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May 21, 1962

TITLE

DESCRIPTION OF THE NET RETURN
OPTIMIZATION COMPUTER PROGRAM -
IBM 7090, FORTRAN MONITOR

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DESCRIPTION OF THE NET RETURN
OPTIMIZATION COMPUTER PROGRAM -
IBM 7090, FORTRAN MONITOR

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INTRODUCTION

During the past four years, IBM data processing computers have been utilized to perform countless studies involving the optimization of the HAPO plutonium production complex (HAPO and off-site supporting plants). During this time, three process optimization models have been constructed and associated Fortran programs have been written. These three are 1) maximum net return, 2) minimum reactor unit cost, and 3) maximum grams. This document will be concerned only with the first program: net return optimization.¹

In January of 1960, a new program was written for the IBM EDPM 709.² This new program incorporated the desirable features of the previous programs and provided additional output data.

During the two years since January, 1960, the net return optimization program has undergone many changes. These changes have been caused by improvements in the process technology and a major change in the definition of the Pu-240 specification.

It is the purpose of this document to describe the current version of the net return optimization program. (The reader should understand that even as this is being written, changes to the existing program are being contemplated. It is anticipated that a future description will include these changes.)

¹Music, J.F., et al, Reactor Process Optimization, HW-61579, August 17, 1959, Secret.

²Turner, R.L., and C.F. Poor, Process Optimization 709 Program, HW-64654, April 6, 1960, Secret.

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DISCUSSION

Description of the Program

The description of the net return optimization program is divided into the following sections and appendices:

SECTIONS

- A. Process Optimization
- B. Program Utilization
- C. Search Routine
- D. Definition of Optimum, Ridges, Fixed, Case, Set and Run
- E. Program Flexibility
- F. Program Control
- G. Assembling a Set of Input Data
- H. Summation Routine
- I. Assembling a Run

APPENDICES

- A. Sample Printout Pages
- B. Input Data Card Formats
- C. Glossary of Input-Output Symbols
- A. Process Optimization

The net return optimization computer program is a Fortran system program designed to simulate the physical and economic performance of the HAPO plutonium production complex. Simulation of the process is accomplished by the use of a mathematical model which describes the plant operation as a function of the plant operating conditions. A conceptual equation describing the net return model is:

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$$\text{net return} = \text{production} \times \text{marginal value} - \text{variable costs} - \Delta \text{fixed costs}^*$$

This program can be used in two basically different ways:

1. A set of operating conditions can be specified and the program will determine the associated plutonium production, net return, operating costs, and other dependent variables.
2. A marginal value (sales prices of plutonium) can be specified and the program will determine the operating conditions which will yield the maximum net return.

The general technique used in the latter application is one of successive iteration of reactor powers and fuel exposures until the combination is reached which produces the optimum performance of the complex.

B. Program Utilization

The use of this program falls into two general categories: 1) the evaluation of process parameter changes, and 2) forecasts and operating plan recommendations.

The evaluation of varying one or more of the process variables can be carried out to study such problems as the optimum charge length, incentive for fuel performance improvement, total reactor control, project justifications, etc.

Plant power level and goal exposure recommendations made by Process Engineering Unit are based upon results emanating from this program.

Process Analysis Unit uses the program in the preparation of two and

* In the program, net return plus fixed costs are denoted by the quantity Z. ZMAX is the maximum Z and represents the condition of maximum net return plus fixed costs.

five-year power level forecasts and optimum plant goal exposure recommendations.

Process Technology Sub-Section administers and maintains the program and serves various customers (Manufacturing Section, IPD; and FPD) by either performing studies dependent upon the program or offering to assist other components in adapting the program to their specific needs.

C. Search Routine

The heart of this program is the optimization search routine which varies P (power), EMI, EME, EMS (three metal type exposures) until Z (net return plus fixed costs) is a maximum. To describe this routine in infinite detail would be a disservice to the reader, but the general philosophy is important to a basic understanding of the program.

Think of a mountain where the north-south direction is called P and the east-west direction is EMI and the peak of the mountain is our goal, Z MAX. Starting at a point on the mountain (we are at a three dimensional intercept where P, EMI, and Z have unique values), we walk up the mountain on a constant EMI line. P and Z will increase as we walk unless we are very lucky and have chanced upon the EMI line that will take us directly to the peak. We will eventually reach a crest on the side where Z is maximum then start down the other side where Z now becomes less than the crest Z. Now, we back up to the crest Z and start walking at a right angle up the mountain on a constant P line until we hit another crest. This process will be repeated until we find ourselves at the peak, or Z max--our goal. At this point on the mountain, we can see what P and EMI lines we are on as well as the value of the maximum Z.

This is a rather simple analogy of the net return optimization concept since it deals with only two variables, P and EMI, and the program model is based on four variables.

The foregoing describes what we call the optimum search routine. A specialized search routine is called the "ridge" and gets its name from the fact that it is designed to find the crest Z's for a fixed schedule of P or EMI lines.

D. Definition of Optimum, Ridges, Fixed, Case, Set, and Run

The following words are used throughout the discussion and have special meanings as follows:

"Optimum" refers to the results obtained when the power level (P) and the goal exposures of the three metal types (EMI, EME, EMS) are varied by the search routine until the combination of power level and goal exposures result in the maximum net return plus fixed cost (Z) for the given set of input data.

"Ridges" refers to the results obtained when the goal exposures of metal type 1 (EMI) is held constant at pre-set values, and the power level (P) and the remaining two metal type goal exposures (EME, EMS) are allowed to vary until the maximum Z is obtained with the restraint on metal type 1 goal exposure. Nine cases of the above type are calculated with metal type 1 (EMI) goal exposure fixed at 200 MWD/T through 1000 MWD/T at intervals of 100 MWD/T.

Eleven cases are also calculated for determining the optimum goal exposures of the three metal types (EMI, EME, EMS) to give maximum Z when the tube power (P) is held constant. The tube powers at which the above calculations are made are fixed at 1.0 MW through 2.0 MW at intervals of 0.1 MW.

With the results of the above type of calculations, effects on metal throughput, production losses, and costs can be evaluated for varying exposure and power conditions.

"Fixed" refers to the type of cases where the power level (P) and the goal exposures of the three metal types (EMI, EME, EMS) are fixed and are submitted as input data (one card per case). The program does not go through the search routine, but calculates the standard output directly.

"Case" refers to the calculation and printout of a standard output. One or more cases can be calculated from one set of input data, each case being given a number in the order of its preparation for printout. For example, from one set of input data: one optimum case, 20 ridge cases, and up to 279 fixed cases* may be prepared.

