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THE OAK RIDGE SYSTEMS ANALYSIS CODE (ORSAC) INPUT INSTRUCTIONS

H. F. Bauman

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REACTOR DIVISION

THE OAK RIDGE SYSTEMS ANALYSIS CODE (ORSAC) INPUT INSTRUCTIONS

H. F. Bauman

APRIL 1974

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
operated by
UNION CARBIDE CORPORATION
for the
U. S. ATOMIC ENERGY COMMISSION

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THE OAK RIDGE SYSTEMS ANALYSIS CODE (ORSAC)
INPUT INSTRUCTIONS

H. F. Bauman

ABSTRACT

The input instructions for the ORSAC code were originally published in the "User's Manual"[1] in 1971. Since that time, to meet the changing needs of specific studies, a number of modifications have been made in the code, particularly to improve the convenience and versatility of the input and output. These changes have been incorporated into the "Input Instructions" which are the subject of this report, and which are intended to supplant the instructions in the User's Manual. In most other respects, the information in the User's Manual is still valid, and this report may be used as a supplement to the Manual.

1. INTRODUCTION

The main steps in preparing a problem to run on ORSAC are as follows:

1. Prepare the reactor mass balances in ORSAC format.
2. Place the mass balance data on a storage device, such as a tape or, preferrably, a disk.
3. Provide storage for the programs "MPSOUT" and "SYSCO", and for the various input-output files. It is convenient to use a single private disk for the storage required in steps 2 and 3. (The LP program is currently stored at ORNL on the system disk ZZZZZZ.)
4. Enter or update the basic data for the problem in the BLOCK DATA sections of the program.
5. Prepare the SYSCO input deck.
6. Prepare the LP input deck (which now includes MPSOUT, formerly a separate job).
7. Iterate between SYSCO and LP until a converged solution is obtained.

Since there is more to running a problem than just preparing the input decks, we have included information that our experience indicated may be helpful to the user covering all of the above steps.

The mass balances may be conveniently prepared by the ORSAM code.[2] A set of mass balances may be stored on tape, and transferred to disk when ready to be used. The tape then provides a backup in case the information on disk should be lost. The handling of information on the disk is discussed in Section 5, Job Setup.

The preparation of the BLOCK DATA is covered in Section 4, and the input instructions for SYSCO and LP follow immediately in Sections 2 and 3.

2. SYSCO INPUT DESCRIPTION

Data Section 1. Cards 1 to 16, read into MAIN program.

Card 1A. General Information (Integer) [I5,25(I3)]

Cols	Name	Definition	Value Used
1-5	KASE	Users case number.	101
6-8	ITER	Iteration number.	From 0 up as appropriate
9-11	MOP(1)	Number of periods in operating horizon. (Max. 35.)	35
12-14	MOP(2)	Number of years per period. Can be 1 or 2.	2
15-17	MOP(3)	Number of pre-operation periods in reactor cost history.	1
18-20	MOP(4)	Number of post-operation periods in reactor cost history.	1
21-23	MOP(5)	Number of periods in reactor operating life.	15
24-26	MOP(6)	Initial year of operating horizon (input as calendar year minus 1900).	70
27-29	MOP(7)	Number of look-ahead years in power plant selection.	70
30-32	MOP(8)	Number of look-ahead years in selection of fuel cycle plants.	4
33-35	MOP(9)	Number of reactor types in library. (Max. 48.)	48
36-38	MOP(10)	Number of types of fuel cycle plants.	60
39-41	MOP(11)	Bond repayment option (POWERCO).	1

Cols	Name	Definition	Value Used
		1 = proportional case.	
		2 = uniform principal reduction.	
		3 = uniform annual payment.	
		4 = per input schedule.	
		5 = delayed uniform principal reduction.	
42-44	MOP(12)	Depreciation option (POWERCO).	
		1 = straight line.	2
		2 = sum-of-years-digits.	
45-47	MOP(13)	Delayed bond repayment option (POWERCO).	0
		The number entered here indicates the year in which bond repayment is to start.	
48-50	MOP(14)	Fixed charge rate breakdown option (POWERCO).	0
		0 = omit breakdown.	
		1 = include breakdown.	
		2 = include both breakdown and detailed printout.	
51-53	MOP(15)	Power cost breakdown option (POWERCO).	0
		0 = omit power cost breakdown.	
		1 = include power cost breakdown.	
54-56	MOP(16)	If > 0, omit POWERCO output by plant.	0
57-59	MOP(17)	Operating life of fuel cycle plant, years.	15
60-62	MOP(18)	Number of fossil fuel cost categories. (Max. 13.)	13
63-65	MOP(19)	Number of power plant cost data change cards (cards 11).	0
66-68	MOP(20)	If > 0, optimize tails assay.	1
69-71	MOP(21)	If > 0, do not call MATRIX.	0
72-74	MOP(22)	If > 0, omit output when fuel cycle history is restored.	
75-77	MOP(23)	If > 0, restrict FUELCO output.	1
78-80	MOP(24)	If > 0, restrict POWERCO output.	1

Card 1B. General Information (Integer) [I5,25(I3)]

1-5	MOP(25)	Not used.

