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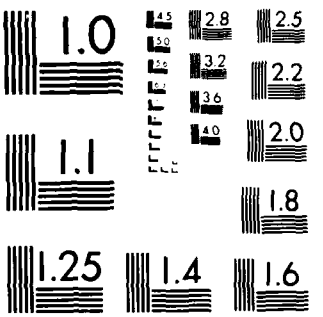

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August 1986
An Investigation Conducted
By SYSTECH Corporation
Sponsored By Naval Facilities
Engineering Command

NCEL
Contract Report

AD-A173 982

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FINAL REPORT: RDF CO-FIRING COST/BENEFIT ANALYSIS USING THE NCEL RDF COST MODEL VOLUME III, RDF COST MODEL MANUAL

ABSTRACT The object of this effort was to determine the cost effectiveness of co-firing RDF in existing Navy boilers. The cost benefit analysis was performed using the NCEL RDF Cost Model and site specific boiler and cost data acquired from four naval activities that were determined to have the highest probability of successful co-firing. The cost effectiveness was measured by the savings to investment ratio (SIR) and computed over a range of cost and operating conditions to determine optimum RDF co-firing scenarios for each facility. Based on present laid-down coal costs and solid waste disposal charges, no set of operating conditions could be identified wherein the use of either co-fired RDF 3 or RDF 5 could be economically justified. Volume I presents the report; Volume II contains appendixes, and Volume III is the terminal manual of RDF cost model.

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SECTION 1.0
INTRODUCTION

The NCEL RDF Cost Model is based on the Microsoft Multiplan® Spread Sheet Program, and is IBM PC compatible. The instructions presented here are intended to provide the information required to effectively use the model, and do not attempt to include all the specifics involved with using Multiplan®. For more detail on Multiplan®, refer to the Mulitplan® User Manual. For further information about the model itself, the user is referred to Volume I of "RDF Co-Firing Cost/Benefit Analysis Using the NCEL RDF Cost Model."

2.0 HARDWARE REQUIREMENTS

The model is designed for the IBM PC (or compatible) with the following basic configuration:

A. Disk operating system.
B. 64 K bytes of memory.
C. One floppy disk drive.
D. Text printer capable of 132 characters per line.

3.0 PROGRAM DISK CONTENTS

The program disk contains 14 files. These include six Multiplan® Program files and eight RDF Cost Model files (referred to as "sheets"). Table 3.1 lists these file names and their functions.

TABLE 3.1. RDF COST MODEL PROGRAM DISK DIRECTORY

File name	Function
MP.LOD	Multiplan® system file
MP.SYS	Multiplan® system file
MP40.DAT	Multiplan® system file
MP.HLP	Multiplan® system file
MP80.DAT	Multiplan® system file
MP.COM	Multiplan® system file
RDFMDLIN	Input data sheet
WORK1	Calculates preliminary values
WORK2	Calculates final values
OUT1	Prints out intermediate data
OUT2	Prints out intermediate data
OUT3	Prints out intermediate data
OUT4	Prints out final operational and economic data

4.0 BEFORE STARTING - COPYING THE PROGRAM

4.1 Multiplan® Program Notes

As a memory conservation technique, Multiplan® uses a spread sheet linking function, called External Copy, to transfer data from one sheet to another. Once established, this External Copy is dependent on both a named range of values and the name of the sheet in which these values originally reside. For example, the data input to the RDFMDLIN sheet is stored in the range RDFMDLIN.XFERDATA. Using the External Copy function, Multiplan® transfers those values (which are stored in RDFMDLIN.XFERDATA) to WORK1. WORK1 then uses those transferred values to perform preliminary calculations. This inherent dependency, as illustrated in Figure 4.1, places the requirement that the file name remains unchanged. If the file names are changed, the External Copy function will not work. Therefore, to save data on various facilities or various data sets on the same facility, the sheets (along with the program files) must be saved under the original file names on separate disks or in separate directories.

