PROGRAM USERS MANUAL FOR

ESTIMATES OF CEMS AND ANNUAL O&M COSTS

FOR NEW AND EXISTING COMBUSTION FACILITIES

EPA Contract No. 68D90055
Work Assignment No. 49

March 21, 1991

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1.0 INTRODUCTION

Compliance with emission limits can be demonstrated by the periodic use of manual or instrumental test methods; or, the use of continuous emission monitoring systems (CEMS;s). If it is determined that compliance will be determined using manual or instrumental test methods, it may be desirable to use CEMS's to provide on-going information on the proper operation and maintenance of the process and emissions control equipment. Estimates of the costs of CEMS's are needed to decide the correct approach. The computer cost model programs outlined in this manual will estimate the incurred costs of installing CEMS's, COMS's, and flow monitors and their annual O&M costs for new and existing plants.

2.0 PURPOSES

The purposes of this manual are to provide instructions and information on how the estimated CEMS costs for different plant and CEMS configurations are derived using a computer model developed to simulate:

- Costs for the purchase, installation, and initial performance testing of CEMS's (first-costs).
- Costs for the operation and maintenance of CEMS's, including QA activities as required under Appendix F, 40 CFR Part 60 (Annual O&M Costs).

- **Section 8 provides instructions on how to run the model.**

3.0 OUTLINE

The CEMS cost estimates provided by the cost model programs are based on the judgement and experience of Entropy Environmentalists, Inc. personnel, with supporting information on approximate system costs from several CEMS vendors. Vendor estimates were provided verbally, and were modified and averaged to fit the structure and constraints of the estimating procedure.

Programs using Paradox 3.5 software were developed for extractive and point in-situ CEMS. For each type of CEMS a program was developed for:
(1) planning, purchasing, installation, and initial performance testing of CEMS's (first-costs), for new and existing facilities; and (2) annual operating and maintenance (O&M) costs. Annual O&M costs were considered the same for new and existing facilities, given the same monitoring requirements.

Section 4 summarizes the project approach and major assumptions used in the programs; Section 5 provides a description of the models and cost calculations for labor, travel, material and supplies. Section 6 is a discussion of selected results. Section 7 summarizes the more important findings of the study. Section 8 describes how to use the costing program.

4.0 PROJECT APPROACH AND MAJOR ASSUMPTIONS

4.1 PROJECT APPROACH

Estimation of CEMS costs for facilities is complex because of the permutations and combinations of parameters that might be

required to be measured; the number of work elements and tasks included in the development and implementation of a CEMS program; the diversity of CEMS designs, analytical techniques, and approaches to CEMS application at specific sources; and other factors, such as CEMS expertise and experience within a specific company and implementation practices and policies of individual control agencies. Clearly, it is not practical to attempt to estimate the costs for all CEMS programs under all conditions. It is possible, however, to structure cost-estimation models that define the work elements and tasks and provide a structure for revising case-specific cost factors such as labor rates, overhead, travel expenses, and equipment costs.

4.2 MAJOR ASSUMPTIONS

For purposes of the cost models, it was necessary to make some simplifying assumptions. These are:

4.2.1 Gas CEMS's are divided into two types: extractive and point in-situ. Extractive CEMS's are defined as systems which extract a gas sample at a measurement site and transport the sample through a conditioning system, and into separate gas analyzers. Point in-situ CEMS's are defined as those systems which allow the effluent to enter a measurement cell in the stack or duct; the effluent in the sample cell is then analyzed by a variety of techniques, some of which allow for the analysis of multiple gases by the same instrument.

4.2.2 A number of factors used in estimating costs are considered constant in all calculations. These factors are listed in Table 1. It is reasonable to expect, for example, that labor rates for environmental engineers will vary from company to company. As shown in Table 1, a fixed value of $30.00/hr was used. The labor rate becomes $66.00/hr when overhead is included.

4.2.3 The major work elements and tasks associated with the

design and implementation of a CEMS program are also fixed. The work elements and tasks are listed in Table 2.