Cols	Name	Definition	Value Used
6-8	MOP(26)	Logical input init for EXTEND.	50
9-11	MOP(27)	Logical output unit for EXTEND.	51
12-14	MOP(28)	Logical unit for EXTEND "full-power time" mass balances.	10
15-17	MOP(29)	If > 0, omit shadow price output for fossil plants.	1
18-20	MOP(30)	0 = FUELCO loads the oldest plants first. 1 = FUELCO loads all plants in proportion to their capacity.	0
21-23	MOP(31)	If > 0, omit fuel charge— discharge output.	1
24-26	MOP(32)	If > 0, revise capacity demand data.	0
27-29	MOP(33)	If > 0, print net materials consumption for each period and reactor.	0
30-32	MOP(34)	0 = Fossil fuel costs are adjusted 1 time by OPT(32). 1 = Fossil fuel costs are adjusted each year by OPT(32).	
33-35	MOP(35)	Not used.	
36-38	MOP(36)	Not used.	
39-41	MOP(37)	Number of segments in load factor curves. Limit 6.	5
42-44	MOP(38)	If > 0, POWERCO output is suppressed after the first table for each reactor.	1
45-47	MOP(39)	If > 0, activate HTGR market capture constraints (See card 24.)	0
48-50	MOP(40)	If > 0, use the condensed matrix. Use 1 for nuclear plants not region dependent.	1
51-53	MOP(41)	U_3O_8 price options may be set as follows:	

MOP(41)	OPT(30)	U_3O_8 Price and Amount: In SYSCO	U_3O_8 Price and Amount: In LP
1	> 0.	= OPT(30) ∞ limit	= input table normal limit (formerly ∞ limit)
0	> 0.	= OPT(30) ∞ limit	
0	0.	= input table normal limit	

Option 1 may be used for the initial iteration. Enter OPT(30) on Card 2C.

Cols	Name	Definition	Value Used
54-56	MOP(42)	If > 0, omit recall and printout of reactor histories in subroutine STORE.	1
57-59	MOP(43)	If > 0, omit output from AUX.	1
60-62	MOP(44)	The number of period with which tails optimization is to start (start two years before horizon).	1
63-65	MOP(45)	If > 0, make revise LP input tape. = 0 make complete LP input tape.	0
66-68	MOP(46)	If > 0, read in diffusion plant tails assay for each period (cards 8). = 0, code will calculate optimum tails assay.	0
69-71	MOP(47)	If > 0, omit POWERCO output for fossil plants.	1
72-74	MOP(48)	If > 0, output detailed ^{233}U material balance.	0
75-77	MOP(49)	If > 0, output ^{233}U material balance summary table.	1
78-80	MOP(50)	If > 0, output GDP, materials, and ^{233}U balance tables every pass thru tails calculation. = 0 last pass only.	0

Card 2A. Decimal Information (10F8.4)

1-8	OPT(1)	Discount rate.	0.10
	POWERCO REACTOR COST DATA		
9-16	OPT(2)	Fraction of investment in bonds.	0.52
17-24	OPT(3)	Interest rate on bonds.	0.08
25-32	OPT(4)	Rate of return on equity.	0.12
33-40	OPT(5)	Federal income tax rate.	0.50
41-48	OPT(6)	State income tax rate.	0.03
49-56	OPT(7)	State gross revenues tax rate.	0.04
57-64	OPT(8)	Local property tax rate.	0.032
65-72	OPT(9)	Annual interim replacements factor.	0.0035
73-80	OPT(10)	Annual property insurance factor	0.0025

Card 2B. Decimal Information (Cont.) (10F8.4)

1-8	OPT(11)	Fraction of core for tax assessment.	0.0

Cols	Name	Definition	Value Used
9-16	OPT(12)	Property tax rate on nonfuel working capital.	0.0
	FUELCO FUEL CYCLE PLANT COST DATA		
17-24	OPT(13)	Fraction of investment in bonds.	.30
25-32	OPT(14)	Interest rate on bonds.	.07
33-39	OPT(15)	Rate of return on equity.	.16
40-48	OPT(16)	Federal income tax rate.	.50
49-56	OPT(17)	State gross revenue tax rate.	.00
57-64	OPT(18)	State income tax rate.	.03
65-72	OPT(19)	Local property tax rate.	.032
72-80	OPT(20)	Interim replacement factor.	.0035

Card 2C. Decimal Information (10F8.4)

1-8	OPT(21)	Property insurance factor.	0.0025
	GENERAL DATA		
9-16	OPT(22)	Not used.	
17-24	OPT(23)	Not used.	
25-32	OPT(24)	Not used.	
33-40	OPT(25)	Not used.	
41-48	OPT(26)	Not used.	
49-56	OPT(27)	Not used.	
57-64	OPT(28)	Store depleted U if U-235 weight fraction is less than OPT(28).	0.0035
65-72	OPT(29)	Relative value of U-235 to U-233 in mixtures.	0.8571
73-80	OPT(30)	Maintain this constant U_3O_8 price in $/lb. (If zero, the schedule of costs, card 3, vs cumulative use from block data 5 is used. See table of U_3O_8 price options under MOP(41), card 1B.)	

Card 2D. Decimal Information (10F8.4)

1-8	OPT(31)	Gaseous diffusion plant tails assay, weight fraction.	0.0025
9-16	OPT(32)	Factor by which fossil fuel cost is adjusted.	1.0

Cols	Name	Definition	Value Used
17-24	OPT(33)	Factor by which AAA(K) and AAC(K) are adjusted in the calculation of fuel cycle plant capital cost.	1.0
25-32	OPT(34)	Factor by which AAD(K) and AAG(K) are adjusted in calculation of fuel cycle plant operating cost.	1.0
33-40	OPT(35)	Factor by which AAH(K) and AAK(K) are adjusted in calculation of fuel cycle hardware cost.	1.0
41-48	OPT(36)	Factor by which the minimum cost AAL(K) is adjusted.	1.0
49-56	OPT(37)	Escalation factor for FUELCO capital constants B(10) to B(23).	1.3
65-72	OPT(39)	Escalation factor for waste costs.	1.3
73-80	OPT(40)	Escaltion factor for shipping costs in SYSCO	1.3

Cards 3. U_3O_8 Price Schedule (7E10.0)

UPRICE(K), K = 1,11.

Enter the U_3O_8 price, dollars/kg, for each of the 11 availability groups defined in block data 5. Requires 2 cards.

