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URANIUM ACCOUNTABILITY FOR ATR FUEL FABRICATION: A COMPUTER SIMULATION

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A stochastic computer model has been designed to simulate the material control system used during the production of fuel plates for the Advanced Test Reactor. The model is designed so that manufacturing process and measurement parameters are fed in as input. Changes in the manufacturing process and measurement procedures are easily incorporated. Individual operations in the plant are described by program subroutines. By using this model values for Inventory Difference (ID) and Limit of Error on Inventory Difference (LEID) may be calculated for predetermined plant operating conditions. Furthermore the effect on ID and LEID produced by changing plant operating procedures and measurement technique may also be examined.

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Summary

A computer model has been designed to simulate the material control system used during the production of Advanced Test Reactor (ATR) fuel plates. Great care has been used to assure that this simulation model follows the manufacturing and measuring procedures actually in use at the plant.

The model is stochastic, using a Monte Carlo technique to simulate variations in process parameters and measurement errors. Values are obtained by sampling distributions whose type and characteristics best fit those found in the plant. Parameters in the model are based on operating data wherever possible.

The simulation model is designed for maximum flexibility, since changes in the process and in the measuring system are each likely to occur. Changes in the process can be handled by simple changes in the sequence of process subroutine calls, or modification of parameters read in as data. Changes in the number and type of measurements can be done as easily.

Advantages of the simulation are:

(1) If the use of different measuring instruments with known characteristics is proposed, the effect on the overall performance of the accountability system may be studied.

(2) The effects of the use of different processing equipment whose characteristics are known may be studied.

(3) The impact of various proposed regulations upon the operation of the plant and the frequency of required physical inventories can be studied.

(4) Thief subroutines can be included to study diversion sensitivity. Simulated material removal may be from any point in the process and its amount and distribution are arbitrary.

(5) Virtually any changes in procedures can be included in the program by changing the calling sequence of subroutines.

ATR fuel is fabricated by melting, alloying, crushing and forming uranium and aluminum. The process and accountability samples points are shown in figure 1.

Table I and figures 2-4 show the effects of changes in operating parameters. Three cases are examined, normal operation, abnormal furnace holdup, and the introduction of a sampling error. The changes in the Inventory Difference (ID) and Limit of Error on Inventory Difference (LEID) distributions are examined by evaluation of the mean, variance, skewness and kurtosis.

The model could find application in the study of material accountability systems and as a predictor of instant inventory with which actual plant material distribution may be compared.

TABLE I

SIMULATED MEASURED INVENTORY DIFFERENCE

	Mean	Standard Deviation	LEID[1]	LEID[2]
Example 1. No Sampling Error; Small Furnace Holdup				
Net Weight	30.64	7.57	15.13	14.83
Uranium Weight	21.58	8.19	16.37	15.86
^{235}U Weight	20.03	7.98	15.97	15.21
Example 2. Furnace Holdup .4%				
Net Weight	143.28	17.82	35.65	36.05
Uranium Weight	102.19	14.06	28.11	28.17
^{235}U Weight	95.12	13.33	26.67	26.96
Example 3. Acceptable Powder Sampling Error Mean = .001				
Net Weight	30.03	7.64	15.29	14.90
Uranium Weight	4.74	24.96	69.92	70.88
^{235}U Weight	4.31	32.72	65.45	66.41

1. Calculated as twice the standard deviation.

2. Calculated from the upper 97.5 percentiles obtained from the plotted cumulative distribution functions for measured ID.