TABLE 1. COST FACTORS USED IN ALL PROGRAMS

Item	Staffing Category			
	1	2	3	4
1. $/hr/person w/o overhead	30.00	15.00	27.00	16.00
2. Overhead	1.20	1.20	1.60	1.60
3. Hrs/person/trip	6.00	6.00	12.00	12.00
4. Fare/person/trip	200.00	200.00	600.00	600.00
5. Per Diem	100.00	75.00	100.00	75.00
6. Fee			0.10	0.10

NOTE: Column 1 = Company Environmental Engineer
Column 2 = Plant Technicians
Column 3 = Consultant
Column 4 = Emissions Testing Personnel

TABLE 2. LIST OF FIRST-COST AND O&M TASKS

FIRST-COST TASKS

1.) PLANNING:

A.) REVIEW REGULATIONS
RESOLVE QUESTIONS
C.) REVIEW DRAWING
D.) INSPECT SOURCE
E.) DEFINE SPECIFIC CONSTRAINTS
WRITE ENGINEERING REPORT

2.) SELECT TYPE OF EQUIPMENT:

A.) DECIDE ON APPROACH
B.) WRITE SPECIFICATIONS
C.) IDENTIFY POTENTIAL BIDDERS
D.) WRITE RFPs & GUARANTEES
E.) COPY & MAIL RFPs
F.) RESPOND TO BIDDERS QUESTIONS
G.) REVIEW & EVALUATE PROPOSALS
H.) SELECT WINNERS
I.) NEGOTIATE CONTRACTS

3.) PROVIDE SUPPORT FACILITIES:

A.) SAMPLING PORTS
B.) UTILITIES
C.) PLATFORMS & LADDERS
D.) INSTRUMENT ROOM

4.) PURCHASE CEMS HARDWARE:

A.) BUY OPACITY EQUIPMENT
B.) BUY GAS CEMS EQUIPMENT
C.) BUY DAS
D.) BUY SAMPLING SYSTEMS
E.) BUY FLOW MONITORS

5.) INSTALL AND CHECK CEMS:

- A.) STRATIFICATION TESTS
- B.) FINALIZE SAMPLING SITES
- C.) GET AGENCY APPROVAL
- D.) INSTALL CEMS
- E.) START-UP EQUIPMENT
- F.) RESOLVE PROBLEMS
- G.) CALIBRATIONS

6.) PERFORMANCE SPEC TEST (PST):

- A.) SELECT TEST CONTRACTOR
- B.) PRETEST MEETING W/ CONTRACTOR
- C.) DRIFT TESTS PER EPA SPECS
- D.) GAS CEMS PSTs
- E.) WRITE PST TEST REPORT
- F.) REVIEW REPORT & SEND TO AGENCY
- G.) AGENCY REVIEW & APPROVAL

7.) PREPARE QA/QC PLAN:

- A.) REVIEW NEEDS & REQUIREMENTS
- B.) HIRE CONSULTANT
- C.) ON-SITE MEETING
- D.) WRITE DRAFT PLAN
- E.) REVIEW & COMMENT ON DRAFT
- F.) WRITE FINAL PLAN
- G.) GET AGENCY APPROVAL OF PLAN
- H.) KICK-OFF MEETING AT PLANT

(Continued)

TABLE 2. (Continued)

ANNUAL O&M TASKS

8.) DAY-TO-DAY ACTIVITIES:

- A.) DAILY CHECKS OF COMS
- B.) DAILY CHECKS OF CEMS *
- C.) WEEKLY CHECKS OF COMS
- D.) WEEKLY CHECKS OF CEMS *
- E.) MONTHLY CHECKS OF COMS
- F.) MONTHLY CHECKS OF CEMS *

* NOTE FLOW MONITORS INCLUDED IN CEMS

9.) ANNUAL RATA:

- A.) PRETEST PREPARATION
- B.) HIRE TESTING TEAM
- C.) NOTIFY AGENCY
- D.) DO RATA
- E.) TAKE CORRECTIVE ACTION
- F.) RETEST
- G.) WRITE REPORT
- H.) CERTIFY & SEND REPORT TO AGENCY
- I.) AGENCY REVIEW & APPROVAL

