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REPORT

**FABRICATION COSTS FOR PLUTONIUM FUEL ELEMENTS
PART D:
VARIABLE COST OF FABRICATING $\text{UO}_2\text{-PuO}_2$ FUEL ELEMENTS
FOR THE PLUTONIUM RECYCLE TEST REACTOR**

C. H. BLOOMSTER

OCTOBER, 1965

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RICHLAND, WASHINGTON

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FOR THE PLUTONIUM RECYCLE TEST REACTOR

By

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FABRICATION COSTS FOR PLUTONIUM FUEL ELEMENTSPART D: VARIABLE COST OF FABRICATING $\text{UO}_2\text{-PuO}_2$ FUEL ELEMENTS
FOR THE PLUTONIUM RECYCLE TEST REACTORINTRODUCTION

Fourth of a series of reports on the costs of fabricating plutonium fuel elements on a laboratory scale, this report covers the variable (shop) cost of fabricating fuel elements for the Plutonium Recycle Test Reactor (PRTR). The fuel elements, which will be used in High Power Density (HPD) core experiments, are designed to operate at an estimated surface heat flux of 600,000 Btu/hr-ft², a central fuel temperature above melting, and exposures exceeding 15,000 MWD/ton. Although this report covers the cost of fabricating the first fuel elements of the HPD design, the HPD fuel design was similar to previous PRTR fuel designs, and the fabrication proceeded quite smoothly under process conditions that were well developed. The main difference between the HPD fuel design and previous PRTR fuel designs was the inclusion of a plenum at one end and depleted UO_2 pellets at each end of the fuel column. The design change did cause an increase in the recycle rate; and this was the principle effect on costs, new or unique, to the HPD design, other than additional direct material requirements.

The first three reports of this series covered the fabrication costs of plutonium fuel elements for the Plutonium Recycle Critical Facility, Experimental Boiling Water Reactor, and the Saxton Reactor. In the

processes common to each fabrication, this report is more significant and updates the previous reports, for the data are both more recent and based on processing larger quantities of fuel.

The first four reports in this series pertain to the observed variable fabrication costs of specific fuel designs. Since the fabrication costs vary with several parameters of the fuel design, the costs are necessarily specific to the fuel design and vary widely. Although the costs in this report are an accurate presentation of the shop costs, the dollar amounts are also necessarily specific to an organization primarily devoted to research and development, and the labor and overhead rates may differ significantly from an organization devoted primarily to fabrication. Future reports in this series will (1) analyze the effect of some design parameters on fuel fabrication cost, (2) analyze the effect of nuclear material costs, (3) estimate the incremental costs attributable to plutonium, and (4) analyze some of the indirect and fixed costs.

SUMMARY

The variable (shop) cost of fabricating the HPD fuel element for the PRTR is \$113/kg of fuel (as oxide) or a unit cost of \$3900 per fuel element (Table I). The costs are based on the fabrication of the first

24 fuel elements by the pneumatic impaction-vibrational compaction processes. The shop labor requirements for each fuel element are 113 man-hours direct labor and 44 man-hours indirect labor. The variable costs include direct materials, some processing costs for nuclear materials, shop labor, direct overhead, and consumable supplies but do not include the cost of nuclear materials themselves, use charges, administrative overhead, research, development, or engineering costs.

Each fuel element contains 19 fuel rods and 34.6 kg of natural UO_2 -2 wt% PuO_2 fuel. The fuel rods are 170 cm long and 1.4 cm OD with 0.76 mm Zircaloy-2 cladding. The fuel length is 149 cm, and an 18 cm plenum extends above the fuel. A depleted UO_2 pellet is placed on each end of the fuel column. The fuel is held in place by an Inconel spring in the plenum.

DISCUSSION

The conversion of the PRTR to the HPD core is essential to obtain data on the utilization of plutonium in thermal reactors needed by the power reactor industry. The High Power Density Experiment will test the operation of plutonium fuel elements under severe irradiation conditions and provide reactor physics information previously not available. Although performance of the fuel is of prime importance, the cost of preparing high performance fuel elements is an important consideration in the economic utilization of plutonium in thermal reactors.

