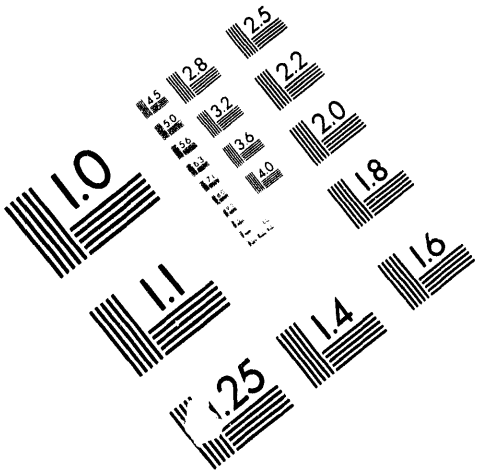

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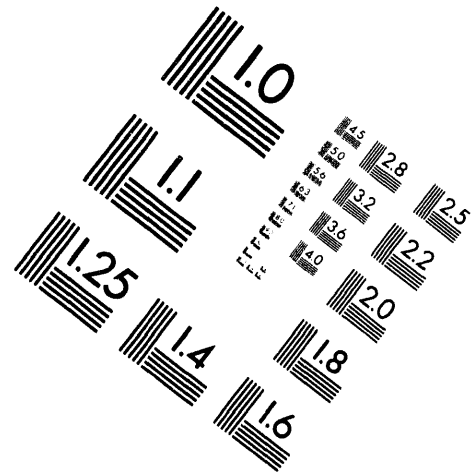

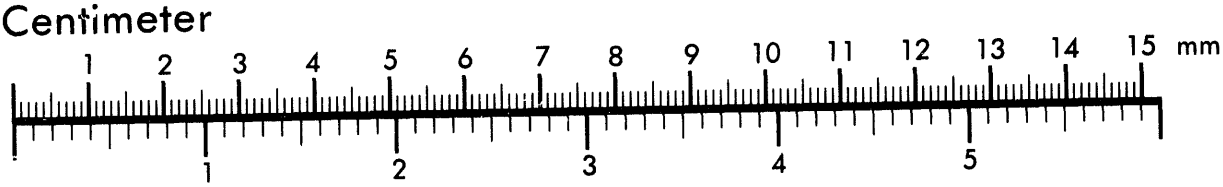

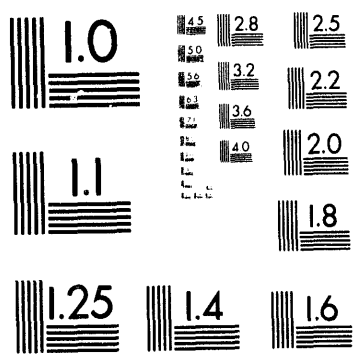

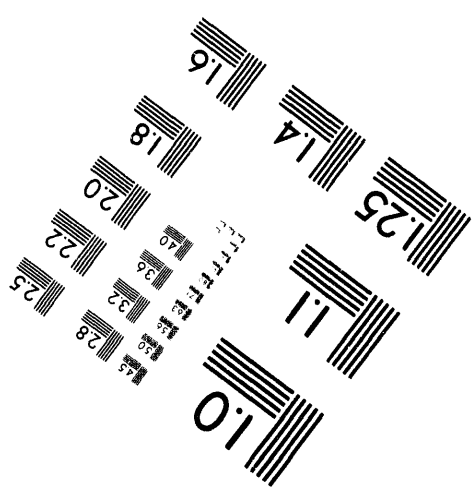

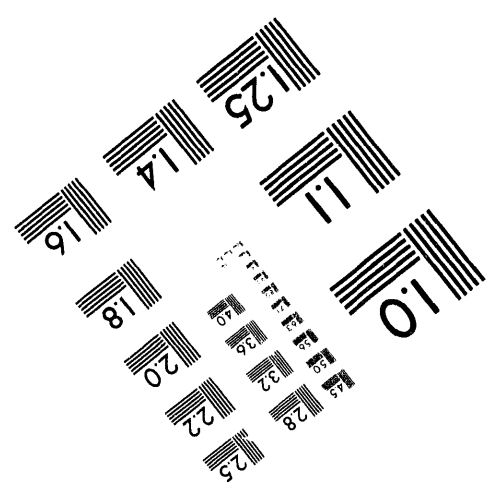

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Preliminary Report on The Tensile Properties of Plutonium