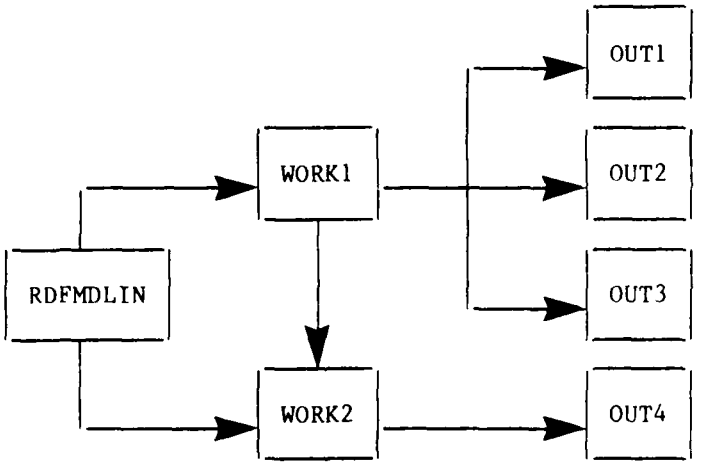

Figure 4.1. Dependency diagram.

4.2 Hard Disk Systems

Create a directory using the appropriate DOS command and copy the contents of the program disk to the new directory. Store the original program disk and use the hard disk copy exclusively. The hard disk will significantly increase the operating speed of the program, especially the External Copy and recalculation functions. It is recommended that individual directories or sub-directories be created to maintain individual data sets.

4.3 Floppy Disk Systems

Using the appropriate DOS command, copy the contents of the program disk to a working disk. If individual data sets are to be maintained, a separate disk should be used for each.

5.0 RUNNING THE MODEL

5.1 Booting and Loading the Input Data Sheet (RDFMDLIN)

A. Boot the computer using the DOS.

B. Insert the working program disk in Drive A or change directories to the one containing the program.

C. At the system prompt (A> or C>), type MP, depress ENTER.

D. Figure 5.1 illustrates the opening screen. From the COMMAND line, select Transfer by either:

1. Typing T, or

2. By moving the cursor with the TAB key and then depressing ENTER.

3. If an incorrect letter is typed or if an undesired menu selection is made, use the ESC key to return to the previous menu.

E. The COMMAND line will then change, as illustrated in Figure 5.2 Select Load by typing L or moving the cursor as described in Step 4 above.

F. As illustrated in Figure 5.3, a file name is requested. Enter RDFMDLIN by either:

1. Typing RDFMDLIN and depressing ENTER, or

2. Viewing the directory by depressing any of the cursor movement keys, and then selecting the file name RDFMDLIN by moving the cursor and depressing ENTER. Figure 5.4 illustrates the directory screen.

G. RDFMDLIN is now the current sheet. Figure 5.5 illustrates how it appears on the computer screen.

5.2 Changing Data Values

At this point, changes to the existing values should be input. To do this:

A. Move the cursor to the appropriate cell with the cursor movement keys.

B. Type in the correct value, depress ENTER.

5.3 Saving RDFMDLIN

When all the desired values are input, save RDFMDLIN. From the COMMAND line, select:

A. Transfer, Save (Type "T", then "S").

B. The name of the current sheet, which appears in the lower right corner of the screen, will automatically appear as the file name under which new data will be saved (see Figures 5.6 and 5.7). As discussed above, do not change the file name. When prompted "Overwrite existing file?", type "Y" for yes. A No ("N") response will return you to the main command line. If it is necessary to save the new RDFMDLIN on a different disk drive or a different directory, type in the full path name; i.e., B:\RDFMDLIN or C:\MP1\RDFMDLIN, etc.

5.4 Executing the Calculations

To execute the calculations of the model with the newly input values, it is only necessary to Load and Save files WORK1 and WORK2 as follows:

A. Transfer, Load WORK 1 (as described in Section 5.1, Step 5).

B. Transfer, Save WORK1 (following the procedures described in Section 5.3.

C. Transfer, Load WORK2.

D. Transfer, Save WORK2.

5.5 Printing the Results

At this point, any of the sheets that are used to obtain printouts of the data can be loaded and printed. The following describes how to load and print any of the OUT sheets (1, 2, 3, or 4). OUT4 will be the most frequently used sheet as this sheet presents final co-fire and non co-fire operational and economic data. Therefore, it will be used for this example:

A. After having Loaded and Saved both WORK1 and WORK2, Transfer - Load OUT4 (or the desired OUT sheet).

B. To add a descriptive title line:

1. Depress the Home key.

2. Select Edit from the COMMAND line.

3. Use the backspace (◄——) key to erase the current contents.

4. Type in the desired text - it will appear in the edit line (Figure 5.8).

5. End text with double quotes ("), depress ENTER.

C. From the COMMAND line, select Print (type "P").

D. Figure 5.9 illustrated the main Print commands.

1. Select MARGINS and set as described in Table 5.1 for standard or Table 5.2 for wide page (also see Figure 5.10).

2. Use the TAB key to move the cursor to each selection. Type in the desired value, then tab to the next setting. Do not depress ENTER until the setting changes are complete. Depressing ENTER will return you to the main Print Command line.

3. From the main Print Command line, select OPTIONS (Figure 5.11), then Area. This defines what will be printed. It can be the entire sheet or a portion of the sheet. To select an Area:

a. Use the DEL key to clear the current setting.

b. The Area to be printed is defined by the top left cell and the bottom right cell.

c. To define the Area either:

(1) Enter the cell locations by directly typing them in; i.e., R1C1:R10C10. This represents the 10 rows between Columns 1 and 10, inclusive, or;

(2) Point to the cells. To do this:

(a) Depress the HOME key.

(b) Move the cursor to the desired top left cell using the cursor movement keys.

(c) Depress the colon (:) key.

(d) Move the cursor to the bottom right corner cell.

(e) Depress ENTER to compete the selection of the area to be printed and return to the main Print Command line.

(f) Align the paper in the printer and make any other printer adjustments as may be required.

(g) Type "P" to start printing. When printing is complete, the main Command line will appear.

TABLE 5.1. STANDARD PAGE MARGINS
(8 1/2 × 11)

Left:	0 to 5 characters
Top:	0 to 10 characters
Width:	70 to 80 characters
Print length:	54 lines
Page length:	66 lines

TABLE 5.2. WIDE PAGE MARGINS
(11 × 14)

Left:	0 to 5 characters
Top:	0 to 10 characters
Width:	136 characters (10 cpi) 240 characters (12 cpi)
Print length:	54 lines
Page length:	66 lines

E. Transfer, Save OUT4.

6.0 EXITING THE PROGRAM

A. From the main command line, type "Q" for Quit.
B. Type "Y" to confirm the Quit command.
C. This returns you to the operating system.

