United States
Environmental Protection
Agency

Control Technology
Center
Research Triangle Park NC 27711

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EPA

Tutorial Manual for CAT (Controlling Air Toxics)

Version 1.0

New Jersey
Department of Environmental Protection

and

control technology center

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
AIR AND ENERGY ENGINEERING RESEARCH LABORATORY
RESEARCH TRIANGLE PARK
NORTH CAROLINA 27711

October 21, 1988

The Control Technology Center (CTC) is happy to provide the document and disks, "CAT (Controlling Air Toxics) Version 1.0." It is the result of a joint project between the CTC and the New Jersey Department of Environmental Protection (NJDEP). Instructions for installation of the program are in the tutorial manual. Common problems to be aware of are listed in a read.me file included with the program. After the program is installed, you can view this file by typing on your computer keyboard, "type read.me." The program is not copy-protected and may be copied. However, it is advantageous to register your use with the CTC so that you will receive future updates.

The CTC was established by the EPA Office of Research and Development (ORD) and Office of Air Quality Planning and Standards (OAQPS) to provide technical assistance to State and Local Air Pollution Control Agencies and the EPA Regional Offices. The CTC's assistance is available ONLY to State and Local Agency and Regional Office personnel, and provides control technology assistance for all air pollutants and control activities. If you have a need for control technology assistance or questions about the CTC, please call the HOTLINE at (919)541-0800 or FTS 629-0800. The enclosures further describe the CTC and its projects.

The program, CAT, is a computerized aid for State and Local air agency and Regional Office personnel who review air emission permit applications. The program is designed to eliminate the need to perform complex calculations by hand. The engineering software, CAT, is based on the EPA document, Control Technologies for Hazardous Air Pollutants, EPA/625/6-86/014, September, 1986. This document has been used extensively by State and Local personnel with favorable results. In talking to the users and examining the document, it became evident that the material in the document would be even more useful on a computer, eliminating the necessity of repetitively performing complex calculations.

The permit reviewer inputs information on the air emission stream characteristics as well as other information provided in the permit application. The program allows the permit reviewer to select a specific pollutant/control device for evaluation. The program then calculates design parameters and estimates costs for each control technology selected. The results can be compared against the applicant's actual or proposed design. The software is designed to easily allow what-if type calculations, allowing the reviewer to change one or more parameters and recalculate the results. A report generator is included in the program.

Work is already underway on a second version of this program. In this second version, a screening version of the program will be included to assist the permit reviewer in determining which permits are most deserving of a more thorough review. We are also interested in hearing your comments on any problems you may have and how the program can be improved. Send any comments on problems or improvements to Carlos Nunez at MD-61 at the above address. Please include your name and phone number so he can contact you if he has questions about your comments.

If additional copies of CAT are needed for State and Local Agency or Regional Office personnel, if you did not receive your copy through the CTC and would like to register your use for future updates, or if you have comments for version 2, you may contact Beth Crabtree at (919)541-4005 or FTS 629-4005 or MD-61 at the above address. Copies of the document and disks will also be available soon through the National Technical Information Service (NTIS).

Sincerely yours,

Sharon L. Nolen

Sharon L. Nolen
Control Technology Center
Air Toxics Research Division

Attachments (3)
- Control Technology Center - Update
- Control Technology Center Project Update
- Tutorial Manual for CAT (Controlling Air Toxics) with Diskettes 1 and 2

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TUTORIAL MANUAL FOR

CAT

(Controlling Air Toxics)

Version 1.0

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PREFACE

The CAT program was funded as a cooperative project by EPA's Control Technology Center (CTC) and the New Jersey Department of Environmental Protection (NJDEP).

The CTC was established by EPA's Office of Research and Development (ORD) and Office of Air Quality Planning and Standards (OAQPS) to provide technical assistance to State and Local air pollution control agencies. Three levels of assistance can be accessed through the CTC. First, a CTC HOTLINE has been established to provide telephone assistance on matters relating to air pollution control technology. Second, more in-depth engineering assistance can be provided when appropriate. Third, the CTC can provide technical guidance through publication of technical guidance documents, development of personal computer software, and presentation of workshops on control technology matters.

The technical guidance projects, such as this one, focus on topics of national or regional interest that are identified through contact with State and Local agencies. In this case, the CTC became interested in automating the calculations from the ORD document, *Control Technologies for Hazardous Air Pollutants*, EPA/625/6-86-014, September 1986. The document discusses choosing the appropriate control technology for vapor and particulate emissions streams and leads the reader, step-by-step, through the calculations required for design and cost estimations of 10 different control devices.

Soon after the CTC decided to fund a project to computerize the document, it was discovered that the NJDEP had plans to develop a similar system to help automate the permit review process for the State of New Jersey. CTC and NJDEP agreed to work together to produce a computer program to assist permit reviewers across the country in the review of air emission permit applications. This document is the tutorial manual for the program resulting from the joint effort.

EPA REVIEW NOTICE

This report has been reviewed by the U. S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policy of the Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

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SECTION 1
INTRODUCTION

This document is a tutorial manual for the program, Controlling Air Toxics (CAT). The purpose of the program is to assist permit engineers in the review of permit applications for control of air toxics. The program performs design and cost calculations for the control device based on the emission stream characteristics.

This manual describes how to operate the software on a personal computer, the commands used, and how to enter and receive information. Examples are included with the software, and one is used in this tutorial. The manual also contains several appendices to aid in using the program, including data input forms which may be used as work sheets.

The CAT program is based on the EPA Handbook, *Control Technologies for Hazardous Air Pollutants*, EPA/625/6-86/014, and is meant to be used with the handbook. If you intend to use CAT to review permit applications, you should acquire a copy of this handbook. More up-to-date costs have been used when available and are explained in Appendix A.

SECTION 2
INSTALLATION

This section tells you how to install CAT on your IBM® personal computer or clone. CAT requires a hard disk with one megabyte of available space, 640K of memory, and DOS 2.0 or higher.

First, insert your CAT distribution disk 1 into the A: drive and type

```
A:INSTALL
```

Next, insert CAT distribution disk 2 when prompted. This procedure will create a directory C:\CAT and place a copy of the CAT program and its data files there.

An example for each control device is included in the files provided with CAT. The example files are:

File Name	Control Device
AB.CAT	Absorber
CA.CAT	Carbon Adsorber
CI.CAT	Catalytic Incinerator
CO.CAT	Condenser
FF.CAT	Fabric Filter
FL.CAT	Flare
TI.CAT	Thermal Incinerator
VS.CAT	Venturi Scrubber

SECTION 3
OPERATION

To run the program, change directories to the CAT directory:

```
CD \CAT
```

then invoke the program by typing:

```
CAT
```

A few moments will pass while the program loads a number of files from the disk, then the title page will appear (see Figure 1). Use **[PgUp]**, **[PgDn]**, **[Home]**, and **[End]** keys to view the preface material. Use the [Esc] key to begin using the program.

```
Press PgUp, PgDn, Home, and End to scroll, Esc when finished

                                CAT

                      (Controlling Air Toxics)


Sharon Nolen                                Tom Micai
Control Technology Center                   New Jersey Department of
U.S  Environmental Protection Agency        Environmental Protection


                    Developed by Radian Corporation


The purpose of this program is to assist permit engineers in the review
of permit applications for control of air toxics  The program performs
design and cost calculations for the control device based on the
emission stream characteristics.  The program is based on the EPA
```

Figure 1. The Title Page for CAT.

THE MAIN MENU

CAT uses a menu styled after Lotus® which permanently appears at the top of the computer screen. Figure 2 presents the main menu which now appears at the top of your screen. To use the menus, you may use the arrow keys on the cursor pad at the right of your keyboard to highlight a desired menu option and press **[Enter]** or simply press the first character of the option. This will either elicit some action from the program or produce another menu of options (a sub-menu). Selection is made from the sub-menu as before; to exit the sub-menu and return to the parent menu, press the [Esc] key.

Note: The options on each menu are placed generally in the order, left to right, that will be most useful to the permit reviewer who is entering data.

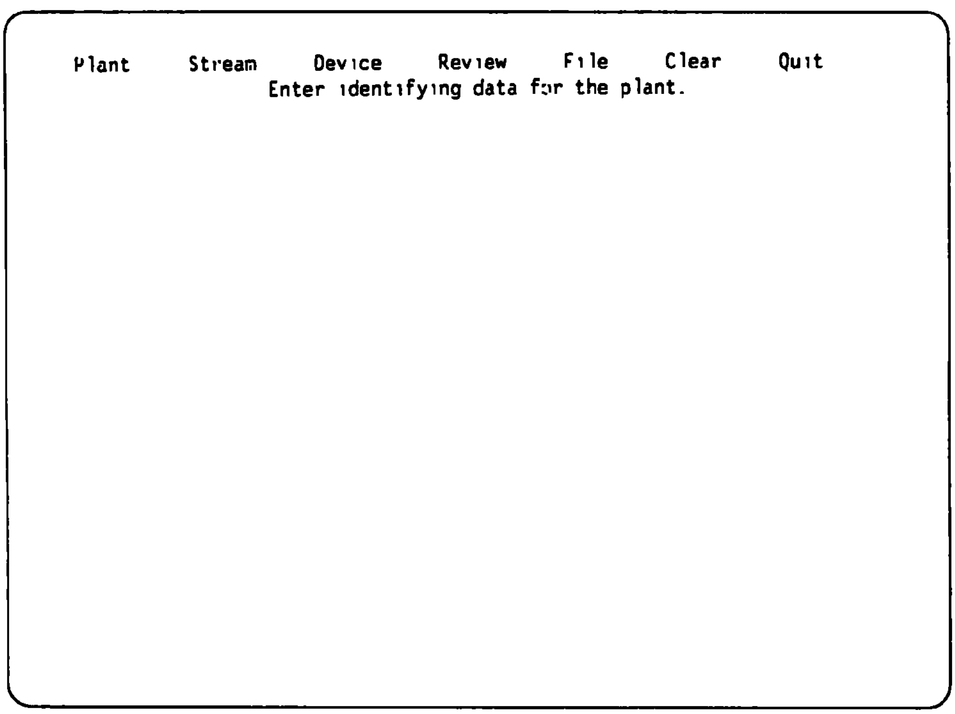

Figure 2. The CAT Main Menu.

This tutorial uses an example file called TI.CAT, which is loaded by using the File menu (see page 25). The other example files are discussed on page 2. For now, to load the file:

Press F for File, then press R for Recall.

Now, enter TI.CAT and press [Enter] to load the file and return to the main menu.

PLANT

Now, press P from the main menu to run the Plant activity.