"Set" refers to one set of input data, which may consist of up to five different groups of input data cards. For example, if an optimum case with a bulk temperature loss schedule is to be calculated, the input data set would consist of two groups of cards: the main group (cards 1-11) and the auxiliary loss-bulk temperature group (cards 12-13).

"Run" refers to one or more sets of input data which will be entered to Electronic Data Processing Operation (EDPO) for Fortran Monitor processing. One or more runs may be entered at a time, but each run will be accompanied by the customary binary deck and identity cards. A run should not exceed 300 cases.*

E. Program Flexibility

The net return optimization program flexibility allows us to obtain

*The restriction on total cases for one run is explained in Summation Routine.

several types of output data from one set of input data. By the use of various controls (described in Program Control), we can calculate an optimum, a ridge, or a number of fixed cases, or any combination of these types of output. We can also calculate these same types of cases with or without auxiliary losses. These auxiliary losses may be used as a schedule of losses or as a cut-off routine to suspend calculation when a certain value associated with the auxiliary loss is reached. We can also sum the significant output values of up to nine cases at a time for an unlimited combination of cases.

F. Program Control

There are several ways to control the flow of data calculations in a program. The net return optimization program uses three: 1) control parameters which indicate to the program (a) the type of output cases to calculate, and (b) the type of input data to be read-in to calculate the cases; 2) the order of the input data cards; and 3) a blank card used to terminate the calculation of fixed cases.

(1) Control Parameters

The control parameters associated with the ordering of an input data set are described in Assembling a Set of Input Data which follows. These control parameters (L4, I, L7, L8, L9) are specifically associated with controlling the reading-in of input data groups and performing calculations for individual sets of input data.

The control parameter (L20, Card A) associated with the summation routine is described in Assembling a Run and Summation Routine sections of this document.

The remaining card 1 control parameters (L2, L3) do not control

input data. These control parameters indicate whether an optimum case (L2) will be calculated and/or a ridge (L3) will be calculated for a set of input data.

A similar control (L4) indicates whether fixed case(s) will be calculated, and has been treated as part of the first group because L4 also controls the reading-in of input data.

(2) Order of Input Data Cards

As stated before, the order of the deck of input data cases for a run is important. The input data cards necessary to make the required calculations must be read into the system when they are required and in the order required. The proper ordering of a set and a run are described in the following sections: Assembling a Set of Input Data and Assembling a Run.

(3) Blank Card

The blank card is used to tell the program that no more fixed case cards are to be read-in for that set of input data.

F. Assembling a Set of Input Data

As defined earlier, a set of input data may include from one to five groups of input data cards. The number of groups will be determined by the type of study being performed. The program has been designed to read-in only the input data groups required for the study. The order in which these groups are read-in is fixed:

<u>Order</u>	<u>Group</u>
1	Main (cards 1-11)
2	Auxiliary loss-bulk temperature (cards 12, 13)
3	Auxiliary loss-production efficiency (cards 14-16)

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<u>Order</u>	<u>Group</u>
4	Auxiliary loss-total control (cards 17, 18)
5	Fixed case (card 19) (one card for each case, terminated by a blank card)

The method of indicating which group of a set are to be read-in is a function of the program control parameters: L4, I, L7, L8, L9.

The main group (cards 1-11) will always be read-in.

If the auxiliary loss-bulk temperature group (cards 12, 13) are to read-in, they will follow immediately after the main group and I and L7 will be set equal to 2 in card 1. If the cards are not to be read-in, L7 will be set to 0 and cards 12, 13 will not be included in the set.

If the auxiliary loss-production efficiency group (cards 14-16) are to be read-in, they will follow in order. I and L9 will be set to 2 in card 1. If the cards are not to be read-in, L9 will be set to 0 and cards 14-16 will not be included in the set.

If the auxiliary loss-total control group (cards 17, 18) are to be read-in, they follow in order. I and L8 will be set to 2 in card 1. If the cards are not to be read-in, L8 will be set to 0 and cards 17, 18 will not be included in the set.

If fixed case group (card 19) card(s) are to be read-in, they will follow in order. L4 will be set to 2 in card 1. To terminate the fixed case group, a blank card follows the last card 19. If the card(s) are not to be read-in, L4 will be set to 0 and the card(s) will not be included in the set.

This completes a set of input data. The method of assembling a number of sets into a run is explained in a following section.

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H. Summation Routine

The Pu-240 specification caused the summation routine to be included in the current version of the net return optimization program. Prior to its inclusion, the summation of selected case output values was done by hand.

As each case is calculated, the case number identification starting with 1 and increasing by one for each succeeding case is assigned. Certain output quantities of the case (see Appendix A for complete list) are stored away at the time of calculation into a series of 300-unit single-dimension arrays. Consequently, no run should ever exceed 300 cases.

After all of the cases in a run have been calculated, the summation of these quantities for selected cases (up to nine cases at a time) may be accomplished by the use of pairs of card A and card B.*

When card A is read, the program reads the card as if it were card 1 of a new set of input data. A test is performed on the L20 quantity to determine whether it is card A or card 1. If L20 is 0, it is card 1. If L20 is 2, it is card A.

Card B, which always follows card A,* contains the case numbers of the cases to be summed (N1-N9), and the total number of cases (NC) on the card. One or more cases (up to nine) comprise a summation and any number of summations can be made.

Experience has taught us to layout a visual chart of the case numbers and their unique identification to aid in preparing the card B's and as a quick reference to the summation outputs. For example: case 38 is B reactor, 10 C inlet, 25 dollar Pu, etc.

*In the future, only one card A will be required to precede all card B's.

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I. Assembling a Run

As defined earlier, a run is a grouping of one or more input data sets. To "make a run," all input data sets are combined, one after the other, into an input deck. The input data deck follows the binary deck, which follows the identification card. If summation output is desired, the card A, card B groups must follow the last set of input data in the run.*

Since the inception of the Monitor, there is no need to terminate the program by a blank card. The blank card is still required to terminate the fixed case calculations of each set of input data when fixed cases are to be calculated.

If the summation routine will be used, it is important to be cognizant of the order in which the input data sets are arranged. Remembering that the summation routine sums cases by case number identification, the ordering of the input data sets and the number of cases, which will be outputted for each set of input data, must be kept in mind when preparing the CARD B list of cases to be summed.

There is a limit to the number of cases which can be calculated in a run. This number is 300 and is dictated by the summation routine. If more than 300 cases are required at one time, break the number up into less than 300 case groups and process these groups as individual runs at the same time. This will require extra copies of the binary deck and identification card.

The following page graphically describes the assembly of a run.

*In the future, only one card A will be used, followed by all card B's.