10.) SUPPLEMENTAL RATA:

- A.) PRETEST PREPARATION
- B.) HIRE TESTING TEAM
- C.) NOTIFY AGENCY
- D.) DO RATA
- E.) TAKE CORRECTIVE ACTION

11.) QUARTERLY CGAs:

- A.) NOTIFY AGENCY
- B.) DO CGAs
- C.) TAKE CORRECTIVE ACTION
- D.) RETEST
- E.) WRITE REPORT

F.) RETEST
WRITE REPORT

H.) CERTIFY & SEND REPORT
TO AGENCY

I.) AGENCY REVIEW & APPROVAL

F.) CERTIFY & SEND REPORT
TO AGENCY

G.) AGENCY REVIEW & APPROVAL

12.) RECORD KEEPING & REPORTING:

A.) DAILY DATA REDUCTION

B.) MONTHLY REDUCTION & REVIEW

C.) QUARTERLY EMISSIONS REPORT

D.) QUARTERLY QA REPORT

13.) ANNUAL REVIEW & UPDATE:

A.) MTG W/ PLANT TECHNICIANS

B.) REVIEW PERFORMANCE DATA

C.) UPDATE QA PLAN

D.) UPDATE EQUIPMENT INVENTORY

E.) TRAINING & CONFERENCES

4.2.4 A requirement that measurements be corrected to a dry basis strongly favors extractive systems that include moisture removal. All in-situ systems, all dilution based systems, and some extractive systems provide measurements on a wet basis. For the cost models it was assumed that CEMS which use an estimate of effluent moisture content are acceptable.

4.2.5 It was also assumed that it is acceptable to use carbon dioxide (CO_2) as a diluent gas, with an appropriate calculation procedure to correct emission concentrations to standard conditions.

5.0 DESCRIPTION OF COST MODELS

5.1 GENERAL

Calculations are performed for each task for: (1) labor; (2) travel; and (3) materials and supplies. Individual estimates are made for the company or plant environmental engineer, plant technicians, consulting engineers, and test personnel. Work load factors were estimated for a base case with opacity, CO, SO_2, NO_x, and diluent monitors located after the control device. For cases other than the base case, linear multipliers are used to adjust the calculations.

5.2 LABOR COSTS

Direct labor costs are calculated from the estimated number of hours needed to complete a task, the number of persons involved, and the generic labor rates. Total labor costs are calculated as the sum of the direct labor costs and direct labor times overhead. Overhead is included as a generic factor for each labor group.

5.3 TRAVEL COSTS

It is assumed that the office of the company environmental engineer is not located at the plant site. Therefore, travel costs are calculated for each task that requires the presence of the engineer at the plant. When required, travel is also included for the consultant and testing personnel. Travel costs per person are calculated from generic travel fares, generic per diem, and an estimated number of days on travel status. Multipliers are used to adjust the estimates for cases other than the base case.

5.4 MATERIALS AND SUPPLIES

The cost of materials and supplies is included in a number of tasks. Major costs, however, are the costs of the support facilities and the CEMS's. Because of their magnitude these costs are calculated and discussed separately in Sections 5.4.1 and 5.4.2. The O&M models include an estimate of the annual cost of replacing worn and used equipment, valued at 10 percent of the CEMS cost.

5.4.1 The costs of Support Facilities are intended to include sampling ports, utilities, platforms, ladders, and an instrument room or environmental shelter for the analyzers.

5.4.2 The cost of the CEMS is intended to include the cost of the analyzers, the data acquisition system (DAS), and all associated sampling lines, probes, calibration gas equipment, and sample conditioning hardware. Analyzer costs are provided in the programs generated report. Vendor costs to install the equipment and train plant technicians is assumed to be included in these prices.