Figure 3 shows the form which will be displayed on your screen. You fill out the form by placing data in each field. A field is the highlighted area which contains the blinking cursor. To enter data in a field, just type using the keyboard. You may move between fields by using the arrow keys and **[Home]** and **[End]**. Some of the function keys on the keyboard may be used to help in this task; refer to Data Entry Control Keys, Section 4.

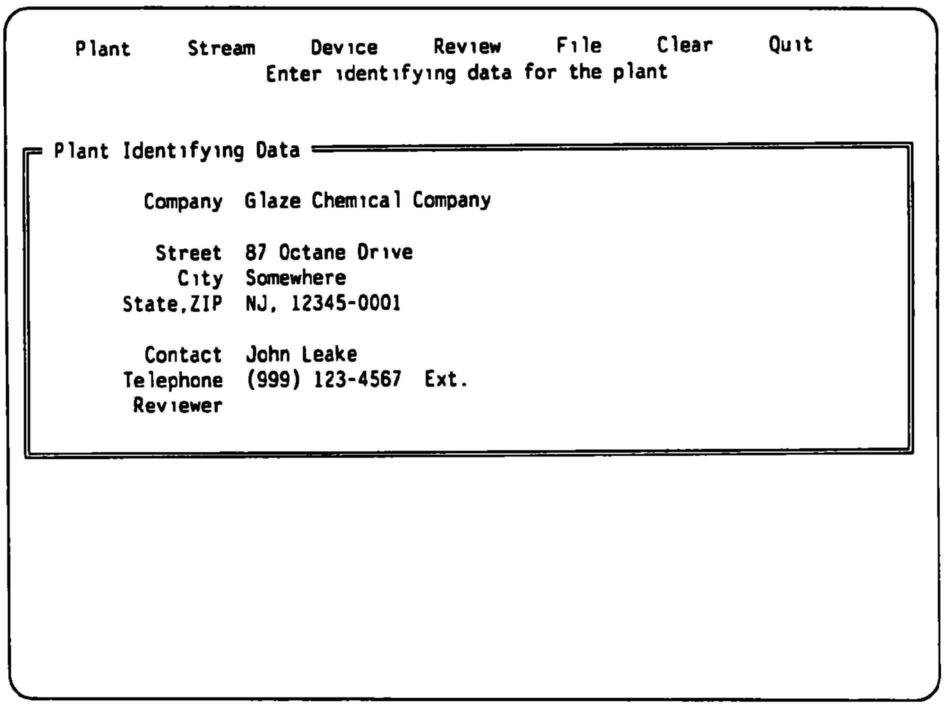

Figure 3. The Plant Form.

The information on this plant form will be printed out on any reports you print from this file. It is not required for calculations, but will be useful in future review of the reports generated.

When you strike the [**Enter**] key from the last field, CAT will ask if you are ready to leave the form. Answer Y to go back to the main menu or N if you want to continue working on the form. You may skip directly to this question from any other field on the Plant form by pressing the [**F10**] key. If you have made changes to the Plant form and wish to abandon them, press the [Esc] key from anywhere inside the form.

You will encounter other forms in the CAT program. A form will always be surrounded by a double line box with a description in the upper left-hand corner of the box. [**F10**] will always exit the form, keeping any changes you may have made.

Now, press the [F10] key and then press Y to confirm and return to the main menu.

STREAM

Now, press S from the main menu to invoke the Stream menu.

You will see a sub-menu with four options; Type, Parameters, HAP, and Clear, as shown at the top of Figure 4. The Stream activity prompts you to characterize an emission stream by entering its type, its physical parameters, and the pollutants it contains.

STREAM/TYPE

Now, press T to specify the Type of emission stream.

You must categorize the emission stream before you can proceed further. As you become more experienced with the program, you will find that your choice of stream type will influence which device types you may choose from the Device menu and the questions you are required to answer.

You will now see a pop-up menu on the left side of the display (see Figure 4). This pop-up menu is similar to other pop-up menus in the CAT program in its appearance and manipulation. A pop-up menu will always be surrounded by a single-line box. The box may or may not have a title on its top line; this one does not. You will also see a question or prompt displayed on the third line of the display which tells you what information CAT is trying to elicit from you. To make a selection from the pop-up menu, use the cursor keys to highlight the option you desire and press [Enter]. In some pop-up menus this will cause a form to pop up; here, it does not. You may always leave a pop-up menu without selecting anything by pressing [Esc].

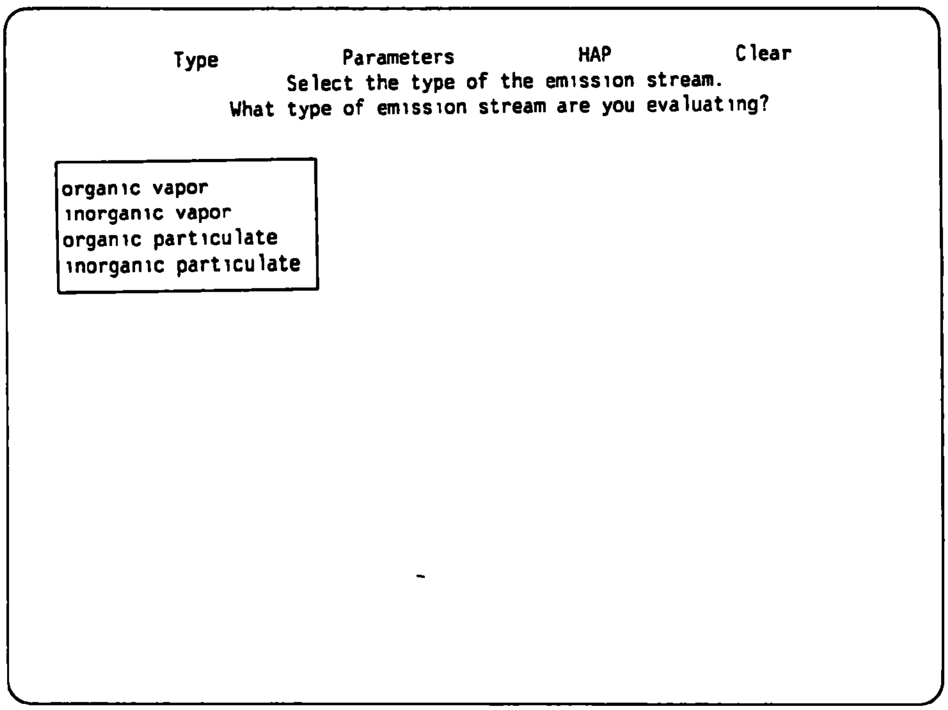

Figure 4. Stream Types.

Now, select the organic vapor stream type and press [Enter].

Note: Once a stream type has been selected, it can be changed by choosing the Type option again and selecting another type. If, however, you have already filled out other stream information and then select a new stream type, the other information you have filled in will be lost. This is unavoidable, since different information is required by the different stream types.

STREAM/PARAMETERS

Now, press P for Parameters.

Figure 5 shows what your display will look like. This is a pop-up menu of parameters which contains four entries for each menu option. The first column shows what the parameter is. The name is right-justified on the display and the next three columns contain the Applicant's value, the Calculation value, and Checked, yes or no - more about these in a moment.

```
        Type           Parameters          HAP          Clear
             Enter parameters describing the emission stream
           Select a parameter and press Enter, or Esc to exit.

 Parameter ---------------------------------------- Appl ----- Calc - Checked
                      Maximum flow rate (scfm)                 15000
                               Pressure (mmHg)
                            Temperature (degF)                   120
                        Heat content (Btu/scf)                    .4
                            Oxygen content (%)                  20.6
                          Moisture content (%)                     2
                         Relative humidity (%)
       Are halogenated organics present? (Y/N)                     N
                    Are metals present? (Y/N)
```

Figure 5. Characterizing the Emission Stream.

To input or change the values on the display, choose a parameter from the pop-up menu by highlighting the parameter and pressing **[Enter]**.

Now, select the Maximum flow rate from the menu and press [Enter].

Your display should appear as in Figure 6. Selecting a parameter will cause a parameter form to pop up in the center of your screen which has fields for each of the three columns on the menu line, plus a Recommended value field. The name of the form is the name of the associated variable from the HAP manual. This will help you backtrack CAT computations if you wish. The first line of the form contains a full description of the parameter. The Recommended value field may contain some default value to be used for the calculation value if none is available from the applicant. In general, you should always try to obtain all information from the applicant, but this is not always possible. CAT will recommend default values for some of the more difficult-to-find values. You can never enter a value into the Recommended value field.

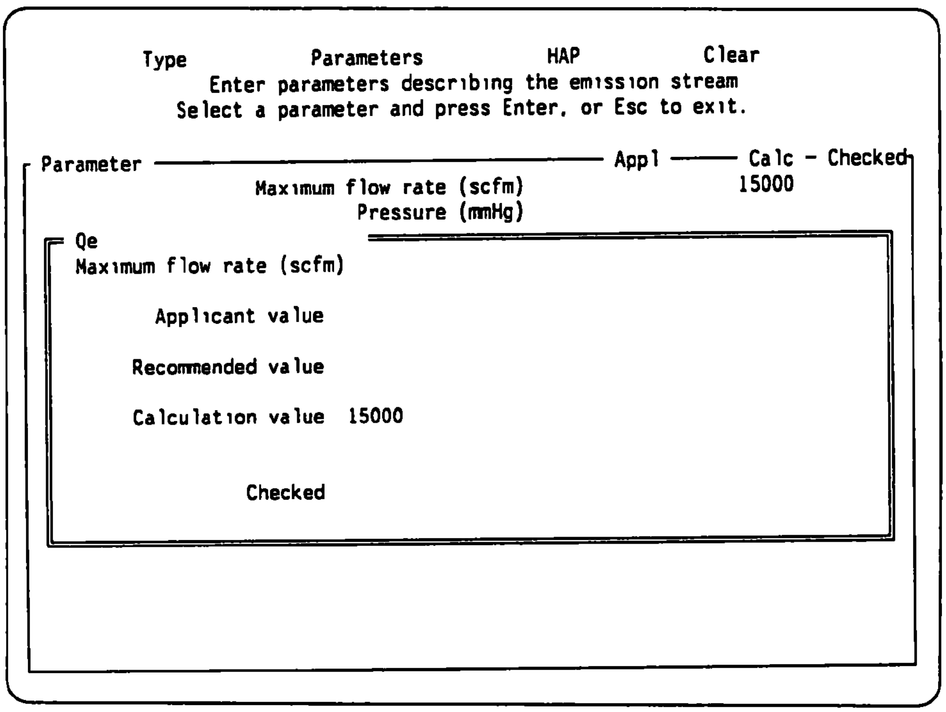

Figure 6. Changing a Parameter Value.