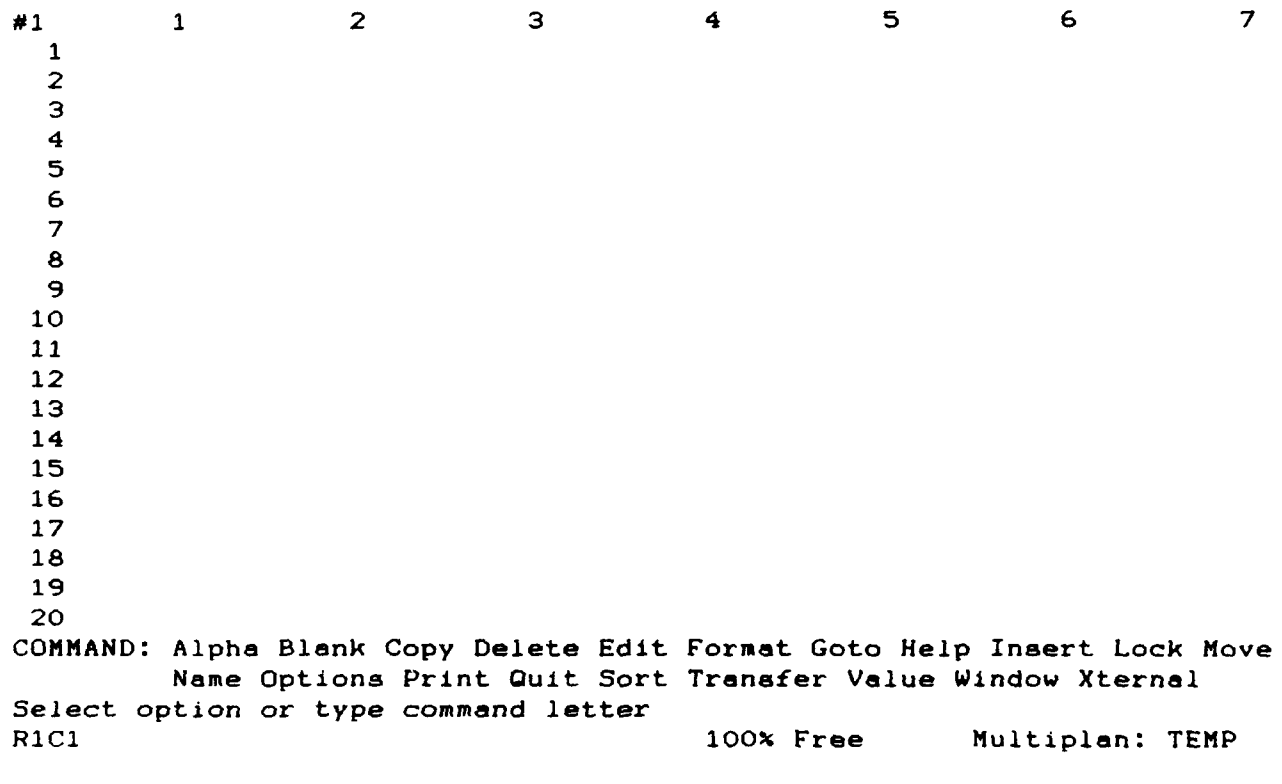

Figure 5.1. Multiplan® opening screen.

```
#1        1          2          3          4          5          6          7
  1
  2
  3
  4
  5
  6
  7
  8
  9
 10
 11
 12
 13
 14
 15
 16
 17
 18
 19
 20
TRANSFER: Load Save Clear Delete Options Rename

Select option or type command letter
R1C1                                      100% Free      Multiplan: TEMP
```

Figure 5.2. Transfer command line.