The HPD fuel element is a 19 rod cluster similar to previous PRTR fuel

element designs. In the HPD design, the core is shortened by 1/3, the plutonium enrichment is doubled, and a plenum is provided for fission gas and other gas release. The HPD fuel will operate at much more severe conditions than previous PRTR fuel elements. As presently planned, power generation will exceed 25 kW/ft, central fuel temperatures will exceed melting, and exposures will exceed 15,000 MWd/ton. Each fuel rod contains 1793 g of UO_2 -2 wt% PuO_2 fuel prepared by pneumatic impaction. A depleted UO_2 pellet (12 g) is placed at each end of the fuel column to depress the temperature and prevent full interaction with the end cap or the Inconel spring contained in the plenum. The fuel rods are 170 cm long by 1.4 cm OD. The cladding is 0.76 mm Zircaloy-2. The fuel length is 149 cm; an 18 cm plenum extends above the fuel.

Although the costs in this report are based on the fabrication of the first 24 fuel elements of the HPD design, the design change from previous PRTR fuel elements was not sufficiently significant to seriously affect fabrication costs with one exception. The exception was that the bottom UO_2 pellet tends to float during the vibrational compaction process, resulting in a relatively high recycling rate in the finishing processes (the floating pellet is detected by radiography, one of the finishing steps). Other than this "new" problem, techniques and processes were previously well developed during the fabrication of other fuel elements.

MATERIAL REQUIREMENTS

The cost and labor requirements for each process step are summarized on a fuel element basis (Table II), a single rod basis (Table III), and a 100 kg basis (Table IV). The gross material requirements and yields for each process step are shown in Table V. Plutonium losses, muf (material unaccounted for), were 0.44% and the plutonium to be recovered from samples and reject fuel was 6.3%. The uranium losses (muf) were 0.8%, and the uranium to be recovered from samples and reject fuels was 7.7%. The zirconium losses were 8.1%. The combined recycle-reject rate for mixed oxide fuel was 13.1%

for powder preparation steps and 8.1% in the rod fabrication steps.

COST DATA

The cost data for the UO_2 preparation, PuO_2 preparation, and pneumatic impaction process steps are based on the preparation of more than 1000 kg of fuel, and the cost data for the vibrational compaction and finishing process steps are based on the fabrication of 24 fuel elements containing 456 fuel rods. The cost data for the UO_2 preparation, PuO_2 preparation, and the pneumatic impaction process steps differ slightly from the data reported in Parts A, B, and C reflecting a more significant base for the data. However, a larger difference occurred in the

FIGURE 1

Flow Diagram: Fabrication of UO_2 - PuO_2 Fuel Elements for the PRTR

pneumatic impaction step itself in which the installation and rearrangement of new heating equipment substantially reduced the labor requirement for that process step.

The method of accumulating costs and description of the process steps (Figure 1) was presented in the previous reports, e.g., BNWL-131, Parts A, B, and C, and will not be described in detail, but the cost items for each process step (Tables VI through XVIII) are presented in detail. The average wage, including fringe benefits, of the direct labor was \$5.01/hr, an increase from \$4.85/hr used in the previous reports.

The laboratory expense rate was 175% of direct labor. Laboratory expenses include a wide variety of direct and indirect expenses which are approximately distributed as follows: general and administrative expense 78%, maintenance 48%, miscellaneous direct services 33%, and supplies 16%.

Cost Data for Each Process Step

Tubing Preparation (Table VI)

The direct materials cost was \$23.60 for tubing and \$2.00 for inspection and shipping.

UO₂ Preparation (Table VII)

The direct material charge is \$2.02/lb for arc fusion of the UO₂. The direct labor usage is 0.296 man-hours/kg for crushing, sieving, and packaging UO₂ and 0.051 man-hours/kg (of UO₂) for U₃O₈ production. Average U₃O₈ usage is 3 1/2% of UO₂ usage. The direct service cost is for analytical quality control.

