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MILLIWATT GENERATOR SOURCE
PROGRESS REPORT

October 16, 1977 - January 15, 1978

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Program Manager

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MOUND FACILITY

Miamisburg, Ohio

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MILLIWATT GENERATOR HEAT SOURCE PROGRESS REPORT

I. Introduction

Activities at MRC associated with the Milliwatt Generator Heat Source efforts over the period October 16, 1977, to January 15, 1978, are presented below.

II. Hardware Production (R. W. Saylor)

To date three blanking dies (strength member body, strength member cap, and liner body) have been modified. A punch chipping problem was remedied by replacing the carbide punches with hardened steel punches.

In the forming of strength member bodies 256 through 330, a high number of parts were unacceptable because of dye penetrant crack indications. The problem was traced to an evidently poor quality sheet of T-111 (Sheet #16). Upon investigation, it was found that the failure rate for Sheet #16 was 25.7%, which was a significantly higher reject rate than normally experienced. Sheet #16 was removed from the process, and other strength member bodies were fabricated to replace the components with cracks.

Thirty strength member bodies and caps are presently being fabricated from Lot 8 T-111. These components will be used for the pressure burst capsules to qualify Lot 8 T-111 for production usage. Hardware fabrication and evaluation will be completed by January 31, 1978, with the pressure burst capsule fabrication and initial testing to be in February, 1978.

Hardware continues to be produced on schedule with high acceptance rates for each of the seven components. Shown in Table I are the number of components produced to date and the acceptance rates. Also shown are the cost of defectiveness and the dollar percent defective values. These latter data permit a more realistic

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Table I
Quality Report on Hardware

<u>Component</u>	<u>Number Fabricated</u>	<u>Number Prime</u>	<u>Number Example Weld</u>	<u>Eng. Eval</u>	<u>Number Scrap</u>	<u>Process Yield (%)</u>
Liner Shim	345	341	-	-	4	99
Liner Cap	345	342	3	-	0	100
Liner Body	345	340	5	-	0	100
Strength Member Cap	360	342	14	-	4	99
Strength Member Body	360	292	45	12	11	97
Clad Cap	360	351	7	-	2	99
Clad Body	360	350	5	-	5	99

Overall Process Yield	98.9%
Dollar Value of Fabricated Hardware	\$115,611
Cost of Defectiveness	\$ 1,279
Dollar Percent Defective	1.1%

view of the reject costs than the simple acceptance or reject rates because it reflects whether the problem occurred early or late in the process.

III. Heat Source Fabrication (C. E. Burgan)

After the initial production welding problems were resolved (Section V, MWG Progress Report, July 16 - October 15, 1977), no major problems have been encountered with any phase of the encapsulation processes. To date, 232 units have been encapsulated through the liner, 213 units through the strength member, and 147 units through the clad. The first data package and unit presentation to DOE will be performed prior to January 31. Encapsulation progress to date is slightly ahead of the projected schedule of 60 units/month encapsulated through the liner.

Shown in Table II is the Quality Report on Assemblies. Again, the dollar percent defective values are shown, which are more representative of the process than the simple acceptance or reject rates.

The total dollar percent defectiveness to date for the program is 3.6%, or a total cost of defectiveness of \$15,583 vs. a total dollar value of all product of \$433,395.

IV. Inconel 600/T-111 Alloy Compatability Studies (P. E. Teaney)

Oxidation resistant Hastelloy-C (registered trademark of Cabot Corporation) is the material presently used to clad the Milliwatt Generator radioisotopic heat source. Hastelloy-C is no longer commercially available and the limited supply at Mound will be depleted before the projected heat source production is completed. Inconel 600 (registered trademark of the International Nickel Company, Inc.) alloy has properties and composition similar to Hastelloy-C and is under consideration as an alternate clad material.