6.0 DISCUSSION

6.1 RESULTS FOR THE BASE CASES

Labor, travel, and material and supply costs were estimated for a base case with opacity, CO, SO_2, NO_x and diluent CEMS's installed at the control device outlet. After reviewing a few trial estimates, one is led to the conclusion that total first-costs are about 1.7 times the purchase cost of the CEMS. The estimating programs show no significant difference between new and existing sources. This, of course, is entirely dependant on the costs assumed for site modifications at an existing plant, and is inherently site-specific.

For a base case, annual O&M costs are about 40 to 50 percent of the first-costs, and about 70 to 80 percent of the cost of the CEMS. The programs include 10 percent of the CEMS cost as a recurring expense to replace worn equipment and maintain an inventory of spare parts.

6.2 INCREMENTAL COSTS FOR EXTRACTIVE CEMS

The total first-cost increases with the number of pollutants

monitored. In general, total costs range from about 1.9 to 1.7 times the cost of the CEMS. This ratio decreases as the number of pollutants increases. Of importance is the first-cost associated with a simple CEMS for CO, which is estimated at about $130,000. This is about $90,000 more than the estimated first-cost for an opacity CEMS.

6.3 INCREMENTAL COSTS FOR HCl MONITORING

A computer run was conducted to calculate the first-cost of adding an HCl monitor to a CEMS with CO and SO_2 monitors installed at the control device outlet. The increase in first-cost was estimated at $27,000. This incremental cost is, however, highly dependant on the cost of the HCl analyzer and sampling system. An adequate sampling system for HCl will probably cost an additional $8,000 to $10,000, while the cost of an HCl analyzer could be as high as $150,000.

6.4 COSTS TO MONITOR PERCENT REDUCTION FOR SO_2

There is an incremental cost associated with a percent reduction standard for SO_2 compared to an emission limit at the stack outlet. In particular, there would be a significant increase in cost because of the additional sampling site and the need for a more costly sampling system at the control device inlet. First-costs are estimated to increase by about $100,000; annual O&M costs are estimated to increase by approximately $10,000 to $40,000, with the greater increase related to the point in-situ CEMS.

6.5 CEMS FOR COMPLIANCE VS. CEMS FOR EXCESS EMISSIONS

The cost programs assume that regulations or permits will define the CEMS as the performance test method as was done under 40 CFR Part 60, Subparts Da and Db. As a result, the cost of developing a Quality Assurance Plan (QAP) and the costs of quarterly audits and Data Assessment Reports (DARs) required under

40 CFR Part 60, Appendix F are included in the estimates. Considering the magnitude of the costs, it is reasonable to expect that a source owner would incur most of these quality assurance costs independent of regulatory requirements.

A computer run was conducted to calculate the cost of developing a QAP for the base case described in Section 5.1. The resulting estimate for the QAP is about 10 percent of the total first-costs. The costs of quarterly audits and DARs include an annual Relative Accuracy Test Audit (RATA), a supplemental RATA, and three Cylinder Gas Audits (CGA's). The supplemental RATA is included to account for a RATA that might need to be repeated or a RATA that might be necessary after replacement of a major CEMS component or start-up of the source after a prolonged shut-down. The annual and supplemental RATA's are estimated at about 10 percent each and the quarterly CGA's are estimated at about 5 percent, for a total of approximately 25 percent of the annual O&M costs. The cost of the quarterly DAR's and the annual update of the QA plan are estimated to be less than about 2 percent of annual O&M costs.

6.6 COST OF OPACITY CEMS

Several computer runs were made with an opacity monitor by itself and in combination with gas monitors. An examination of the results indicates that the first-costs for an opacity monitor without other gas monitors are about $35,000 to $50,000, and annual O&M costs are approximately $20,000. When used in combination with gas monitors, the incremental first-cost of an opacity monitor is decreased by about $5,000, and the corresponding incremental O&M costs are decreased by about $4,000.

7.0 SUMMARY

- Total first-costs are approximately 1.7 times the purchase

costs of the CEMS, given the purchase costs used in this study. This ratio decreases if purchase costs are increased.

- Annual O&M costs are about 40 to 50 percent of first-costs and about 70 to 80 percent of the CEMS costs.