You will be prompted to fill out three fields on the parameter form; The Applicant value, the Calculation value, and Checked. These fields will help you to track your progress in reviewing the application. They will be especially useful if your review takes more than one session with the CAT program or if your agency runs quality control checks on your review.

The Applicant value is the value reported by the applicant on the permit application. This field is stored strictly for comparison purposes; it will never be used in any computation.

The Calculation value field should contain the value you wish to be used to compute design parameters for a device. Normally this value should be the same as the Applicant value. This will not be true if the applicant did not supply a value, or if you wish to study the effect of changing the value on the design. Some calculation values will be computed by CAT; you will not be able to change the calculation value for these "Evaluation" parameters.

The Checked field is supplied to allow you to annotate which parameters you have reviewed and agree with. This field should also be used if the applicant value is non-blank and you use some other value for the calculation value. Enter a Y in this field if you agree with the applicant's value.

As with other forms, you may discard your changes by pressing [Esc]. In the parameter forms, press [Esc] before entering a value in the Checked field.

Now, press [Esc] to return to the Parameter menu, then press [Esc] again to return to the Stream menu.

STREAM/HAP

Now, press H to invoke the HAP sub-menu.

The HAP sub-menu activity is designed to help you to specify which hazardous air pollutants (HAPs) exist in the emission stream and to specify the physical parameters for each. There are four options under this sub-menu, as shown in Figure 7.

STREAM/HAP/GENERATE

Now, press G for Generate.

CAT contains a data base that identifies which pollutants may be associated with different Standard Industrial Classification (SIC) codes. Figure 7 presents the pop-up menu of SIC codes obtained by running the Generate option. Try the **[Home]** and **[End]** keys and note that they will take you to the start and end of the pop-up menu.

```
          Generate          Review          Add          Delete
              Generate a list of candidate HAPs from the SIC code.
             Select the SIC code and press Enter or Esc to abort

2591 DRAPERY HARDWARE & BLINDS & SHADES
2599 FURNITURE AND FIXTURES, NEC
2611 PULP MILLS
2621 PAPER MILLS, EXCEPT BUILDING PAPER
2631 PAPERBOARD MILLS
2641 PAPER COATING AND GLAZING
2643 BAGS, EXCEPT TEXTILE BAGS
2644 CONVERTED PAPER AND PAPERBOARD PRODUCTS
2645 DIE-CUT PAPER AND BOARD
2647 SANITARY PAPER PRODUCTS
2648 STATIONERY PRODUCTS
2649 CONVERTED PAPER PRODUCTS, NEC
2651 FOLDING PAPERBOARD BOXES
2653 CORRUGATED AND SOLID FIBER BOXES
2654 SANITARY FOOD CONTAINERS
2655 FIBER CANS, DRUMS & SIMILAR PRODUCTS
2661 BUILDING PAPER AND BOARD MILLS
2700 PRINTING AND PUBLISHING
2711 NEWSPAPERS
```

Figure 7. Selecting Pollutants Based on SIC Code.

Now, use the [UpArrow] and [DnArrow] keys to select 2641 PAPER COATING AND GLAZING, and press [Enter].

After a moment, CAT will display a list of pollutants and CAS numbers (see Figure 8). As of now, CAT believes that these are the pollutants contained in the emission stream. This display is also a pop-up menu; to edit the parameters for any pollutant, highlight the pollutant using the cursor motion keys and press **[Enter]**.

```
        Generate          Review          Add          Delete
            Generate a list of candidate HAPs from the SIC code

  67-64-1  ACETONE
7664-41-7  AMMONIA
  78-93-3  BUTANONE,2-
 630-08-0  CARBON MONOXIDE
  64-17-5  ETHANOL
  50-00-0  FORMALDEHYDE
7783-06-4  HYDROGEN SULFIDE
  78-83-1  ISOBUTYL ALCOHOL
  67-63-0  ISOPROPANOL
  67-56-1  METHANOL
 127-18-4  TETRACHLOROETHYLENE
 108-88-3  TOLUENE
  71-55-6  TRICHLOROETHANE,1,1,1-
```

Figure 8. Possible Pollutants from SIC Code 2641.

Now, select the pollutant TOLUENE and press [Enter].

A parameter pop-up menu for TOLUENE overlays the pollutant pop-up menu (see Figure 9). This pop-up menu shows physical parameters for TOLUENE, with all available parameters filled out from the data base.

```
   Generate            Review            Add            Delete
             Review the HAPs in the emission stream.
   Select TOLUENE parameter and press Enter, or Esc to exit

Parameter ------------------------------------ Appl ----- Calc - Checked
        Inlet HAP concentration (ppmv)                      73
         Molecular weight (lb/lb-mole)                   92 15
     Specific heat equation constant A                   0 576
     Specific heat equation constant B                  93 493
     Specific heat equation constant C                 -31 227
           Antoine equation constant A                 6 95464
           Antoine equation constant B                  1344 8
           Antoine equation constant C                  219.48
   Heat of vaporization (Btu/lb-mole)                 14262 60
```

Figure 9. Changing the Parameters for TOLUENE.

Now, select the Inlet HAP concentration (ppmv) parameter and press [Enter]. Add a Calculation value of 73 ppmv. Use the [UpArrow] and [DnArrow] keys, the [Enter] key or the [F10] key to return to the TOLUENE parameter menu. Press [Esc] to return to the pop-up menu of pollutants and then [Esc] again to return to the HAP menu.

STREAM/HAP/REVIEW

Once you have selected the pollutants for the stream, you may get a pop-up menu of them by pressing R for Review. The screen will appear again as in Figure 8 and CAT will work as before.

STREAM/HAP/ADD

CAT stores a data base of several hundred air toxic species. You may select any one specifically by invoking A for Add from the HAP menu. There will be a slight delay while CAT accesses the data base.

Now, press A for Add. Use the [Home], [End], [PgUp], and [PgDn] keys to view the entire pop-up menu

Figure 10 depicts a portion of the pop-up menu of air toxics which may be evaluated by the CAT program. A pollutant is added to the stream by selecting it from this menu. As you do so, you will notice that the pollutant you selected disappears from the menu. You may continue to select pollutants from the menu by pressing **[Enter]**.

Note: Each pollutant you choose will be loaded from the data base and will consume several thousand bytes of memory. As a matter of practicality, you may wish to restrict the number of pollutants evaluated.

```
       Generate            Review           Add            Delete
          Add a HAP to the list of HAPs selected for evaluation

     83-32-9  ACENAPHTHENE
    208-96-8  ACENAPHTHYLENE
     75-07-0  ACETALDEHYDE
     64-19-7  ACETIC ACID
    108-24-7  ACETIC ANHYDRIDE
     67-64-1  ACETONE
     75-05-8  ACETONITRILE
     74-86-2  ACETYLENE
     50-78-2  ACETYLSALICYLIC ACID
    107-02-8  ACROLEIN
     79-06-1  ACRYLAMIDE
     79-10-7  ACRYLIC ACID
    107-13-1  ACRYLONITRILE
  15972-60-8  ALACHLOR
    107-18-6  ALLYL ALCOHOL
   7429-90-5  ALUMINUM
    133-90-4  AMIBEN
     92-67-1  AMINOBIPHENYL,4-
    504-29-0  AMINOPYRIDINE,2-
```

Figure 10. The Add Menu can Select any Species in the CAT Data base.

Now, press [Esc] to return to the HAP menu.

STREAM/HAP/DELETE

To remove a pollutant from the list of pollutants in the stream, press D for Delete and a menu similar to Figure 8 will appear. Each pollutant you select from the menu will be deleted from the stream and from the menu display.

Now press [Esc] to return to the Stream menu

STREAM/CLEAR

Now, press C for Clear.

CAT will ask if you are really sure that you want to clear the stream information; answering Y will erase all stream data from memory. The Clear option is particularly helpful if you want to review another stream from the same plant, but don't want to type in the plant identifying data again.

Now, press [Esc] or N to abort the clear operation, and press [Esc] again to return to the main menu.

DEVICE

Now, press D for Device.

A menu with the options Type and Parameters will appear.

DEVICE/TYPE

Now, press T for Type.

Figure 11 depicts what your display should look like. The devices in the pop-up menu are those devices which might be applied to an organic vapor stream. As with the Stream parameters, there are a number of parameters attached to each kind of device. Therefore, you cannot choose the Parameter option before you have specified the Type. Also, once a device type has been selected, choosing another will destroy any device data you have already entered. If you find yourself in this menu by accident and want to abandon the menu, press [Esc].

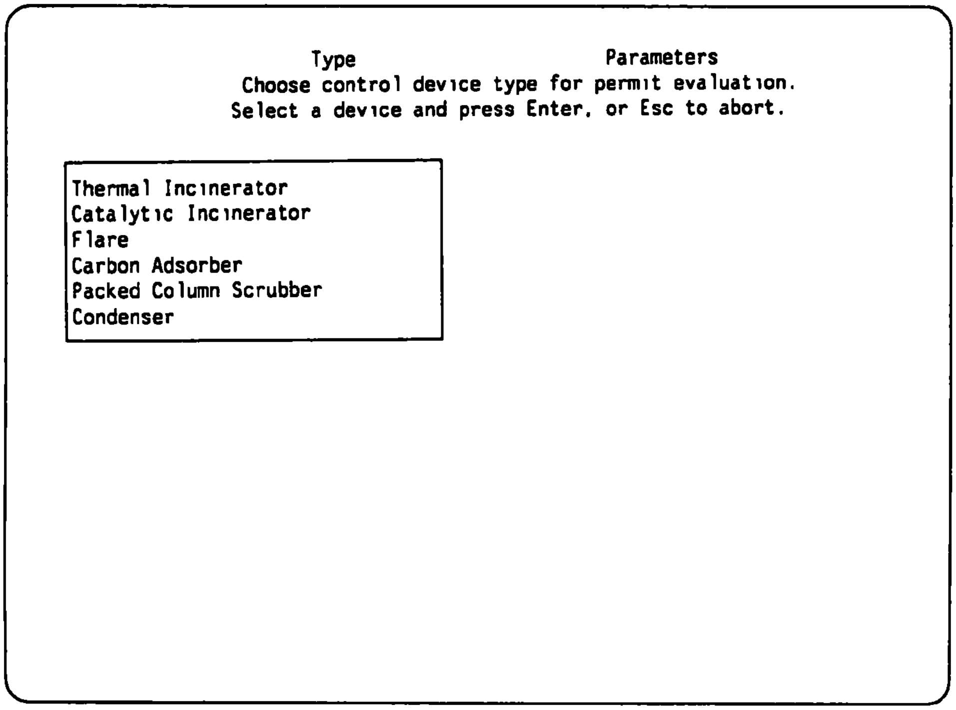

Figure 11. Selecting a Device Type.

Now, select the Thermal Incinerator and press [Enter].