Cards 4. Year of Availability. [12(I4,1X)]

KFIRST(K), K = 1,48

Specify first year of availability for each of up to 48 plants, in order as entered in block data 3. Requires 4 cards.

Card 5. Power Plant Type Names [6(2A4,2X)]

PN(I), I = 1,12.

Enter a name (up to 8 characters) for each power plant type (limit 6) for which capital cost data will be provided on card 7. These names are used only as headings for the data printout.

Card 6. Power Plant Type Numbers (48I1)

K38(K), K = 1,48

Enter an interger from 1 to 6, to identify the power plant type for assignment of capital costs, for each of up to 48 plants, in order as in block data 3.

Card 7. Capital Cost (6F10.3)

CAPI(M,N)

Enter the capital cost, $/kW, for each power plant type, in order of type number. One card per period, up to 6 entries, one for each type, per card. Requires MOP(1) number of cards.

Cards 8. Tails Assay (7F10.7)

Omit when MOP(46) = 0.

XW(L)

Enter the tails assay by period, including 1 period before and 1 period after the horizons. Use up to 6 cards (37 entries).

Cards 9 and 10. Load Factor Data

Load factor data are input for two categories of plants, "high" load factor and "low" load factor. Each load factor curve is represented by up to six line-segments, by specifying the time and load factor at the beginning and end of each segment.

Cards 9. Load Factor Data, High (4E10.0)

Cols.	Name	Definition
1-10	G1(N,KH)	Load factor at start of segment.
11-20	G2(N,KH)	Load factor at end of segment.
21-30	T1(N,KH)	Time at start of segment, years.
31-40	T2(N,KH)	Time at end of segment, years.

Use one card per segment of load factor curve, number of cards = MOP(37).

Cards 10. Load Factor Data, Low (4E10.0)

Same format as Cards 9.

Where one of the load factor curves requires fewer than MOP(37) segments, use blank cards for the remaining segments.

Cards 11. Adjustment of Operating Cost (2I5,3F10.6)

One card for each reactor for which changes are to be made. The number of such cards must be equal to MOP(19). Omit when MOP(19) = 0.

Cols.	Name	Definition
1-5	J	The number of the reactor from the table "Properties of Reactors and Fossil Fuel Plants".
6-10	ICCNY(J)	The year after which the annual operating cost decline is to begin.
11-20	OPCA(J)	Factor by which the operating cost of reactor J is to be adjusted. This factor is applied to the value listed in the table "Properties of Reactors and Fossil Fuel Plants".
21-30	OPCB(J)	The annual operating cost decline factor.
31-40	FUECYL(J)	If nonzero, the fuel cycle cost is to be held constant at this value (mills/kWhr).

Cards 12 to 16. Prices (10F8.0)

The various price schedules by period are entered on these cards, all in the same format. The program will fill blank or zero entries (except the first) with the last non-zero entry from a preceeding period. If a price is the same for all periods, an entry is required only for period 1. For 35 periods, 4 cards are required for each price schedule. When all entries are zero, use 4 blank cards.

Cards 12. CM(N,1) Thorium Price, $/Kg

Cards 13. CM(N,2) Tails Price, $/Kg

Cards 14. CM(N,4) Separative Duty Price, $/Kg

Cards 15. CM(N,5) Fissile Plutonium Price, $/Kg

Cards 16. CM(N,6) Uranium 233 Price, $/Kg

Data Section 2. Cards 17 to 30, read into MATRIX subroutine.

Card 17. Output Instruction to MATRIX (3I5)

Cols.	Name	Definition	Value Used
1-5	LUNITS(1)	= 0 no LP input file is made.* > 0 The logical number of the LP input file which is being prepared.	1
6-10	LUNITS(2)	= 0 The LP data are not written out. > 0 The logical number of the unit upon which the LP data are to be output.	0
11-15	LUNITS(3)	= 0 No additional outputs are used. > 0 The logical number of an additional output device.	0

Card 18. LP Name (A8,2X,A8)

1-8	DATNAM**	The name by which the input data for the LP are to be called. These data must be called by the same name in the LP.	GGA 01.
11-18	RHSNAM	The name to be assigned to the vector consisting of the right hand side of the constraint equations.	RHSIDE

Card 19. Demand Options (A1)

1	DEMCON	E = The electrical capacity is equal to the demand. G = The electrical capacity is equal to or greater than the demand.	E

Cards 20. Demand Data (10F7.3)

DMD(M,I,N)

The incremental demand is given in gigawatts in the following form: For the high plant factor type and the first time period, the demand for each cost region is given. Then for the low plant factor type and the first period, the demand for each cost region is given. This format is then repeated for each succeeding time

---

*Note: When no LP input is made, JCL cards for LP input may be left in the deck. However, JCL error scan does not permit DISP = NEW for an existing file, even if it will not be used. But apparently DISP = SHR is permitted for files not yet made.

**Note: If an AUXINP file is being used from a previous LP solution (ITER ≠ 0 on Card 1), then this DATNAM must be identical with the XPBNAME used in the LP run which created the AUXINP. See Note B in Section 3, "The LP Program".

Cards 20. Demand Data (10F7.3) (Continued)

period. The number of time periods must be consistent with MOP(1), and the number of cost regions must be consistent with both MOP(18) and the region versus cost data (FOSCST) which is input in BLOCK DATA3. The total number of entries is equal to the number of plant factor categories times the number of cost regions times the number of time periods. For 2 plant factor categories, 13 cost regions, and 35 time periods, since 13 cost regions require 2 cards, the number of cards required is 2 × 2 × 35 = 140 cards.

Card 21. Fixed LWR Build Schedule (2I5)

Cols.	Name	Definition
1-5	LWR3	Calendar year of start of last fixed period. Up to 10 fixed periods permitted.