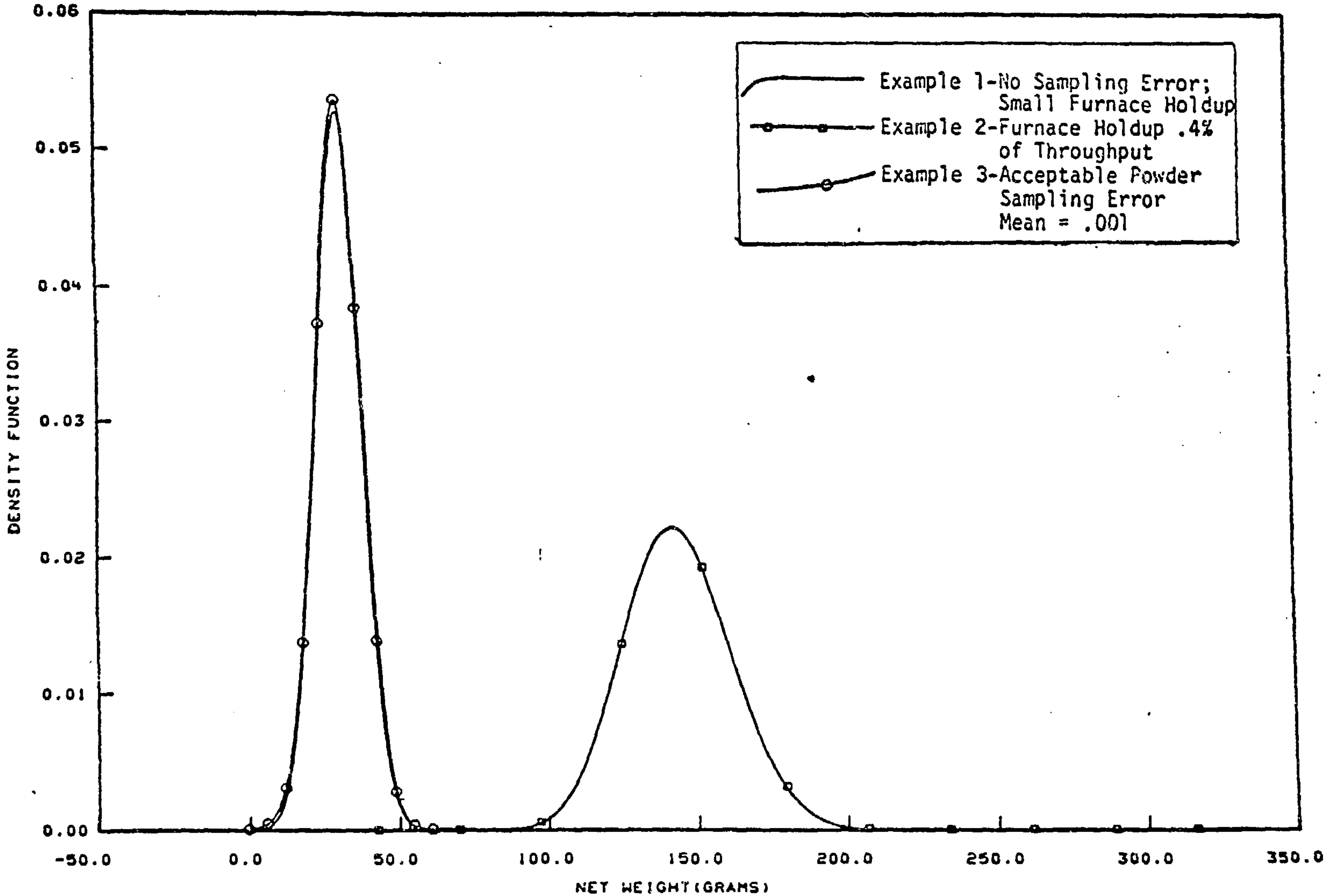

Figure 2. SIMULATIONS OF UALX POWDER PRODUCTION

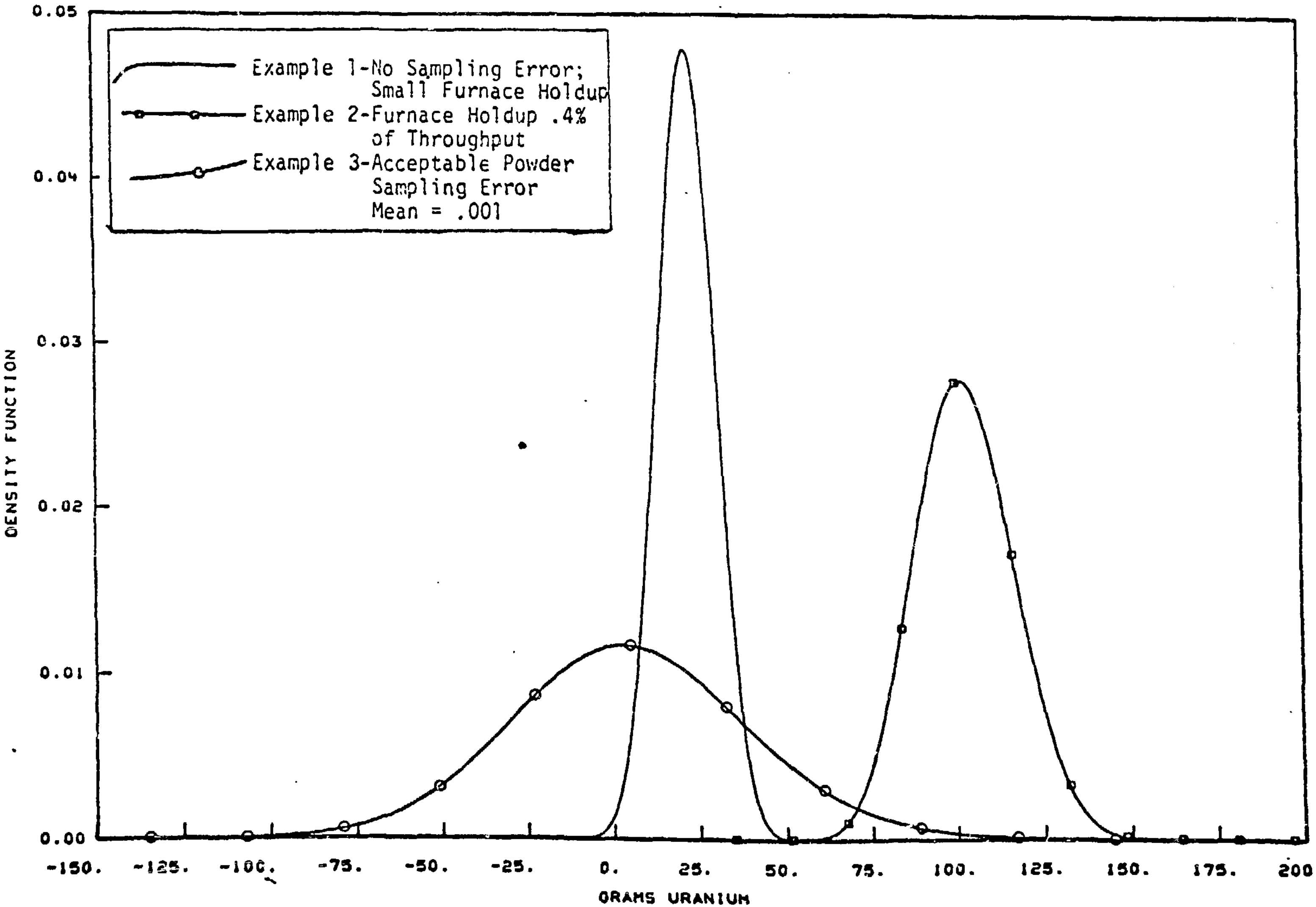