EXAMPLE OF TYPICAL RUN ASSEMBLY

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APPENDIX A

SAMPLE PRINTOUT PAGES

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The sample pages which follow are representative of one type of program flexibility only. The following notes have been generalized to fit all possible combinations.

First Sample Page

1. A set of input data will be printed out under the heading, Net Return Optimization - Input Data. Each pair of lines represents an input data card: the first line indicating the input data symbol (see Appendix C for definition of symbols) and the quantity of each item directly below on the second line.
2. Immediately following the printout of input data, one of three case type headings will be shown: Optimum Parameters, Ridges, or Fixed Points. Following Fixed Points, a pair of lines will identify the input data values for card 19. These two lines will appear prior to the output for subsequent fixed cases.
3. Following the case type heading will be the case number identification: Case Number - XXX. The case number starts at 1 for each run and continues in numerical order (2, 3, 4 ...) up to 300 for each run. The case number is used in the Summation Routine.
4. Following the case number is the standard case output consisting of two pairs of lines (a few input quantities are repeated for convenience and a block of five lines of calculated values). The symbol of the quantities (see Appendix C for definitions) appear directly above the quantities. The block of four quantity lines represent the values for the three metal types (I,E,S) and the total value (TOT) of the three metal types for each

[REDACTED]

of the major column headings, e.g., CD(I) is the charge-discharge loss in days per day of metal type 1.

5. The values printed out in the standard output represent the final or maximum Z calculated from the input data. In the process of finding the maximum Z, the program search routine may have calculated several hundred separate Z's.

Second Sample Page

6. Each summation will be printed out on a separate page with the heading -
Summation by Case Number.
7. A pair of lines identify the input data values of card B (see Appendix C for definition of symbols). A block of five lines represents the summation values of the cases summated. The same convention as used above, in note 4, describes the block.
- [REDACTED]

NET RETURN OPTIMIZATION - INPUT DATA

L1	L2	L3	L4	I	L7	L8	L9	L14	L15	A16	A17	A18	A19	L20			
0	2	-0	-0	2	3	-0	-0	-0	-0	-0	-0	-0	-0	-0			
ATI				BTI				CTI				DTI				A24I	B24I
C.95548E 00				0.15256E-03				0.14687E-07				0.20400E-00				124.44	0.02389
ATE				STE				CTE				DTE				A24E	B24E
C.79470E 00				0.14637E-03				0.13100E-07-0.								128.45	0.02303
ATS				ETS				CTS				DTS				A24S	B24S
C.79388E 00				C.14984E-03				0.13755E-07-0.								124.61	0.02388
GR	AT	CR	CS	RF	SF	EMB	QMI	PB	EN	GP							
1.000	1900.	327.	1.	1.050	1.160	620.-0.	1.125	1500.-0.									
AI	AF	AS	ELN	EQI	NQXI	EQE	NQXE	EQS	NQXS								
C.500	C.150	0.005	24.0	0.057	-39	0.507	-39	0.132	-39								
XPI	XTI	XEI	XPE	XTE	XEE	XPS	XIS	XES	TFI	TFE	TFS						
3.3	8.7	5.0	3.3	8.7	5.0	3.3	8.7	5.0	1.000	1.000	1.000						
FNI	FNE	FNS	FR	TIN	TB	TBC											
45.0	49.8	45.4	86100.	16.8	93.5	10000.											
CK	CK1	RK	DM	DMR	CTR	FC	EMISC	S									
1.200	C.00080	1.180	30.0	30.0	24.0	34502.	0.140	0.135									
PU	BI	DE	BS	EMCI	EMCE	EMCS											
50.00	9.75	13.32	13.32	4045.00	3785.00	3785.00											
TTI	TTE	TTS	CDRI	CDRE	CDRS	CDLINE	CDLENE	CDLSNE									
9.170	11.059	8.743	400.0	400.0	400.0	1.100	1.100	1.100									

OPTIMUM PARAMETERS

CASE NUMBER- 41

Z	UCMR	P	EMI	EME	EMS	EN	PH	EYE	E	S	BT	CONVRI	CONVRE	CONVRS	PH
41336.	44.3615	1.160	810.	900.	1220.	1500.	1740.	0.674	0.191	0.135	93.5	0.967	0.704	0.675	0.704
CR11	NXI	DRIE	NXE	DRIS	NXS	OSI	TRL	RUP	PEMISC	ZSELL					
3.81012	38	0.11089	38	4.45332	36	5.352	0.031	0.022	0.111	31846.					
CD	RL	CON24	TP	BOC	TPC	AVIN	PMWD	GRM24	RGR	TEGR	GRM				
I	C.029	0.017	0.0563	1.149	8776.08	4646.68	14.912	930.49	40.01	710.29	139.82	900.11			
E	0.009	C.004	0.0603	0.294	2479.35	1111.88	19.293	264.33	11.23	186.14	-0.	136.14			
S	0.004	C.000	0.0794	0.153	1676.47	578.55	17.917	186.48	9.99	125.86	-0.	125.86			
TCT	0.042	0.022	0.0599	1.595	12931.90	6337.11	15.897	1381.35	61.23	1022.29	189.82	1212.11			

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APPENDIX B

INPUT DATA CARD FORMATS

The four pages of input data formats which follow represent six groups of input data cards and are described in the following notes.

1. As explained in Preparation of Input Data, the types of case(s) to be calculated will dictate the number and arrangement of the cards for each set of input cards.
2. The designation for each card group is given as a main heading and are as follows:

Main - cards 1 thru 11

Auxiliary loss-bulk temperature - cards 12, 13

Auxiliary loss-production efficiency - cards 14, 15, 16

Auxiliary loss-total control - cards 17, 18

Fixed case - card 19

Summation routine - cards A, B

3. Within each group, each card is identified on the right side by its number or letter.
4. Each card is described by three horizontal lines and a group of vertical lines as follows: the vertical lines indicate the field size of each input data quantity, the first horizontal line describes the symbol names of the input data quantities (see Appendix C for definition of symbols), the second horizontal line indicates the decimal point position of E and F type formats and the usual magnitude (X's) of the quantities, the third horizontal line shows the standard Fortran format identification for each input data.
5. The same Fortran formats are used for reading-in and writing-out.

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6. I-type formats are used for integers and care must be used in right-adjusting the integer number within the data field.
7. E-type formats are used for decimal numbers with the powers of ten convention. The power of ten (signed) following the E. For example, 1.384×10^{-37} with a format of E9.3 would be 1.384E-37. The "9" refers to the field size and the "3" refers to the number of places to the right of the decimal point.
8. F-type formats are used for decimal numbers. For example, 930.7834 with a format of F8.4 would be 930.7834. The "8" refers to the field size and the "4" refers to the number of places to the right of the decimal.
9. For a more complete definition of Fortran format rules see IBM Reference Manual C28-6054-2, 709/7090 Fortran Programming System.