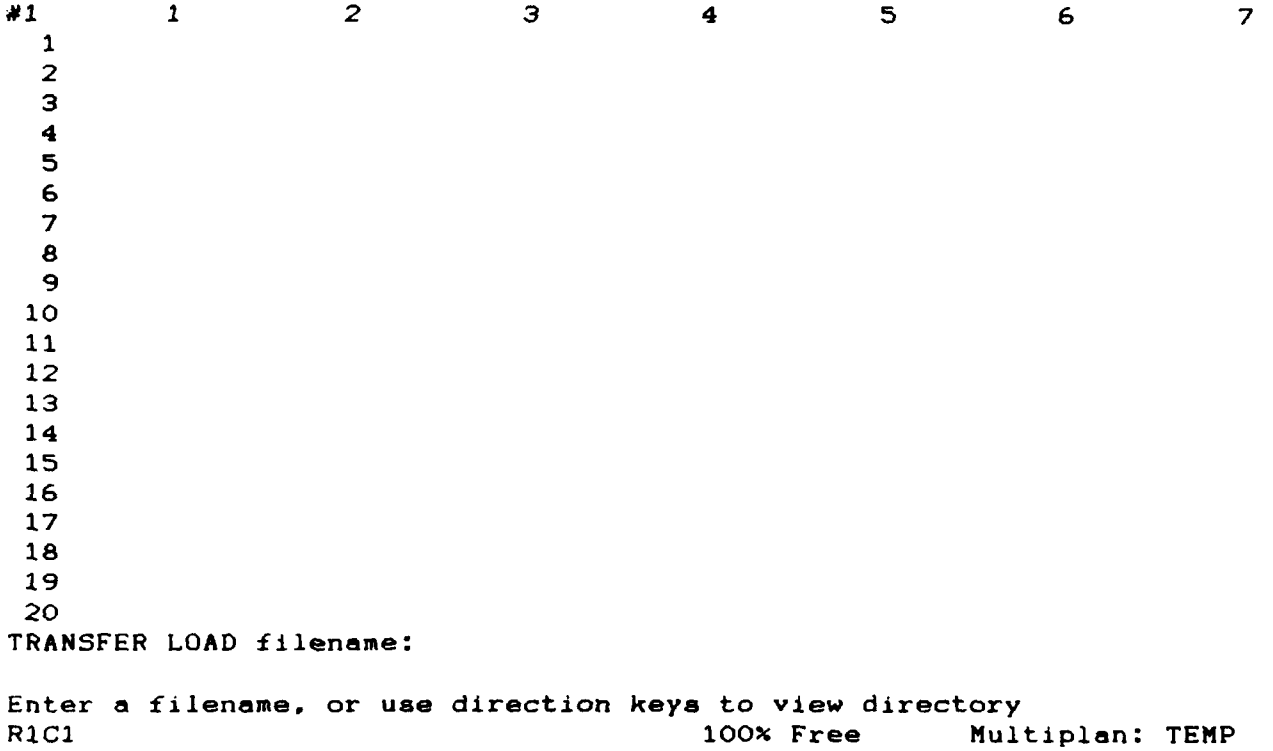

Figure 5.3. Transfer load command line.

```
MP.LOD          MP.SYS          MP40.DAT        MP.HLP
MP80.DAT        MP.COM          OUT1            RDFMDLIN
WORK1           OUT2            OUT3            WORK2
OUT4            OUT5

TRANSFER LOAD filename: RDFMDLIN

Enter a filename, or use direction keys to view directory
R1C1                                  100% Free      Multiplan: TEMP
```

Figure 5.4. File name selection using the directory.

```
#1     1        2             3          4          5          6          7
  1    1 PORT HUENEME ALGORITHM. REVISED AND SIMPLIFIED 12/01/84
  2    2                         MODIFIED JANUARY 1986
  3    3 Facility:
  4    4                         INPUTS(LINES 3 TO 105):
  5    5 SUMMER STEAM DEMANDS:
  6    6                 AVERAGE HOURLY BTU INPUT IN THESE MATRICES
  7    7                                    SHIFT 1    SHIFT 2    SHIFT 3
  8    8                 MON-FRI             50000000   45000000   45000000
  9    9                 SAT                 40000000   40000000   40000000
 10   10                 SUN                 40000000   40000000   40000000
 11   11 WINTER STEAM DEMANDS:
 12   12                 AVERAGE HOURLY BTU STEAM
 13   13                                    SHIFT 1    SHIFT 2    SHIFT 3
 14   14                 MON-FRI            150000000  140000000  135000000
 15   15                 SAT                130000000  130000000  130000000
 16   16                 SUN                130000000  130000000  130000000
 17   17 SPRING AND FALL STEAM DEMANDS:
 18   18                 AVERAGE HOURLY BTU
 19   19                                    SHIFT 1    SHIFT 2    SHIFT 3
 20   20                 MON-FRI            100000000   92500000   90000000
COMMAND: Alpha Blank Copy Delete Edit Format Goto Help Insert Lock Move
         Name Options Print Quit Sort Transfer Value Window Xternal
Select option or type command letter
R8C5     50000000                          96% Free      Multiplan: rdfmdlin
```

Figure 5.5. RDFMDLIN.

```
#1    1       2                3          4          5          6          7
 52   52 Days of storage desired                                    1 days
 53   53 Length of mechanical transfer conveyor                     0 Miles
 54   54 Fuel temperature at boiler boundary                       70 Deg F
 55   55 ECONOMIC FACTORS
 56   56 Financial life of project                                 25 Years
 57   57 Discount factor                                         9.54
 58   58 Cost of electricity                                   0.0227 $/kWh
 59   59 Ash disposal cost                                        16 $/ton
 60   60 Operator wage rate, unburdened                        13.68 $/hr
 61   61 Burdening rate, (a multiplier)                        1.305
 62   62 Annual quantity of MSW generated on base              42000 Tons/yr
 63   63 MSW disposal cost: tipping fee                           10 $/ton
 64   64                    transportation                         6 $/ton
 65   65 Conventional fuel cost, delivered                        78 $/ton
 66   66 RDF cost, delivered                                    18.2 $/ton
 67   67 IF THE FOLLOWING STATEMENTS ARE TRUE, ENTER 1 :
 68   68
 69   69 BOILER HAS SOOT BLOWERS FOR THE CONVECTIVE                1
 70   70 BOILER HAS SOOT BLOWERS FOR THE ECONOMIZER                1
 71   71 BOILER HAS AN ECONOMIZER                                  1
TRANSFER SAVE filename: rdfmdlin

Enter a filename
R66C6    18.2                          96% Free      Multiplan: rdfmdlin
```

