1 Mechanically Mixed Fuel

Pellet samples from 25 different mechanically mixed fuel pellet lots were dissolved. Dissolution data, calculated as weight percent of the original pellet undissolved, are shown in Table 4. The average residue for 24 pellet lots (excluding the high value for fuel lot N-135) was 0.048 weight percent of the original pellet. The largest and smallest residues were 0.295 and 0.000 weight percent, respectively. Three samples gave a negative weight percent undissolved due to weighing errors (i.e., the final weight of the filtering crucible and pellet residue was less than the original weight of the filtering crucible, usually by only 0.1 or 0.2 mg which represents -0.008 to -0.02 weight percent of the pellet). The values were recorded as 0.000 to calculate the average residue; however, the actual negative value was used to calculate the standard deviation for the sample.

In general, duplication of dissolution results within pellet lots was very good indicating general consistency during fabrication of the various pellets.

Pellets from fuel lot N-135 showed a noticable difference in completeness of dissolution and were examined further. The initial three pellets dissolved had residues of 0.130, 1.051, and 6.087 wt% of the original pellets. This wide variation in completeness of dissolution suggested that there might be significant differences in fuel pellet characteristics within the fuel lot.

Fuel dissolution experiments were performed on an additional 14 pellets from fuel lot N-135. The dissolution procedure was identical to that used previously except that final residues were dissolved in 25 ml of 12M nitric

TABLE 4

FFTF MECHANICALLY MIXED FUEL DISSOLUTION DATA - 1976

Fuel Lot Number	Pellet Wt% Undissolved			Average wt % Undissolved	Standard Deviation, ±
	1	2	3		
N-135	1.051	0.130	6.087	2.423	3.207
N-164	-0.015*	-0.040*		0.000	0.017
N-165	0.016	0.008		0.012	0.006
N-166	0.008	0.032		0.020	0.017
N-167	0.056	0.089		0.072	0.023
N-168	0.032	0.016		0.024	0.011
N-169	-0.008*	0.032		0.016	0.028
N-170	0.024	0.031		0.027	0.005
N-172	0.141	0.093		0.117	0.034
N-173	0.047	0.023		0.035	0.017
N-174	0.065	0.032		0.048	0.023
N-175	0.047	0.056		0.052	0.006
N-176	0.073	0.081		0.077	0.006
N-177	0.072	0.099		0.086	0.019
N-178**	0.137	0.048		0.078	0.051
N-178**	0.056	0.295	0.105	0.152	0.126
N-179	0.032	0.016		0.024	0.011
N-180	0.065	0.056		0.061	0.006
N-181	0.072	0.081		0.077	0.006
N-182	0.024	0.048		0.036	0.017
N-185	0.032	0.032		0.032	0.000
N-187	0.024	0.032		0.028	0.006
N-188	0.024	0.024		0.024	0.000
N-189	0.016	0.016		0.016	0.000
N-190	0.032	0.032		0.032	0.000

*Numbers were negative due to weighing differences; however, the actual value was used to calculate the standard deviation for the sample.

**Samples from two different fuel pins: N1Y 416 and N1Z 310.

acid -0.05 M hydrofluoric acid or were analyzed using an electron microprobe. This was done in order to determine if the undissolved residue was rich in plutonium due to preferential dissolution of the uranium. The residues remaining following 12 hours dissolution in 12 M HNO_3 are shown in Figure 8.

Dissolution data from fuel lot N-135, summarized in Table 5, were erratic. The residues ranged from 0.13 to 8.91 wt% of the original pellet with an average value of 3.25 wt% undissolved. Residues from pellet samples 1, 4, and 5 were sent to HEDL's Microstructural Analysis group for electron microprobe analysis. Two as-fabricated pellets were also sent for comparison purposes. In all three of the pellet residues, the composition of the mixed oxide particles was the same as the composition of the as-fabricated pellets (i.e., no isolated zones of plutonium were noted). Additionally, no physical differences or differences in the elemental distribution between the particles of residue and the as-fabricated fuel pellets was noted (i.e., no preferential dissolution of uranium had occurred).