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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80																																																		
																																								MAIN - CARDS 1 THRU 11																																																																																									
L1	L2	L3	L4	I	L7	L6	L9	L14	L15	A16	A17	A18	A19	L20																											CARD 1																																																																																								
X	X	X	X	X	X	X	X	X	X	X	X	X	X	0																																																																																																																			
I3	I3	I3	I3	I3	I3	I3	I3	I4	I4	F4.0	F4.0	F4.0	F4.0	I4																																																																																																																			
ATI										BTI										CTI										DTI										A24I										B24I										CARD 2																																																																					
X.XXXXXE±XX										X.XXXXXE±XX										X.XXXXXE±XX										X.XXXXXE±XX										XXX.XX										.XXXXX																																																																															
E12.5										E12.5										E12.5										E12.5										F7.2										F8.5																																																																															
ATE										BTE										CTE										DTE										A24E										B24E										CARD 3																																																																					
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APPENDIX C

GLOSSARY OF INPUT-OUTPUT SYMBOLS

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In the following definitions of the input and output printout symbols, several conventions have been used.

1. Groups of symbols ending in I, E, and S refer to the three metal groups, respectively. Originally, these symbols represented: I&E natural, I&E enriched, and Solid natural metal.
2. Groups of symbols which are subscripted (I), (E), (S), and (TOT) refer to the output section of the printout where the data is presented in block form (see sample printout) with the major designation appearing at the top of the column and the subscripted designations appearing only once on the left side of the columns. For example, CD(I) refers to the calculation of CDI, CD(E) refers to CDE, CD(S) refers to CDS, and CD(TOT) refers to CDT.
3. In "Origin" equations used in the program, notice that wherever the heat split of the first metal type (formerly I) is used, the term EYE is used instead. This obvious substitution is a result of certain Fortran programming rules.
4. It is expected that this glossary will be used to identify the input and output data, the origin of the data (input or calculated), and the units of the data.

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A16

Definition

Constant by which the daily values for the first optimum case are multiplied prior to accumulation.

NOTE: This part of the program will be removed in the future.

Unit

None

Origin

Input data.

A17

Definition

Constant by which the daily values for succeeding cases are multiplied prior to accumulation.

NOTE: This part of the program will be removed in the future.

Unit

None

Origin

Input data.

A18

Definition

Constant similar to A16 for fixed cases.

NOTE: This part of the program will be removed in the future.

Unit

None

Origin

Input data.

DECLASSIFIED

A19

Definition

Constant similar to A17 for fixed cases.

NOTE: This part of the program will be removed in the future.

Unit

None

Origin

Input data.

A24I, A24E, A24S

Definition

One of the Pu-240 conversion ratio constants of the three metal types.

Unit

None

Origin

Input data.

AI, AE, AS

Definition

Ratio of the tube metal performance index to the reactor metal performance index of the three metal types.

Unit

None

DECLASSIFIED

Origin

Input data.

AT

Definition

The number of active tubes.

Unit

Tubes

Origin

Input data.

ATI, ATE, ATS

Definition

One of the plutonium (all isotopes) conversion ratio constants of the three metal types.

Unit

None

Origin

Input data.

AVIN(I), AVIN(E), AVIN(S), AVIN(TOT)

Definition

Average incremental cost of plutonium (all isotopes) of three metal types plus the total production incremental cost of the three metal types.

Unit

Dollars per gram.

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Origin

Calculated:

$$AVINI = \frac{BOCI + TPCI}{GRMI}$$

$$AVINE = \frac{BOCE + TPCE}{GRME}$$

$$AVINS = \frac{BOCS + TPES}{GRMS}$$

$$AVINT = \frac{BOCT + TPCT}{GRMT}$$

B24I, B24E, B24S

Definition

One of the Pu-240 conversion ratio constants of the three metal types.

Unit

None

Origin

Input data.

BI, BE, BS

Definition

The cost of the U-235 isotope burnout per gram of plutonium produced of the three metal types.

Unit

Dollars per gram

Origin

Input data.

DECLASSIFIED

BOC(I), BOC(E), BOC(S), BOC(TOT)

Definition

The burnout cost of the three metal types and the total burnout cost of these three metal types.

Unit

Dollars per calendar day.

Origin

Calculated:

$$BOCI = BI(GRMI)$$

$$BOCE = BE(GRME)$$

$$BOCS = BS(GRMS)$$

$$BOCT = BOCI + BOCE + BOCS$$

BT

Definition

The reactor bulk outlet temperature.

Unit

Degree centigrade

Origin

Calculated:

$$BT = TIN + \frac{1000. (P)(EN)}{.2635 (FR)}$$

NOTE: In the future, (FR) will be replaced with (FR + FS), where
FS is the shield flow.

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BTI, BTE, BTS

Definition

One of the plutonium (all isotopes) conversion ratio constants of the three metal types.

Unit

None

Origin

Input data.

CD(I), CD(E), CD(S), CD(TOT)

Definition

Charge-discharge loss of the three metal types and the total charge-discharge loss of the three metal types.

Unit

Days per calendar day.

Origin

Calculated:

$$CDI = \frac{EYE(PN)(TTI)(CDLINE)(PE)}{EMI(CDRI)}$$

$$CDE = \frac{E(PN)(TTE)(CDLENE)(PE)}{EME(CDRE)}$$

$$CDS = \frac{S(PN)(TTS)(CDLSNE)(PE)}{EMS(CDRS)}$$

$$CDT = CDI + CDE + CDS$$

CDLINE, CDLENE, CDLSNE

Definition

The factor for multiplying charge-discharge downtime loss so that non-equilibrium losses will also be represented.

DECLASSIFIED

Unit

None

Origin

Input data.

CDRI, CDRE, CDRS

Definition

The charge-discharge rate, including setup and button-up time, of the three metal types.

Unit

Tubes per calendar day.

Origin

Input data.

CK

Definition

A factor to adjust the calculated corrosion rates to those representative of the reactor.

Unit

None

Origin

Input data.

CKI

Definition

A tube corrosion factor used by N. R. Miller and which is equal to 0.0008.

Unit

None

Origin

Input data.

DECLASSIFIED

CONVRI, CONVRE, CONVRS

Definition

The conversion ratio of plutonium (all isotopes) of the three metal types.

Unit

Grams per megawatt-day.