PuO₂ Preparation (Table VIII)

The direct materials charge is \$0.45/g of purified PuO₂ obtained from the chemical processing group. The direct labor usage is based on the weighing, sampling, and repackaging of 35 kg of PuO₂. The direct service charge is for chemical quality control of the PuO₂.

Loading Cans for Pneumatic Impaction (Table IX)

Consumable supplies* are the costs of the inner can assembly and a plastic bag used to attach the can to the glove box. The direct labor usage is 0.034 man-hours/kg for preparing the can, 0.125 man-hours/kg for blending the oxides, and 0.081 man-hours/kg for loading the can.

Double Canning (Table X)

Consumable supplies are the cost of the outer can assembly.

Pneumatic Impaction (Table XI)

Consumable supplies are the cost for punches, punch protectors, and back-up plugs. Direct labor usage is 0.608 man-hours per can for the pneumatic impaction process and 0.139 man-hours per can for grit-blasting the exterior of the can after impaction. Each can contains 6 kg of fuel.

* Consumable supplies is a term used for certain significant cost indirect materials which although not contained in the end product have the variable characteristics of direct materials. All other supplies are included in laboratory expense.

Break Out (Table XII)

The direct service is the analytical cost of determining fuel density.

Crushing and Sieving (Table XIII)

Direct labor usage is 0.215 man-hours/kg crushing and sieving, 0.045 man-hours/kg outgassing, 0.067 man-hours/kg sampling, and 0.117 man-hours/kg blending and packaging. Direct service is the analytical cost for quality control of the fuel purity.

Vibrational Compaction (Table XIV)

Direct materials is the cost of the fuel-in process, tubing-in process, and bottom end caps which enter the process at this step. Supplies are the cost of a plastic bag and filter plug used in each rod. An improvement in the method of attaching the rod to the glove box during vibrational compaction eliminated the need for fittings previously used, reducing the cost of supplies. Direct labor usage is 0.088 man-hours per rod for welding, 0.087 man-hours per rod for tubing preparation, 1.137 man-hours per rod for vibrational compaction, 0.475 man-hours per rod for decontamination, and 0.142 man-hours per rod for pellet fabrication.

Finishing (Table XV)

Direct material cost per 19 rod cluster is \$356.63; top end caps, \$56.10, springs, \$23.20, end brackets, \$2.60 and other hardware, \$17.33. The material cost per 100 kg is \$1033. Although the end brackets are fabricated internally, the cost of the end brackets is computed

separately, and the end brackets are considered direct material.

Direct labor usage is 0.132 man-hours per rod for welding, 0.093 man-hours per rod for drilling and degreasing, 0.234 man-hours per rod for etching and inspection, 0.096 man-hours per rod for leak checking, 0.209 man-hours per rod for autoclaving and inspection. The above work totals 0.764 man-hours per rod or 14.5 man-hours per 19 rod fuel element. In addition, 6.1 man-hours direct labor is required to wire wrap and assemble each fuel element. Direct service is the cost of radiographing and ultrasonic testing of the finished fuel rods.

Rework (Table XVI)

Recycled material requires a small amount of recover work before it reenters the process.

Indirect work (Table XVII)

Indirect labor includes 0.675 man-hours per rod for record keeping, accountability, procurement of supplies, and other work attributed directly to the PRTR fuel fabrication, and 1.614 man-hours per rod for general cleanup, meeting, change time, and other work not attributable directly to a particular job. This latter indirect work was prorated on a labor hours basis to each job in process during the period under study.