- The first-costs for a CO CEMS are estimated at approximately $130,000, which are significantly greater than first-costs of about $35,000 to $50,000 for an opacity CEMS.

- Incremental costs for HCl monitoring are dominated by the cost of the HCl analyzer, which can vary from the $15,000 value used in this study to about $150,000.

- A requirement to determine the percent reduction for SO_2 is estimated to increase CEMS first-costs by about $100,000 and annual O&M costs by about $10,000 to $40,000.

- The cost of implementing the requirements of 40 CFR Part 60 Appendix F are estimated to be about 25 to 30 percent of the estimated annual O&M costs.

8.0 USING THE COSTING PROGRAM

8.1 GENERAL

This program has been designed to be user friendly. Function keys have been programmed to move the user through the program with speed and ease.

The main screen of the program (Figure 1) is broken into three boxes covering (1) Location/Type of Monitor/Cost/# of Monitors, (2) Plant, (3) Location/# of Sampling Lines. A description of the

function keys and the boxes in which they can be used are shown in Table 3.

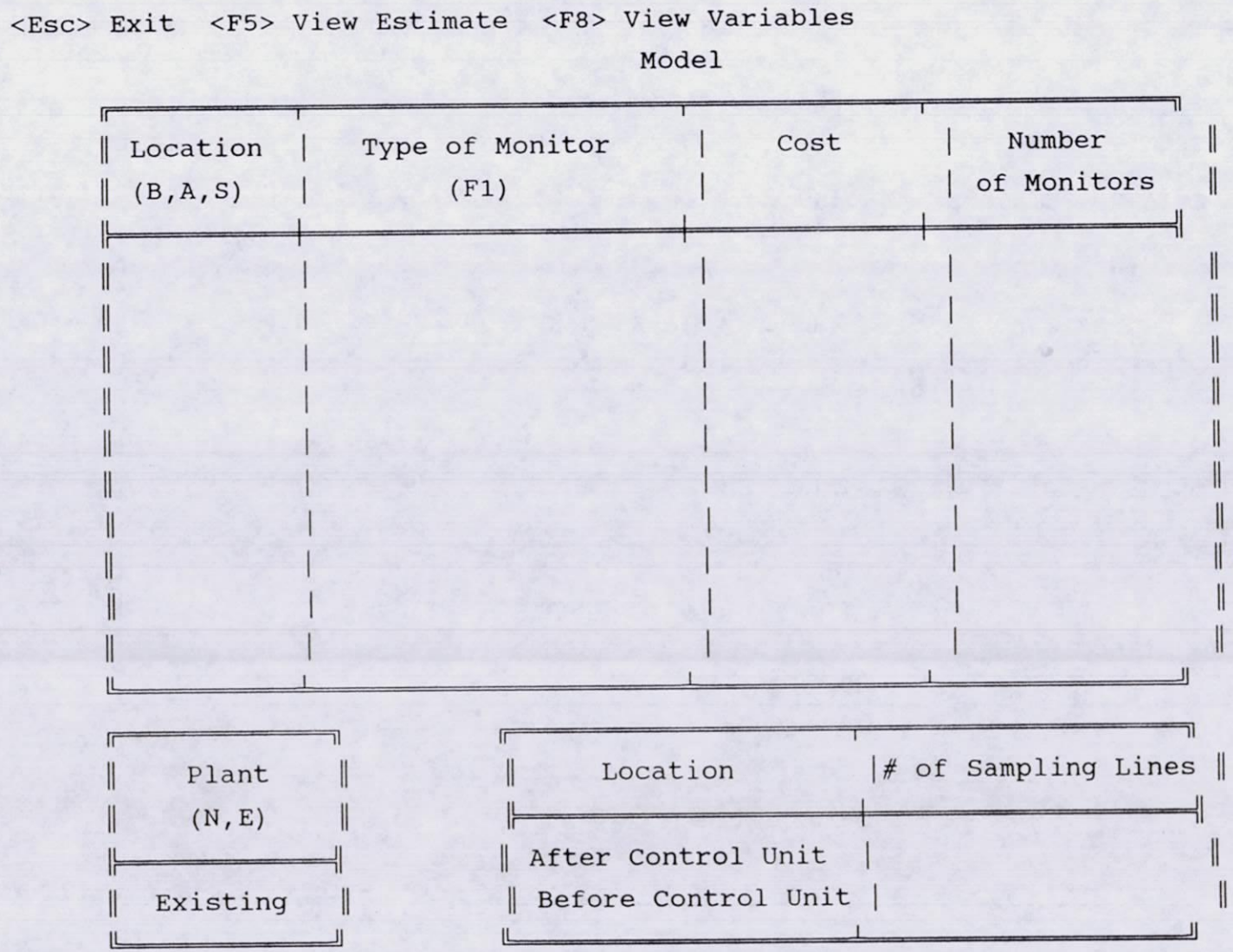

Figure 1. Main Program Screen.

TABLE 3. DESCRIPTION OF FUNCTION KEYS

BOX	KEY	DESCRIPTION OF KEY FUNCTION
ANY BOX	F5	CALCULATES THE COST OF THE ESTIMATE
ANY BOX	F3	ENABLES THE USER TO MOVE COUNTER CLOCKWISE FROM BOX TO BOX ON THE MAIN PROGRAM SCREEN
TYPE OF MONITOR	F1	BRINGS UP THE MONITOR SELECTION LIST WITH CORRESPONDING MONITOR COSTS