Origin

Calculated:

$$\text{CONVRI} = (\text{ATI})_e - \text{BTI}(\text{EMI}) + \text{CTI}(\text{EMI})^2 + \text{DTI}$$

$$\text{CONVRE} = (\text{ATE})_e - \text{BTE}(\text{EME}) + \text{CTE}(\text{EME})^2 + \text{DTE}$$

$$\text{CONVRS} = (\text{ATS})_e - \text{BTS}(\text{EMS}) + \text{CTS}(\text{EMS})^2 + \text{DTS}$$

CON24(I), CON24(E), CON24(S), CON24(TOT)

Definition

Ratio of Pu-240 gram production to real gram plutonium (all isotopes) production of the three metal types and the ratio of total Pu-240 grams to total real grams of the three metal types.

Unit

None

Origin

Calculated:

$$\text{CON24I} = \frac{.01 (\text{EMI})}{\text{A24I} + \text{B24I}(\text{EMI})}$$

$$\text{CON24E} = \frac{.01 (\text{EME})}{\text{A24E} + \text{B24E}(\text{EME})}$$

$$\text{CON24S} = \frac{.01 (\text{EMS})}{\text{A24S} + \text{B24S}(\text{EMS})}$$

$$\text{CON24T} = \frac{\text{GRM24T}}{\text{RGRT}}$$

DECLASSIFIED

CTI, CTE, CTS

Definition

One of the plutonium (all isotopes) conversion ratio constants of the three metal types.

Unit

None

Origin

Input data.

DBT(90-109)

Definition

A table of dollar loss per day as a function of the calculated bulk outlet temperature (BT).

The dollar loss value for each integer bulk outlet temperature from 90-109 C is placed in the DBT table, then each time Z is calculated in the program, the value of Z will be reduced by the interpolated amount between table positions as a function of the BT calculated for that Z.

This schedule concept is ideally suited to a varying loss schedule as a function of the bulk outlet temperature.

To use the schedule concept, both cards 12 and 13 must be submitted for each case in addition to setting I=2 and L7=2.

DECLASSIFIED

Unit

Dollars per calendar day.

Origin

Input data.

DE(6-20)

Definition

A table of fractions of Z (total control loss in dollars per day) as a function of the calculated heat generated (E) in metal type (2).

Each time Z is calculated, the value will be reduced by the product of Z and the fraction in the table corresponding to the truncated E value calculated for that Z .

This schedule may be used as a cut-off or as a varying total control loss schedule.

To use the schedule or cut-off concepts, cards 17 and 18 must be submitted for each case in addition to setting $I=2$ and $L8=2$.

Unit

None

Origin

Input data.

DM

Definition

The number of days per month. It is customary to use the value 30.

Unit

Days per month.

Origin

Input data.

DECLASSIFIED

DMR

Definition

The number of mils removed from a tube wall before the tube is replaced.

Unit

Mils per tube.

Origin

Input data.

DPE(61-85)

Definition

A table of dollar loss per day as a function of the calculated production efficiency (PE).

The dollar loss value for each integer production efficiency value from 61-85 per cent is placed in the DPE table, then each time Z is calculated in the program, the value of Z will be reduced by the amount in the table position corresponding to the truncated PE value calculated for that Z.

This schedule may be used as a cut-off or as a varying loss schedule as a function of the production efficiency.

To use the schedule or cut-off concepts, cards 14, 15, and 16 must be submitted for each case in addition to setting I=2, L9=2.

Unit

Dollars per calendar day.

Origin

Input data.

DECLASSIFIED

$$\underline{DRII \times 10^{NXI}, DRIE \times 10^{NXE}, DRIS \times 10^{NXS}}$$

Definition

The delta rupture index (ΔRI) of the three metal types are a measure of the severity of operating conditions as related to ruptures.

$$\text{Ruptures} = (\Delta RI) (q)$$

Units

Rupture potential (ΔRI) per equilibrium day.

Origin

Calculated:

$$DRII \times 10^{NXI} = EYE(AI)(P)(EN) \left(\frac{TTI}{EMI} \right) \left[1000. (TFI)(P) \right]^{XPI} \\ \left[TIN + \frac{(1000.) (TFI)(P)}{.2635(FNI)} \right]^{XTI} \left(\frac{EMI}{TTI} \right)^{XEI}$$

$$DRIE \times 10^{NXE} = E(AE)(P)(EN) \left(\frac{TTE}{EME} \right) \left[1000. (TFE)(P) \right]^{XPE} \\ \left[TIN + \frac{(1000.) (TFE)(P)}{.2635(FNE)} \right]^{XTE} \left(\frac{EME}{TTE} \right)^{XEE}$$

$$DRIS \times 10^{NXS} = S(AS)(P)(EN) \left(\frac{TTS}{EMS} \right) \left[1000. (TFS)(P) \right]^{XPS} \\ \left[TIN + \frac{(1000.) (TFS)(P)}{.2635(FNS)} \right]^{XTS} \left(\frac{EMS}{TTS} \right)^{XES}$$

DTI, DTE, DTS

Definition

The conversion ratio constant for tritium equivalent grams of plutonium for

the three metal types. For non-E-N, or non-N metal types, this value would be zero.

Unit

Grams per megawatt-day.

Origin

Input data.

DECLASSIFIED

DTR

Definition

The tube replacement rate.

Unit

Tubes per calendar day.

Origin

Input data.

E

Definition

The fraction of total reactor heat generated in metal type (2). (Formerly, I&E enriched metal.)

Unit

None

Origin

Calculated:

$$RE = \frac{(QR)(RF)}{AT}$$

$$SE = \left[(QS)(SF) + (EMB-EMI)(QMI)(SF) + (P-PB)(EN)(QP)(SF) \right] / AT$$

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If $SE \leq 0$,

$$E = RE$$

If $SE > 0$,

$$E = RE + SE$$

ELN

Definition

The hours lost, including non-equilibrium losses, due to one rupture.

Unit

Hours per rupture.

Origin

Input data.

EMB

Definition

The goal exposure of metal type (1) at base condition.

Unit

Megawatt-days per ton.

Origin

Input data.

EMCI, EMCE, EMCS

Definition

Incremental metal cost of the three metal types.

Unit

Dollars per ton.

Origin

Input data.

DECLASSIFIED

EMI

Definition

The goal exposure of metal group (1).

Unit

Megawatt-days per ton.

Origin

Input data for fixed case, varied for optimum case, schedule for exposure ridge cases (200-1000, $\Delta 100$ MWD/T), varied for power ridge cases.

EME, EMS

Definition

Goal exposure of metal groups (2) and (3).

Unit

Megawatt-days per ton.

Origin

Input data for fixed cases, varied for optimum cases, varied for ridge cases.