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TABLE IVARIABLE (SHOP) COSTS OF FABRICATING PRTR FUEL ELEMENTS

Direct Materials	Cost Per Fuel Element, \$
Zirconium Cladding	596
Uranium	151
Plutonium	307
Other Hardware	301
Shop Labor	791
Direct Services	167
Supplies	102
Laboratory Expense	1388
Reject Material Expense	97
Total	3900

TABLE II

VARIABLE COST PER FUEL ELEMENT
(34.6 kg UO₂-PuO₂ + Depleted UO₂)

Process Step	Direct Material	Processing	
	\$	\$	Man-Hours
Tubing Preparation	492	24	1.9
UO ₂ Preparation	151	151	10.7
PuO ₂ Preparation	307	69	3.1
Can Loading		150	9.4
Double Canning		48	1.5
Pneumatic Impaction		75	4.9
Break-Out		67	23.6
Crushing and Sieving		338	15.4
Vibrational Compaction	48	553	39.6
Finishing	357	442	21.8
Rework		30	2.2
Indirect		598	43.5
	1355	2545	157.6
		1355	
Total		3900	

TABLE III
VARIABLE COST PER FUEL ROD
(1820 g)

<u>Process Step</u>	<u>Direct Material</u>	<u>Processing</u>	
	<u>\$</u>	<u>\$</u>	<u>Man-Hours</u>
Tubing Preparation	25.90	1.30	0.10
UO ₂ Preparation	7.90	7.90	0.56
PuO ₂ Preparation	16.20	3.60	0.16
Can Loading		7.90	0.50
Double Canning		2.60	0.08
Pneumatic Impaction		4.00	0.26
Break-Out		3.60	0.19
Crushing and Sieving		17.70	0.81
Vibrational Compaction	2.50	29.10	2.09
Finishing	18.80	23.20	1.15
Rework		1.60	0.12
Indirect		31.50	2.29
	71.30	134.00	8.31
		71.30	
		205.30	

TABLE IV
VARIABLE COSTS PER 100 KG OF FUEL

<u>Process Step</u>	<u>Direct Materials</u>	<u>Processing</u>	
	<u>\$</u>	<u>\$</u>	<u>Man-Hours</u>
Tubing Preparation	1423	69	5.4
UO ₂ Preparation	436	435	30.8
PuO ₂ Preparation	888	201	9.0
Can Loading		432	27.2
Double Canning		140	4.3
Pneumatic Impaction		217	14.1
Break-Out		195	10.3
Crushing and Sieving		975	44.4
Vibrational Compaction	138	1598	114.7
Finishing	1033	1277	63.0
Rework		88	6.4
Indirect		1730	125.8
	3918	7357	455.4
		3918	
		11,275	

TABLE V

MATERIALS REQUIREMENTS PER PROCESS STEP

	Fuel		Zirconium		Uranium		Plutonium	
	In	Out	In	Out	In	Out	In	Out
Tubing Preparation			1.081	1.081				
UO ₂ Preparation					1.085	1.064		
PuO ₂ Preparation							1.067	1.064
Loading	1.131	1.130			1.064	1.064	1.064	1.064
Double Canning	1.130	1.130			1.064	1.064	1.064	1.064
Pneumatic Impaction	1.130	1.100			1.064	1.064	1.064	1.064
Break-Out	1.100	1.094			1.064	1.058	1.064	1.058
Crush Sieve	1.094	1.000			1.058	1.000	1.058	1.000
Vibrational Compaction	1.081	1.058	1.081	1.058				
Finishing	1.058	1.000	1.058	1.000				

TABLE VI

TUBING PREPARATION, PRTR-HPD

INPUTS

Variable Costs	Primary Units	Cost Per 100 kg In
Direct Material	\$25.60 per tube	\$1423
Consumable Supplies		
Direct Labor	0.091 Man-Hours per Tube	25
Laboratory Expense	175%	44
Direct Services		
Total Shop Cost		\$1492

OUTPUTS

	Percent	Output Per kg In	Destination
Yield	100		Vibrational Compaction
Recycle			
Samples			
Reject			
Muf.			

VALUE ANALYSIS

Value of Direct Material Entering Process	\$1423
Process Variable Cost per 100 kg Fuel	69
Total Value 100 kg Fuel Leaving Process	
Quantity of Fuel Processed per 100 kg Fuel in Finished Rod	kg
Total Value of ___ kg Fuel Leaving Process	
Value of Recycle: ___ kg @ \$_____ per kg	
Total Value of ___ kg Acceptable Fuel	1492
Unit Value of 100 kg Fuel Entering Next Process	1492
Value of Direct Material Entering This Process	1423
Process Variable Cost per 100 kg Acceptable Fuel	\$ 69

TABLE VII.

