DUN-1604

Cover Sheet for a Hanford Historical Document Released for Public Availability

Released 1994

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute

Battelle

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

DECLASSIFIED [redacted]

(CLASSIFICATION)

DOUGLAS UNITED NUCLEAR, INC.

RICHLAND, WASHINGTON

DOCUMENT NO.

DUN-1604
Hanford Code C-65

SERIES AND COPY NO.

[redacted]

DATE

October 5, 1966

XX [redacted]ICTED [redacted]A
THIS [redacted] CONTA[redacted]ICTED DAT[redacted] IN THE [redacted] ENERGY AC[redacted] TRANSMI[redacted] THE DISCL[redacted] ITS CONTEN[redacted] MANNER TO A[redacted]HORIZED PERSO[redacted]ROHIBITED.

TITLE

ORALLOY COST FOR PRODUCTION REACTOR FUEL USE

☐ OTHER OFFICIAL CLASSIFIED INFORMATION
THIS MATERIAL CONTAINS INFORMATION AFFECTING THE NATIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANING OF THE ESPIONAGE LAWS, TITLE 18, U. S. C., SECS. 793 AND 794, THE TRANSMISSION OR REVELATION OF WHICH IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.

AUTHOR

H. G. Spencer

ISS...

BATTELLE-NORTHWEST RECEIVED OCT 20 1966 CIRCULATING COPY TECHNICAL INFO. SECTION

THIS DOCUMENT [redacted]NOT BE LEFT UN[redacted]TENDED OR WHERE AN[redacted]THORIZED PERSO[redacted]AVE ACCESS TO IT. WHE[redacted]IN USE, IT MUS[redacted]RED IN AN APPR[redacted]CKED REPOSITO[redacted]IN AN A[redacted]D GUARD[redacted]A. WHILE IT [redacted] POSSESSION AN[redacted] YOU HAVE OBT[redacted] SIGNED RECEI[redacted]OM CL[redacted]ED FILES, IT[redacted]UR RESPONSIBIL[redacted]KEEP IT AND IT[redacted]ENTS WITHIN THE[redacted]TS OF [redacted] PROJECT AND [redacted] ANY UNAUTHORI[redacted]RSON. ITS TRANS[redacted] TO, AND STORAGE [redacted]OUR PLACE OF RESIDENC[redacted]PROHIBITED. IT[redacted] TO BE DUPL[redacted] IF ADDITIONAL CO[redacted]RE REQUIRED, OBTAIN [redacted]ROM THE REL[redacted]UING FILE. ALL [redacted]NS READING THIS DOCU[redacted] ARE REQUESTED TO SIGN[redacted]THE SPACE PROVIDED BELOW.

ROUTE TO:	PAYROLL NO.	LOCATION	FILES ROUTE DATE	SIGNATURE AND DATE
Battelle				
~~EA Eschbach~~	~~30535~~	~~703~~	10-21-66	
				E J Merrill 10/26/66
				R L Reynolds 10/26/66
				W A Reardon 10/26/66

54-5100-166 (10-65)
AEC-RLOO RICHLAND, WASH.

[redacted]

(CLASSIFICATION)

DECLASSIFIED

[redacted]

DUN-1604
Hanford Code C-65
Page 1

October 5, 1966

This document classified by
W. K. Woods

This document consists of
7 pages. [redacted]

Distribution:

1. T. W. Ambrose
2. D. H. Bangerter
3. R. S. Bell
4. W. A. Blanton
5. R. W. Bown
6. W. J. Dowis - GE
7. E. A. Eschbach - BNW
8. S. M. Graves
9. R. O. Gumprecht
10. A. K. Hardin
11. R. D. Jensen
12. R. T. Jessen
13. S. Koepcke
14. H. R. Kosmata
15. C. W. Kuhlman
16. L. E. Kusler
17. W. M. Mathis
18. R. Nilson
19. G. F. Owsley
20. R. W. Reid
21. K. L. Robertson
22. O. C. Schroeder
23. A. E. Smith - Isochem
24. H. G. Spencer
25. A. P. Vinther
26. W. K. Woods
27. DUN File
28. DUN Record

ORALLOY COST FOR PRODUCTION REACTOR FUEL USE

H. G. Spencer

[redacted]

[redacted] document contains restricted [redacted]
[redacted] Atomic [redacted]
Its [redacted] of its
[redacted] to [redacted]
[redacted] prohibited.