Cards 22. LWR Build Schedule, High Load Factor (7E10.0)

FX70(N,1)

Enter the capacity, gigawatts, of high load factor LWR's built in each period, for periods indicated on Card 21.

Cards 23. LWR Build Schedule, Low Load Factor (7E10.0)

FX70(N,2)

Same as Cards 22, for low load factor LWR's.

Card 24. Fraction of Market Permitted to HTGR's. (3I5,5X,2F10.4)

If MOP(39) is zero, this card is ignored.

1-5	NHTGR6	Year beginning first restricted interval.
6-10	NHTGR7	Year beginning last period in first restricted interval. Second restricted interval starts immediately in the following period.
11-15	NHTGR8	Year beginning last period in second restricted interval.
21-30	V33	Fraction of market permitted in first interval.
31-40	V67	Fraction of market permitted in second interval.

Card 25. Growth Rate Restraints (I5)

Cols.	Name	Definition	Value Used
1-5	NREGRP	The number of reactor construction rate constraint groups which are to be defined.	7

Cards 26. Growth Rate Restraints (A3,2I5,F12.5)

Omit if NREGRP is zero.

Specify reactor construction rate restraints in accordance with the group assignments made in the table, "Properties of Reactors and Fossil Fuel Plants". The number of such cards must be equal to NREGRP.

1-3	VVV(I)	Name of limit growth rate group.	HTG
4-8	ICONYR(I)	First year of the period in which the introduction restraint begins.	1978
9-13	NPDS(I)	The number of periods in which the introduction restraint is to apply.	7
14-25	RHSLIM(I)	RHSLIM(I) is the restraint on the number of reactors which may be built during the first restraint period. The limit for succeeding periods is found by successively doubling the previous restraint.	2.0

Card 27. Number of Fissile Materials (I5)

1-5	NFISML	Number of fissile materials to be balanced by period. Limits 1 to 20.	5

Cards 28. Name of Fissile Material (A4,F12.5)

Number of cards equals NFISML.

1-4	ZZZZ(I)	Name of a material to be balanced by period.	U308
5-16	CJZZZZ(I)	Cost of transferring fissile material from the beginning of one period to the beginning of the next.	0

Cards 29. Cost of New Enrichment Capacity (2F12.5)

These values are used when the limits on available capacity (card 30) are exceeded.

Cols.	Name	Definition	Value Used
1-12	GDCAPL	Cost of adding one metric ton of separative duty capacity (millions of dollars).	200.
13-24	ADCOST	Cost of separative duty in newly added plants (millions of dollars per metric ton).	.026

Cards 30. Separative Duty Limits (6F12.4)

1-12	ESDCPY(1)	Upper limit on the separative duty capability, tons per per period.	9999999.

Time for separative duty calculations starts two years before the start of the power horizon. Therefore, if two-year periods are used, the first entry is for the pre-operational period and the number of entries required is the number of periods within the horizon plus 1. If one-year periods are used the first entry is for the year -2 and the number of entries is equal to the number of periods within the horizon plus 2. This format is continued on as many cards as are necessary to make the required number of entries. For the present case, consisting of 35 periods of two years, a total of 36 entries (6 cards) is required. The actual values used are very large, since no limits on separative duty capability are assumed in this problem.

Data Section 3. Cards 31 to 35, read into EXTEND subroutine.

This section controls the input of mass balance data, which is currently stored on disk. Where the instructions refer to "tape," they apply also to disk.

Cards 31. Control Mass Balance Input (A4,I2,E6.0)

1-4	YYYY	Alphabetic portion of a reactor name if data is to be read from cards; blank if data is to be read from tape.	Blank
5-6	JJ	Numeric portion of a reactor name if data is to read from cards; a nonzero integer if data is read from tape.	01
7-12	PROC	Efficiency applied to chemical processing of recycle material.	Blank

Card 32. Mass Balance Input (14I3)

Cols.	Name	Definition	Value Used
1-3	ITYPE	Describes the location and type of data input according to the following definitions: .LE.0 - Data will be read from cards. .EQ.0 - Data will be in form of start, end and discharge masses for each cycle. .LT.0 - Data will be in form of fresh feed, recycle feed, discharge masses, and will require an equilibrium reactor concentration. .GT.0 - Data will be read from tape. .EQ.1 - Data will be read from tape in form of start, end and discharge masses for each cycle. .EQ.2 - Data will be read from tape in normal ORSAC format. Remaining fields are ignored.	2
4-6	NCYC	Number of cycles of data provided.	
7-9	NRPET	Number of cycles repeated in the equilibrium cycle.	
10-12	NRCYC	Number of cycles lag for recycle feed.	
13-15	IREG	Number of different types of fueled regions. Data must be supplied in order for core, axial blanket, and radial blanket.	

Card 33. Number of Reactors (I3)

1-3	IREACT	Number of reactors for which mass balances are to be read from tape.	4

Cards 34. Reactor Types 7(A4,I2,4X)

1-4	YYYY	A four-digit alphanumeric reactor name	PW01
5-6	JJ	The number assigned to the reactor in the table of reactor data. 14 < JJ < 48. Must be same number as position in block data. Need not be the same as on mass balance file.	14
7-10		Blank.	

This format is repeated on this and following cards until the number of reactor names specified is equal to IREACT.

Card 35. End Mass Balance Data.

Blank

Data Section 4. Cards 36 and 37, read into SYSTEM subroutine. Required only for iteration zero. Otherwise ignored (may be omitted).

Cards 36 and 37. Build Schedule

One complete set consisting of a power plant name (Card 36 and four demand cards (Cards 37) must be input for each power plant type and load factor type to be considered.

Card 36. Plant Name (2A4,I2)

Name of power plant type for which the estimated build schedule follows. The first card 36 is illustrated below.