By

H. R. Gardner
Plutonium Metallurgy Operation
HANFORD LABORATORIES OPERATION

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Preliminary Report on The Tensile Properties of Pu-0.9 w/o Ga Delta Stabilized Plutonium

Preliminary data have been obtained on the effect of temperature on the tensile properties of a Pu-0.9 w/o Ga delta stabilized alloy. Contoured castings for tensile specimen fabrication were obtained by pouring in vacuo from 900 C into a MgO coated graphite mold heated to 475 - 500 C. To minimize the formation of alpha plutonium during cooling to room temperature the specimens were held in the mold at 475 C for one hour. Subsequent x-ray diffraction studies indicated that no alpha was present after this treatment. Total impurity contents ranged from 575 to 1128 ppm with an average of 750 ppm. The average density was 15.80 g/cc with a range of 15.66 to 15.89.

The contoured castings were machined to 0.250 inch diameter taper head and 0.505 inch diameter threaded tensile specimens. The 0.250 inch diameter specimens were used for tests to 300 C and the larger specimens for tests to 580 C. Agitated baths of trichlorethylene and dry ice and peanut oil were used as cooling and heating media respectively for the tests conducted at -55 C and above room temperature to 300 C. Above 300 C a resistance heated tube furnace in a nitrogen atmosphere was used to control test temperature. In all tests conducted above room temperature varying degrees of surface oxidation took place on the specimen.

The test results are presented in Figure 1 and Table I. In addition a stress-strain curve at room temperature is presented in Figure 2. The

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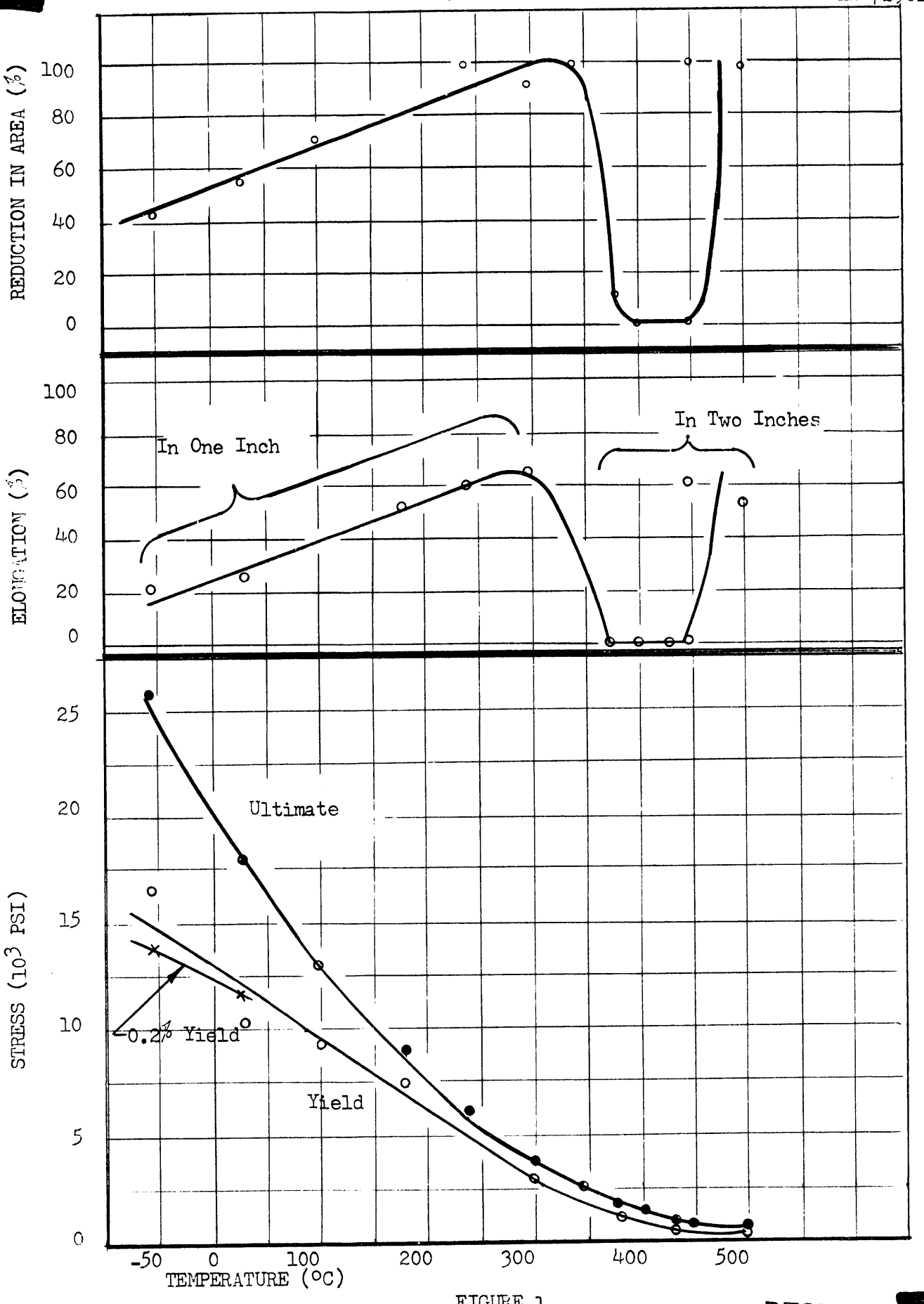