UO₂ PREPARATION, PRTR-HPDINPUTS

<u>Variable Costs</u>	<u>Primary Units</u>	<u>Cost Per 100 kg In</u>
Direct Material	\$2.02 per lb of UO ₂	\$436
Consumable Supplies		
Direct Labor	0.296 Man-Hours per kg Out	143
Laboratory Expense	175%	250
Direct Services	\$0.25 per kg	25
Total Shop Cost		\$854

OUTPUTS

	<u>Percent</u>	<u>Output Per 1.085 kg In</u>	<u>Destination</u>
Yield	98%	1.060	Loading Cans
Recycle			
Samples	0.5%	.005	Scrap Recovery
Reject	1.0%	.011	Scrap Recovery
Muf	0.5%	.005	

VALUE ANALYSIS

Value of Direct Material Entering Process	\$436
Process Variable Cost per 100 kg Fuel	418
Total Value 100 kg Fuel Leaving Process	854
Quantity of Fuel Processed per 100 kg Fuel in Finished Rod	108.5 kg
Total Value of 1.085 kg Fuel Leaving Process	926
Value of Recycle: ___kg @ \$ ___per kg	0
Total Value of 106.4 kg Acceptable Fuel	926
Unit Value of 100 kg Fuel Entering Next Process	<u>871</u>
Value of Direct Material Entering This Process	<u>436</u>
Process Variable Cost per 100 kg Acceptable Fuel	<u>\$435</u>

TABLE VIIIPuO₂ PREPARATION, PRTR-HPDINPUTS

<u>Variable Costs</u>	<u>Primary Units</u>	<u>Cost Per 100 kg In</u>
Direct Material	\$0.45 per gram PuO ₂	\$888
Consumable Supplies		
Direct Labor	4.27 Man-Hours per kg PuO ₂	43
Laboratory Expense	175%	75
Direct Services	\$40 per kg	80
Total Shop Cost		<u>\$1086</u>

OUTPUTS

	<u>Percent</u>	<u>Output Per 106.3 kg In</u>	<u>Destination</u>
Yield	99.66%	106.0	Loading Cans
Recycle			
Samples	0.20%	.2	Scrap Recovery
Reject			Scrap Recovery
Muf	0.14%	.1	

VALUE ANALYSIS

Value of Direct Material Entering Process	\$ 888
Process Variable Cost per 100 kg Fuel	198
Total Value 100 kg Fuel Leaving Process	1086
Quantity of Fuel Processed for 100 kg Fuel in Finished Rod	106.7 kg
Total Value of 106.7 kg Fuel Leaving Process	1159
Value of Recycle: ___ kg @ \$ ___ per kg	0
Total Value of 106.4 kg Acceptable Fuel	1159
Unit Value of 100 kg Fuel Entering Next Process	<u>1089</u>
Value of 100 kg Fuel Entering This Process	<u>888</u>
Process Variable Cost per 100 kg Acceptable Fuel	<u>\$ 201</u>

TABLE IX
LOADING CANS FOR PNEUMATIC IMPACTION, PRTR-HPD

INPUTS

<u>Variable Costs</u>	<u>Primary Units</u>	<u>Cost Per 100 kg In</u>
Direct Material		
Consumable Supplies	\$6.10 per 6 kg	\$102
Direct Labor	0.240 Man-Hours per kg	120
Laboratory Expense	175%	210
Direct Services		
Total Shop Cost		<u>\$432</u>

OUTPUTS

	<u>Percent</u>	<u>Output Per 113.1 kg In</u>	<u>Destination</u>
Yield	99.87	113.0	Next Process Step
Recycle	0.1	.1	Loading Cans
Samples	0		Scrap Recovery
Reject	0.025	insignificant	Scrap Recovery
Muf	0.004	insignificant	