Cols.	Name	Definition	Value Used
1-4	YYYY	Four-digit alphanumeric name identifying the following build schedule.	FFIR
5-8	LDFT	L in Col. 5 = low load factor type. H in Col. 5 = high load factor type.	H
9-10	NEXT	0 = one or more estimated build schedules are to follow. 1 = end of estimated build schedules.	0

Cards 37. Estimated Build Schedules (10F8.3/10F8.3/10F8.3/5F8.3)

BUILD(J,I)

For each type of power plant which is to be included in the study, an estimated build schedule is to be entered on these cards. The estimated build schedule is to be entered in electrical gigawatts (1 gigawatts = 10^9 watts) for each period of the horizon. A ground rule established for the systems analysis work was the so-called "full penetration model." In this model, the initial set of cost coefficients is based on the assumption that each power plant type captures the entire expansion of the power industry. The calculated optimum build schedule is used to determine cost coefficients for the next iteration. The fossil plant power costs are not demand dependent so that zero values may be input.

Any order

End the build schedules with a Card 36 having only a 1 in Col. 10. This ends the SYSCO input.

3. LP INPUT

The LP program and its associated output subprogram MPSOUT, formerly run as separate jobs, have been combined into a single job. The functions of the various input cards, as described by Welfare,[1] have not changed, and these descriptions need not be repeated here. Instead, a list of the current LP program is given in Table 1, along with explanatory notes that may be helpful to the user.

4. BLOCK DATA

A large amount of data is input to SYSCO in the form of data blocks. These data range from inflexible constants to data that must be changed for every problem, if not for every case. This section is intended as a guide as to what data is entered in which of the various data blocks. The comments in each block data subroutine identify the individual data arrays. The data blocks are described as follows:

BCDNOS

FLC

These data are constants which are normally not changed.

BDA

The B array, FUELCO permanent constants, is normally not changed. The remaining data include the sequence of processing plant sizes and related data. This data appears in the output table starting with "Maximum Size Sequences for Fuel Cycle Plants."

BD1

The constants in the FUELCO process cost equations. Refer to output table "Fuel Cycle Process Data."

BD2

These data include the process holdup times and MATFLO decision indices, and appear in output table "Reactor Fuel Cycle Decision Indices Chain 1/Chain 2."

BD3, 4, and 5 are in the same subroutine.

Table 1. The LP Program

```
          PROGRAM('ND')
          INITIALZ
          MOVE(XTOLERR,NEWTOL)
          MOVE(XFREQINV,NEWFREQ)
          MOVE(XTOLDJ,DJTOLR)
          MVADR(XDODELTM,PASTIML)
          MOVE(XDELTM,TWENTY9)                                          (A)
          MOVE(XLASTIM,ZERO)
          MOVE(XOBJ,'PWCOST')
          MOVE(XRHS,'RHSIDE')
          MOVE(XPBNAME,'GGA 15.')                                       (B)
          MOVE(XDATA,'GGA 15.')                                         (C)
          ASSIGN('FORTFILE','FT10F001','COMM')
          PREPOUT('FORTFILE')
          MOVE(PBNAME,XPBNAME)
          ICHECK=-1
          FREECORE
          MPSCUT01(LUNIT,PBNAME,LOUT,ISOL,IROW,ICOL,ICHECK)
          CONVERT('SUMMARY')
          SETUP('BOUND','UPBOUNDS')
          MOVE(XDATA,'GGA 15.')                                         (D)
          INSERT('FILE','INSTFILE')                                     (D)
          MOVE(XDATA,'GGA 15.')                                         (E)
          PRIMAL
          SAVE('NAME','OPTBASIS')
          PUNCH                                                         (F)
          SOLUTION('FILE','FORTFILE','RSECTION','2/3/4D/5D/6D/7D/8D/1S/'X
                  ,'CSECTION','2/3/4D/5D/6D/7D/8D/1S/')                 (G)
          ICHECK=0
          FREECORE
          MPSOUT01(LUNIT,PBNAME,LOUT,ISOL,IROW,ICOL,ICHECK)
          GOTO (FINISH)
PASTIME   SAVE('NAME','TMPBASIS')
          MOVE(XDELTM,FOUR)                                             (H)
          CONTINUE
FINISH    EXIT
NEWTOL    DC(1.0E-05)                                                   (I)
NEWFREQ   DC(35)
DJTOLR    DC(1.0E-07)                                                   (I)
LUNIT     DC(10)
PBNAME    DC('PROBNAME')
LOUT      DC(20)
ISOL      DC(1)                                                         (J)
IROW      DC(0)                                                         (J)
ICOL      DC(0)                                                         (J)
ICHECK    DC(1)
ZERO      DC(0)
ONE       DC(1)
TWO       DC(2)
THREE     DC(3)
FOUR      DC(4)
FIVE      DC(5)
NINE      DC(9)
FIFTEEN   DC(15)
TWENTY9   DC(29)
FIFTY9    DC(59)
EIGHTY9   DC(89)
ONE19     DC(119)
ONE49     DC(149)
          PEND
/*
```

Table 1. Notes:

A. The number TWENTY9 assigned here is the running time in minutes after which the PASTIME section is called. If the program has not found the optimum in the assigned time, it will begin saving the incomplete solution, at intervals, as TMPBASIS, for use in restarting a continuation of the run.
The "program time" is not the same as "CPU" time on the 360/91, and 20 minutes CPU time is ample to complete a run for which 29 is assigned as the running time.

B. The XPBNAME is the name assigned to this LP program. This name will be assigned to the AUXINP file created by the MPSOUT step. The following SYSCO run, which will use this AUXINP, must use a DATNAM which is identical to this XPBNAME.