DEVICE/PARAMETERS

Now, press P for Parameters.

Your display should appear as in Figure 12, with a pop-up menu of parameters. The left-justified parameters in all upper-case (e.g., DESIGN RELATED PARAMETERS) are present to organize the parameters; you cannot enter data for them.

```
                 Type                      Parameters
                 Enter parameters describing the device
   Select Thermal Incinerator parameter and press Enter, or Esc to exit

 Parameter ------------------------------------ Appl ----- Calc - Checked
DESIGN RELATED PARAMETERS..
                     Destruction efficiency (%)                99
                  Combustion temperature (degF)              1800
                          Residence time (sec)                 75
               Is a heat exchanger used? (Y/N)                  Y
  Emission stream temp. after preheat (degF)                  960
                                Excess air (%)                  0
 Heating value of supplement fuel (Btu/scf)                   882
                  Reference temperature (degF)                 70
COST RELATED PARAMETERS
                       Duct cost ($/linear ft)                 50
                           Length of duct (ft)                100
                    Total pressure drop (in H2O)                6
                    Average equipment life (yr)                10
       Operator labor requirements (hr/shift)                   5
    Maintenance labor requirements (hr/shift)                   5
```

Figure 12. The Parameter Menu for a Thermal Incinerator.

Explore the menu. As with other parameter pop-up menus, selecting any parameter will cause a parameter form to appear.

Now, select the Combustion temperature using [UpArrow] and [DnArrow], then press [Enter].

Figure 13 presents the parameter form for the variable Tc.

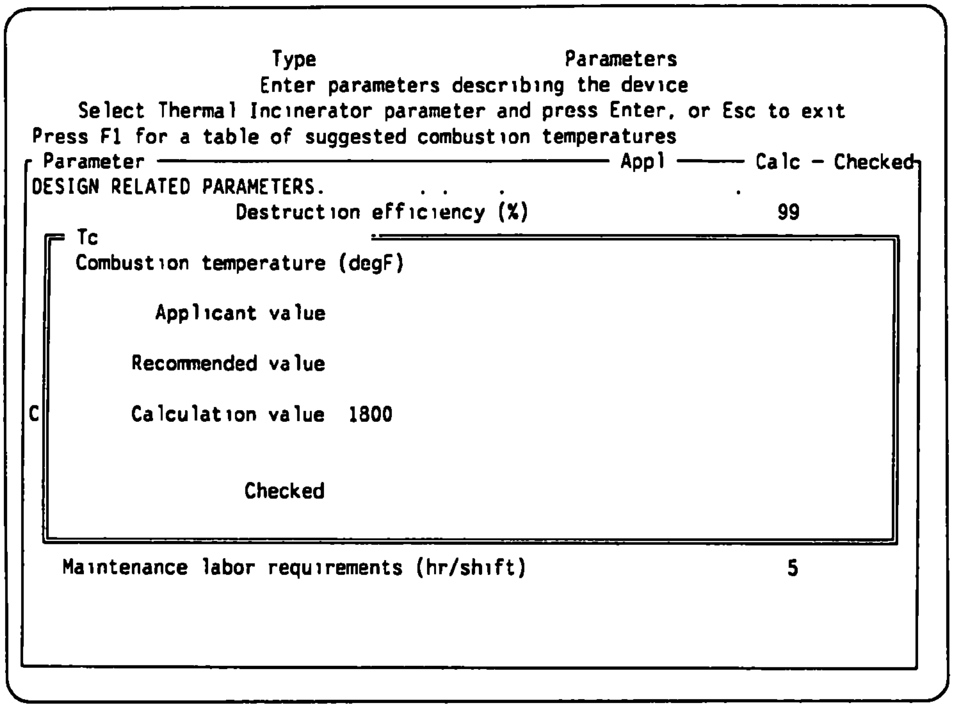

Figure 13. Changing the Calculation Value for the Combustion Temperature.

Now, press [F1] for on-line help.

If you follow the suggestion on line 4 of the display, you will receive on-line help for this parameter (see Figure 14). Help is available from many of the fields in the CAT program. From any field, simply press the help key, [F1], and the text should be displayed in the lower portion of the screen. While in the help window, you may scroll the text by using the arrow keys. To turn help off, press the help key again.

```
                    Type                          Parameters
                    Enter parameters describing the device.
        Select Thermal Incinerator parameter and press Enter, or Esc to exit.
   Use cursor pad keys to scroll through help file
 Parameter ------------------------------------ Appl ----- Calc - Checked
DESIGN RELATED PARAMETERS
                 Destruction efficiency (%)                  99
  Tc

      Based on the required destruction efficiency, the combustion
        temperature and residence time are determined from Table 4-1
        in the manual:
```

Required Destruction Efficiency DE (%)	Nonhalogenated Stream Combustion Temperature Tc (F)	Nonhalogenated Stream Residence Time tr (sec)	Halogenated Stream Combustion Temperature Tc (F)	Halogenated Stream Residence Time tr (sec)
98	1,600	0 75	2,000	1 0
99	1,800	0 75	2,200	1 0

Figure 14. Getting On-Line Help.

Now, press [F1] again to turn help off. Press [Esc] to return to the Parameters menu, and press [Esc] again to return to the Device menu. Then press [Esc] once more to return to the main menu.

REVIEW

Now, press R to Review the application.

The Review menu (Figure 15) allows you to see the results of the review on your display or print them on your printer. You can also control which portions of the review that you want to see.

```
          Evaluate          Cost          View          Print
                   Evaluate the applicant's design parameters
```

Figure 15. The Review Menu.

REVIEW/EVALUATE

Now, press E to Evalute the application.

Your display should appear as in Figure 16. The Intermediate Results always list intermediate computed values. This is intended to help you trace the calculations performed by CAT. The Permit Evaluation section lists the parameters from the PERMIT EVALUATION section of the device parameter menu. If the evaluation is longer than the display box, you may scroll through it by using the **[UpArrow]**, **[DnArrow]**, **[PgUp]**, and **[PgDn]** keys.

```
          Evaluate            Cost             View             Print
                  Evaluate the applicant's design parameters
         Press PgUp, PgDn, Home, and End to scroll, Esc when finished

Intermediate Results:

                       Cpair(960) = 0.0189
                      Cpair(1800) = 0.0203
                               Qc = 0
                         deltaTLM = 840

Permit Evaluation

    Supplementary heat requirement (Btu/min)                 313486
         Supplementary fuel flow rate (scfm)                    355
                   Flue gas flow rate (scfm)                  15355
             Combustion chamber volume (ft3)                    859
           Heat exchanger surface area (ft2)                   4279
```

Figure 16. Evaluating the Design Parameters.

Now, press [Esc] to return to the Review menu.

REVIEW/COST

Now, press C to get estimates of the Cost of the equipment.

Figure 17 shows the detail produced by running the Cost option. The total capital investment and components of the annualized cost are presented.

```
        Evaluate          Cost           View           Print
           Present estimates of the capital and annualized cost
        Press PgUp, PgDn, Home, and End to scroll, Esc when finished

Total Capital Investment (June 1985 Dollars)

                                         355462

Direct Operating Costs

    Natural Gas                          778515
    Electricity                           39867
    Operator Labor                         6197
    Operator Supervision                    930
    Maintenance Labor                      6197
    Maintenance Materials                  6197

Indirect Operating Costs
```

Figure 17. Computing Capital and Operating Costs.

Now, press [Esc] to return to the Review menu.

REVIEW/VIEW

Now, press V for the View option.

Your display should appear as in Figure 18, with a pop-up menu of four choices on the left side of the display. View is intended to allow you to preview the report before it is printed. View and Print will produce exactly the same results, except that View sends its output to a window on the screen, while Print sends output to a file or the printer.

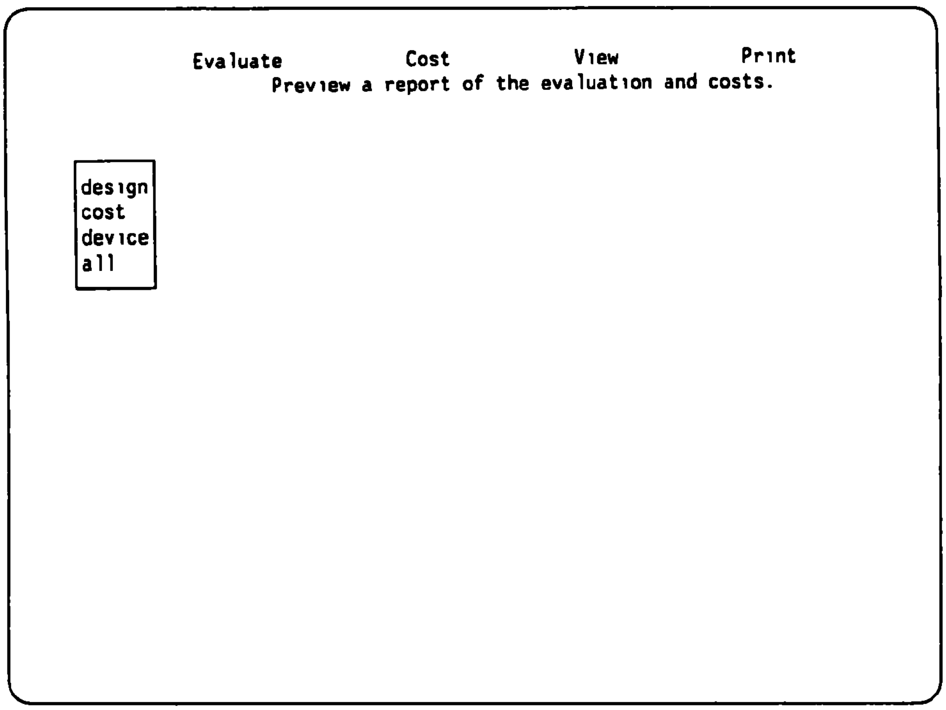

Figure 18. Viewing a Report on the Screen.

If you select design or cost from the menu, you will get the same report as if you selected Evaluate or Cost, above. If you select device, you will receive a report detailing how well suited the device may be to the emission stream. If you select all, you will receive a report with all of the design, cost, and device data.

Now, select device from the menu and press [Enter]. Then press [Esc] to return to the Review menu.

REVIEW/PRINT

Now, press P for Print.

Figure 19 shows CAT prompting you for the file name to which you wish your report to go. The default name PRN provided for you will send your output to the printer. If you wish the result to go to a file, erase the "PRN" and enter the name of the file in which you wish to store the report. Otherwise, the Print option behaves the same as the View option, described above.

```
            Evaluate          Cost          View          Print
                      Print a report of the evaluation and costs
 File Name.  PRN
  Enter the name of the file in which to place the report.
```

Figure 19. Printing a Report.