Nominal chemical compositions of the alloys are compared in Table III. Hastelloy-C contains several elements not

Table II
Quality Report on Assemblies

Liner Assembly	Fabricated	232
	Rejected	4 ¹
	Yield	98%
	Cost of Defective- ness	\$2,480
	Value of Fabricated Units	\$ 141,360
	\$ % Defective	1.8%
Strength Member Assembly	Fabricated	213 ²
	Rejected	7 ³
	Acceptable	206
	Yield	97%
	Cost of Defective- ness	\$4,298
	Value of Fabricated Units	\$92,494
	\$ % Defective	4.6%
Clad Assembly	Fabricated	147 ⁴
	Rejected	11 ⁵
	Acceptable	136
	Yield	93%
	Cost of Defective- ness	\$7,690
	Value of Fabricated Units	\$91,528
	\$ % Defective	8.4%

Remarks:

¹2-dye indications 1-power failure 1-bad weld

²Includes 7 rework

³7-ultrasonic indication in the weld area

⁴Includes 11 rework

⁵11-outside diameter in the heat affected zone too large

Table III

Nominal Chemical Compositions of Inconel Alloy
600 and Hastelloy Alloy C (Weight Percent)

<u>Element</u>	<u>Inconel Alloy 600^A</u>	<u>Hastelloy Alloy C^B</u>
Ni	76.0	54.25
Cr	15.5	15.5
Mn	0.5	1.0
Fe	8.0	5.5
S	0.008	0.03
Si	0.25	1.0
Cu	0.25	-
C	0.08	0.08
Co	-	2.5
Mo	-	16.0
W	-	3.75
V	-	0.35
P	-	0.04

^AJoining of the Huntington Alloys, Technical Bulletin T-2,
Huntington Alloy Products Division of the International
Nickel Company

^BHastelloy-C Product Information Booklet, Stellite Division
of the Cabot Corporation

included in Inconel 600 such as cobalt, molybdenum, tungsten, vanadium, and phosphorus. Inconel 600 contains 0.25% copper which is not in Hastelloy-C. The majority of the constituents are similar with some difference in composition.

In order to be used as a clad, the material must be compatible with the underlying strength member material at the 450°C operating temperature of the RTG. Therefore, tests were conducted to determine the compatibility of Inconel 600 and T-111 which is used for the strength member. The configuration of the test capsules is shown in Figure 1. Differences in the thermal expansion coefficients of the two materials indicated that contact at test temperatures would be enhanced by enclosing the Inconel 600 in the T-111. The three compatibility discs were pressed in place and the top disc was gas tungsten arc welded to assure intimate contact. After fabrication, the specimens were tested according to the matrix in Table IV.

After testing, metallographic examination of the cross-sectioned specimens revealed reaction zones that appeared to be a function of time and temperature. Although diffusion occurred in both directions, the diffusion of the Inconel 600 components into the T-111 material predominated. As a result, a line of Kirkendall type voids existed along the Inconel 600 side of the reaction zone. The reaction zone of the specimen tested at 1225°C for 16 hours is shown in Figure 2. The remaining specimens had similar reaction zones.

The widths of the reaction zones were determined by measurements from the photomicrographs, with the results shown in Table V. These data were fitted to the equation $(\Delta X)^2 = kt + b$, where X is the width of the reaction zone in μm and t is the time at temperature in hours. The resulting rate curve for each temperature is shown in Figure 3. The natural logs of the reaction rates for each temperature were then plotted versus 1/T in Figure 4 for determination of the activation energy for the reaction. The activation energy of the reaction whose rate is described by $(X)^2 = kt + b$ was determined to be

NOTE: SAMPLES TESTED AT 1225°C CONTAINED A TUNGSTEN BARRIER TO PREVENT REACTION BETWEEN THE CLAD AND THE CAPSULE

FIGURE 1. CONFIGURATION OF T-111/INCONEL 600 TEST CAPUSLE

Table IV

T-111/Inconel 600 Compatibility Test
Matrix

<u>Temperature (°C)</u>	<u>Time (Hr.)</u>		
1225	1	4	16
1100	10	40	160
1000	100	400	1600