C. This XDATA name must be the same as the LP name given as DATNAM in the SYSCO input, Card 18.

D. Supply the name assigned to the data (see Note E) in the case in which the INSERT to be used was made. When available, an insert made in the previous iteration of the current run should be used. For the first iteration, an insert made in a similar previous case should be used. The program will ignore such parts of the insert as do not apply to the current case. If no insert is available, substitute a card with the command CRASH for the two cards labeled (D).

E. This entry assigns a name to the data set which will be written on the punch file for INSERT. This XDATA name does not have to agree with any name assigned previously. However, the next LP iteration, which will use this INSERT, must use an XDATA (see Note D) which agrees with this XDATA name.

F. The PUNCH command is used for the purpose of recording a new insert. In current practice, the record is made on disk and no cards are punched.

G. The SOLUTION command is used to obtain a printout of the BASIS. Some selectivity in the printout is available via the MPSOUT01 parameters. See Note J.

Table 1. Notes (Continued)

H. The interval, in minutes, after which the saved incomplete solution is updated. Refer to Note A.

I. Tighter tolerances (by a factor of 3) have been tried with no difference in the solution.

J. These are output options. For example, when DC(1) is specified for IROW, the row output is obtained; DC(0) gives no row output. In general, the row and column output are not required, because the same data appear in the following SYSCO output.

BD3

Data for reactors and fossil plants. Power, efficiency, costs, etc. appear in output table "Properties of Reactors and Fossil Fuel Plants." Note that the first feasible year is entered in the SYSCO input data deck.

BD4

Process and reactor designations. Loss and reject-recycle rates. This information appears in the various fuel cycle tables.

BD5

Shipping costs, which appear in output table "Constants for Shipment of Fresh and Spent Fuel." Fossil fuel costs, and the U_3O_8 price/availability schedule; these appear in separate tables below the "Maximum Size Sequences."

CXXIN

Input data, not in block data format, for the SYSTE2 subroutine. Permits processing and related costs to be entered directly by period, overriding the cost calculation in FUELCO. Enter zero for AAL(K) in BD1 to bypass FUELCO.

These data appear in output table "Input CXXIN Unit Costs, $/Kg."

5. JOB SETUP

The job setup for ORSAC is unusually complicated because a number of data files are used to store information and transfer information between SYSCO and LP. In current practice, these files are stored on the same disk as the SYSCO program and the mass balance data. A sample job setup for each program is given with explanatory notes, in Tables 2 and 3. The checklists given in the Appendix may be useful in making the changes required in job setup from a previous case or iteration.

In general, a given run requires a number of iterations between SYSCO and LP. For files used to transfer information, such as LP.INPUT, if a new file is created each iteration, the storage space on the disk is rapidly used up. On the other hand, if the same file is updated each iteration, any of a number of common errors would obliterate the previous data so that the run would have to be restarted from the initial iteration. Our strategy has been to alternate files each iteration, so that only two files are created per run, and yet, in a given iteration, we do not write over the starting information for that iteration.

Normally, for each iteration, we submit two cases to run in sequence; the LP followed by the SYSCO. (To start a case, this would be preceded by SYSCO iteration zero). If the LP job fails, so that the AUXINP file is not updated, the SYSCO job may run on the old AUXINP file. To avoid this waste of machine time, we now always write a new AUXINP file each iteration, so that if the LP fails, the SYSCO will not have a valid AUXINP file and will promptly fail also. We generally use three AUXINP files, labeled, for example, A, B, and C. In a given iteration we might scratch file A from two iterations back, save file B from the previous iteration, and write the new file C for use by SYSCO.

The PROBFILE is used internally in the LP case. There is no need to save it unless the LP does not finish in the allotted time, when the PROBFILE is required to restart the LP. Generally, we use one PROBFILE for all cases and continually update it, saving space on the disk.

The INSERT file is used to feed a feasible solution to the LP as a starting point, saving vast amounts of computing time over a start from scratch. In general, the updated INSERT written in the previous iteration is used. For the first iteration, an INSERT from a previous case with a similar LP input matrix may be used. Usually any similar INSERT will work, because the LP will ignore reactor information that does not apply to the current case.