Now, press [Esc] to return to the Review menu without printing. Press [Esc] again to return to the main menu.

FILE

Now, press F for File.

The File option allows you to save your evaluation on disk and recall it later; a handy way to save that hard work.

FILE/SAVE

Now, press S for Save.

Figure 20 shows CAT asking for the name of the file in which to save the current review data. The name entered must be any valid DOS pathname. Some possibilities are:

glaze.cat
A:glaze.cat
glaze\stream1.cat
\john\nov88\glaze.cat

The first example shows using a simple file name. Refer to your DOS manual for the rules governing file names. The second example demonstrates saving a file on a floppy in drive A. Examples three and four demonstrate taking advantage of the DOS file hierarchy to organize the files you use. See your DOS manual for more on directory hierarchies.

If you enter the name of an existing file, CAT will ask if you want to overwrite the file. If you answer Y, the previous contents of the file will be lost.

```
                    Save                         Recall
          Save the review information to a disk file for later use
File Name   ti cat
 Enter the name of the file in which to save the evaluation
```

Figure 20. Saving Your Work.

Now, enter MYFILE. CAT and press [Enter] to save the review.

Note: Unlike other menu options in CAT, when a File option is finished, it returns you automatically to the main menu. This was done intentionally to make the program easier for you to use.

FILE/RECALL

Now, press F for File, then R for Recall.

Figure 21 shows the CAT program asking for the name of the file to read. The file named must conform to the rules discussed under FILE/SAVE, above, and must have been Saved by the CAT program.

```
                     Save                          Recall
                Recall permit information which was Saved previously.
File Name
 Enter the name of the file from which to read the evaluation
```

Figure 21. Recalling a Review.

Now, press [Esc] to return to the File menu, and press [Esc] again to return to the main menu.

CLEAR

Now, press C for Clear.

The Clear option provides a way for you to start the CAT program from scratch without having to quit and return to the program. As shown in Figure 22, Clear asks you if you really want to proceed before it clears memory.

```
      Plant     Stream     Device     Review     File     Clear     Quit
                       Erase the current review from memory.
Are you really sure? [Y/N]
 Clear will erase everything from memory
```

Figure 22. Clearing Memory.

Now, press N to leave without clearing memory.

QUIT

Now, press Q to Quit the CAT program.

CAT will ask if you are sure that you want to quit. Be sure that you have saved whatever you are working on before you answer Y, as all your work will be lost if you do not.

Now, press Y to return to DOS.

SECTION 4

DATA ENTRY CONTROL KEYS

Edit Commands

[Backspace]
Deletes character to the left of cursor and closes text.

[Del]
Deletes character at the cursor and closes text.

[Ins]
Toggles insert mode. In insert mode, characters are inserted at the current cursor position. Characters will not be inserted if they would push existing text beyond the boundary of a field.

[F5]
Clear the data field. Protected characters remain.

[F6]
Clear to end of field. Protected characters remain.

Field Commands

[Left Arrow]
Moves cursor to the left without affecting text.

[Right Arrow]
Moves cursor to right without affecting text.

[Enter]
Enter a block of data into the computer's memory.

[PgUp]
[UpArrow]
Prior field is made the active field. If already in the first field, remain in that field.

[PgDn]
[DnArrow]
Next field is made the active field. If already in the last field, remain in that field.

[Home]
Go to the first field on the form.

[End]
Go to the last field on the form.

[Esc]

Abort the data entry.

[F10]

Exit the data form; save entered data.

Help Commands

[F1]

Enter and Exit (toggle) Help Window.

APPENDIX A - COSTING METHODOLOGY

The following is a discussion of the methodology used to develop costs for controlling emissions of hazardous air pollutants. The approach and cost data are those used in the manual *Control Technologies for Hazardous Air Pollutants*, (EPA/625/6-86/014) unless specified differently. The possible control devices include thermal incinerators, catalytic incinerators, flares, carbon adsorbers, packed column scrubbers, condensers, fabric filters and venturi scrubbers. A general costing methodology for capital and annualized costs is developed and a brief description of costing for each control device is presented. This appendix concludes with an example of costing a thermal incinerator. All costs in this program are based on June 1985 dollars.

TOTAL CAPITAL INVESTMENT

The total capital investment can be broken down into direct and indirect costs, as shown below:

Direct Capital Costs:
- Control Device
- Auxiliary Equipment
- Instrumentation and Controls
- Taxes
- Freight Charges

Direct Installation Costs:
- Site Preparation
- Foundation and Supports
- Erection and Handling
- Electrical
- Piping
- Insulation
- Painting

Indirect Capital Costs:
- Engineering and Supervision
- Construction and Field Expenses
- Construction Fee
- Start-Up
- Performance Test
- Model Study

Based on the cost data available, the cost for some control devices includes auxiliary equipment, instrumentation and controls, taxes, and freight charges in the direct capital cost. For example, the cost for a thermal incinerator system includes the cost of a heat exchanger (if heat recovery is practiced), an exhaust stack, instrumentation and controls, taxes, and freight charges, but the cost for ducting must be determined separately. For each control device, the cost items included in the total capital investment are shown below.

ANNUAL OPERATING COSTS

The annual operating costs are also broken down into direct and indirect costs:

Direct Operating Costs:

Utilities
- Natural Gas
- Electricity
- Steam
- Water

Operating Labor and Maintenance
- Operating Labor
- Supervisory Labor
- Maintenance Labor
- Maintenance Materials

Replacement Parts

Replacement Labor

Indirect Operating Costs:

Overhead
Property Tax
Insurance
Administrative
Capital Recovery

Summing the direct and indirect operating costs yields the total annualized operating cost. The net annualized cost is determined by subtracting the solvent recovery credit, where it applies.

THERMAL INCINERATOR

Total Capital Investment
- Incinerator System Cost (Reference 2)
- Ducting Cost

Direct Operating Costs
- Natural Gas Cost
- Electricity Cost
- Operating Labor and Maintenance Cost

Indirect Operating Costs

CATALYTIC INCINERATOR

Total Capital Investment
- Incinerator System Cost (Reference 2)
- Ducting Cost

Direct Operating Cost
- Natural Gas Cost
- Electricity Cost
- Operating Labor and Maintenance Cost
- Replacement Parts Cost
- Replacement Labor Cost

Indirect Operating Costs

FLARE

Total Capital Investment
- Flare System Cost (Reference 3)
- Ducting Cost

Direct Operating Costs
- Natural Gas Cost
- Electricity Cost
- Steam Cost
- Operating Labor and Maintenance Cost

Indirect Operating Costs

CARBON ADSORBER

Total Capital Investment
- Adsorber System Cost (Reference 2)

Direct Operating Costs
- Steam Cost
- Natural Gas Cost
- Electricity Cost
- Operating Labor and Maintenance Cost
- Replacement Parts Cost
- Replacement Labor Cost

Indirect Operating Costs

Solvent Recovery Credit

PACKED COLUMN SCRUBBER

Total Capital Investment
- Absorber System Cost
- Ducting Cost
- Fan Cost
- Stack Cost
- Platform Cost
- Packing Cost

Direct Operating Costs
- Electricity Cost
- Absorbent Cost
- Operating Labor and Maintenance Cost

Indirect Operating Costs

CONDENSER

Total Capital Investment
- Condenser System Cost
- Refrigerant Cost

Direct Operating Costs
- Electricity Cost
- Coolant (water or other) Cost
- Operating Labor and Maintenance Cost

Indirect Operating Costs

Solvent Recovery Credit

FABRIC FILTER

Total Capital Investment
- Baghouse Cost
- Bag Cost
- Ducting Cost
- Fan Cost

Direct Operating Costs
- Electricity Cost
- Operating Labor and Maintenance Cost
- Replacement Parts Cost
- Replacement Labor Cost

Indirect Operating Costs

VENTURI SCRUBBER

Total Capital Investment
- Scrubber System Cost
- Ducting Cost
- Fan Cost

Direct Operating Cost
- Water Cost
- Electricity Cost
- Operating Labor and Maintenance Cost

Indirect Operating Cost

EXAMPLE

Following is an example of estimating the costs for the purchase and operation of a thermal incinerator. The example incorporates the emission stream characteristics presented in the HAP manual.

The emission stream parameters are:

Maximum flow rate (scfm)	15000
Pressure (mmHg)	
Temperature (degF)	120
Heat content (Btu/scf)	0.4
Oxygen content (%)	20.6
Moisture content (%)	2.0
Are halogenated organics present? (Y/N)	N
Are metals present? (Y/N)	N

The input design parameters are: -

Destruction efficiency (%)	99
Combustion temperature (degF)	1800
Residence time (sec)	0.75
Is a heat exchanger used? (Y/N)	Y
Emission stream temp. after preheat (degF)	960
Excess air (%)	0
Heating value of supplement. fuel (Btu/scf)	882
Reference temperature (degF)	70

The costing parameters are:

Duct cost (June 1985$/linear ft)	50
Length of duct (ft)	100
Total pressure drop (in. H2O)	6
Average equipment life (yr)	10
Operator labor requirements (hr/shift)	0.5
Maintenance labor requirements (hr/shift)	0.5

The evaluation parameters relevant to costing are:

Supplementary fuel flow rate (scfm)	355
Flue gas flow rate (scfm)	15,355

Calculation of percent heat recovery:

HR = 100 X ((The - Te)/(Tc - Te))

where:

The = emission stream temperature after preheat (degF)
Te = emission stream temperature before preheat (degF)
Tc = combustion temperature (degF)

HR = 100 X ((960 - 120)/(1800 - 120))

HR = 50%

Determination of incinerator cost for 50% heat recovery:

The incinerator cost equation from Reference 2 is based on a combution temperature of 1,500 degF. Use the following correction for the flue gas flow rate for temperatures higher than 1,500 degF:

Qfgc = Qfg X (Tc + 460.0)/1960.0 = 17,705 scfm

Equipment Cost = $e^{.001 \times (15,784 - 1,165(\ln Qfgc) + 81 \times \ln Qfgc \times \ln Qfgc)}$

Equipment Cost = $187,284 (April 1986 dollars)

The equipment cost must be de-escalated from April 1986 dollars to June 1985 dollars, where:

April 1986 Index = 310.6
June 1985 Index = 336.2

Equipment Cost = (187,284) X (336.2/310.6)

Equipment Cost = $202,458 (1985 dollars)

Note: This includes instrumentation and controls. Assuming that these costs are 9-10% of the equipment cost, the actual equipment cost is $202,458 X 0.9, or $182,213.