300X (as polished)

Reaction between Inconel 600 and T-111 alloy
after 16 hrs. at 1225°C

FIGURE 2

Table V

Reaction Zone Measurements for
Inconel 600/T-111 Compatibility Tests

<u>Temperature (°C)</u>	<u>Width of Reaction Zone in μm at Various Times</u>		
	<u>1 Hr.</u>	<u>4 Hr.</u>	<u>16 Hr.</u>
1225	25.7	40.7	73.3
1100	<u>10 Hr.</u>	<u>40 Hr.</u>	<u>160 Hr.</u>
	26.0	38.7	70.0
1000	<u>100 Hr.</u>	<u>400 Hr.</u>	<u>1600 Hr.</u>
	26.0	42.0	83.3

FIGURE 3. REACTION RATE CURVES FOR INCONEL 600/T-111
ALLOY COMPATIBILITY STUDIES

72.6 kcal/mole. Electron microprobe analyses of the specimens showed that diffusion of nickel and iron into the T-111 predominated, followed by chromium. This value is in the range of activation energies one would expect for the diffusion of nickel and iron in tantalum. Activation energies for the diffusion of several major constituents of superalloys in tantalum and niobium are shown in Table VI for comparison. Agreement with these data is good. Assuming that this same mechanism is the rate controlling one at temperatures below 1100°C, these data would indicate that reaction between these materials would be minimal below 940°C.

A literature search failed to reveal any Hastelloy-C/T-111 compatibility data for direct comparison with this study. However, the results for several tests where Hastelloy-X and Hastelloy-C were coupled with tantalum and cycled between 700°C and 1100°C were found.¹ Diffusion zones of about 150 µm were reported after cycling between 700°C and 1100°C for a total of approximately 170 hours at 700°C and approximately 280 hours at 1100°C. Using only the time that the specimens were at 1100°C, the possible diffusion zone was calculated (assuming that the rate from this study for 1100°C in Figure 3 applied). The result indicated a zone of 91 µm compared to the 150 µm zone reported.

Results for a Hastelloy-X/tantalum test at 1100°C were also reported in the same study. Reaction zones of 0.0025 inches (63.5 µm) after 600 hours and 0.003-0.005 inches (76.2 µm - 127 µm) after 840 hours were reported. Using the rate for 1100°C in Figure 3, comparable zones of 131 µm after 600 hours and 155 µm after 840 hours would be estimated for the Inconel 600/T-111 couple. Differences in the test design, the minor constituents of the alloys and the composition of the major constituents make exact correlation of these data unlikely. The report corroborated the preferential diffusion of nickel and iron and enrichment on the tantalum rich side of the reaction zone that was present in the Inconel 600/T-111 tests.

¹Reactions of Selected Metal-Metal Couples at 1100°C,
L. J. Kirby and H. T. Fullman, BNWL-421, June, 1967.

Table VI

Activation Energies for Diffusion of Several Major Superalloy
Components in Tantalum and Niobium^A

<u>Component</u>	<u>Value for Diffusion in Ta (kcal/mole)</u>	<u>Value for Diffusion in Nb (kcal/mole)</u>
Fe	71.4	77.7 $\pm$ 1.2
Cr	Not Given	83.5 $\pm$ 1.8
Ni	Not Given	Not Given
Mo	81.0	Not Given
Co	Not Given	70.5 $\pm$ 1.6

^AC. J. Smithells, Metals Reference Handbook, 5th. Ed.

No compatibility information for these types of couples at or below 900°C was found in the literature. However, a considerable number of thermally aged milliwatt heat sources have been evaluated at Mound. No Hastelloy-C/T-111 reactions were observed in heat sources maintained at or below 900°C for up to a maximum test time of two years. These data for Inconel 600 and the similarity in chemical composition with Hastelloy-C imply that the same results would be true for Inconel 600 alloy. Therefore, the substitution of Inconel 600 for Hastelloy-C should pose no compatibility problem in the heat source.