Figure 3. SIMULATIONS OF UALX POWDER PRODUCTION

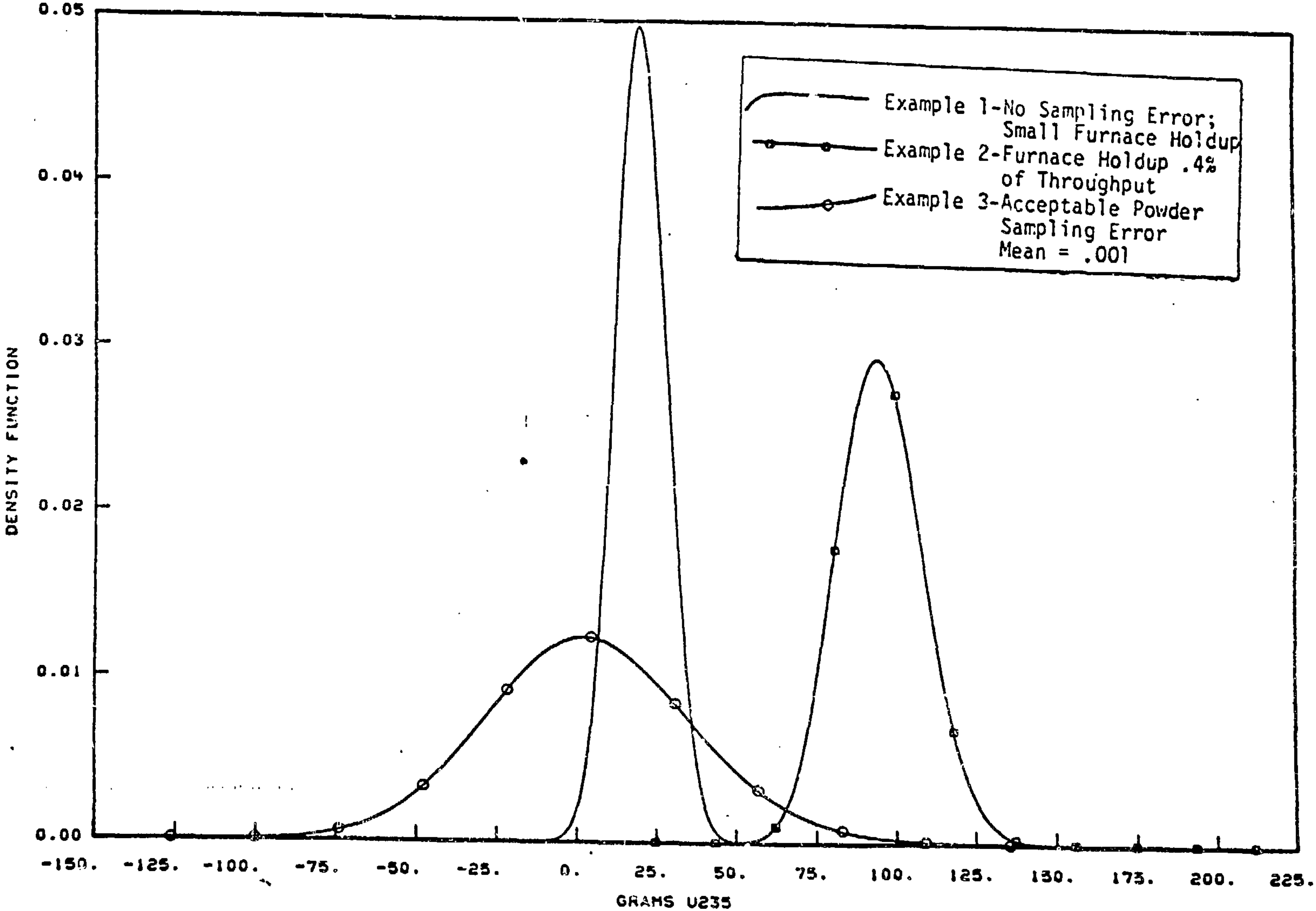

Figure 4. SIMULATIONS OF UALX POWDER PRODUCTION