FIGURE 1
Effect of Test Temperature on Tensile Properties of
Pu-0.9 w/o Ga Delta Stabilized Plutonium

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TABLE I

Effect of Temperature on Tensile Properties[1] of Pu - 0.9 w/o Ga Alloy

Specimen Number	Test Temperature (°C)	Ultimate Strength (psi)	Yield[2] Strength (psi)	0.2% Yield Strength (psi)	0.01% Yield Strength (psi)	Proportional Limit (psi)	Elastic Modulus (10^6 psi)	Elongation in One Inch (%)	Reduction in Area (%)	Density (g/cc)
21-5-7P	-55	28,200	--	15,700	--	--	--	6.2	27.4	15.75
21-5-6K	-55	21,800	--	11,800	--	--	--	--	34.0	15.76
21-5-8R	-55	21,400	16,400	--	--	--	--	34.4	64.2	15.76
21-5-4D	30	19,650	--	14,000	5,960	3,900	6.66	--	56.2	15.84
21-5-5F	30	16,400	--	9,980	7,130	5,700	6.18	--	70.8	15.74
21-5-6L	30	17,320	10,250	--	--	--	--	--	61.4	15.76
21-5-7N	30	18,600	--	11,500	6,450	4,450	5.86	25.0	31.3	15.75
21-5-5E	100	12,800	8,830	--	--	--	--	--	65.8	15.74
21-5-8U	100	13,300	9,480	--	--	--	--	37.5	75.2	15.76
21-5-4C	180	8,030	7,390	--	--	--	--	--	63.9	15.84
21-5-6J	180	9,050	7,360	--	--	--	--	50.0	80.0	15.76
21-5-8S	180	9,590	7,380	--	--	--	--	53.1	92.3	15.76
21-5-7M	240	5,930	4,600	--	--	--	--	59.3	97.2	15.75
21-5-8T	240	6,400	5,390	--	--	--	--	--	99.0	15.76
21-5-4A	300	3,540	2,880	--	--	--	--	59.3	83.3	15.84
21-5-4B	300	3,710	2,900	--	--	--	--	78.2	88.1	15.84
21-5-6I	300	3,770	3,180	--	--	--	--	55.1	99.2	15.76
21-9-6F	345	2,500	--	--	--	--	--	35.0	98.8	15.87
21-5-10A	380	1,570	1,060	--	--	--	--	0	11.2	--
21-5-11C	380	1,500	1,085	--	--	--	--	0	0	--
21-9-4A	400	1,130	1,050	--	--	--	--	0	0	15.87
21-5-11D	430	1,040	662	--	--	--	--	0	0	--
21-9-5C	450	830	650	--	--	--	--	60.0	99.0	15.89
21-9-[illegible]	450	970	730	--	--	--	--	0	0	15.87
21-5-12[illegible]	500	512	378	--	--	--	--	--	--	15.66
21-9-[illegible]	500	500	470	--	--	--	--	52.0	97.0	15.87

(1) Testing speed: 0.015 inches/minute

(2) This yield strength is determined at the point of departure from linearity on a load vs. platen motion curve. Although it is an arbitrary definition, at 30 C it appears to compare closely with the 0.2% offset yield strength data.