V. Oxygen Partial Pressure Studies (D. R. Schaeffer)

Continuing are the thermodynamic studies related to $\text{PuO}_2/\text{Y}_2\text{O}_3/\text{T-111}$ equilibria to provide better understanding toward capsule compatibility. Planned is an electrolytic cell measurement of the oxygen partial pressure in the capsule after fabrication, during pretreatment and during a subsequent fire test.

The cell has been fabricated and preliminary tests have been conducted in measuring the ΔG° of Cr_2O_3 using a Ni/NiO reference electrode. The results are shown in Table VII and in Figure 5, along with results previously published in the literature. The results agree with the literature values when the temperature was increased in 100°C increments from 900°C to 1200°C. However, when the temperature was lowered back to 900°C, the values did not repeat. All results were obtained after equilibrium had been established at each temperature. The reason for this anomaly is presently being investigated.

Table VII

 ΔG° of Cr_2O_3 Using a Ni/NiO Reference Electrode

<u>Temperature (°C)</u>	<u>Cell emf (volts)</u>	<u>$\Delta G^\circ \text{Cr}_2\text{O}_3$ (cal)</u>
896	.71238	-194,100
990	.71748	-188,800
1093	.71832	-182,330
1203	.71536	-174,890
1094	.70794	-180,830
987	.68047	-183,870
1095	.70643	-180,560
989	.67885	-183,560

References to Figure 5 (page 17)

1. L. A. Pugliese and G. R. Fitterer, Met Trans, 1970, Vol. 1, p. 1997-2002.
2. J. D. Tretjakow and H. Schmalzried, B. Bunsengesellschaft, Phys. Chem., 1965, Vol. 69, p. 396.
3. O. Kubaschewski, E. L. Evans, and C. B. Alcock, Metallurgical Thermochemistry, Pergamon Press, N.Y. 1967.
4. Y. Jeannin, C. Mannerskantz, and R. D. Richardson, Trans. Met. Soc. AIME, 1963, Vol. 227, p. 300.

VI. Fuel Aging Studies (P. E. Teaney)

Fuel aging studies were performed to determine the possible degradation of the fuel form used in the heat source under operating conditions of the RTG and the resultant generation of respirable fines. (Respirable fines are considered to be all particles less than 4.5 μm diameter. The largest particle size that will remain airborne in agitated air is 10 μm diameter.) These data are necessary in the unlikely event that the heat source is accidentally breached during the life of the RTG. In addition to long term thermal aging of the fuel, evaluations included thermal ramping of the aged fuel to 1000°C and impacting a thermally hot (450°C) heat source at 150 m/sec after thermal aging.

The matrix for this study is shown in Table VIII. The study was originally designed for fines determinations in the >5 μm and 5-10 μm size ranges, but later was modified to include the 10-20 μm particle size range. As the tests progressed, proposed aging times for the specimens were extended in order to obtain long term data. Plutonia fines generation data were obtained for specimens aged at 450°C for up to 27 months after the one hour at 1350°C pretreatment.

Plutonia fines data for the studies are summarized in Table IX. In addition, the microstructures of the fuel at each stage of aging were compared. The pressure mounting technique used for the metallographic processing of the samples caused some shard break-up, and the photomicrographs should not be used to estimate the generation of fines.