VALUE ANALYSIS

Value of 100 kg UO ₂ and PuO ₂ Entering Process	\$1960
Process Variable Cost per 100 kg Fuel	432
Total Value 100 kg Fuel Leaving Process	2392
Quantity of Fuel Processed per 100 kg Fuel in Finished Rod	113.1 kg
Total Value of 113.1 kg Fuel Leaving Process	2705
Value of Recycle: 0.1 kg @ \$20 per kg	2
Total Value of 113.0 kg Acceptable Fuel	2703
Unit Value of 100 kg Fuel Entering Next Process	<u>2392</u>
Value of 100 kg Fuel Entering This Process	<u>1960</u>
Process Variable Cost per 100 kg Acceptable Fuel	<u>\$ 432</u>

TABLE XDOUBLE-CANNING, PRTR-HPDINPUTS

<u>Variable Costs</u>	<u>Primary Units</u>	<u>Cost Per 100 kg In</u>
Direct Material		
Consumable Supplies	\$5.25 per 6 kg	\$ 88
Direct Labor	0.227 Man-Hours per 6 kg	19
Laboratory Expense		33
Direct Services		
Total Shop Cost		<u>\$140</u>

OUTPUT

	<u>Percent</u>	<u>Output Per kg In</u>	<u>Destination</u>
Yield	100		Next Process Step
Recycle			Loading Cans
Samples			Scrap Recovery
Reject			Scrap Recovery
Muf			

VALUE ANALYSIS

Value of 100 kg Fuel Entering Process	\$2392
Process Variable Cost per 100 kg Fuel	140
Total Value 100 kg Fuel Leaving Process	2532
Quantity of Fuel Processed per 100 kg Fuel in Finished Rod	kg
Total Value of ___ kg Fuel Leaving Process	
Value of Recycle: ___ kg @ \$ ___ per kg	
Total Value of ___ kg Acceptable Fuel	
Unit Value of 100 kg Fuel Entering Next Process	<u>2532</u>
Value of 100 kg Fuel Entering This Process	<u>2392</u>
Process Variable Cost per 100 kg Acceptable Fuel	<u>\$ 140</u>

TABLE XI
PNEUMATIC IMPACTION, PRTR-HPD

INPUTS

<u>Variable Costs</u>	<u>Primary Units</u>	<u>Cost Per 100 kg In</u>
Direct Material		
Consumable Supplies	\$1.64 per 6 kg	\$ 27
Direct Labor	0.747 Man-Hours per 6 kg	62
Laboratory Expense		109
Direct Services		
Total Shop Cost		<u>\$198</u>

OUTPUTS

	<u>Percent</u>	<u>Output Per 113.0 kg In</u>	<u>Destination</u>
Yield	97.39	110.00	Next Process Step
Recycle	2.61	3.0	Loading Cans
Samples			Scrap Recovery
Reject			Scrap Recovery
Muf			

VALUES ANALYSIS

Value of 100 kg Fuel Entering Process	\$2532
Process Variable Cost per 100 kg Fuel	198
Total Value 100 kg Fuel Leaving Process	2730
Quantity of Fuel Processed per 100 kg Fuel in Finished Rod	113.0 kg
Total Value of 113.0 kg Fuel Leaving Processes	3085
Value of Recycle: 3.0 kg @ \$ 20.3 per Kg	61
Total Value of 110.0 kg Acceptable Fuel	3024
Unit Value of 100 kg Fuel Entering Next Process	<u>2749</u>
Value of 100 kg Fuel Entering This Process	<u>2532</u>
Process Variable Cost per 100 kg Acceptable Fuel	<u>\$ 217</u>

TABLE XII
BREAK-OUT, PRTR-HPD

INPUTS

<u>Variable Costs</u>	<u>Primary Units</u>	<u>Cost Per 100 kg In</u>
Direct Material		
Consumable Supplies		
Direct Labor	0.560 Man-Hours per 6 kg	\$ 47
Laboratory Expense		82
Direct Services	Analytical	50
Total Shop Cost		<u>\$179</u>