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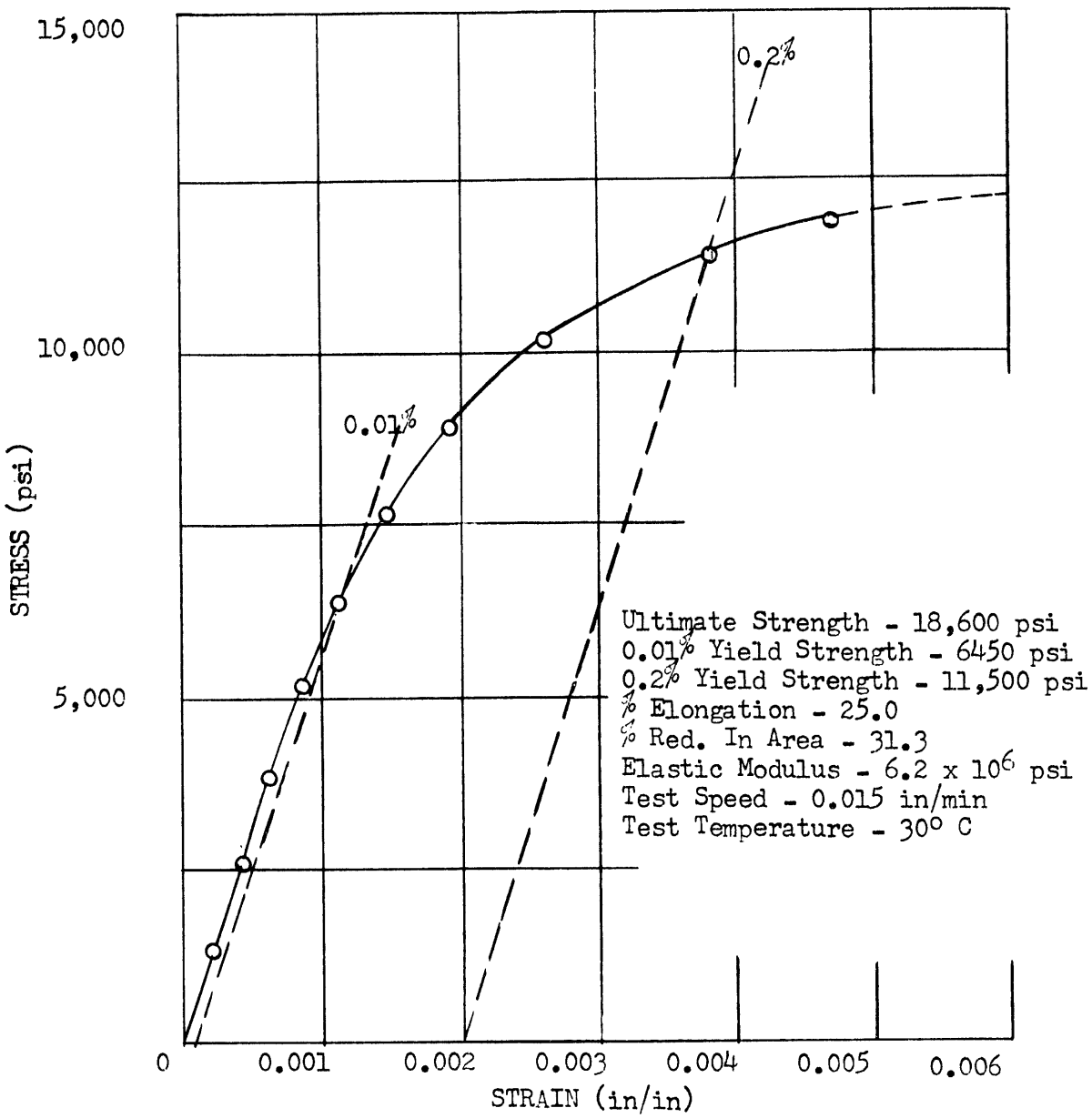

FIGURE 2

Stress-Strain Curve For Pu-0.9 w/o Ga Delta Stabilized Plutonium
0.250 Inch Diameter Specimen

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ultimate and yield strength data decrease continuously as a function of temperature. However the elongation and reduction in area data indicate a ductile to brittle transition between 345 and 380 C. This is then followed by a brittle to ductile transition in the vicinity of 450 C. Additional test specimens will be prepared and tested to firm up the above results. Annealing studies will be initiated in conjunction with metallography in an attempt to determine the cause of the ductility discontinuity.

In future work a study of the effect of testing speed on tensile properties at a number of temperatures will be initiated.

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