EMISC

Definition

Miscellaneous losses: downtime due to miscellaneous reasons and chargeable to one day's equilibrium operation.

Unit

Days per equilibrium day.

Origin

Input data.

DECLASSIFIED

EN

Definition

The number of effective central zone tubes (ECT).

Unit

Tubes

Origin

Input data.

$E_{QI} \times 10^{NQXI}, E_{QE} \times 10^{NQXE}, E_{QS} \times 10^{NQXS}$

Definition

The metal performance level multiplier (q) of the three metal types.

Ruptures = $\Delta RI \times q$

Unit

Ruptures per ΔRI .

Origin

Input data.

EYE

Definition

The fraction of total reactor heat generated in metal type (1). (Formerly, I&E).

Unit

None

Origin

Calculated:

EYE = 1. - E - S

DECLASSIFIED

FC

Definition

The fixed cost per day. These are costs which are considered not to vary significantly with process variables.

Unit

Dollars per calendar day.

Origin

Input data.

FNI, FNE, FNS

Definition

The average tube flow rate of the three metal types.

Unit

Gallons per minute.

Origin

Input data.

FR

Definition

The reactor flow rate.

NOTE: In the future, FR will represent the reactor flow and a new input data quantity, FS (shield flow) will be added to the input data. Bulk temp-

erature (BT) will then be calculated using the bulk flow (FR + FS) and tube corrosion values will be calculated using the reactor flow (FR) only.

Unit

Gallons per minute.

Origin

Input data.

DECLASSIFIED

GR

Definition

The ratio of heat generated in an enrichment column to that generated in a natural column, when both are at the same location.

NOTE: The location factor value is programmed to be 1.0, regardless of the input data value.

Unit

None

Origin

Input data (see note).

GRM(I), GRM(E), GRM(S), GRM(T)

Definition

Total production of plutonium (all isotopes) of the three metal types and the grand total production of the three metal types. (Includes tritium equivalent grams (TEGR)).

Unit

Grams per calendar day.

Origin

Calculated:

$$GRMI = CONVRI (PMWDI)$$

$$GRME = CONVRE (PMWDE)$$

$$GRMS = CONVRS (PMWDS)$$

$$GRMT = GRMI + GRME + GRMS$$

DECLASSIFIED

GRM24(I), GRM24(E), GRM24(S), GRM24(TOT)

Definition

Production of Pu-240 isotope of the three metal types and the total Pu-240 production of the three metal types.

Unit

Grams per calendar day.

Origin

Calculated:

$$GRM24I = CON24I(RGRI)$$

$$GRM24E = CON24E(RGRE)$$

$$GRM24S = CON24S(RGRS)$$

$$GRM24T = GRM24I + GRM24E + GRM24S$$

I

Definition

The primary control parameter associated with the auxiliary loss schedules or optimization cut-off control parameters: L7, L8, L9. If auxiliary loss schedules or cut-off routine is used, set I = 2. If not, set I = 1. (Refer to L7, L8, and L9 for further definition of inter-dependence.)

DECLASSIFIED

Unit

None

Origin

Input data.

L1

Definition

Reactor identification: $B = 1$, $C = 2$, $D = 3$, $DR = 4$, $F = 5$, $H = 6$, $KE = 7$,
 $KW = 8$, $N = 9$.

Unit

None

Origin

Input data.

L2

Definition

The control parameter for optimum case calculation. If an optimum case is to be calculated from the input data, set $L2 = 2$. If not, set $L2 = 0$.

Unit

None

Origin

Input data.

L3

Definition

The control parameter for power and exposure ridge calculations. If ridge cases are to be calculated from the input data, set $L3 = 2$. If not, set $L3 = 0$.

DECLASSIFIED

Unit

None

Origin

Input data.

L4

Definition

The control parameter for fixed case calculations. If fixed case(s) are to be calculated from the input data, set $L4 = 2$, and submit one card 19 for each case. If not, set $L4 = 0$.

Unit

None

Origin

Input data.

L7

Definition

The control parameter indicating the use of the bulk temperature auxiliary loss schedule as a function of BT, or the bulk cut-off routine. If the auxiliary loss schedule is used, set $I = 2$, $L7 = 2$, and submit cards 12 and 13 for each set of input data. If the bulk cut-off routine is used (TB, TBC), set $I = 2$, $L7 = 3$. If neither are used, set $L7 = 0$.

Unit

None

Origin

Input data.

DECLASSIFIED

L8

Definition

The control parameter indicating the use of the total control auxiliary loss schedule as a function of **E**. If the auxiliary loss schedule is used, set **I** = 2, **L8** = 2, and submit cards 17 and 18 for each set of input data. If not, set **L8** = 0.

Unit

None

Origin

Input data.

L9

Definition

The control parameter indicating the use of the production efficiency auxiliary loss schedule as a function of **PE**. If the auxiliary loss schedule is used, set **I** = 2, **L9** = 2, and submit cards 14, 15, and 16 for each set of input data. If not, set **L9** = 0.

Unit

None

Origin

Input data.

L14

Definition

The control parameter for accumulation of optimum case results. If accumulation is desired, set **L14** = 2. If not, set **L14** = 0.

NOTE: This part of the program will be removed in the future.

DECLASSIFIED

Unit

None

Origin

Input data.

L15

Definition

The control parameter for accumulation of fixed case results. If accumulation is desired, set L15 = 2. If not, set L15 = 0.

NOTE: This part of the program will be removed in the future.

Unit

None

Origin

Input data.

L20

Definition

The control parameter used in the summation routine. If a summation is desired, set L20 = 2 in CARD A. L20 must be set to 0 (blank) in CARD 1 of the input data group.

Unit

None

Origin

Input data.

DECLASSIFIED

N(1-9)

Definition

The case numbers used in the summation routine. One or more (up to nine) cases can be summed by placing the case number(s) in positions N1 through N9. The total number of cases (NC) must also be included on CARD B.

Unit

None

Origin

Input data.

NC

Definition

The number of cases (N1-N9) to be summed in the summation routine.

Unit

None

Origin

Input data.

OSI

Definition

Operational Severity Index.

Unit

None

Origin

Calculated:

$$OSI = [(TFI)(P)]^{XPI} \left[TIN + \frac{1000 \cdot (TFI)(P)}{100 \cdot (.2635)(FNI)} \right]^{XTI}$$

DECLASSIFIED

P

Definition

Average power of the ten highest power tubes.

Unit

Megawatts

Origin

Input data for fixed case, varied for optimum case, schedule for power ridge cases (1.0-2.0, Δ 0.1 MW), varied for exposure ridge cases.