MONITOR SELECTION LIST	F2	SELECTS TYPE OF MONITOR AND CORRESPONDING COST AND TRANSFERS THE SELECTION TO THE MAIN PROGRAM SCREEN
LOCATION	B	DENOTES A MONITOR LOCATION BEFORE THE CONTROL DEVICE
LOCATION	A	DENOTES A MONITOR LOCATION AFTER THE CONTROL DEVICE
LOCATION	S	DENOTES A MONITOR LOCATION IN THE STACK
NO. OF	0-9	SELECTS THE NUMBER OF MONITORS CORRESPONDING TO THE

MONITORS		TYPE AND LOCATION OF THAT PARTICULAR LINE
PLANT	E	DENOTES A MONITOR BEING INSTALLED AT AN EXISTING PLANT
PLANT	N	DENOTES A MONITOR BEING INSTALLED AT A NEW PLANT
NO. OF SAMPLING LINES	0-9	SELECTS THE NUMBER OF SAMPLING LINES BEFORE OR AFTER THE CONTROL DEVICE
ANY BOX	F8	LISTS A VARIABLES TABLE, WHERE COST CHANGES CAN BE MADE. ALL CHANGES ARE AUTOMATICALLY CARRIED THROUGH THE ENTIRE PROGRAM
AFTER ESTIMATE IS CALCULATED	F7	THIS WILL SAVE THE ESTIMATE UNDER THE GIVEN NAME, GENERATE A REPORT AND SEND IT TO THE PRINTER

8.2 EXAMPLE ESTIMATE

A schematic flow chart for an EXISTING plant is shown in Figure 2. The plant wishes to monitor the control efficiency of their wet scrubber, (The Control Device) to remove out SO2 from the emission gas stream. So they choose to install an SO2 Monitor at locations B and A. They also wish to monitor the air Flow and Opacity at the outlet location or Stack. So they install a Flow Monitor and Opacity Monitor at the S location.

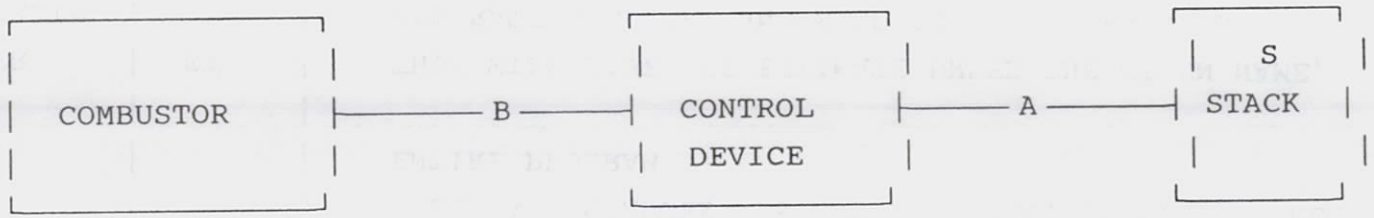

Figure 2. Flow Chart for Example Plant.