Residues from the other pellets were dissolved in boiling 12 M HNO_3 - 0.05 M HF. The resulting solutions were diluted to volume and analyzed for plutonium content. The weight of UO_2 and the ratio of PuO_2/UO_2 in the undissolved residue were then calculated, as shown in Table 5. The ratio of PuO_2/UO_2 confirmed that preferential dissolution of uranium had not occurred. This was completely different from earlier dissolution data at HEDL which showed preferential dissolution of uranium normally took place whenever large residues resulted following dissolution of mixed oxide fuel pellets.

The reason for the wide variation in dissolution behavior for pellets from fuel lot N-135 is unknown. The differences do not appear to be due to particle differences within the pellets.

4.3.2. Coprecipitated Fuel

Pellets from 34 different coprecipitated fuel pellet fabrication lots were dissolved in nitric acid alone. Results are shown in Table 6. Average residue for 27 of the 34 lots* was only 0.021 weight percent of the original pellet. The largest and smallest residues were 0.098 and 0.000 weight percent, respectively. Duplication of dissolution results within pellet lots was very good.

*Negative numbers were obtained on the first seven lots run due to use of two different balances. The samples were not rerun and the values were not used to calculate the overall average residue for the coprecipitated pellets.

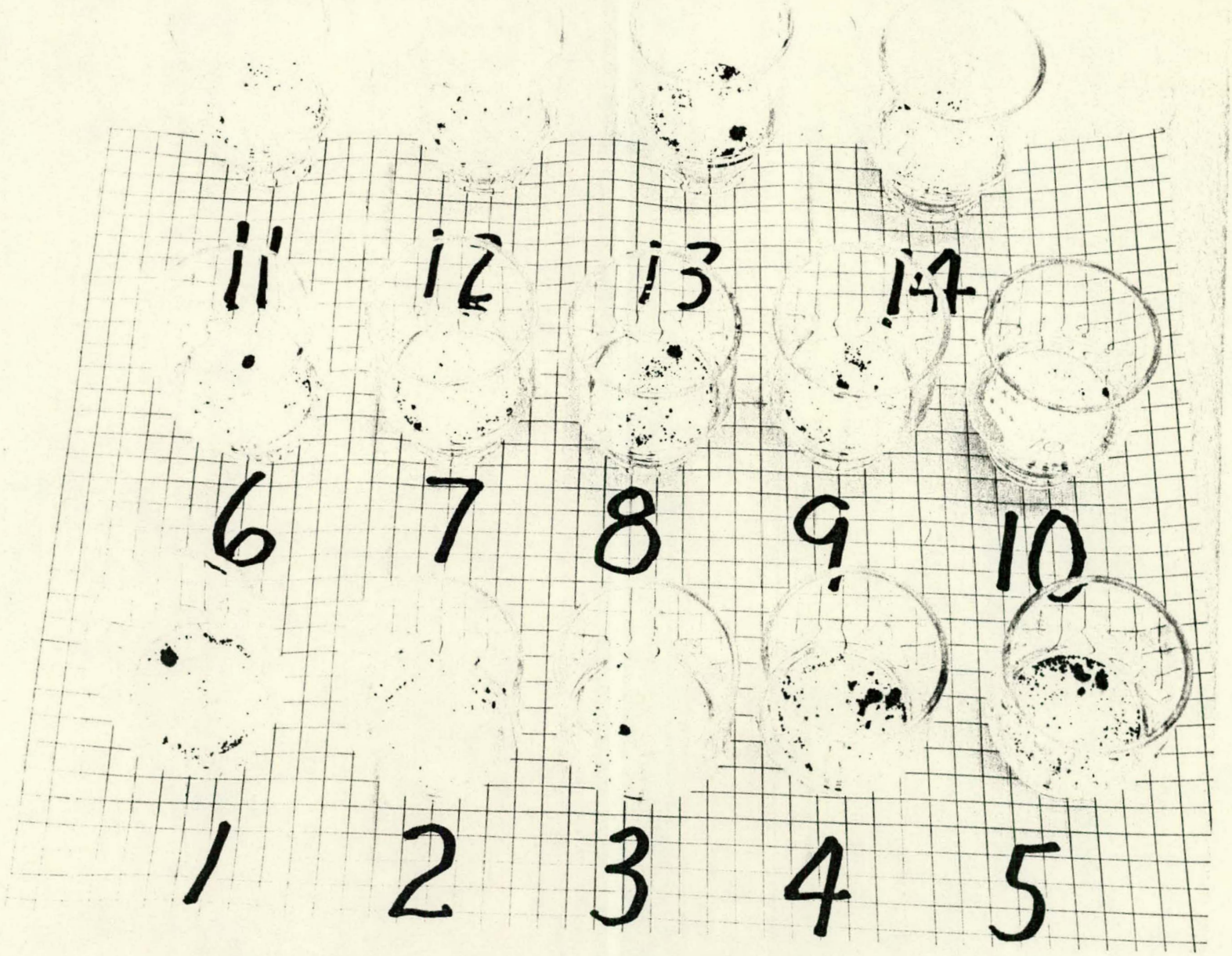


Figure 8: Residues Following Dissolution of Pellets from Fuel Lot N-135. (Neg. No. 761937-1)

TABLE 5

DISSOLUTION OF PuO_2-UO_2 PELLETS FROM FABRICATION RUN N-135

No.	Sample wt. g	Residue wt. mg	wt. % Undissolved[a]	Solution Vol, ml	Pu Content mg/ml[b]	Calculated mg Pu	Pu Content mg PuO_2	UO_2 Content[c] mg	PuO_2[d] UO_2
135-1	1.2119	104.6	8.63						
-2	1.2346	7.2	0.58	25.0	0.0678	1.695	1.923	5.28	0.36
-3	1.2056	16.1	1.34	25.0	0.148	3.700	4.195	11.90	0.35
-4	1.2204	63.4	5.20						
-5	1.2065	82.7	6.85	25.0	0.830	20.75	23.53	59.17	0.40
-6	1.2045	40.6	3.37						
-7	1.2083	13.3	1.10	25.0	0.128	3.200	3.630	9.67	0.38
-8	1.2142	58.4	4.81	25.0	0.591	14.775	16.75	41.65	0.40
-9	1.2153	27.1	2.23	25.0	0.270	6.750	7.653	19.45	0.39
-10	1.2153	5.3	0.44	25.0	0.0514	1.285	1.457	3.84	0.38
-11	1.2174	6.4	0.53						
-12	1.2505	5.8	0.48	25.0	0.0561	1.402	1.590	4.21	0.38
-13	1.2316	111.4	8.91	25.0	1.110	27.75	31.46	79.94	0.39
-14	1.2252	16.3	1.32	25.0	0.158	3.950	4.479	11.82	0.38
-15	1.2267	12.9	1.05						
-16	1.2250	1.6	0.13						
-17	1.2221	74.4	6.09						
			3.25						