[redacted]

[redacted]

DT

DECLASSIFIED

[redacted]

ORALLOY COST FOR PRODUCTION REACTOR FUEL USE

I. INTRODUCTION

A study of relative plutonium and oralloy values is being made by representatives of the production sites under direction of AEC Headquarters, Division of Production. (Oralloy is uranium enriched to 93.15 percent U-235.) Under study assumptions that will be detailed later, oralloy would cost less than formerly, and may be cheap enough to enrich production reactor discharged uranium to reactor input assays. To date, uranium recycle enriching assays have been held below two percent U-235 -- usually 1.2 to 1.5. Use of oralloy for enriching reactor tails would conserve U-236, which would increase neptunium and Pu-238 production. There may be other profitable reactor uses for the cheaper oralloy.

The intent of this document is to give the oralloy cost data to those who may study or evaluate oralloy use, and to explain the basis for oralloy cost so that the validity of any use may be assessed.

II. SUMMARY AND RECOMMENDATIONS

An equation and data from which a rather low oralloy cost to production reactors can be calculated for study purposes is presented on Pages 3-6.

The advice of the AOP Steering Committee should be obtained before any data derived from this equation is distributed outside the Company.

III. DISCUSSION

A. Assumption Pertinent to Oralloy Value

Principal assumptions upon which oralloy value is based are as follows:

1. The U. S. Government wishes to sell some of its oralloy to nuclear power producers at the highest price it can get.

2. The price will be based on toll enriching criteria; all power producers must supply full natural feed to obtain enriched uranium.

3. During the period of interest, which goes through at least 1980, power reactor operators will have to get all their enriched uranium from the U. S. Government. The total power fuel demand will be assumed to follow a particular fixed schedule in any one study case.

4. Cascade operation for toll enriching will be inversely proportional to oralloy use for enriching. That is, for any one study case, assumption three specifies a fixed demand which will be met by some combination of two alternates: (1) oralloy blending as in mode "I" on page 5, and (2) toll enriching as in mode "II". The sum of the mode outputs, in kilograms of power fuel, is fixed in any one study case.

[redacted]

To date, AEC-OROO has issued Cascade operating data and uranium prices both estimated for two cases: (1) "most likely requirements" of 90,000 domestic and 50-60,000 foreign electrical megawatts by 1980, and (2) "high requirements" up by twenty percent. The following tables list the cascade cost and operating estimates, C and X_W, and the natural uranium value estimates, for these two cases.

TABLE I
URANIUM AND CASCADE DATA
"Most Likely Requirements" Case (1)

Fiscal Year	X_W/100 % U-235 in Cascade Tails	C_f Estimated Natural U Value, $/Kg	C_Δ $/Kg of Separative Work
66	0.1852	7.94	6.51
67	0.1852	8.53	7.00
68	0.1852	9.17	7.52
69	0.1852	9.86	8.09
70	0.1852	10.60	8.69
71	0.1852	11.39	9.35
72	0.1852	12.25	10.05
73	0.2081	13.17	12.27
74	0.2088	14.15	13.23
75	0.2118	15.21	14.48
76	0.2129	16.36	15.67
77	0.2148	17.58	17.04
78	0.2171	18.90	18.54
79	0.2197	20.32	20.21
80	0.2227	21.84	22.19
81	0.2315	23.48	24.58
82	0.2296	23.92	24.58
83	0.2277	24.35	24.58

(1) TT-10341, Sapirie, S. R., OROO, 8/3/66.

DECLASSIFIED

[redacted]

[redacted]

DECLASSIFIED

TABLE II
URANIUM AND CASCADE DATA
Twenty Percent High Requirements Case[2]

Fiscal Year	$X_w/100$ % U-235 in Cascade Tails	C_f Estimated Natural U Value, $/Kg	C_Δ $/Kg of Separative Work
66	0.2071	8.83	7.84
67	0.2071	9.50	8.42
68	0.2071	10.21	9.06
69	0.2071	10.98	9.74
70	0.2071	11.80	10.47
71	0.2071	12.68	11.25
72	0.2116	13.63	12.39
73	0.2130	14.66	13.44
74	0.2130	15.76	14.45
75	0.2156	16.94	15.80
76	0.2169	18.20	17.09
77	0.2193	19.57	18.59
78	0.2221	21.04	20.34
79	0.2254	22.62	22.26
80	0.2335	23.05	24.58

5. The natural uranium value estimates of Tables I and II are based on a U_3O_8 price of about eight dollars per pound in 1981 and 1979, respectively, discounted at 7.5 percent annually in preceding years.