Figure 5.6. Transfer/save command.

```
#1    1       2                3          4          5          6          7
 52   52 Days of storage desired                                      1 days
 53   53 Length of mechanical transfer conveyor                       0 Miles
 54   54 Fuel temperature at boiler boundary                         70 Deg F
 55   55 ECONOMIC FACTORS
 56   56 Financial life of project                                   25 Years
 57   57 Discount factor                                           9.54
 58   58 Cost of electricity                                     0.0227 $/kWh
 59   59 Ash disposal cost                                           16 $/ton
 60   60 Operator wage rate, unburdened                           13.68 $/hr
 61   61 Burdening rate, (a multiplier)                           1.305
 62   62 Annual quantity of MSW generated on base                 42000 Tons/yr
 63   63 MSW disposal cost: tipping fee                              10 $/ton
 64   64                    transportation                            6 $/ton
 65   65 Conventional fuel cost, delivered                           78 $/ton
 66   66 RDF cost, delivered                                      18.2 $/ton
 67   67 IF THE FOLLOWING STATEMENTS ARE TRUE, ENTER 1 :
 68   68
 69   69 BOILER HAS SOOT BLOWERS FOR THE CONVECTIVE                   1
 70   70 BOILER HAS SOOT BLOWERS FOR THE ECONOMIZER                   1
 71   71 BOILER HAS AN ECONOMIZER                                     1
TRANSFER SAVE filename: rdfmdlin

Overwrite existing file?
R66C6    18.2                              96% Free      Multiplan: rdfmdlin
```

Figure 5.7. Transfer/save options.

```
#1    1       2          3           4           5          6          7
  1 SUMMARY RESULTS BEGIN ON LINE 410: MODIFICATION 8: CHERRY POINT DAT
  2  407
  3  408 UNITS          RDF      CONVENTIONAL             VARIABLE
  4  409              COFIRING      FUEL                  DEFINITION
  5  410 BTUH        6.84E+07    6.84E+07                ENTHALPY TRANSFERED
  6  411 BTUH        1.45E+08    1.41E+08                MCR, ABS MAX FOR COF
  7  412 BTUH        3.27E+07       NA                   MAXIMUM TURNDOWN STE
  8  413 NONE            0.78         0.82               BOILER EFFICIENCY AT
  9  414 NONE            0.70         0.82               BOILER EFFICIENCY AT
 10  415 BTUH        1.50E+08    1.50E+08                MAXIMUM STEAM DEMAND
 11  416 NONE            0.00       NA                   DERATE
 12  417 BTUH        9.81E+07    8.37E+07                TOTAL FUEL INPUT ENT
 13  418 TPH             3.11       NA                   RDF FLOWRATE, AVERAG
 14  419 LB/HR           5605          7969              CONVENTIONAL FUEL IN
 15  420 LB/HR           1927           791              SOLID RESIDUE GENERA
 16  421 NONE            0.47         0.30               CARBON CONTENT OF SO
 17  422 NONE            2.31         0.37               FLYASH FRACTION OF S
 18  423 LB/HR              3            0               FLYASH EMISSION ABSO
 19  424 LB/MMBTU        0.02         0.00               EMISSION OF TSP, MAX
 20  425 LB/MMBTU       31.38         3.43               UNCONTROLLED FLYASH
EDIT: "SUMMARY RESULTS BEGIN ON LINE 410: MODIFICATION 8: CHERRY POINT DATA

Enter a formula
R1C1      "SUMMARY RESULTS BEGIN ON LI   88% Free      Multiplan: out4
```