Table 2. Job Setup for LP

```
//HFB6D005 JOB (13064),'Y-12 9104-2 H BAUMAN',MSGLEVEL=(2,0),CLASS=D,
// TYPRUN=HOLD
/*ROUTE  PRINT LOCAL
/*ROUTE  PUNCH LOCAL
//JOBLIB  DD DSN=MPSOUT01,VOL=SER=BENNET,UNIT=2314,DISP=SHR                  (A)
//           DD DSNAME=A5.G3.P31177.C10193.DURFEE.MPS27,UNIT=2314,            (A)
//              DISP=(SHR,PASS),VOLUME=SER=ZZZZZZ                            (A)
//ERASE EXEC PGM=IEHPROGM,REGION=80K                                         (B)
//SYSPRINT DD SYSOUT=A                                                       (B)
//DDZ DD UNIT=2314,VOLUME=SER=BENNET,DISP=SHR                                (B)
//SYSIN DD *                                                                 (B)
 SCRATCH VOL=2314=BENNET,DSNAME=AUXINP15.B                                  (B)
/*                                                                           (B)
//ST1A     EXEC PGM=COMPILER,REGION=150K
//SCRATCH1  DD UNIT=SYSDA,SPACE=(TRK,(5,2))
//SCRATCH2  DD UNIT=SYSDA,SPACE=(TRK,(5,2))
//SCRATCH3  DD UNIT=SYSDA,SPACE=(TRK,(5,2))
//SCRATCH4  DD UNIT=SYSDA,SPACE=(TRK,(5,2))
//SYSMLCP   DD UNIT=SYSDA,DISP=(NEW,PASS),SPACE=(TRK,(5,2))
//SYSPRINT  DD SYSOUT=A,SPACE=(3458,(1000),RLSE)
//SYSABEND  DD SYSOUT=A,SPACE=(3458,(1000),RLSE)
//SYSIN     DD *
                    *
                    *
                    * LP PROGRAM DECK HERE.
                    *
                    *
//ST2A     EXEC PGM=EXECUTOR,COND=(0,NE,ST1A),REGION=1080K,TIME=20
//ETA1       DD UNIT=SYSDA,SPACE=(CYL,(23),,CONTIG),DISP=(NEW,DELETE)
//ETA2 DD UNIT=(SYSDA,SEP=ETA1),SPACE=(CYL,(23),,CONTIG)
//SCRATCH1  DD UNIT=SYSDA,SPACE=(CYL,(18),,CONTIG),DISP=(NEW,DELETE)
//SCRATCH2 DD UNIT=(SYSDA,SEP=SCRATCH1),SPACE=(CYL,(18),,CONTIG)
//PROBFILE DD DSN=PROBFILE.A01W,VOL=SER=BENNET,UNIT=2314,                    (C)
// DISP=SHR                                                                  (C)
//SYSMLCP   DD UNIT=SYSDA,DSNAME=*.ST1A.SYSMLCP,DISP=(OLD,DELETE)
//MATRIX1 DD UNIT=SYSDA,SPACE=(CYL,(20,1),,CONTIG),DISP=(NEW,DELETE)
//SYSPUNCH  DD DSN=INSERT.GGA015.A,UNIT=2314,VOL=SER=BENNET,                 (D)
// DISP=(NEW,KEEP),SPACE=(3200,(40,10),RLSE),                                (D)
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200)                                      (D)
//SYSPRINT DD SYSOUT=A,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=3458),          X
//              SPACE=(3458,(1000,100),RLSE)
//SYSABEND  DD SYSOUT=A
//SYSIN DD DSN=LP.INPUT.GGA015.A,VOL=SER=BENNET,UNIT=2314,DISP=SHR           (E)
//INSTFILL DD DSN=INSERT.GGA015.B,VOL=SER=BENNET,UNIT=2314,DISP=SHR          (F)
//FT10F001  DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,(500,100)),      X
//              DSNAME=&MPSCOMM
//FT20F001 DD DSN=AUXINP15.A,VOL=SER=BENNET,UNIT=2314,DISP=(NEW,KEEP),       (G)
// SPACE=(TRK,(19,1)),                                                       (G)
// DCB=(RECFM=VS,BLKSIZE=800)                                                (G)
//FT51F001 DD SYSOUT=A,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=3458),          X
//              SPACE=(3458,(2000,100),RLSE)
//FT52F001 DD SYSOUT=B,DCB=(RECFM=FB,LRECL=80,BLKSIZE=3520),            X
//              SPACE=(3520,(30,2),RLSE)
/*
//


TO CREATE A NEW PROBFILE, SUBSTITUTE THE FOLLOWING CARDS FOR DISP=SHR
// DISP=(NEW,KEEP),                                                          (C)
// SPACE=(CYL,(5,1),,CONTIG)                                                 (C)
```

Table 2 Notes:

A. The MPSOUT program, stored on disk ZZZZZZ.

B. The utility program ERASE, used to remove files from the disk. Any number of files can be erased, one SCRATCH card per file. The use of the ERASE program in the job setup is optional.

C. To create the PROBFILE, use the space parameters indicated at the end of the list.

D. SYSPUNCH is used, not to punch, but to save an INSERT file on the disk. When rewriting an existing file, the second card is:
// DISP=SHR

E. The LP.INPUT matrix written by SYSCO in the previous iteration.

F. An INSERT, saved from a previous LP, and used as the starting point for the LP optimization. Omit only for the first case in a new problem for which no compatible insert exists.

G. AUXINP transmits the results of the LP solution to the following SYSCO.

Table 3. Job Setup for SYSCO

```
//HFBZD005 JOB (13C64),'Y-12 9104-2 H BAUMAN',MSGLEVEL=(2,0),CLASS=D,
// TYPRUN=HOLD
/*ROUTE  PRINT LOCAL
/*ROUTE  PUNCH LOCAL
//STEP EXEC FORTPCLG,PARM.FORT='BCD,NLMAP,DECK',
// REGION.FORT=400K,
// PARM.LINK='LIST',
// PARM.GO='EU=-1,TIME=5',REGION.GO=898K
//FORT.SYSIN DD *                                                        (A)
/*
//LINK.HEX DD DSN=SYSCO.FFB.JUL3173,UNIT=2314,VOL=SER=BENNET,DISP=SHR    (B)
//LINK.SYSIN DD *                                                        (C)
  INCLUDE  HEX
/*
//GO.FT01F001 DD DSN=LP.INPUT.GGA015.B,VOL=SER=BENNET,UNIT=2314,         (D)
// DISP=(NEW,KEEP),SPACE=(3200,(800,40),RLSE),                           (D)
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200)                                  (D)
//GO.FT10F001 DD DSN=BAUMAN.MATBAL.C,UNIT=2314,VOL=SER=BENNET,DISP=SHR, (E)
// DCB=(RECFM=VBS,LRECL=388,BLKSIZE=3884)                                (E)
//FT20F001 DD DSN=AUXINP15.A,VOL=SER=BENNET,UNIT=2314,DISP=SHR          (F)
//GO.FT50F001 DD *
                    *
                    *
                    * SYSCO DATA DECK HERE.
                    *
                    *
/*
//LOOK EXEC LISTER                                                      (G)
//FT50F001 DD *                                                         (G)
  L35,BENNET                                                            (G)
/*                                                                      (G)
//
```

Table 3 Notes:

A. Insert FORTRAN decks here to revise block data as necessary.

B. The SYSCO program file.

C. Insert hex decks here to revise block data as necessary.

D. Writes the LP.INPUT matrix for the next LP iteration. Omit when option to write LP matrix is not exercised. When rewriting an existing file, the second card is: // DISP=SHR

E. The reactor mass balance file.

F. AUXINP transmits the results from the previous LP iteration. Not used in iteration zero, but the card may be left in.

G. A utility program to list the contents and available space on the disk. Use optional.

REFERENCES

1. F. G. Welfare, et al., *The Oak Ridge Systems Analysis Code (ORSAC) User's Manual*, ORNL-TM-3223 (June 1971).

2. H. F. Bauman, *The ORSAM-2 Code Input Instructions*, ORNL-CF-72-11-26 (November 1972).

APPENDIX

The following check lists have proven helpful in making the changes in the data decks from iteration to iteration and from case to case.