PB

Definition

The average tube power of the ten highest powered tubes at the base condition.

Unit

Megawatts

Origin

Input data.

PE

Definition

Production efficiency: 1.) the ratio of the actual production for any period to the production which would have been obtained had the reactor operated the entire period at the maximum power level attained during the period, 2.) the product of time operated and level operated efficiencies. 3.) the ratio of equilibrium day to calendar day,

$$PE = 1. / (1. + \text{TUBE REPLACEMENT LOSS} + \text{MISC. LOSS} + \text{C-D LOSS} + \text{RUPTURE LOSS})$$

Unit

None

DECLASSIFIED

PEMISC

Definition

The miscellaneous loss term adjusted by the production efficiency.

Unit

Days per calendar day.

Origin

Calculated:

$$PEMISC = EMISC (PE)$$

PMWD(I), PMWD(E), PMWD(S), PMWD(TOT)

Definition

The production of the three metal types and the total production of the three metal types.

Unit

Megawatt-days per calendar day.

Origin

Calculated:

$$PMWDT = PN (PE)$$

$$PMWDI = EYE (PMWDT)$$

$$PMWDE = E (PMWDT)$$

$$PMWDS = S (PMWDT)$$

PN

Definition

The reactor power level or production for one equilibrium day.

DECLASSIFIED

Unit

Megawatt, megawatts per equilibrium day.

Origin

Calculated:

$$PN = (P)(EN)$$

FU

Definition

The assigned worth of plutonium.

Unit

Dollars per gram.

Origin

Input data.

QMI

Definition

The change in number of enrichment (metal type (2)) columns per one MWD/T change from the base exposure (EMB).

Unit

Tubes per MWD/T.

Origin

Input data.

QP

Definition

The change in number of enrichment (metal type (2)) columns per one megawatt change from the base tube power (PB).

DECLASSIFIED

Unit

Tubes per megawatt.

Origin

Input data.

QR

Definition

The number of enrichment columns in the flattening ring.

Unit

Tubes

Origin

Input data.

QS

Definition

The number of enrichment columns used for spike enrichment.

Unit

Tubes

Origin

Input data.

RF

Definition

The average tube factor of the flattening ring columns (QR).

Unit

None

DECLASSIFIED

Origin

Input data.

RGR(I), RGR(E), RGR(S), RGR(TOT)

Definition

The production of real grams of plutonium (all isotopes) of three metal types and the total production of real grams of the three metal types. (Does not include tritium equivalent grams (TEGR)).

Unit

Grams per calendar day.

Origin

Calculated:

$$\begin{aligned} \text{RGRI} &= \text{PMWDI}(\text{ATI})e^{-\text{BTI}(\text{EMI})} + \text{CTI}(\text{EMI})^2 \\ \text{RGRE} &= \text{PMWDE}(\text{ATE})e^{-\text{BTE}(\text{EME})} + \text{CTE}(\text{EME})^2 \\ \text{RGRS} &= \text{PMWDS}(\text{ATS})e^{-\text{BTS}(\text{EMS})} + \text{CTS}(\text{EMS})^2 \\ \text{RGRT} &= \text{RGRI} + \text{RGRE} + \text{RGRS} \end{aligned}$$

RK

Definition

The average ratio of the tube annulus delta temperature to the tube bulk delta temperature.

Unit

None

Origin

Input data.

DECLASSIFIED

RL(I), RL(E), RL(S), RL(TOT)

Definition

The slug rupture removal time loss of the three metal types and the total rupture removal time loss of the three metal types.

Unit

Days per calendar day.

Origin

Calculated:

$$RLI = DRII (EQI)(10)^{NXI} + NQXI \frac{(ELN)}{(24)} (PE)$$

$$RLE = DRIE (EQE)(10)^{NXE} + NQXE \frac{(ELN)}{(24)} (PE)$$

$$RLS = DRIS (EQS)(10)^{NXS} + NQXS \frac{(ELN)}{(24)} (PE)$$

$$RLT = RLI + RLE + RLS$$

RUP

Definition

The total number of ruptures of the three metal types.

Unit

Ruptures per calendar day.

Origin

Calculated:

$$RUP = \frac{RLT(24)}{ELN}$$

S

Definition

The fraction of the total reactor heat generated in metal group (3).

DECLASSIFIED

(Formerly, solid natural metal.)

Unit

None

Origin

Input data.

SBOC(I), SBOC(E), SBOC(S), SBOC(TOT)

Definition

The summation of the burnout cost for specified cases (N1-N9) of three metal types and total burnout cost of the three metal types.

Unit

Dollars per calendar day.

Origin

Calculated:

$$SBOCI = \sum_{i = N1}^{N9} BOCI_i$$

$$SBOCE = \sum_{i = N1}^{N9} BOCE_i$$

$$SBOCS = \sum_{i = N1}^{N9} BOCS_i$$

$$SBOCT = SBOCI + SBOCE + SBOCS$$

SC024(I), SC024(E), SC024(S), SC024(TOT)

Definition

The ratio of the Pu-240 grams summation (SGR24) to the real gram plutonium (all isotopes) summation (SRGR). Does not include tritium equivalent grams (TEGR).

DECLASSIFIED

Unit

None

Origin

Calculated:

$$SC024I = \frac{SGR24I}{SRGRI}$$

$$SC024E = \frac{SGR24E}{SRGRE}$$

$$SC024S = \frac{SGR24S}{SRGRS}$$

$$SC024T = \frac{SGR24T}{SRGRT}$$

SF

Definition

The average tube factor of the spike enrichment columns (QS).

Unit

None

Origin

Input data.

SGR24(I), SGR24(E), SGR24(S), SGR24(TOT)

Definition

The summation of Pu-240 isotope grams for specified cases (N1-N9) of three metal types and total Pu-240 grams of the three metal types.

Unit

Grams per calendar day.

DECLASSIFIED

Origin

Calculated:

$$SGR24I = \sum_{i=N1}^{N9} GRM24I_i$$

$$SGR24E = \sum_{i=N1}^{N9} GRM24E_i$$

$$SGR24S = \sum_{i=N1}^{N9} GRM24S_i$$

$$SGR24T = SGR24I + SGR24E + SGR24S$$

SGRM(I), SGRM(E), SGRM(S), SGRM(TOT)

Definition

The summation of total grams (GRM) for specified cases (N1-N9) of three metal types and total grams of the three metal types. Includes tritium equivalent grams (TEGR).

Unit

Grams per calendar day.