Determination of ducting cost:

Duct Cost = (Length of Duct) X ($ per linear foot)

Duct Cost = (100 feet) X (50 $ per linear foot)

Duct Cost = $5,000 (1985 dollars)

Determination of Total Capital Investment (TCI):

Table 3-3 from Capital and Operating Costs of Selected Air Pollution Control Systems (Reference 4) is used to determine the total capital investment. The sum of the control device cost and ducting cost (auxiliary equipment) yields the variable 'A'.

Direct Costs

Control Device	182,213
Ducting	5,000
Purchased Equipment Costs (A)	187,213
Instruments and Controls	0.10A
Taxes	0.03A
Freight	0.05A
Purchased Eqpt. Costs	1.00A
Total Purchased Equipment Cost (B)	1.18A

Direct Installation Costs	
Foundations and Supports	0.08B
Erection and Handling	0.14B
Electrical	0.04B
Piping	0.02B
Insulation	0.01B
Painting	0.01B
Total Direct Installation Costs	0.30B
Total Purchased Eqpt. Cost	1.00B
Total Direct Costs	1.30B
Indirect Costs	
Engineering and Supervision	0.10B
Construction & Field Expenses	0.05B
Construction Fee	0.10B
Start-Up	0.02B
Performance Test	0.01B
Contingencies	0.03B
Total Indirect Costs	0.31B
Total Direct and Indirect Costs	1.61B

To determine the total capital investment, sum the control device cost and the ducting cost, then multiply by the capital cost factors.

Purchased Equipment Cost = Incinerator + Ducting

Purchased Equipment Cost = 182,213 + 5,000

Purchased Equipment Cost = $187,213

TCI = Purchased Equipment Cost X 1.18 X 1.61

TCI = $355,666

Elements of the Operating Costs (Table 5-9, Reference 1):

Element Unit	Cost/Factor
Natural Gas	$0.00425 per scf
Water	$0.0003 per gal
Steam	$0.00504 per lb
Electricity	$0.059 per kWh
Solvent	As Applicable
Operator Labor	$11.53 per hour
Supervisory Labor	15% Operator Labor
Maintenance Labor	$11.53 per hour
Maintenance Materials	100% Maintenance Labor
Replacement Parts	As Applicable
Replacement Labor	100% Replacement Parts

Determination of Indirect Operating Costs:

Overhead	60% of Operator, Supervisory, Maintenance and Replacement Labor (Reference 2)
Property Tax	1.0% of Total Capital Investment
Insurance	1.0% of Total Capital Investment
Administrative	2.0% of Total Capital Investment

Determination of Natural Gas Cost:

Gas = Fuel Flow Rate X Annual Operation X Gas Price

Annual Operation = (8600 hrs per yr) X (60 min per hour) = 516,000 min per yr

Gas = (355 scfm) X (5.16E5 min per yr) X (0.00425 $ per scf) = $778,515

Determination of Fan Electricity Requirement (FER):

FER = 2.0E-4 X Qfg,a X delta P X Annual Operation

where: Qfg,a = Flue Gas Flow Rate at Actual Conditions
Qfg,a = Qfg X (Tc + 460)/530
Qfg,a = 15,355 X (1,800 + 460)/530
Qfg,a = 65,480 acfm

FER = 2.0E-4 X 65,480 X 6 X 8600 = 675,750 kWh

Determination of Electrical Cost:

Elec = FER X Elec Price

Elec = (675,750 kWh) X (0.059 $ per kWh) = $39,870

Determination of Labor Costs:

Operating Labor = Labor Required X Annual Hours X Labor Rate

Operating Labor = (0.5 hr per shift) X (2 shifts per 8 hr) X (8600 hr per yr)
X (11.53 $ per hr)

Operating Labor = $6,200

Supervisory Labor Cost = 15% of Operating Labor Cost

Supervisory Labor Cost = $930

Maintenance Labor = Labor Reqd X Annual Hrs. X Labor Rate

Maintenance Labor = (0.5 hr per shift) X (2 shifts per 8 hr) X (8600 hr per yr)
X (11.53 $ per hr)

Maintenance Labor = $6,200

Maintenance Materials = Maintenance Labor

Operating Labor and Maintenance Cost = 6,200 + 930 + 6,200 + 6,200

Operating Labor and Maintenance Cost = $19,530

Replacement Labor = $0 (not required for Thermal Incineration)

Replacement Parts = $0 (not required for Thermal Incineration)

Determination of Direct Operating Costs (DOC)

DOC = Gas + Elec + Operating Labor and Maintenance Cost + Replacement Labor + Replacement Parts

DOC = 778,515 + 39,870 + 19,530 + 0 + 0

DOC = $837,910

Determination of Indirect Operating Costs (IDOC):

IDOC = Overhead + Property Tax + Insurance + Administration

where:

Overhead	= 60% of Operator, Supervisory, Maintenance, and Replacement Labor = 60% (6,200 + 930 + 6,200 + 0) = $7,998
Property Tax	= 1% TCI = $3,557
Insurance	= 1% TCI = $3,557
Administration	= 2% TCI = $7,114

Indirect Operating Costs = $22,226

Determination of Total Annual Operating Costs:

Total Operating = Direct Cost + Indirect Cost

Total Operating = 837,910 + 22,226

Total Operating = $860,136

Determination of Capital Recovery Cost:

$$CRF = \frac{i\,(1+i)^n}{(1+i)^n - 1}$$

where:

CRF represents capital recovery factor
i represents interest rate (fraction)
n represents equipment life (years)

CRF = 0.163 at 10% for 10 years

Annual Capital Recovery = CRF X TCI = $57,974

Determination of Net Annualized Cost:

Net Annualized Cost = Total Operating + Capital Recovery - Recovery Credit

Recovery Credit = 0

Net Annualized Cost = 860,136 + 57,974 - 0 = $918,110

REFERENCES

1.) Control Technologies for Hazardous Air Pollutants, Report No. EPA/625/6-86/014, U.S. Environmental Protection Agency, Research Triangle Park, NC, September 1986.

2.) EAB Control Cost Manual, 3rd Edition, Report No. EPA/450/5-87-001A, U.S. Environmental Protection Agency, Research Triangle Park, NC, February 1987.

3.) Chemical Engineering, "Costs of Flares," Volume 90, Number 4, February 21, 1983, p.89-90.

4.) Neveril, R.B., Capital and Operating Costs of Selected Air Pollution Control Systems, Report No. EPA/450/5-80-002, Research Triangle Park, NC, December 1978.

APPENDIX B - DATA INPUT FORMS

In the following forms, fields preceded by asterisks (*) **must** be entered by the user in order for CAT to perform calculations.

CAT Analysis for Thermal Incinerator

Plant:

Name:
Address:
City: State: Zip:
Contact:
Phone:
Reviewer:

Emission Stream Input Parameters:

* Maximum flow rate (scfm) .... ____________
* Pressure (mmHg) .... ____________
* Temperature (degF) .... ____________
* Heat content (Btu/scf) .... ____________
* Oxygen content (%) .... ____________
* Moisture content (%) .... ____________
Relative humidity (%) .... ____________
* Are halogenated organics present? (Y/N) .... ____________
Are metals present? (Y/N) .... ____________

Hazardous Air Pollutant:

Molecular weight (lb/lb-mole) .... ____________
* Inlet HAP concentration (ppmv) .... ____________
Heat of vaporization (Btu/lb-mole) .... ____________

Design-related Input Parameters:

* Destruction efficiency (%) .... ____________
* Combustion temperature (degF) .... ____________
* Residence time (sec) .... ____________
* Is a heat exchanger used? (Y/N) .... ____________
* Emission stream temp. after preheat (degF) .... ____________
* Excess air (%) .... ____________
* Heating value of supplementary fuel (Btu/scf) .... ____________
* Reference temperature (degF) .... ____________

Cost-related Input Parameters:

* Duct cost (1985 $/linear ft) .... ____________
* Length of duct (ft) .... ____________
* Total pressure drop (in. H2O) .... ____________
Average equipment life (yr) .... ____________
* Operator labor requirements (hr/shift) .... ____________
* Maintenance labor requirements (hr/shift) .... ____________

CAT Analysis for Catalytic Incinerator

Plant:

Name:
Address:
City: State: Zip:
Contact:
Phone:
Reviewer:

Emission Stream Input Parameters:

* Maximum flow rate (scfm) .... ____________
Pressure (mmHg) .... ____________
* Temperature (degF) .... ____________
* Heat content (Btu/scf) .... ____________
* Oxygen content (%) .... ____________
* Moisture content (%) .... ____________
Relative humidity (%) .... ____________
Are halogenated organics present? (Y/N) .... ____________
Are metals present? (Y/N) .... ____________

Hazardous Air Pollutant:

Molecular weight (lb/lb-mole) .... ____________
* Inlet HAP concentration (ppmv) .... ____________
Heat of vaporization (Btu/lb-mole) .... ____________

Design-related Input Parameters:

* Destruction efficiency (%) .... ____________
* Is a heat exchanger used? (Y/N) .... ____________
* Emission stream temp. after preheat (degF) .... ____________
* Temp. of gas from the bed (degF) .... ____________
* Temp. of combined gas entering the bed (degF) .... ____________
* Space velocity (per hr) .... ____________
* Excess air (%) .... ____________
* Heating value of supplementary fuel (Btu/scf) .... ____________
* Reference temperature (degF) .... ____________
* Min. temp. of stream for adequate rxn. (degF) .... ____________
* Min. temp. of gas from the catalyst bed (degF) .... ____________
* Max. temp. of gas from the catalyst bed (degF) .... ____________

Cost-related Input Parameters:

* Duct cost (1985 $/linear ft) . . . . ____________
* Length of duct (ft) . . . . ____________
* Total pressure drop (in. H2O) . . . . ____________
* Average equipment life (yr) . . . . ____________
* Operator labor requirements (hr/shift) . . . . ____________
* Maintenance labor requirements (hr/shift) . . . . ____________

CAT Analysis for Flare

Plant:

Name:
Address:
City: State: Zip:
Contact:
Phone:
Reviewer:

Emission Stream Input Parameters:

* Maximum flow rate (scfm)	____________
Pressure (mmHg)	____________
* Temperature (degF)	____________
* Heat content (Btu/scf)	____________
Oxygen content (%)	____________
Moisture content (%)	____________
Relative humidity (%)	____________
Are halogenated organics present? (Y/N)	____________
Are metals present? (Y/N)	____________

Design-related Input Parameters:

* Destruction efficiency (%)	____________
* Flare tip diameter (in)	____________
* Temperature of flare gas (degF)	____________
* Flare gas heat content (Btu/scf)	____________
* Supplementary fuel heat content (Btu/scf)	____________
* Avg. mol. wt. of the stream (lb/lb-mole)	____________

Cost-related Input Parameters:

* Duct cost (1985 $/linear ft)	____________
* Length of duct (ft)	____________
* Total pressure drop (in. H2O)	____________
Average equipment life (yr)	____________
* Operator labor requirements (hr/shift)	____________
* Maintenance labor requirements (hr/shift)	____________

CAT Analysis for Carbon Adsorber

Plant:

Name:
Address:
City: State: Zip:
Contact:
Phone:
Reviewer:

Emission Stream Input Parameters:

* Maximum flow rate (scfm)	____________
Pressure (mmHg)	____________
* Temperature (degF)	____________
Heat content (Btu/scf)	____________
Oxygen content (%)	____________
Moisture content (%)	____________
* Relative humidity (%)	____________
Are halogenated organics present? (Y/N)	____________
Are metals present? (Y/N)	____________

Hazardous Air Pollutant:

Molecular weight (lb/lb-mole)	____________
* Inlet HAP concentration (ppmv)	____________
Heat of vaporization (Btu/lb-mole)	____________

Design-related Input Parameters:

* Removal efficiency (%)	____________
* Adsorptive capacity (lb HAP/100 lb carbon)	____________
* Number of beds	____________
* Cycle time for adsorption (hr)	____________
* Cycle time for regeneration (hr)	____________
* Stream velocity through the bed (ft/min)	____________
* Steam ratio (lb steam/lb carbon)	____________
* Steam inlet temperature (degF)	____________
* Condensed steam outlet temperature (degF)	____________
* Cooling water inlet temperature (degF)	____________
* Cooling water outlet temperature (degF)	____________
* Carbon bed density (lb/ft^3)	____________
* Cycle time for drying and cooling (hr)	____________
* Latent heat of vaporization (Btu/lb)	____________
* Average specific heat of water (Btu/lb-degF)	____________
* Overall heat trans. coeff. (Btu/hr-ft^2-degF)	____________

Cost-related Input Parameters:

* Value of recovered product (1985 $/lb)	____________
* Duct cost (1985 $/linear ft)	____________
* Stack capital cost (1985 $)	____________
Length of duct (ft)	____________
* Total pressure drop (in. H2O)	____________
Average equipment life (yr)	____________
* Operator labor requirements (hr/shift)	____________
* Maintenance labor requirements (hr/shift)	____________

CAT Analysis for Packed Column Scrubber

Plant:

Name:
Address:
City: State: Zip:
Contact:
Phone:
Reviewer:

Emission Stream Input Parameters:

* Maximum flow rate (scfm) .... ____________
Pressure (mmHg) .... ____________
* Temperature (degF) .... ____________
Heat content (Btu/scf) .... ____________
Oxygen content (%) .... ____________
Moisture content (%) .... ____________
Relative humidity (%) .... ____________
Are halogenated organics present? (Y/N) .... ____________
Are metals present? (Y/N) .... ____________

Hazardous Air Pollutant:

Molecular weight (lb/lb-mole) .... ____________
* Inlet HAP concentration (ppmv) .... ____________
Heat of vaporization (Btu/lb-mole) .... ____________

Design-related Input Parameters:

* Removal efficiency (%)	____________
What solvent is used?	____________
* Slope of the equilibrium curve	____________
* Absorption factor	____________
* Schmidt number for HAP/emission stream	____________
* Schmidt number for HAP/solvent	____________
* Density of the emission stream (lb/ft^3)	____________
* Density of the solvent (lb/ft^3)	____________
Avg. mol. wt. of the stream (lb/lb-mole)	____________
* Mol. wt. of the solvent (lb/lb-mole)	____________
* Solvent viscosity (centipoise)	____________
* Packing material	____________
* Packing constant a	____________
* Packing constant b	____________
* Packing constant c	____________
* Packing constant d	____________
* Packing constant epsilon	____________
* Packing constant Y	____________
* Packing constant s	____________
* Packing constant g	____________
* Packing constant r	____________
* Fraction flooding velocity	____________

Cost-related Input Parameters:

* Cost of the packing material (1985 $/ft^3)	____________
* Cost of fans and motors (1985 $)	____________
Duct cost (1985 $/linear ft)	____________
* Stack cost (1985 $)	____________
Length of duct (ft)	____________
* Total pressure drop (in. H2O)	____________
Average equipment life (yr)	____________
* Operator labor requirements (hr/shift)	____________
* Maintenance labor requirements (hr/shift)	____________

CAT Analysis for Condenser

Plant:

Name:
Address:
City: State: Zip:
Contact:
Phone:
Reviewer:

Emission Stream Input Parameters:

* Maximum flow rate (scfm) . . . . ____________
* Pressure (mmHg) . . . . ____________
* Temperature (degF) . . . . ____________
Heat content (Btu/scf) . . . . ____________
Oxygen content (%) . . . . ____________
* Moisture content (%) . . . . ____________
Relative humidity (%) . . . . ____________
Are halogenated organics present? (Y/N) . . . . ____________
Are metals present? (Y/N) . . . . ____________

Hazardous Air Pollutant:

Molecular weight (lb/lb-mole) . . . . ____________
* Inlet HAP concentration (ppmv) . . . . ____________
Heat of vaporization (Btu/lb-mole) . . . . ____________

Design-related Input Parameters:

* Removal efficiency (%) . . . . ____________
* Coolant . . . . ____________
* Inlet coolant temperature (degF) . . . . ____________
* Overall heat transf. coeff. (Btu/hr-ft^2-degF) . . . . ____________
* Avg. specific heat for coolant (Btu/lb-degF) . . . . ____________

Cost-related Input Parameters:

* Value of the recovered product (1985 $/lb) . . . . ____________
* Total cost of required coolant (1985 $) . . . . ____________
* Total pressure drop (in. H2O) . . . . ____________
Average equipment life (yr) . . . . ____________
* Operator labor requirements (hr/shift) . . . . ____________
* Maintenance labor requirements (hr/shift) . . . . ____________

CAT Analysis for Fabric Filter

Plant:

Name:
Address:
City: State: Zip:
Contact:
Phone:
Reviewer:

Emission Stream Input Parameters:

* Maximum flow rate (scfm)	________
Pressure (mmHg)	________
* Temperature (degF)	________
Moisture content (% volume)	________
Particulate content (grains/scf)	________
Mean particle diameter (microns)	________
SO3 content (ppmv)	________

Hazardous Air Pollutant:

Molecular weight (lb/lb-mole)	________
HAP concentration (% mass)	________
Heat of vaporization (Btu/lb-mole)	________

Design-related Input Parameters:

* Filter cleaning method	________
* Material type: cotton, wool, etc.	________
* Air to cloth ratio (ft/min)	________
* Baghouse configuration	________

Cost-related Input Parameters:

* Cost of baghouse (1985 $)	________
* Cost of cloth (1985 $/gross ft^2)	________
* Cost of fans and motors (1985 $)	________
* Duct cost (1985 $/linear ft)	________
* Length of duct (ft)	________
* Total pressure drop (in. H2O)	________
Average equipment life (yr)	________
* Operator labor requirements (hr/shift)	________
* Maintenance labor requirements (hr/shift)	________

CAT Analysis for Venturi Scrubber

Plant:

Name:
Address:
City: State: Zip:
Contact:
Phone:
Reviewer:

Emission Stream Input Parameters:

* Maximum flow rate (scfm)	____________
Pressure (mmHg)	____________
* Temperature (degF)	____________
Moisture content (% volume)	____________
Particulate content (grains/scf)	____________
Mean particle diameter (microns)	____________
SO3 content (ppmv)	____________

Hazardous Air Pollutant:

Molecular weight (lb/lb-mole)	____________
HAP concentration (% mass)	____________
Heat of vaporization (Btu/lb-mole)	____________

Design-related Input Parameters:

* Control efficiency (%)	____________
* Total pressure drop (in. H2O)	____________

Cost-related Input Parameters:

* Cost of fans and motors (1985 $)	____________
* Duct cost (1985 $/linear ft)	____________
Length of duct (ft)	____________
Average equipment life (yr)	____________
* Operator labor requirements (hr/shift)	____________
* Maintenance labor requirements (hr/shift)	____________

APPENDIX C - NOMENCLATURE

English units are used throughout this appendix. Metric conversion factors may be found in Appendix D.

a	= packing constant
A	= heat exchanger surface area, ft^2
A_{bed}	= carbon bed cross sectional area, ft^2
A_{column}	= absorber column cross sectional area, ft^2
A_{con}	= condenser surface area, ft^2
A_{nc}	= net cloth area, ft^2
A_p	= collection plate area, ft^2
A_t	= venturi scrubber throat area, ft^2
A_{tc}	= total cloth area, ft^2
ABS	= abscissa
AC	= adsorption capacity of carbon bed, lb HAP/100 lb carbon
A/C	= air to cloth ratio for baghouse, acfm/ft^2
AF	= absorption factor
b	= packing constant
c	= packing constant
C	= annual credits, $/yr
C_{req}	= amount of carbon required, lb
Cp_{air}	= average specific heat of air, Btu/scf-degF
$\overline{C}p_{air}$	= average specific heat of air, Btu/lb-mole-degF
Cp_{com}	= average specific heat of combined gas stream, Btu/scf-degF
$\underline{C}p_{coolant}$	= average specific heat of coolant, Btu/lb-degF
Cp_e	= average specific heat of emission stream, Btu/scf-degF
$\underline{C}p_e$	= average specific heat of emission stream, Btu/lb-degF
$\underline{C}p_f$	= average specific heat of supplementary fuel (natural gas), Btu/lb-degF
Cp_{fg}	= average specific heat of flue gas, Btu/scf-degF
$\underline{C}p_{flg}$	= average specific heat of flare gas, Btu/lb-degF
$\underline{C}p_w$	= average specific heat of water, Btu/lb-degF
$\overline{C}p_{HAP}$	= average specific heat of HAP, Btu/lb-mole-degF
CE	= collection efficiency (based on mass), %
CRF	= capital recovery factor
CRF_w	= weighted average capital recovery factor
d	= packing constant
D	= annual direct labor costs, $/yr
D_{bed}	= carbon bed diameter, ft
D_{column}	= absorber column diameter, ft
D_{duct}	= duct diameter, in.
D_p	= mean particle diameter, microns
D_t	= venturi scrubber throat diameter, ft