ORSAC Iteration Zero Check List

1. Update reactor mass balances on MATBAL file as necessary.
2. Compile any changes in the block data (or insert hexdecks).
3. Compile any changes in the CXXIN data (or insert hexdecks).
4. Set up the SYSCO data deck. The following data is usually changed from case to case:

Card	Col.	Description
1A	1-5	Case number
	8	Iteration. Enter 0.
1B	51-53	Set MOP(41) = 1 if constant U_3O_8 price is desired for iter 0. Reset for subsequent iterations.
2C	73-80	Set OPT(30) to initial U_3O_8 price as desired for MOP(41) option. Reset for subsequent iterations.
4		Enter first year of availability for each type of power plant.
18	1-8	Assign a "DATNAM" for the case.
33	1-3	Number of reactors
34		Reactor names
36-37		Build schedule for each reactor

5. Proceed to Iteration "n" check list.

ORSAC Iteration "n" Check List

Job Setup: Check DISP instructions on data file specifications. If an existing file is being used or updated, specify DISP = SHR. If a new file is being created, specify DISP = (NEW, KEEP) and provide space parameters.

SYSCO Problem:

1. Enter the correct file name for the AUXINP file created by the preceding LP run. DISP = SHR

   Example:

   //FT20F001 DD DSN=AUXINP38.A,VOL=SER=BENNET,UNIT=2314,DISP=SHR

2. Make sure that the DATNAM entered on data card 18 is identical with the XPBNAME assigned to the LP problem which created the AUXINP file.

   Example:

   GGA138. RHSIDE

3. Enter the correct Iteration Number on data card 1, column 8.
4. Use the utility program to "scratch" LP Input files that have no further use, or to clear the file that is to be created by this SYSCO problem. Normally, the same LP Input file is used for all iterations of a given problem. The file is "scratched" prior to each SYSCO run in order to insure that the LP problem will be using the newly-created SYSCO results.

   Example:

```
//ERASE EXEC PGM=IEHPROGM,REGION=80K
//SYSPRINT DD SYSOUT=A
//DDZ DD UNIT=2314,VOLUME=SER=BENNET,DISP=SHR
//SYSIN DD *
SCRATCH VOL=2314=BENNET,DSNAME=LP.INPUT.GGA038.A
/*
```

5. Check the file name assigned to receive the LP Input. DISP = (NEW, KEEP), since the old file was scratched.

   Example:

```
//GO.FT01F001 DD DSN=LP.INPUT.GGA038.A,VOL=SER=BENNET,UNIT=2314,
// DISP=(NEW,KEEP),SPACE=(3200,(800,40),RLSE),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200)
```

LP Problem:

1. Is the XPBNAME satisfactory?
2. Is the XDATA name for input data identical to the DATNAM used in the SYSCO problem which created the LP Input File?

   Example:

```
MOVE(XPBNAME,'GGA138.')
MOVE(XDATA,'GGA138.')
```

3. Is the XDATA name for insert data identical to the XDATA assigned to the "PUNCH" step in the LP problem which created the INSERT file?

   Example:

```
MOVE(XDATA,'GGA138.')
INSERT('FILE','INSTFILE')
```

4. Is the file name entered on the INSTFILE DD card correct? It should be identical to the file name entered on the SYSPUNCH DD card in the LP run which created the INSERT file.

   Example:

```
//INSTFILE DD DSN=INSERT.GGA038.A,VOL=SER=BENNET,UNIT=2314,DISP=SHR
```

5. "Scratch" the data file which is going to receive the AUXINP results from this LP run.
   "Scratch" the data file which is going to receive the INSERT data from the PUNCH step.

Example:

```
//ERASE EXEC PGM=IEHPROGM,REGION=80K
//SYSPRINT DD SYSOUT=A
//DDZ DD UNIT=2314,VOLUME=SER=BENNET,DISP=SHR
//SYSIN DD *
SCRATCH VOL=2314=BENNET,DSNAME=INSERT.GGA038.B
SCRATCH VOL=2314=BENNET,DSNAME=AUXINP38.B
/*
```

6. Enter the correct file name for the AUXINP data file on Unit 20.

   Example:

```
//FT20F001 DD DSN=AUXINP38.B,VOL=SER=BENNET,UNIT=2314,DISP=(NEW,KEEP),
// SPACE=(TRK,(19,1)),
// DCB=(RECFM=VS,BLKSIZE=800)
```

7. Enter the correct file name for the INSERT data file on the SYSPUNCH DD card.

   Example:

```
//SYSPUNCH DD DSN=INSERT.GGA038.B,UNIT=2314,VOL=SER=BENNET,
// DISP=(NEW,KEEP),SPACE=(3200,(40,10),RLSE),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200)
```

Notes:

1. It is advisable to alternate between two INSERT file names on successive LP runs, so that a good INSERT file is not destroyed before the next LP successfully creates one.
2. It is also advisable to alternate AUXINP files for the same reason.
3. If more than one problem is being run, each problem should use a different PROBFILE. Otherwise, if an LP run does not reach OPTIMAL, the TMPBASIS results saved on PROBFILE may be destroyed by another LP problem.

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