A COMPUTERIZED CAPITAL COST ESTIMATING SYSTEM
FOR A MANUFACTURING ENGINEERING COMPANY

by

Shashi Singh

A Graduate Project Report
Submitted to the Faculty of the College
of Science and Technology
CORPUS CHRISTI STATE UNIVERSITY
in Partial Fulfillment of the Requirements
for the Degree of
MASTER OF SCIENCE
in Computer Science

December, 1981
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Acknowledgements</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 1- Introduction</td>
<td>2</td>
</tr>
<tr>
<td>Chapter 2- A Brief Description of the Main Control Programs and the Subroutines</td>
<td>5</td>
</tr>
<tr>
<td>Chapter 3- Piping</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Chapter 4- Insulation</td>
<td>433</td>
</tr>
<tr>
<td></td>
<td>434</td>
</tr>
<tr>
<td></td>
<td>437</td>
</tr>
<tr>
<td>Appendix B. Sample Input Data Sheets (Piping)</td>
<td>589</td>
</tr>
<tr>
<td>Appendix C. Sample Input Data Sheets (Insulation)</td>
<td>616</td>
</tr>
<tr>
<td>Appendix D. List of Subroutines</td>
<td>626</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENTS

I would like to thank the Capital Cost Estimating Department (Mr. T.M. Knox, Mr. A.G. Custer, and Mr. M.R. White) of Celanese Chemical Co. for providing me with this project and for their assistance throughout the course of this work. Many thanks to Mr. J.R. Walker for his advice and useful discussions. The assistance of Mr. E.J. Russek for running the programs is kindly acknowledged. Thanks are also due to Lenora Cannon for her help.

I gratefully acknowledge the supervision provided by my project advisor, Mrs. N.L. Cameron. My thanks to Dr. R.S. Ellzey and Dr. M.H. McKinney for serving on the project committee.
CHAPTER 1

INTRODUCTION

Capital cost estimating is crucial for the operation and growth of a manufacturing engineering company. New research and development, modification of existing processes, evaluation of alternate processes to find the most economical one, and the construction of a plant or equipment are all dependent on capital cost estimating*. A business adventure is pursued further only when it looks economically attractive based on capital cost estimates and profitability analysis.

The objective of this project is to develop a computerized capital cost estimating system. Capital cost estimates can be made on various components like piping, insulation, instruments, electrical equipment, concrete, etc. However, this project covers only piping and insulation.

It is a very time consuming process to generate and update the cost estimates manually. First the changes have to be made using long cost equations. Then the cost sheets have to be typed, proofed and distributed. This process takes several weeks. Thus the data contained in different cost books are not the same nor are they necessarily up-to-date. The value of the computerized approach lies in the standardization of the cost books at different plant locations. The rapidity with which updates can be made and the flexibility the plants will

* A data flow diagram showing the relationship of capital cost estimating to other phases of process development is shown in Appendix A.
have in keeping their own books up-to-date are the major advantages. Thus the computerized system will be fast, accurate, convenient, and easily accessible to users at all locations of the company. It will be able to handle all user options and provide output in the form required by the users.

As mentioned earlier, this project covers two major sections of cost estimation - piping and insulation. The two sections are independent of each other. The piping section has one main control program which calls 26 subroutines, each representing piping used in different types of process equipment (e.g. pumps, control valves, towers, heat exchangers, turbines, product receivers, etc.). The insulation section also has one main control program which calls 12 subroutines, each representing different types of insulation (e.g. foamglas, fiberglass, dimetcote, calcium silicate, etc.) used in various equipment.

The piping cost is calculated for different pipe sizes made of commonly used materials like carbon steel, 304 stainless steel, 316 stainless steel. The prices are generally based on 100 ft of pipe and take into account the different fittings (e.g. ells, tee, etc.) that may be used. Efficiency is a measure of labor productivity and is used in generating and updating labor costs. The unit of material cost is '$' while the unit of labor cost is 'manhours' because the local wage rate may vary widely depending on the location of the plant. Hence the manhours must be multiplied by the local wage rate to get the actual labor cost. The date column in each cost table corresponds to the prices effective on that particular date.
Chapter 2 describes the logic used in the main control programs and the subroutines of each section. Chapter 3 consists of the actual listings and outputs of the control programs and the subroutines for the piping section. Each subroutine is preceded by the cost equations used in it, its input and output, and a brief description. Chapter 4 covers the insulation section.

Appendix A has the data flow diagram showing the relationship of capital cost estimating to other phases of process development. Appendices B and C include the sample input data sheets. Appendix D gives a listing of all the subroutines for piping and insulation.
CHAPTER 2

A BRIEF DESCRIPTION OF THE MAIN CONTROL PROGRAMS AND THE SUBROUTINES

1. Each cost table has been assigned an ordinal number 1-N.

2. A master control program will select the correct subroutine to update a specific table. The subroutine will be picked by the control program based on the table number specified by the user. The system allows a maximum of 99 cost tables. Subroutines have been written for tables 1-26 in the piping section and 1-12 in the insulation section.

3. Each subroutine will handle the necessary options for a table operation i.e. modifying an element, row or column.

4. Each subroutine has its own input data format. The sample sheets are given in appendices B & C. There is one main input data format for the control program that will contain three variables:
   (i). Table number the user wants
   (ii). Current number of rows in the table
   (iii). Value of code
5. 'Code' is a flag to indicate what the user intends to do with the table. Valid operations are:

Code=1 : A cost table is to be added:
The user must input the cost table cards and will get a printed copy of the cost table as output.

Code=2 : The cost table is to be updated:
For this to work, the cost table data should be in (see (6)). The user must input the update card (or cards) for the option he wants (see (8)) and will get a printed copy of the updated cost table for each option.

Code=3 : A cost table is to be added and updated:
The user must input the cost table cards and the update cards for the option. The output will be printed copies of the cost table and the updated cost table.

6. To help the main control program check on invalid table numbers entered for updating, a one-dimensional file called 'TABNUM' is established. Negative numbers 1-99 are stored sequentially in TABNUM. When the data for a cost table is added, the corresponding number in TABNUM is made positive. This enables the control program to check if a valid table number has been entered for updating, e.g. if the user specifies table#51 to be updated (code=2) and the control program brings in the file TABNUM-checks the 51st location and the value is negative then it knows that the cost data for table# 51 has not been entered yet. The program will then stop after writing an error message.
7. The main control program also validates the three variables specified in the main input format—the table number, current number of rows in the table and the code value. If any of these exceed their maximum allowed values the program stops after writing the appropriate error message. Since subroutines have been written for cost tables 1-26 in the Piping section and 1-12 in the Insulation section the program gives an error message and quits if the user specifies a table number greater than 26 for piping or greater than 12 for insulation.

8. Once control is transferred to the proper subroutine, depending on the value of code the subroutine either reads the cost table cards and/or the update cards. The option selections are all the different ways in which the table can be updated. Cost equations are used to accomplish this. There are 5 general option selections in each subroutine.

Option #1 is for cost change of pipe or other fittings like ells, tees, flanges, reducers, etc.

Option #2 is for efficiency change.

Option #3 is for cost change of material other than piping, e.g. insulation, paint, etc.

Option #4 is used for changes other than those mentioned above. For example, it is used in some of the programs to make a percentage change in the cost of pipe of all sizes.

Option #5 is to add in a new row to the cost table.
If an option is not applicable in a subroutine it is left open. Each subroutine validates the option number specified by the user.

9. All the subroutines are independent of each other.
CHAPTER 3

PIPING

Main Control Program

Subroutines 1-26