Comparison of the fuel microstructure prior to testing (Figure 6) with the microstructure of the fuel after pretreatment (Figure 7) shows that during pretreatment, helium in the fuel migrated to the grain boundaries, forming small round bubbles which delineated the boundaries. The two phase appearance of several of the fuel shards in both the aged and pretreated specimens is

TABLE VIII
FUEL AGING STUDIES

<u>Sample Description</u>	<u>Type of Sample</u>	<u>No. Samples</u>	<u>Age</u>	<u>Analyses Performed</u>
Baseline Fuel	A	2	-	<5 μ fines, fuel microstructure
Pretreatment Effects	B	2	-	<5 μ fines, fuel microstructure
Impact Effects on Non-Aged Fuel	C	2*	-	<5 μ fines, >5 μ fines distribution
Aging Effects	C	2	6 mo at 450°C	<5 μ fines, fuel microstructure
	C	2	≥ 9 mo at 450°C	<5 μ fines, fuel microstructure
	C	2	≥ 12 mo at 450°C**	<5 μ fines, fuel microstructure
	C	1	≥ 15 mo at 450°C***	<5 μ fines, fuel microstructure
Impact Effects on Aged Fuel	C	2	≥ 15 mo at 450°C***	<5 μ fines, >5 μ fines distribution
Thermal Ramp (to 1000°C) Effects on Aged Fuel	C	2	≥ 15 mo at 450°C***	<5 μ fines, fuel microstructure

A - PuO₂ shards, no Y

B - PuO₂ shards with Y, encapsulated in liner and strength member, pretreated

C - PuO₂ shards with Y, encapsulated through clad, pretreated in strength member

*Impact data agreed with previous impact data, therefore, second capsule will be reserved for other tests

**Testing extended to 15 months

***Testing extended to 27 months

Table IX
Fuel Aging Studies
(Plutonia Fines Data)

Sample Number	Test Conditions	Weight Percent ²³⁸ Pu Fines		
		<5 μm	5-10 μm	10-20 μm
P-438	Baseline Fuel for MF-29C through -38C	3.83x10 ⁻³	4.3x10 ⁻⁴	*
P-445	Baseline Fuel for MF-39C through -47C	1.73x10 ⁻³	5.9x10 ⁻⁴	*
MF-37C	Pretreated Fuel	6.5x10 ⁻⁴	4.9x10 ⁻⁴	*
MF-38C	Pretreated Fuel	1.36x10 ⁻³	7.0x10 ⁻⁴	*
MF-29C	Impacted Fuel (149 meters/sec at 450°C)	4.08x10 ⁻²	1.0x10 ⁻⁴	*
P-445 (aged)	Aged 10 months in a 20-30 gram batch	4.96x10 ⁻³	6.6x10 ⁻⁴	*
MF-39C	Aged 6 months at 450°C (after pretreatment)	1.53x10 ⁻²	2.98x10 ⁻²	1.32x10 ⁻²
MF-40C	Aged 6 months at 450°C	2.25x10 ⁻²	1.74x10 ⁻²	1.24x10 ⁻²
MF-41C	Aged 9 months at 450°C (after pretreatment)	1.60x10 ⁻²	3.34x10 ⁻²	4.34x10 ⁻²
MF-42C	Aged 9 months at 450°C (after pretreatment)	2.52x10 ⁻²	2.08x10 ⁻²	3.14x10 ⁻²
MF-43C	Aged 15 months at 450°C (after pretreatment)	2.27x10 ⁻²	1.01x10 ⁻²	1.22x10 ⁻²
MF-44C	Aged 15 months at 450°C (after pretreatment)	9.33x10 ⁻³	1.13x10 ⁻²	3.11x10 ⁻²
MF-34C	Aged 27 months at 450°C and thermal ramp to 1000°C (after pretreatment)	2.25x10 ⁻²	1.91x10 ⁻¹	2.37x10 ⁻¹
MF-36C	Aged 27 months at 450°C and thermal ramp to 1000°C (after pretreatment)	1.56x10 ⁻²	1.94x10 ⁻²	1.87x10 ⁻¹
MF-30C	Aged 27 months at 450°C and impacted 150 m/sec at 450°C (after pretreatment)	3.10x10 ⁻²	5.50x10 ⁻¹	1.35x10 ¹
MF-31C	Aged 27 months at 450°C and impacted 150 m/sec at 450°C (after pretreatment)	1.10x10 ⁻²	1.86x10 ⁻¹	1.40x10 ¹
MF-33C	Aged 27 months at 450°C (after pretreatment)	7.47x10 ⁻³	6.86x10 ⁻³	1.08x10 ⁻¹

*Determinations in this size range were not performed during the initial phase of this study.