Figure 5.8. Edit line.

```
#1    1       2          3           4           5          6          7
  1 SUMMARY RESULTS BEGIN ON LINE 410: MODIFICATION 8: CHERRY POINT DAT
  2  407
  3  408 UNITS          RDF     CONVENTIONAL            VARIABLE
  4  409              COFIRING      FUEL                 DEFINITION
  5  410 BTUH        6.84E+07    6.84E+07               ENTHALPY TRANSFERED
  6  411 BTUH        1.45E+08    1.41E+08               MCR, ABS MAX FOR COF
  7  412 BTUH        3.27E+07       NA                  MAXIMUM TURNDOWN STE
  8  413 NONE            0.78        0.82               BOILER EFFICIENCY AT
  9  414 NONE            0.70        0.82               BOILER EFFICIENCY AT
 10  415 BTUH        1.50E+08    1.50E+08               MAXIMUM STEAM DEMAND
 11  416 NONE            0.00       NA                  DERATE
 12  417 BTUH        9.81E+07    8.37E+07               TOTAL FUEL INPUT ENT
 13  418 TPH             3.11       NA                  RDF FLOWRATE, AVERAG
 14  419 LB/HR           5605          7969             CONVENTIONAL FUEL IN
 15  420 LB/HR           1927           791             SOLID RESIDUE GENERA
 16  421 NONE            0.47          0.30             CARBON CONTENT OF SO
 17  422 NONE            2.31          0.37             FLYASH FRACTION OF S
 18  423 LB/HR              3             0             FLYASH EMISSION ABSO
 19  424 LB/MMBTU        0.02          0.00             EMISSION OF TSP, MAX
 20  425 LB/MMBTU       31.38          3.43             UNCONTROLLED FLYASH
PRINT: Printer File Margins Options

Select option or type command letter
R1C2                                        88% Free      Multiplan: out4
```

Figure 5.9. Main print command line.

```
#1    1        2          3           4           5          6          7
  1 SUMMARY RESULTS BEGIN ON LINE 410:
  2  407
  3  408 UNITS          RDF      CONVENTIONAL            VARIABLE
  4  409              COFIRING      FUEL                 DEFINITION
  5  410 BTUH        6.84E+07    6.84E+07               ENTHALPY TRANSFERED
  6  411 BTUH        1.45E+08    1.41E+08               MCR, ABS MAX FOR COF
  7  412 BTUH        3.27E+07      NA                   MAXIMUM TURNDOWN STE
  8  413 NONE            0.78        0.82             BOILER EFFICIENCY AT
  9  414 NONE            0.70        0.82             BOILER EFFICIENCY AT
 10  415 BTUH        1.50E+08    1.50E+08               MAXIMUM STEAM DEMAND
 11  416 NONE            0.00      NA                 DERATE
 12  417 BTUH        9.81E+07    8.37E+07               TOTAL FUEL INPUT ENT
 13  418 TPH             3.11      NA                   RDF FLOWRATE, AVERAG
 14  419 LB/HR           5605        7969               CONVENTIONAL FUEL IN
 15  420 LB/HR           1927         791               SOLID RESIDUE GENERA
 16  421 NONE            0.47        0.30             CARBON CONTENT OF SO
 17  422 NONE            2.31        0.37             FLYASH FRACTION OF S
 18  423 LB/HR              3           0             FLYASH EMISSION ABSO
 19  424 LB/MMBTU        0.02        0.00             EMISSION OF TSP, MAX
 20  425 LB/MMBTU       31.38        3.43             UNCONTROLLED FLYASH
PRINT MARGINS: left: 5    top: 5    print width: 76   print length: 54
               page length: 66
Enter a number
R1C1     "SUMMARY RESULTS BEGIN ON LI   88% Free      Multiplan: out4
```

Figure 5.10. Print margins.

```
#1    1        2          3            4            5          6          7
  1 SUMMARY RESULTS BEGIN ON LINE 410:
  2  407
  3  408 UNITS          RDF      CONVENTIONAL              VARIABLE
  4  409              COFIRING      FUEL                   DEFINITION
  5  410 BTUH        6.84E+07    6.84E+07                 ENTHALPY TRANSFERED
  6  411 BTUH        1.45E+08    1.41E+08                 MCR, ABS MAX FOR COF
  7  412 BTUH        3.27E+07       NA                    MAXIMUM TURNDOWN STE
  8  413 NONE            0.78        0.82                 BOILER EFFICIENCY AT
  9  414 NONE            0.70        0.82                 BOILER EFFICIENCY AT
 10  415 BTUH        1.50E+08    1.50E+08                 MAXIMUM STEAM DEMAND
 11  416 NONE            0.00       NA                    DERATE
 12  417 BTUH        9.81E+07    8.37E+07                 TOTAL FUEL INPUT ENT
 13  418 TPH             3.11       NA                    RDF FLOWRATE, AVERAG
 14  419 LB/HR           5605        7969                 CONVENTIONAL FUEL IN
 15  420 LB/HR           1927         791                 SOLID RESIDUE GENERA
 16  421 NONE            0.47        0.30                 CARBON CONTENT OF SO
 17  422 NONE            2.31        0.37                 FLYASH FRACTION OF S
 18  423 LB/HR              3           0                 FLYASH EMISSION ABSO
 19  424 LB/MMBTU        0.02        0.00                 EMISSION OF TSP, MAX
 20  425 LB/MMBTU       31.38        3.43                 UNCONTROLLED FLYASH
PRINT OPTIONS: area: R1C4:5          setup:
               formulas: Yes(No)   row-col numbers: Yes(No)
Enter reference to cell or group of cells
R1C2                                        88% Free      Multiplan: out4
```