Origin

Calculated:

$$SGRMI = \sum_{i=N1}^{N9} GRMI_i$$

$$SGRME = \sum_{i=N1}^{N9} GRME_i$$

$$SGRMS = \sum_{i=N1}^{N9} GRMS_i$$

$$SGRMT = SGRMI + SGRME + SGRMS$$

SRGR(I), SRGR(E), SRGR(S), SRGR(TOT)

DECLASSIFIED

Definition

The summation of real grams (RGR) for specified cases (N1-N9) of three metal types and total real grams of the three metal types. Does not include tritium equivalent grams (TEGR).

Unit

Grams per calendar day.

Origin

Calculated:

$$SRGRI = \sum_{i=N1}^{N9} RGRI_i$$

$$SRGRE = \sum_{i=N1}^{N9} RGRE_i$$

$$SRGRS = \sum_{i=N1}^{N9} RGRS_i$$

$$SRGRT = SRGRI + SRGRE + SRGRS$$

STEGR(I), STEGR(E), STEGR(S), STEGR(TOT)

Definition

The summation of tritium equivalent grams (TEGR) for specified cases (N1-N9) of three metal types and total tritium equivalent grams of the three metal types.

Unit

Grams per calendar day.

Origin

Calculated:

DECLASSIFIED

$$STEGRI = \sum_{i=N1}^{N9} TEGRI_i$$

$$STEGRE = \sum_{i=N1}^{N9} TEGRE_i$$

$$STEGRS = \sum_{i=N1}^{N9} TEGRS_i$$

$$STEGRT = STEGRI + STEGRE + STEGRS$$

STP(I), STP(E), STP(S), STP(TOT)

Definition

The summation of the metal throughput for specified cases (N1-N9) of three metal types and total throughput of the three metal types.

Unit

Tons per calendar day.

Origin

Calculated:

$$STPI = \sum_{i=N1}^{N9} TPI_i$$

$$STPE = \sum_{i=N1}^{N9} TPE_i$$

$$STPS = \sum_{i=N1}^{N9} TPS_i$$

$$STPT = STPI + STPE + STPS$$

STPC(I), STPC(E), STPC(S), STPC(TOT)

Definition

The summation of the metal throughput cost for specified cases (N1-N9) of

three metal types and total throughput cost of the three metal types.

Unit

Dollars per calendar day.

Origin

Calculated:

$$STPCI = \sum_{i=N1}^{N9} TPCI_i$$

$$STPCE = \sum_{i=N1}^{N9} TPCE_i$$

$$STPCS = \sum_{i=N1}^{N9} TPCS_i$$

$$STPCT = STPCI + STPCE + STPCS$$

TB

Definition

The bulk temperature cut-off limit. By setting $I = 2$, $L7 = 3$, the power (P) will not exceed the TB limit.

Unit

Degrees centigrade.

Origin

Input data.

TBC

Definition

The bulk temperature cut-off limit (TB) dollars required to assure the power (P) will not exceed the TB limit. Normally, this value is \$10,000.

DECLASSIFIED

Unit

Dollars

Origin

Input data.

DECLASSIFIED

TEGR(I), TEGR(E), TEGR(S), TEGR(TOT)

Definition

The production of tritium equivalent grams (E-N, N load) of three metal types and the total tritium equivalent grams of the three metal types.

Unit

Grams per calendar day.

Origin

Calculated:

$$\text{TEGRI} = \text{DTI (FMWDI)}$$

$$\text{TEGRE} = \text{DTE (FMWDE)}$$

$$\text{TEGRS} = \text{DTS (FMWDS)}$$

$$\text{TEGRT} = \text{TEGRI} + \text{TEGRE} + \text{TEGRS}$$

TFI, TFE, TFS

Definition

The rupture model power distribution factor of the three metal groups.

Normally, this value is 1.0.

Unit

None

Origin

Input data.

TIN

Definition

The process water bulk inlet temperature.

Unit

Degrees centigrade.

Origin

Input data.

DECLASSIFIED

TP(I), TP(E), TP(S), TP(TOT)

The metal throughput of the three metal types and the total metal throughput of the three metal types.

Unit

Tons per calendar day.

Calculated:

$$TPI = \frac{PMWDI}{EMI}$$

$$TPE = \frac{PMWDE}{EME}$$

$$TPS = \frac{PMWDS}{EMS}$$

$$TPT = TPI + TPE + TPS$$

TPC(I), TPC(E), TPC(S), TPC(TOT)

Definition

The throughput cost of the three metal types and the total throughput cost of the three metal types.

Unit

Dollars per calendar day.

Origin

Calculated:

$$TPCI = TPI (EMCI)$$

$$TPCE = TPE (EMCE)$$

$$TPCS = TPS (EMCS)$$

$$TPCT = TPCI + TPCE + TPCS$$

DECLASSIFIED

TRL

Definition

The tube replacement loss for power dependent tube corrosion.

Unit

Days per calendar day.

Origin

Calculated:

$$TRL = \frac{CK(CK1)(AT)(2)}{DM(DMR)(DTR)} \left[\frac{TIN + 1000.(PN)(RK)}{12} \right] \frac{.2635 (FR)}{(PE)}$$

TTI, TTE, TTS

Definition

The numbers of tubes whose bare slug weight totals one ton of the three metal types.

Unit

Tubes per ton.

Origin

Input data.

DECLASSIFIED

UCNR

Definition

Unit cost net return.

Unit

Dollars per gram.

Origin

Calculated:

$$\text{UCNR} = \frac{\text{FS} + \text{BOCT} + \text{TFCT}}{\text{GRMT}}$$

XEI, XEE, XES

Definition

The rupture model exposure exponents of the three metal types.

Unit

None

Origin

Input data.

XPI, XPE, XPS

Definition

The rupture model power exponents of the three metal types.

Unit

None

Origin

Input data.

XTI, XTE, XTS

Definition

The rupture model tube outlet temperature exponents of the three metal types.

Unit

None

Origin

Input data.

ZSELL

Definition

Net return plus fixed costs for plutonium worth \$50 per gram.

Unit

Dollars per calendar day.

Origin

Calculated:

$$ZSELL = [RGRT (50.)] - BOCT-TPCT$$

Z

Definition

Net return plus fixed cost.

Unit

Dollars per calendar day.

Origin

Calculated:

$$Z = (P)(EN)(PE) \left\{ \begin{aligned} &EYE \left[(PU-BI)(CONVRI) - \frac{EMCI}{EMI} \right] \\ &+ E \left[(PU-BE)(CONVRE) - \frac{EMCE}{EME} \right] \\ &+ S \left[(PU-BS)(CONVRS) - \frac{EMCS}{EMS} \right] \end{aligned} \right\}$$

DECLASSIFIED

DATE

FILMED

7/27/94

END