D_{tip}	= flare tip diameter, in.
D_G	= diffusivity in gas stream, ft^2/hr
D_L	= diffusivity in liquid, ft^2/hr
D_1	= annual operating labor cost, $/yr
D_2	= annual supervision labor cost, $/yr
DE	= destruction efficiency, %
$DE_{reported}$	= reported destruction efficiency, %
DP	= stream dew point, degF
ex	= excess air, % (volume)
f	= fraction
FE	= fabricated equipment cost index
FER	= fan electricity requirement, kWh
g	= packing constant
g_c	= gravitational constant, = 32.2 ft/sec^2
G	= gas (emission stream) flow rate, lb/hr
G_{area}	= gas (emission stream) flow rate based on column cross sectional area, $lb/sec\text{-}ft^2$
$G_{area, f}$	= gas (emission stream) flow rate at flooding conditions based on column cross sectional area, $lb/sec\text{-}ft^2$
G_{mol}	= gas (emission stream) flow rate, lb-mole/hr
h_d	= heat content of emission stream after dilution, Btu/scf
h_e	= heat content of emission stream, Btu/scf
h_f	= lower heating value of supplementary fuel (natural gas), Btu/scf
h_{flg}	= flare gas heat content, Btu/scf
ΔH	= heat of vaporization of HAP, Btu/lb-mole
H_{con}	= enthalpy change associated with condensed HAP, Btu/min
H_f	= supplementary heat requirement (heat supplied by the supplementary fuel), Btu/min
H_{load}	= condenser heat load, Btu/hr
H_{noncon}	= enthalpy change associated with noncondensible vapors, Btu/min
H_{uncon}	= enthalpy change associated with uncondensed HAP, Btu/min
H_G	= height of a gas transfer unit, ft
H_L	= height of a liquid transfer unit, ft
H_{OG}	= height of a gas transfer unit (based on overall gas film coefficients), ft
Ht_{column}	= absorber column packed height, ft
Ht_{total}	= absorber column total height, ft
HAP_{con}	= quantity of HAP condensed, lb-mole/min
HAP_e	= inlet HAP concentration, ppmv
$HAP_{e,m}$	= quantity of HAP in the emission stream entering the condenser, lb-mole/min
HAP_o	= outlet HAP concentration, ppmv
$HAP_{o,m}$	= quantity of HAP in the emission stream exiting the condenser, lb-mole/min
HP	= fan power requirement, hp (horsepower)
HR	= heat recovery in the heat exchanger, %
HRS	= number of hours of operation per year

L	= solvent flow rate, lb/hr
L''	= solvent flow rate based on absorber column cross sectional area, lb/hr-ft^2
L_{gal}	= solvent flow rate, gal/min
L_{mol}	= solvent flow rate, lb-mole/hr
L_v	= liquid flow rate in venturi scrubber, gal/min
$L_v/Q_{e,a}$	= liquid to gas ratio, gal/10^3 acf
LEL	= lower explosive limit, % (volume)
m	= slope of the equilibrium curve
M	= annual maintenance costs, $/yr
M_e	= moisture content of emission stream, % (volume)
M_1	= annual maintenance labor cost, $/yr
M_2	= annual maintenance supervision cost, $/yr
M_3	= annual maintenance materials cost, $/yr
MW_{avg}	= average molecular weight of a mixture of components, lb/lb-mole
MW_e	= average molecular weight of a emission stream, lb/lb-mole
MW_{fg}	= average molecular weight of a flare gas, lb/lb-mole
$MW_{solvent}$	= molecular weight of solvent, lb/lb-mole
MW_{HAP}	= molecular weight of HAP (average molecular weight if a mixture of HAPs is present), lb/lb-mole
N	= number of carbon beds
N_{OG}	= number of gas transfer units (based on overall gas film coefficients)
O_2	= oxygen content of emission stream, % (volume)
ORD	= ordinate
ΔP	= total pressure drop for the control system, in. H_2O
ΔP_a	= absorber column pressure drop, lb/ft^2-ft
P_e	= emission stream pressure, mmHg
$P_{partial}$	= partial pressure of HAP in emission stream, mmHg
P_{vapor}	= vapor pressure of HAP in emission stream, mmHg
ΔP_{total}	= absorber column total pressure drop, in. H_2O
ΔP_v	= pressure drop across venturi, in. H_2O
PC	= purchased equipment cost, $
Q_a	= flow rate of gas stream at actual conditions, acfm
Q_c	= combustion air flow rate, scfm
Q_{com}	= flow rate of combined gas stream entering the catalyst bed, scfm
$Q_{coolant}$	= coolant flow rate, lb/hr
$Q_{cool,w}$	= cooling water flow rate, lb/min
$Q_{e,a}$	= emission stream flow rate at actual conditions, acfm
$Q_{e,s}$	= saturated emission stream flow rate, acfm
Q_f	= supplementary fuel (natural gas) flow rate, scfm
Q_{fg}	= flue gas flow rate, scfm
$Q_{fg,a}$	= flue gas flow rate at actual conditions, acfm

Q_{fg}	= flare gas flow rate, scfm
$Q_{fg,a}$	= flare gas flow rate at actual conditions, acfm
Q_{rec}	= quantity of HAP recovered, lb/hr
Q_s	= steam flow rate, lb/min
Q_w	= cooling water flow rate, gal/min
r	= packing constant
R	= gas constant = 0.73 ft^3-atm/lb-mole degR; = 1.987 cal/g-mole K
R_{hum}	= relative humidity, %
Ref	= refrigeration capacity, tons
RE	= removal efficiency, %
$RE_{reported}$	= reported removal efficiency, %
s	= packing constant
S	= annual cost of operating supplies, $/yr
Sc_G	= Schmidt number for HAP/emission stream
Sc_L	= Schmidt number for HAP/solvent system
St	= steam ratio, lb steam/lb carbon
SV	= space velocity, hr^{-1}
t_c	= cleaning interval, min
t_r	= residence time, sec
T	= temperature, degF
T_c	= combustion temperature, degF
T_{ci}	= temperature of combined gas stream entering the catalyst bed, degF
T_{co}	= temperature of flue gas leaving the catalyst bed, degF
T_{con}	= condensation temperature, degF
$T_{cool,i}$	= inlet temperature of coolant, degF
$T_{cool,o}$	= outlet temperature of coolant, degF
T_e	= emission stream temperature, degF
$T_{e,s}$	= temperature of saturated emission stream, degF
T_{fg}	= flare gas temperature, degF
T_{he}	= emission stream temperature after heat exchanger, degF
T_r	= reference temperature, = 70 degF
T_{sti}	= inlet steam temperature, degF
T_{sto}	= condensed steam outlet temperature, degF
T_{wi}	= inlet cooling water temperature, degF
T_{wo}	= outlet cooling water temperature, degF
ΔT_{LM}	= logarithmic mean temperature difference, degF
Th_{column}	= absorber column thickness, ft
U	= overall heat transfer coefficient, Btu/hr-ft^2-degF
U_d	= drift velocity of particles, ft/sec
U_{duct}	= velocity of gas stream in the duct, ft/min
U_e	= emission stream velocity through carbon bed, ft/min
$U_{e,s}$	= throat velocity of saturated emission stream, ft/sec

U_{flg} = flare gas exit velocity, ft/sec
U_{max} = maximum flare gas velocity, ft/sec
Ut = annual utility costs, $/yr
V_c = combustion chamber volume, ft^3
V_{carbon} = volume of carbon bed, ft^3
V_{bed} = catalyst bed requirement, ft^3
$V_{packing}$ = absorber column packing volume, ft^3
W = particle grain loading, gr/acf
Wt_{column} = absorber column weight, lb
$\bar{x}$ = mole fraction of solute in solvent, moles solute/(moles solute + moles solvent)
$\bar{X}$ = mole fraction of gaseous component in liquid, moles solute/moles solvent
$\bar{y}$ = mole fraction of solute in air, moles solute/(moles solute + moles air)
Y = packing constant
$\bar{Y}$ = mole fraction of solute in air, moles solute/moles air
Z_{bed} = carbon bed depth, ft
ε = packing constant
λ = latent heat of vaporization for steam, Btu/lb
η = fan efficiency, %
ρ_{bed} = density of carbon bed, lb/ft^3
ρ_c = density of carbon steel plate, lb/ft^3
ρ_G = density of gas (emission stream), lb/ft^3
ρ_L = density of solvent, lb/ft^3
θ_{ads} = cycle time for adsorption, hr
θ_{reg} = cycle time for regeneration, hr
$\theta_{dry\text{-}cool}$ = cycle time for drying and cooling the bed, hr
μ_L = viscosity of solvent, centipoise
μ_L'' = viscosity of solvent, lb/ft-hr

APPENDIX D - ABBREVIATIONS AND CONVERSION FACTORS

EPA policy is to express all measurements used in Agency documents in metric units. Listed below are the International System of Units (SI) abbreviations and conversion factors.

To convert from	To	Multiply by
Cubic meter (m^3)	Barrel (oil) (bbl)	6.290
Cubic meter (m^3)	Cubic feet (ft^3)	3.531×10^1
Cubic meter (m^3)	Gallon (U.S. liquid) (gal)	2.643×10^2
Cubic meter/second (m^3/s)	Gallon (U.S. liquid)/min (gpm)	1.585×10^4
Degree Celsius (degC)	Degree Fahrenheit (degF)	(degC X 9/5) + 32
Joule (J)	British thermal unit (Btu)	9.480×10^{-4}
Joule (J)	Watt-hour (Wh)	2.778×10^{-4}
Kilogram (kg)	Pound-mass (lb)	2.205
Meter (m)	Feet (ft)	3.28
Meter (m)	Inch (in.)	3.937×10^1
Pascal (Pa)	Atmosphere (760 mmHg)	9.870×10^{-6}
Pascal (Pa)	Pound-force/inch^2 (psi)	1.450×10^{-4}
Watt (W)	Horsepower (electric) (hp)	1.340×10^{-3}

Standard Conditions

68 degF = 20 degC
1 atmosphere = 101,325 Pascals

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16. ABSTRACT The manual gives instructions for using Controlling Air Toxics (CAT), a computerized advisory system that can be used to control air toxics. The primary objective of this interactive and user-friendly software package is to assist in the review of air emission permit applications. The engineering software is based on the EPA document, Control Technologies for Hazardous Air Pollutants, EPA/625/6-86/014, September 1986. The software is written for the IBM PC using Microsoft V3.0 C compiler and Windows for Data Library V1.0 for screen and keyboard interaction. The permit reviewer can input information on the air emission stream characteristics as well as other information in the permit application. The program provides guidance on which control devices may be appropriate and allows the reviewer to select a specific pollutant/control device combination for evaluation. The control devices included in this program are thermal and catalytic incinerators, flares, carbon adsorbers, absorbers, condensers, fabric filters, and venturi scrubbers. The program then calculates design parameters and estimates costs for each control device selected. The results can be compared against the permit applicant's actual or proposed design. A report generator is also included in the program.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Pollution	Catalysis	Pollution Control	13B	07D
Computer Programs		Stationary Sources	09B	
Toxicity	Flares	Controlling Air Toxics	06T	19A
Emission	Scrubbers	Hazardous Air Pollutants	14G	07A, 13I
Licenses			05D	
Incinerators		Fabric Filters		

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