6. The average assay of power reactor fuel will be 2.6 percent U-235.

7. Consider a particular toll enriching contract. The government receives natural uranium containing enough U-235 to make a given quantity of 2.6 percent fuel by Cascade operation. When oralloy is blended with some of this natural uranium to make the power reactor fuel instead of operating the Cascade, only about twenty percent of the natural uranium is used. The remainder is assumed to have a unit value to the government equal to C_f dollars per kilogram. For production reactor use, and also in the plutonium-oralloy comparison studies, oralloy is assumed to have the value of the remaining natural uranium plus the Cascade operating cost saved. Cascade operating cost saved per unit oralloy is the units of separative work saved per unit oralloy blended, $S\Delta$, times the Cascade operating cost per unit of separative work, C_Δ. The Cascade operating cost per unit of separative work is very sensitive to how much total work the Cascade is doing. In the plutonium-oralloy comparison studies, a campaign operating schedule for the Cascades is developed by Union Carbide based on estimated power reactor and other product demands, on power costs, on Cascade capability relative to campaign demand, and on the value of money. Values of X_w and C_Δ in Tables I and II are derived from two such campaign operating schedules.

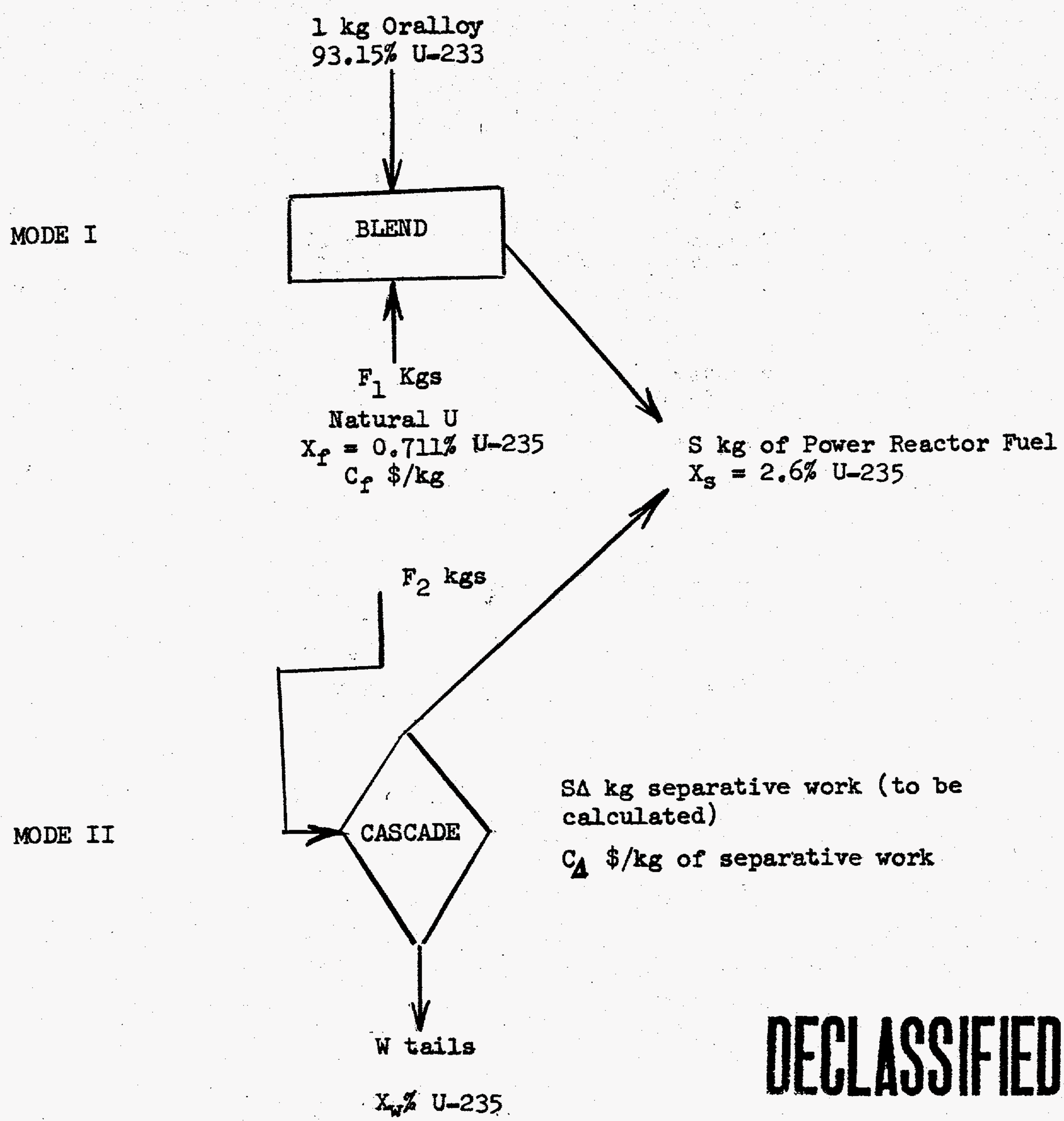
(2) TT-10343, Sapirie, S. R., OROO, 8/4/66.