Figure 5.11. Print options.

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MCLB PWO, Albany, GA; PWO, Barstow CA
McRD PWO, Parris Island, SC
NAF PWO, Atsugi, Japan; PWO, El Centro, CA; Detroit, PWO, Mount Clemens, MI; PWO, Washington, DC
NAS PWO (Code 632), Point Mugu, CA; PWO, Jacksonville, FL; PWO, Meridian, MS; PWO, New Orleans, LA; PWO, Alameda, CA; PWO, Fallon, NV; PWO, Beeville, TX; PWO, Cecil Field, FL; PWO, Corpus Christi, TX; PWO, Dallas TX; PWO, Glenview IL; PWO, Key West, FL; PWO, Kingsville TX; PWO, Lemoore, CA; PWO, Marietta, GA; PWO, Millington, TN; Whiting Fld, PWO, Milton, FL; PWO, Miramar, San Diego, CA; PWO, Moffett Field, CA; PWO, Norfolk, VA
AF 4700 ADS (SPTD) (LAO), Peterson AFB, CO; ABG DER, Patrick AFB, FL
AFB 3480 CES DEEV, Goodfellow AFB, TX; AUL LSE 63-465, Maxwell, AL; HQ MAC DEEE, Scott AFB, IL; AFIT DET, Wright Patterson AFB, OH
AFESC HQ AFESC TST, Tyndall AFB, FL; DEB, Tyndall AFB, FL; HQ TST, Tyndall AFB, FL
ARMY BMDSC RE (H McClellan), Huntsville, AL; Engr Dist Memphis, Lib, Memphis, TN; FESA-EM (Krajewski), Ft Belvoir, VA; FESA-EM, Ft Belvoir, VA
ARMY CERL, Library, Champaign IL; CERL ZN, Champaign IL
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ARMY MISSILE R&D CMD Ch, Docs Sci Info Ctr, Arsenal, AL
ARMY-BELVOIR R&D CTR STRBE-CEO, Ft Belvoir, VA; STRBE-AALO, Ft Belvoir, VA; STRBE-BLORE, Ft Belvoir, VA; STRBE-WC, Ft Belvoir, VA
BUREAU OF RECLAMATION Code 512 (C Selander), Denver, CO
CNO Code OP-987J, Washington, DC; OP-098, Washington, DC
DEFFUELSUPPCEN DESC-OWE, Alexandria, VA
DLSIE Army Logistics Mgt Center, Fort Lee, VA
DOE Wind Ocean Tech Div, Tobacco, MD
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IRE-ITTD Input Proc Dir (R Danford), Eagan, MN
LIBRARY OF CONGRESS Sci & Tech Div, Washington, DC
NAS Lead CPO, PWD, Self Help Div, Beeville, TX; PWO, Oak Harbor, WA; Oceana, PWO, Virginia Bch, VA; PWO, South Weymouth, MA; PWO, Willow Grove, PA
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AFB 82ABG DEMC, Williams AZ; AFSC DEEQ (P Montoya), Peterson AFB, CO; SAMSO MNND, Norton AFB CA; SAMSO DEC (Sauer), Vandenberg AFB, CA
ARMY Facs Engr Dir, Contr Br, Ft Ord, CA; POJED-O, Okinawa, Japan; Comm Cmd, Tech Ref Div, Huachuca, AZ
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