OUTPUTS

	<u>Percent</u>	<u>Output Per 110.0 kg In</u>	<u>Destination</u>
Yield	99.52	109.4	Next Process Step
Recycle			Loading Cans
Samples	.25	.3	Scrap Recovery
Reject	0.23	.3	Scrap Recovery
Muf			

VALUE ANALYSIS

Value of 100 kg Fuel Entering Process	\$2749
Process Variable Cost per 100 kg Fuel	179
Total Value 100 kg Fuel Leaving Process	2928
Quantity of Fuel Processed per 100 kg Fuel in Finished Rod	110 kg
Total Value of 110 kg Fuel Leaving Process	3221
Value of Recycle: ___ kg @ \$ ___ per kg	0
Total Value of 109.4 kg Acceptable Fuel	3221
Unit Value of 100 kg Fuel Entering Next Process	<u>2944</u>
Value of 100 kg Fuel Entering This Process	<u>2749</u>
Process Variable Cost per 100 kg Acceptable Fuel	<u>\$ 195</u>

TABLE XIIICRUSH AND SIEVE, PRTR-HPDINPUTS

<u>Variable Costs</u>	<u>Primary Units</u>	<u>Cost Per 100 kg In</u>
Direct Material		
Consumable Supplies		
Direct Labor	0.444 Man-Hours per kg Out	\$203
Laboratory Expense	Analytical	356
Direct Services	Analytical, \$140 per 96 kg	146
Total Shop Cost		<u>\$705</u>

OUTPUTS

	<u>Percent</u>	<u>Output Per 109.4 kg In</u>	<u>Destination</u>
Yield	91.50	100.0	Next Process Step
Recycle	3.27	3.6	Loading Cans
Samples	0.22	0.2	Scrap Recovery
Reject	4.84	5.3	Scrap Recovery
Muf	0.27	0.3	

VALUE ANALYSIS

Value of 100 kg Fuel Entering Process	\$2944
Process Variable Cost per 100 kg Fuel	705
Total Value 100 kg Fuel Leaving Process	3649
Quantity of Fuel Processed per 100 kg Fuel in Finished Rod	109.4 kg
Total Value of 109.4 kg Fuel Leaving Process	3992
Value of Recycle: 3.6 kg @ \$20.3 per kg	73
Total Value of 100.0 kg Acceptable Fuel	3919
Unit Value of 100 kg Fuel Entering Next Process	<u>\$3919</u>
Value of 100 kg Fuel Entering This Process	<u>2944</u>
Process Variable Cost per 100 kg Acceptable Fuel	<u>\$ 975</u>

TABLE XIVVIBRATIONAL COMPACTION, PRTR-HPDINPUTS

<u>Variable Costs</u>	<u>Primary Units</u>	<u>Cost Per 100 kg In</u>
Direct Material	\$138 per 100 kg*	
Consumable Supplies	\$1 per Rod	\$ 55
Direct Labor	1.927 Man-Hours per Rod	536
Laboratory Expense		940
Direct Services		
Total Shop Cost		<u>\$1531</u>

OUTPUTS

	<u>Percent</u>	<u>Output Per 108.1 kg In</u>	<u>Destination</u>
Yield	97.88	105.8	Next Process Step
Recycle	2.12	2.3	Vibrational Compaction
Samples			Scrap Recovery
Reject			Scrap Recovery
Muf			

VALUE ANALYSIS

Value of 100 kg Fuel + Tubing (See Table VI) + Direct Material*	\$5549
Process Variable Cost per 100 kg Fuel	1531
Total Value 100 kg Fuel Leaving Process	7080
Quantity of Fuel Processed per 100 kg Fuel in Finished Rod	108.1 kg
Total Value of 108.1 kg Fuel Leaving Process	7653
Value of Recycle: 2.3 kg @ \$40 per kg	92
Total Value of 105.8 kg Acceptable Fuel	7561
Unit Value of 100 kg Fuel Entering Next Process	<u>7147</u>
Value of Fuel and Materials Entering This Process	<u>5549</u>
Process Variable Cost per 100 kg Acceptable Fuel	<u>\$1598</u>