125X

250X

Fuel Microstructure Prior to Testing (Single phase with
no helium bubbles)

FIGURE 6

110X (Etched)

130X (As Polished)

210X (Etched)

Fuel Microstructure
after Pretreatment (Two
phases with helium
migrated to grain
boundaries)

FIGURE 7

indicative of substoichiometric fuel. [Analyses of previous fuel has indicated that the lighter (acicular-structured) phase is PuO_2 and that the darker phase is Pu_2O_3 .] Examples of the substoichiometric fuel are particularly evident in the etched photomicrographs in Figure 7.

Figure 8 shows fuel aged for six months at 450°C . The delineation of the grain boundaries by helium bubbles appeared more pronounced than immediately after pretreatment. However, the microstructure did not explain fines generation during the first six months of aging because if break-up occurred along the delineated grain boundaries the estimated grain size of the fuel would only account for increases between 10 and $90\text{ }\mu\text{m}$. No additional changes in microstructure were noted in the fuel after nine months (Figure 9), 15 months (Figure 10) and 27 months (Figure 11). Transgranular fracture of the fuel shards is evident after 27 months of aging and impact at 150 m/sec, 450°C (Figure 12). The clumped fuel (lower left photomicrograph) is a result of fuel being compacted during impact.

In the thermally ramped (to 1000°C) sample, the fuel microstructure appeared no different than aged fuel (Figure 13). Although wide variations in grain size (from 10 to $90\text{ }\mu\text{m}$) were evident, this is characteristic of the fuel and is not related to thermal aging or ramping.

Comparison of data (Table IX) for the baseline fuel with the pretreated fuel indicated that no fines were generated during pretreatment. The baseline fuel was rechecked after aging 10 months in a 20-30 gram batch and no significant increase in fines was observed. Comparison of data for an impacted specimen (MF-29C) with the baseline fuel (P-438) indicated an increase in $<5\text{ }\mu\text{m}$ fines from 3.83×10^{-3} to 4.08×10^{-2} weight percent. However, there was no increase in the 5-10 μm particle size range.

125X

150X

220X

Fuel Microstructure
after Aging for 6 Months

FIGURE 8

150X

150X

150X

Fuel Microstructure after
Aging for 9 Months, 450°C

FIGURE 9

130X (As Polished)

150X (As Polished)

230X (As Polished)

Fuel Microstructure
after Aging for 15 Months,
450°C

FIGURE 10

Fuel Microstructure after Aging for 27 Months, 450°C
FIGURE 11

105X (as polished)

205X (as polished)

105X (as polished)

205X (as polished)

205X (as polished)

Fuel Microstructure
after Aging 27 Months,
450°C, Followed by
Impact at 150 m/sec,
450°C

FIGURE 12

105X (as polished)

105X (as polished)

205X (as polished)

Fuel Microstructure
after Aging 27 Months,
450°C Followed by
Thermal Ramping to
1000°C

FIGURE 13

Comparison of data for the baseline fuel with pre-treated fuel aged for 6, 9, 15 and 27 months at 450°C indicated a slight initial generation of fines during the first six months of aging. No additional fines were generated through 27 months of aging at 450°C in the <5 µm and 5-10 µm size range. However, fines in the 10-20 µm size range increased approximately one order of magnitude between 15 and 27 months of aging at 450°C.

MC-34C and MF-36C were thermal ramped to 1000°C after aging for 27 months at 450°C. No <5 µm or 10-20 µm fines were generated by the thermal ramp to 1000°C. The fines present in the <5 µm size range occurred during the first six months of aging at 450°C and the fines present in the 10-20 µm size range apparently occurred during the 15 to 27 months of thermal aging. In the 5-10 µm size range, one specimen (MF-34C) showed an increase while the other (MF-36C) did not. The results for this size range are therefore inconclusive at the present time.

