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**FUEL FABRICATION COST ESTIMATE FOR THE GE-LMFBR
CONCEPT PRESENTED IN GEAP-4939**

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for the
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ABSTRACT

Fuel fabrication costs were estimated for a 1000-Mw(e) fast, sodium-cooled, mixed-oxide-fueled reactor concept. The design incorporates BeO pins in a pancake core and vented fuel pins.

Cost estimates were made for the core and axial blanket regions, with allowances for the fuel element geometries and complexities. Fabrication costs of \$443 and \$32.40/kg of core U+Pu were determined for the core and axial blanket requirements, respectively, for a 30-reactor industry, each 1000 Mw(e).

INTRODUCTION

Fuel fabrication costs have been estimated for the 1000-Mw(e) sodium-cooled, mixed-oxide-fueled reactor concept described.¹ The report describes a two-zone radially reflected pancake-shaped core with BeO incorporated to soften the neutron spectrum and as the reflector material. The design incorporates fuel pins with a "diving bell" vent in the upper end cap of each pin. Diagrams of the reactor core, the fuel element, and typical fuel pins are shown in Figs. 1, 2, and 3, respectively.

Since this design has no radial blanket, the fuel fabrication cost estimate was limited to an evaluation of the core and axial blanket, both of which are integrally contained within the individual fuel pins. No estimate was made for the BeO reflector since the report did not give detailed information on that portion of the design.

¹K. P. Cohen and G. L. O'Neill, Safety and Economic Characteristics of a 1000-Mw(e) Fast Sodium-Cooled Reactor Design, GEAP-4939 (December 1965).

ORNL-DWG 68-2470

TOP VIEW SECTION E-E

Fig. 1. Core Diagrams for the GE-LMFBR Concept Presented in GEAP-4939.

Fig. 2. Fuel Element Diagrams for the GE-LMFBR Concept Presented in GEAP-4939.

FUEL ROD

BeO ROD

Fig. 3. Typical Fuel and BeO Pins for GE-LMFBR Concept Presented in GEAP-4939.

Analysis of core fabrication costs was complicated by: (1) the presence of BeO-loaded pins in varying numbers as integral parts of the fuel assemblies, (2) fuel assemblies which were modified to accommodate control rods, and (3) wire-wrapping and subassembly requirements of the fuel elements.

The evaluation philosophy assumed that the core fuel was manufactured in a partially shielded glove-box plant starting with mixed oxide powders. The plant was assigned sufficient type 316 stainless steel tubing to encapsulate the mixed oxide fuel plus axial blankets and the required BeO pellets. It was assumed that the depleted UO₂ pellets for the axial blanket were made in an associated plant under contact handling conditions and only the pelletizing operations were considered as costs for the axial blanket (i.e., the axial blanket pellets were assumed to be only a small increment of total production from a plant devoted to depleted pellet production and no shipping charges were assigned). It was also assumed that the BeO pellets were purchased from an outside supplier in finished form.

The design parameters used were:

<u>Fuel Element</u>	<u>Core</u>	<u>Axial Blanket</u>
Type	(U,Pu)O ₂ pellets	Depleted UO ₂ pellets
Rods/element	420 in 34 complete hexagons 503 in 53 complete hexagons 376 in 107 partial hexagons 452 in 88 partial hexagons	
Elements/reactor	282	
Bonding	Helium	
<u>Fuel</u>		
Chemical composition	UO ₂ + 17.9% PuO ₂	UO ₂
Outside diameter, in.	0.237	
Length, in.	16	18/18
Theoretical density, g/cm ³	11.09	10.97
Attained percent of theoretical density	94	94

Fuel (continued)

Stoichiometric factor	0.8815	0.8815
Pellet length, in.	0.3	0.3

Cladding

Material	Type 316 stainless steel
Outside diameter, in.	0.267
Wall, in.	0.010
Length, in.	76.5

Plant

Type	Glove-box, partially shielded	contact, hooded
Operating days/yr	260	
Load factor	0.8	
Fixed capital charge rate, %	30	
Reject rate, %	5	5
Fuel loss	0	0
Capacity, kilograms heavy metal per day	250 to 10,000	

The design parameters were used as input to the FABCOST 5 computer program.² The results are shown in Table 1 for the core fabrication study. Table 2 shows results for the axial blanket study.

These results are based on only rough estimates of how much the additional complications of (1) the vented pins, (2) the four variations in fuel element geometries, (3) the introduction of BeO pins, and (4) the wire-wrapping and subassembly of the elements, would increase the fuel fabrication costs as compared with the conventional light water reactor assembly used as the basis for the FABCOST program.

²A. L. Lotts and T. N. Washburn, "Use of Computer Codes in Estimating Fuel Element Fabrication Costs," Nucl. Appl. 4(5), 307-319 (1968).

Table 1. Core Fabrication Cost Estimates for the GE-LMFBR Concept
Presented in GEAP-4939 (in dollars/kg heavy metal)

Core Plant Capacity (kg/day)	Cost				Total
	Operating	Capital	Hardware	BeO ^a	
250	\$ 106.83	\$ 118.14	\$ 282.25	\$ 19.38	\$ 526.60
500	89.71	96.61	258.97	18.12	463.40
750	82.12	86.51	247.40	17.57	433.60
1,000	78.71	80.25	239.99	16.96	415.91
1,500	74.40	72.48	230.83	16.21	393.62
2,000	71.65	67.61	224.46	15.75	379.47
3,000	68.15	61.52	216.72	15.18	361.57
4,000	65.90	57.68	211.73	14.78	350.09
6,000	63.01	52.84	205.38	13.63	334.86
10,000	\$ 59.76	\$ 47.55	\$ 198.32	\$ 13.57	\$ 319.20

^aPrice based on unofficial estimate from Brush Beryllium Company, based on one core loading of 4917 lb of BeO as pellets and reduced by a scaling exponent of 0.9 for larger throughputs.

Table 2. Axial Blanket Fabrication Cost Estimates for the GE-LMFBR
Concept Presented in GEAP-4939 (in dollars kg/heavy metal)

Core Plant Capacity (kg/day)	Corresponding Axial Blanket Required (kg/day)	Cost		Total (per kg heavy metal)	
		Operating	Capital	In Axial Blanket	In Core
250	557.5	\$ 12.27	\$ 8.27	\$ 20.54	\$ 45.80
500	1,115.0	9.87	6.12	15.99	35.66
750	1,672.5	8.37	5.20	13.57	30.27
1,000	2,230.0	7.39	4.59	11.98	26.72
1,500	3,345.0	6.50	3.86	10.36	23.11
2,000	4,460.0	5.79	3.47	9.26	20.65
3,000	6,690.0	5.04	2.89	7.93	17.68
4,000	8,920.0	4.63	2.61	7.24	16.14
6,000	13,380.0	4.01	2.05	6.06	13.51
10,000	22,300.0	\$ 3.31	\$ 1.76	\$ 5.06	\$ 11.30

The fuel fabrication costs for a 30,000 Mw(e) reactor industry can be extrapolated from the tables. Such an industry would require the production of 632 kg of U+Pu/operating day and the corresponding production of 1409 kg depleted uranium per operating day as axial blanket. The total fabrication costs have been calculated to be \$443 and \$32.40/kg of U+Pu in the core for the core and axial blanket, respectively.

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