The following shows step-by-step how to set up the Main Program Screen and calculate the estimate:

1. In the Location Box type B and press RETURN (for the SO_2 monitor before the control device.)

2. Press F1 to bring up the Monitor Selection List, move the cursor to the SO_2 analyzer, and press F2 to select the SO2 analyzer.

3. Press RETURN to move to the Number of Monitors Box; enter 1, to select one monitor.

4. Press RETURN to return to the Location Box type A and press RETURN (for the SO_2 monitor after the control device); repeat Steps 2-3.

5. Repeat Steps 1-3 to select an opacity monitor and a flow monitor at the stack location; use an S to denote their location in the stack.

6. Press F3 to move to the Plant Box; enter E, for an existing plant.

7. Press F3 to move to the # Of Sampling Lines Box. For this example, 1 sampling line is needed before and 1 after the control device, for the SO_2 system. Type a 1 in the # of sampling lines before the control device, and a 1 in the # of sampling lines after the control device. The Flow Monitor and Opacity Monitor do not require sampling lines.

8. Figure 3 illustrates The Main Program Screen for the example.

9. Press F5 to calculate the estimate. Check your estimate with the estimate shown in Table 4. To save and print a copy of the estimate, press F7 and name the file.

10. The Escape Key will allow you to return to the

Main Program Screen in order to create new estimates. It will also let you escape from the program.

11. To input new estimates you must backspace over the old estimates to erase them.

12. By using the arrow keys, the user can move within the boxes on the Main Program Screen.

<Esc> Exit <F5> View Estimate <F8> View Variables

Model

Location (B,A,S)	Type of Monitor (F1)	Cost	Number of Monitors
B	SO2 Analyzer	10,000.00	1
A	SO2 Analyzer	10,000.00	1
S	Opacity Monitor	20,000.00	1
S	Flow Monitor	20,000.00	1

Plant (N,E)
Existing

Location	# of Sampling Lines
After Control Unit	1
Before Control Unit	1

Figure 3. The Main Program Screen for the Example Plant.

TABLE 4. ESTIMATE FOR THE EXAMPLE PLANT

	Type of Site			
	Existing			
	Monitor Locations			
Unit	Before	After	Stack	Cost
CO Analyzer	0	0	0	10,000.00
CO_2/O_2 Analyzer	0	0	0	5,000.00
Flow Monitor	0	0	1	20,000.00
HCl Monitor	0	0	0	15,000.00
NO_x Analyzer	0	0	0	15,000.00
Opacity Monitor	0	0	1	20,000.00
SO_2 Analyzer	1	1	0	10,000.00
No. of Gas Monitors	1	1	0	
Total No. of Monitors	1	1	2	
Sampling Lines After Control Unit			1	
Sampling Lines Before Control Unit			1	

	Estimated First-Costs			
	Labor w/OH	Test Ctr	Other DCs	Total
Planning	7,100	0	600	7,700
Select Type of Equipment	13,500	0	100	13,600
Provide Support Facilities	0	0	26,000	26,000
Purchase CEMS	0	0	170,000	170,000
Install & Check CEMS	13,300	0	2,000	15,300
Performance Spec Tests	3,900	11,700	1,100	16,700
Prepare QA/QC Plan	3,100	14,300	600	18,000
Totals	40,900	26,000	200,400	267,300
Operation and Maintenance	21,900	0	200	22,100
Annual Rata	2,100	8,000	400	10,500
Supplemental Rata	2,100	7,400	300	9,800
Quarterly CGA's	2,600	0	1,300	3,900
Record Keeping & Reporting	18,700	0	200	18,900
Annual Review & Update	15,500	0	9,200	24,700
Totals	62,900	15,400	11,600	89,900