TABLE XV
FINISHING, PRTR-HPD

INPUTS

<u>Variable Costs</u>	<u>Primary Units</u>	<u>Cost Per 100 kg In</u>
Direct Material	1033 per 100 kg*	
Consumable Supplies		
Direct Labor	20.6 Man-Hours per Cluster	\$302
Laboratory Expense		528
Direct Services (ultrasonic testing and radiography)		148
Total Shop Cost		<u>\$978</u>

OUTPUTS

	<u>Percent</u>	<u>Output Per 105.8 kg In</u>	<u>Destination</u>
Yield	94.51	100.0	Next Process Step
Recycle	5.49	5.8	Vibration Compaction
Samples			Scrap Recovery
Reject			Scrap Recovery
Muf			

VALUE ANALYSIS

Value of 100 kg Fuel and Direct Material* entering Process	\$8180
Process Variable Cost per 100 kg Fuel	978
Total Value 100 kg Fuel Leaving Process	9158
Quantity of Fuel Process per 100 kg Fuel in Finished Rod	105.8 kg
Total Value of 105.8 kg Fuel Leaving Process	9689
Value of Recycle: 5.8 kg @ \$40 per kg	232
Total Value of 100 kg Acceptable Fuel	9457
Unit Value of 100 kg Fuel Entering Next Process	<u>9457</u>
Value of 100 kg Fuel Entering This Process	<u>8180</u>
Process Variable Cost per 100 kg Acceptable Fuel	<u>\$1277</u>

TABLE XVIREWORK, PRTR-HPDINPUTS

<u>Variable Costs</u>	<u>Primary Units</u>	<u>Cost Per 100 kg In</u>
Direct Material		
Consumable Supplies		
Direct Labor	2.21 Man-Hours per Cluster	\$32
Laboratory Expense		56
Direct Services		
Total Shop Cost		\$88

OUTPUTS

	<u>Percent</u>	<u>Output Per kg In</u>	<u>Destination</u>
Yield	100		
Recycle			
Samples			
Reject			
Muf			

VALUE ANALYSIS

Value of 100 kg Fuel Entering Process	\$9457
Process Variable Cost per 100 kg Fuel	88
Total Value 100 kg Leaving Process	9545
Quantity of Fuel Processed per 100 kg Fuel in Finished Rod	kg
Total Value of ___ kg Fuel Leaving Process	
Value of Recycle: ___ kg @ \$ ___ per kg	
Total Value of ___ kg Acceptable Fuel	
Unit Value of 100 kg Fuel Entering Next Process	<u>9545</u>
Value of 100 kg Fuel Entering This Process	<u> </u>
Process Variable Cost per 100 kg Acceptable Fuel	<u>\$ 88</u>

TABLE XVIIINDIRECT WORK, PRTR-HPDINPUTS

<u>Variable Costs</u>	<u>Primary Units</u>	<u>Cost Per 100 kg In</u>
Direct Material		
Consumable Supplies		
Direct Labor	2.289 Man-Hours per rod	\$ 630
Laboratory Expense		1100
Direct Services		
Total Shop Cost		<u>\$1730</u>

OUTPUTS

	<u>Percent</u>	<u>Output Per kg In</u>	<u>Destination</u>
Yield			
Recycle			
Samples			
Reject			
Muf			

VALUE ANALYSIS

Value of 100 kg Fuel Entering Process	\$ 9545
Process Variable Cost per 100 kg Fuel	1730
Total Value 100 kg Fuel Leaving Process	11275
Quantity of Fuel Process per 100 kg Fuel in Finished Rod	kg
Total Value of ___ kg Fuel Leaving Process	
Value of Recycle: ___ kg @ \$ ___ per kg	
Total Value of ___ kg Acceptable Fuel	
Unit Value of 100 kg Fuel Entering Next Process	<u>11275</u>
Value of 100 kg Fuel Entering This Process	<u>9545</u>
Process Variable Cost per 100 kg Acceptable Fuel	<u>\$ 1730</u>

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