Two specimens (MF-30C and MF-31C) were aged for 27 months at 450°C and then impacted at 450°C at 150 meters/second. No additional <5 µm fines resulted from impacting the aged fuel. However, there was a slight increase in 5-10 µm fines and a significant increase (from ~0.1 to 13.5-14.0 wt %) in particles in the 10-20 µm size range. The increase appears to be normal for impacted fuel and appears to be independent of thermal aging. (Unfortunately, determinations in this size range were not being made when the baseline fuel and initial impacted specimen were analyzed.) Similar results were recently obtained for heat sources containing unaged fuel. Four heat source specimens were impacted at ~150 meters/second at 450°C shortly after fabrication using unaged fuel. Results for the 10-20 µm particle size distribution ranged from ~2 to 30 wt %. Results for the aged specimens after impact fall approximately midway in this range.

In summary, no $<5\text{ }\mu\text{m}$ or $5\text{-}10\text{ }\mu\text{m}$ fines were generated during the one hour at 1350°C pretreatment prior to thermal aging. There was an increase in $<5\text{ }\mu\text{m}$ and $5\text{-}10\text{ }\mu\text{m}$ fines during the first six months of thermal aging and an increase in $<5\text{ }\mu\text{m}$ fines during the impact of specimens containing unaged fuel. No further increases in respirable fines ($<5\text{ }\mu\text{m}$) were observed through 27 months of thermal aging or during thermal ramping or impacting of aged fuel specimens. The thermal ramp of the aged fuel to 1000°C apparently does not generate fines, however, results for the $5\text{-}10\text{ }\mu\text{m}$ size range are inconclusive. Impacted aged specimens showed some increase in $5\text{-}10\text{ }\mu\text{m}$ fines. Also, there was a considerable increase in $10\text{-}20\text{ }\mu\text{m}$ particles. However, recent data indicate that this was characteristic of impacted specimens and thermal aging most likely does not contribute to the increase.

VII. Pressure Burst Capsule Evaluation (D. A. Pawlak)

Three additional capsules (MF-71F, -72F, and -73F), which were fabricated from Lot 7 T-111 during TMS activities, were pressure burst tested during the report period. These units are a continuation of data from four other Lot 7 units previously tested (Section IX, MWG Progress Report, July 16-October 15, 1977). All the units failed due to small leaks in the cap-body weld area (no violent failures). A summary of these data is shown in Table X and plotted in Figure 14 with the log of the internal pressure plotted as a function of the log of the time-to-rupture.

Although behavior of six of the seven capsules compares well with previous data (MWG Progress Reports April 16-July 15, 1976; January 16-April 15, 1977, and January 16-April 15, 1977), one of the 8060 psia capsules failed after an abnormally short period of time. The reason for this anomaly is presently being investigated.

Table X

Pressure Burst Test Results
Lot-7 TMS Capsules, Tested @ 1010°C
Pulse Arc Welded

<u>Capsule Identity</u>	<u>Internal Pressure (psia)</u>	<u>Log Internal Pressure (psia)</u>	<u>Time to Rupture (hrs)</u>	<u>Log Time to Rupture (hrs)</u>	<u>Failure Location</u>
MPT-64F	8063.9	3.90654	16.40	1.21484	Cap-to-body weld
MPT-67F	8063.1	3.90650	15.42	1.18808	Cap-to-body weld
MPT-68F	8064.2	3.90656	1.90	0.27875	Cap-to-body weld
MPT-69F	8063.1	3.90650	12.37	1.09237	Cap-to-body weld
MPT-71F	6551.3	3.81633	76.12	1.88150	Cap-to-body weld
MPT-72F	6553.3	3.81646	72.47	1.86012	Cap-to-body weld
MPT-73F	6551.3	3.81633	87.32	1.94111	Cap-to-body weld