(a) After two 6-hr treatments in boiling 12 M HNO_3

(b) After dissolving residue in 25 ml of 12 M HNO_3 - 0.05 M HF

(c) Calculated by subtracting calculated PuO_2 weight from residue weight

(d) Ratio in starting material was 0.33

TABLE 6

FFTF COPRECIPITATED FUEL DISSOLUTION DATA - 1976

Fuel Lot Number	Pellet Wt% Undissolved			Average wt % Undissolved	Standard Deviation, ±
	1	2	3		
K-41M	-0.042*	-0.017*		0.000	0.018
K-42B	-0.024*	-0.017*		0.000	0.006
K-42D	-0.057*	-0.049*		0.000	0.006
K-42E	-0.032*	-0.015*		0.000	0.030
K-42I	-0.041*	-0.033*		0.000	0.006
K-43B	-0.025*	-0.033*		0.000	0.006
K-43D	-0.042*	-0.050*		0.000	0.006
K-47A	0.049	0.089		0.069	0.028
K-47D	0.024	0.057		0.040	0.023
K-47E	0.083	0.016	0.042	0.047	0.034
K-47G	0.033	0.032		0.032	0.001
K-48A	0.025	0.033		0.029	0.006
K-48D	0.024	0.016		0.020	0.006
K-48F	0.016	0.008		0.012	0.006
K-49C	0.017	0.025		0.021	0.006
K-49D	0.016	0.000		0.008	0.011
K-49G	0.000	0.000		0.000	0.000
K-50A	0.008	0.000		0.004	0.006
K-50B	0.098	0.098		0.098	0.000
K-51A	0.058	0.016		0.037	0.030
K-51C	0.042	0.050		0.046	0.006
K-51D	0.042	0.058		0.050	0.011
K-52C	0.008	-0.008*		0.004	0.011
K-52D	0.000	0.017		0.008	0.012
K-53B	0.000	0.000		0.000	0.000
K-53C	0.000	-0.008*		0.000	0.006
K-53E	0.000	-0.008*		0.000	0.006
K-53F	0.008	0.000		0.004	0.006
K-54A	0.017	0.000		0.008	0.012
K-55E	0.000	0.000		0.000	0.000
K-55F	0.008	0.008		0.008	0.000
K-56C	0.008	0.008		0.008	0.000
K-56D	0.000	0.000		0.000	0.000
K-57A	0.008	0.008		0.008	0.000

*Numbers were negative due to weighing differences; however, the actual value was used to calculate the standard deviation for the sample.

4.3.3 Conclusions

As summarized in Table 7, completeness of dissolution continued to show a marked improvement in 1976 compared to the initial results in 1974 for both the mechanically mixed and the coprecipitated fuel. Pellet residues for the mechanically mixed and coprecipitated fuel averaged 0.048* and 0.021 weight percent of the original pellet, respectively. (Corresponding plutonium numbers would be about 0.17 and 0.06 percent of the total plutonium respectively, assuming preferential dissolution of the uranium and a Pu/U ratio in the residue of 4 as shown in previous mixed oxide dissolution residues).

5.0 CONCLUSIONS

Completeness of dissolution of both mechanically mixed and coprecipitated fuel pellets showed a marked improvement between 1974 and 1976. The reason for this is unknown, but may have been attributable to slight changes made in the fuel fabrication procedures (e.g., slight increase in sintering temperature, changes in the UO_2, PuO_2 starting material, etc.)

In general, the bulk of the samples had residues less than 0.1% of the starting material (i.e., greater than 99.9% of the pellet dissolved). At one time it had been proposed that one of the fuel fabrication requirements for mixed oxide fuel be that the completeness of dissolution of the as-fabricated pellet in nitric acid alone be greater than 99.9%. Such a requirement would greatly enhance planning for reprocessing of the fuel since it would probably eliminate the requirement for a secondary dissolver. As can be seen from these data, most of the FFTF pellets would meet such a criterion.

TABLE 7

SUMMARY OF DISSOLUTION DATA ON FFTF VENDOR FUEL PELLETS

Year	Mechanically Mixed Fuel		Coprecipitated Fuel	
	Number of Lots	Average Wt% Undissolved	Number of Lots	Average Wt% Undissolved
FY-1974	16	0.420	6	0.200
FY-1975	15	0.014	15	0.011
FY-1976	24	0.048	27	0.021

*Average excludes one sample which had an average residue of 2.42 weight percent of the original pellet.

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