[redacted]

[redacted]

B. Development of Oralloy Value Equation

1. BASIS: 1.0 kg of Oralloy blended with natural uranium to 2.6% U-235 and sold to nuclear power market.



[redacted]

2. <u>Equations:</u>

<u>For Mode 1</u>

Cost of Feed = $F_1 C_f$

$1.0 + F_1 = S$

$1.0\ (.9315) + F_1\ (.00711) = S(.026)$

$S = 48.9354$ kgs; $F_1 = 47.9354$ kgs

<u>For Mode 2</u>

Cost of Feed = $F_2 C_f$

Cost of Separative Duty = $S \Delta C_\Delta$

$F_2 = S + W = 48.9354 + W$

$F_2\ (.00711) = S(.026) + WX_w$

$F_2 = (1.27232 - 48.9354\ X_w)/(.00711 - X_w)$

$$\Delta = \pi_s + \pi_w \left(\frac{X_s - X_f}{X_f - X_w} \right) - \pi_f \left(\frac{X_s - X_w}{X_f - X_w} \right)$$

Note: Δ is kilograms separative work per kilogram of product S.

$\pi_s = 3.434902$

$\pi_f = 4.868883$

$$\pi_w = (2X_w - 1) \ln \left(\frac{X_w}{1 - X_w} \right)$$

Note: π_s and π_f are the values of functions identical in form to that of π_w but solved for $X_s = 0.26$ and $X_f = .00711$, respectively.

<u>Unit Value of 1.0 Kilogram of Oralloy</u>, V_y = Value to government of using mode 1 rather than 2 = (value of feed saved) + (separative work cost saved).

$$V_y = (F_2 - F_1) C_f + S \Delta C_\Delta$$

$$V_y = \left[\left(\frac{1.2732 - 48.9354\ X_w}{.00711 - X_w} \right) - 47.9354 \right] C_f + 48.9354\ C_\Delta \left[3.434902 + \pi_w \left(\frac{.01889}{.00711 - X_w} \right) - 4.868883 \left(\frac{.026 - X_w}{.00711 - X_w} \right) \right]$$

[redacted]

C. Use of Oralloy Value

In view of the nature of the above assumptions and additional matters concerning the potential availability of oralloy, the oralloy value determined from the equation for V_y using data in either Table I or Table II should be used for study purposes only. Availability of oralloy to NLO should not be assumed before fiscal year 1968, and this may be too early. It is further suggested that the advice of the AOP Steering Committee be obtained before any information in this document or derived therefrom is sent outside Douglas United Nuclear. The AOP Steering Committee may also wish to suggest use of different X_w, C_f, and C_Δ values; Union Carbide may change these estimates at any time.

D. Related Assumptions for Pu-Oralloy Comparison

All of the foregoing can be better understood and used if three additional assumptions and bases for the plutonium-oralloy comparisons are explained. These are as follows:

1. The quantity of oralloy that can be released from weapons stockpiles to power reactor fuel will depend in some manner on how much weapon plutonium is made. Plutonium in excess of normal requirements must be supplied in advance of oralloy release, hence the assumption on timing of oralloy availability. The ratio of traded quantities depends on relative capability of the two materials in weapons.

2. Reactor U-235 burnout costs will be determined using the data from Table I or II, or some similarly developed table, as the constants in the standard U-235 burnout equation.[3]

3. The type of economic comparison has not been chosen definitely, but in any case a campaign period will be analyzed with some interest rate (Union Carbide suggests 7.5 percent) applied to move all cost and sales dollars to a common point in time.

H. G. Spencer

H. G. Spencer, Senior Engineer
Advanced Concepts & Planning

HGS:je

(3) Page 23, DUN-774, "CAGE System Assumptions", D. H. Bangerter, 3/7/66, (Secret).