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A Computer Program for Analysis of Smoke Control Systems

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
National Engineering Laboratory
Center for Fire Research
Washington, DC 20234

June 1982

Final Report

Sponsored in part by:
Department of Health and Human Services
Washington, DC 20201
A COMPUTER PROGRAM FOR ANALYSIS OF SMOKE CONTROL SYSTEMS

John H. Klote

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This report is an interim product of a joint effort of the Department of Health and Human Services and the National Bureau of Standards (NBS), Center for Fire Research. The program is a multi-year activity initiated in 1975. It consists of projects in the areas of: decision analysis, fire and smoke detection, smoke movement and control, automatic extinguishment, and behavior of institutional populations in fire situations.

This report describes a computer program which analyzes pressurized stairwells and pressurized elevators. The program was initially intended as a research tool to investigate the feasibility of specific systems. However, this program may be of interest to design engineers responsible for pressurized stairwells or pressurized elevators.
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A COMPUTER PROGRAM FOR ANALYSIS OF SMOKE CONTROL SYSTEMS

John H. Klote

Abstract

This paper describes a computer program developed to analyze systems intended to control smoke in building fires. These systems include pressurized stairwells, pressurized elevator shafts, zone smoke control systems, and pressurized corridors. This program calculates air flows and differential pressures throughout a building in which a smoke control system is operating. The basic assumptions and limitations of the program are also discussed. The appendices contain a program listing and examples.

Key words: Air movement; computer programs; egress; elevator shafts; escape means; modeling; pressurization; simulation; smoke control; stairwells.

1. INTRODUCTION

The majority of fire fatalities result from smoke inhalation. As a result of this, a number of systems have been designed and built to control smoke movement in building fires. The most common smoke control systems are pressurized stairwells and zone smoke control systems. These systems are intended to control smoke movement in a building by use of air flows and by differential pressures. The computer program described in this paper provides a means to calculate the air flows and differential pressures throughout a building (either real or conceptual) in which a smoke control system is operating.

A number of computer programs have been developed which are applicable to smoke control. Some of these programs calculate steady state air flow and pressures throughout a building [1,2]. Other programs go beyond this to calculate smoke concentrations throughout a building that would be produced in the event of a fire [3-7]. In general, most of these programs are capable of analyzing smoke control

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1 The concept of extending the use of smoke control to protect elevators is currently being investigated at NBS.

2 Numbers in brackets refer to the literature references listed at the end of this paper.
systems. However, the program described in this paper has been specifically written for analysis of smoke control systems and is an extension of a program specifically written for analysis of pressurized stairwells and elevators [8]. While the basic theory of this program is the same as that of the stairwell program it has been extended to include analysis of (1) stairwells with vestibules, (2) elevators with elevator lobbies, (3) zone smoke control systems, and (4) pressurized corridors. The data input has been designed to minimize the quantity of required data and still maintain a high level of generality in the model. The output consists of the pressure differences across all of the building shafts, as well as the flows and pressures throughout the building.

This program was originally intended primarily as a research tool to investigate the feasibility of specific smoke control systems and to determine the interaction between these systems and the rest of the building. The predecessor [8] of this program has already been used to analyze pressurized stairwells without vestibules and to evaluate factors which affect the performance of these systems [9]. And, this program has been used to generate data for an National Bureau of Standards (NBS) Handbook on Smoke Control Design which is being developed. This paper is not intended to be a design guide for smoke control systems. The state-of-the-art of these systems is still under development and designers of these systems should seek the most current data available.

2. PROGRAM CONCEPT

In this computer program a building is represented by a network of spaces or nodes each at a specific pressure and temperature. The stairwells and other shafts are modeled by a vertical series of spaces, one for each floor. Air flows through leakage paths from regions of high pressure to regions of low pressure. These leakage paths are doors and windows which may be opened or closed. Leakage can also occur through partitions, floors, exterior walls and roofs. The air flow through a leakage path is a function of the pressure difference across the leakage path.

In this computer model air from outside the building can be introduced by a pressurization system into any level of a shaft or even into other building spaces. This allows simulation of stairwell pressurization, elevator shaft pressurization, stairwell vestibule pressurization, and pressurization of any other building space. In addition, any building space can be exhausted. This allows analysis of zone smoke control systems where the fire zone is exhausted and other zones are pressurized. The pressures throughout the building and flow rates through all the flow paths are obtained by solving the air flow network including the driving forces such as the wind, the pressurization system or an inside to outside temperature difference.
3. ASSUMPTIONS AND LIMITATIONS

1. Each space is considered to be at one specific pressure and one specific temperature.

2. The flows and leakage paths are assumed to occur at mid-height of each level.

3. The net air supplied by the air handling system or by the pressurization system is assumed to be constant and independent of building pressure.

4. The outside air temperature is assumed to be constant.

5. The barometer pressure at ground level is assumed to be standard atmospheric pressure ($101325 \text{ Pa}$)\(^3\).

4. EQUATIONS

A. Flow equation

$$F = CA \sqrt{2 \rho \Delta P} \quad (3.1)$$

where:

- $F$ = mass flow rate
- $C$ = flow coefficient
- $A$ = flow area
- $\rho$ = density of air in flow path
- $\Delta P$ = pressure difference across flow path

The flow coefficient is dimensionless and for smoke control analysis it is generally taken to be in the range of 0.6 to 0.7. Because of the large number of flow calculations performed during the computer analysis the flow equation is rewritten in the program as $F = C' \sqrt{\Delta P}$. Using the ideal gas law, the adjusted flow coefficient, $C'$, can be expressed as

$$C' = CA \sqrt{\frac{2 \text{ P}_{\text{atm}}}{RT}} \quad (3.2)$$

where:

- $\text{ P}_{\text{atm}}$ = absolute barometric pressure at ground level
- $R$ = gas constant of air
- $T$ = absolute temperature of air in flow path

\(^3\)The results of the program are not very sensitive to changes in atmospheric pressure. For altitudes considerably different from sea level the more accurate value can be substituted by changing an assign statement in the subroutine INPUT and one in the subroutine CORR.
B. Mass Balance Equations

For building compartment

\[ \sum_{j=1}^{N_C} F(i,j) + \sum_{k=1}^{N_O} F_o(i,k) + F_f(i) = 0 \]  

(3.3)

and for shafts

\[ \sum_{i=N_1}^{N_2} \left[ \sum_{j=1}^{N_C} F(i,j) + \sum_{k=1}^{N_O} F_o(i,k) + F_f(i) \right] = 0 \]  

(3.4)

where:

- \( F(i,j) \) = mass flow rate from space \( j \) to space \( i \). For building compartments this flow can be either horizontal or vertical, however for shafts this flow can only be horizontal.

- \( F_o(i,k) \) = mass flow rate from direction \( k \) outside of the building to space \( i \).

- \( F_f(i) \) = net mass flow rate of air due to the air handling system or due to a pressurization system.

- \( N_C \) = number of building spaces connected to space \( i \).

- \( N_O \) = number of connections to the outside from space \( i \).

\( N_1 \) is the space number at the bottom level of the shaft and the spaces in the shaft are numbered consecutively up to \( N_2 \) which is the space number at the top of the shaft.

C. Shaft Pressures

The following relationship is used to calculate the gage pressure, \( P(i) \), at floor \( i \) of a shaft in terms of \( P(i-1) \) at floor \( i - 1 \).

\[ P(i) = P(i-1) - P_z - P_f \]  

(3.5)

where:

- \( P_z \) = hydrostatic pressure difference

- \( P_f \) = pressure loss due to friction

The following equation is used to calculate the hydrostatic pressure difference.

---

In this paper the term building compartment refers to a space in a building other than in a shaft.
\[ P_z = \frac{g\bar{h}}{RT} \ h(i) - h(i-1) \]  

(3.6)

where:

- \( h(i) \) = height of point \( i \)
- \( h(i-1) \) = height of point \( i-1 \)
- \( g \) = gravitational acceleration
- \( R \) = gas constant
- \( T = \frac{T(i) + T(i-1)}{2} \)
- \( \bar{P} = \frac{P(i) + P(i-1)}{2} + P_b \)

\( P_b \) is a constant used to convert an average gage pressure to the average absolute pressure, \( \bar{P} \).

The following equation is used to calculate the pressure loss due to friction.

\[ P_f = S \left( \frac{\dot{m}_u}{C_s} \right)^2 \]  

(3.7)

where:

- \( \dot{m}_u \) = upward flow from \( i-1 \) to \( i \) in shaft
- \( C_s \) = shaft flow coefficient
- \( S \) = sign of \( \dot{m}_u \)

D. Outside Pressures

Outside pressures can either be entered by the user or can be calculated by the following method.

\[ P_{o(i)} = P_{h(i)} + C_w P_{v(i)} \]  

(3.8)

where:

- \( P_{o(i)} \) = outside gage pressure at height \( h(i) \) above absolute pressure at ground level
- \( P_{h(i)} \) = hydrostatic pressure difference between \( h(i) \) and ground level
- \( P_{v(i)} \) = velocity pressure due to the wind at height \( h(i) \)
- \( C_w \) = pressure coefficient

Because the outside temperature is constant

\[ P_{h(i)} = P_{atm} \exp \left( - \frac{gh(i)}{RT_{out}} \right) - P_b \]  

(3.9)
where:
\[ P_{\text{atm}} = \text{absolute barometric pressure at ground level} \]
\[ T_{\text{out}} = \text{outside absolute temperature} \]

When the outside pressures are calculated by the computer the wind velocities are assumed to be described by the power law.

\[ v = V_o \left( \frac{h}{h_o} \right)^n \]

where:
\[ V_o = \text{wind velocity at height } h_o \]
\[ n = \text{wind exponent} \]

This relationship has been extensively used to describe the boundary-layer velocity profile of the wind near the surface of the earth. It assumes that the terrain surrounding the building is homogeneous. That is, that there are no large obstructions near the building which could produce local wind effects. A value of 0.16 for the wind exponent is appropriate for flat terrain. The wind exponent increases with rougher terrain. For very rough terrain such as urban areas a value of 0.40 would be appropriate.

The equation for the velocity pressure at height \( h(i) \) is obtained by substituting the velocity from the power law into the usual relation for velocity pressure \( (P_v = \frac{1}{2} \rho v^2) \).

\[ P_v = \frac{\rho v^2}{2} \left( \frac{h(i)}{h_o} \right)^{2n} \quad (3.10) \]

where \( \rho \) is the outside air density.

The pressure coefficients are in the range of -0.8 to 0.8 where positive values are for windward walls and negative values are for leeward walls. The \( z \) pressure coefficient depends upon building geometry and varies locally over the wall surface. Numerical values for \( C_w \) and \( n \) as well as practical engineering information are available from a number of sources [10-13].

5. PROGRAM DESCRIPTION

This program is written in ANSI FORTRAN on the UNIVAC 1100/82 and a program listing is provided in appendix D. The following is a detailed description of the main program and the major subroutines.
5.1 Main Program

The main program calls the subroutines which read the data, calculate the adjusted flow coefficients, calculates the initial values of pressures and iteratively solves for the pressures according to the logic illustrated in the flow chart of figure 1.

5.2 INPUT Subroutine

This routine reads the data that are necessary for a flow analysis of the stairwell or elevator, including an analysis of the rest of the building. These data consist of the following:

1. Outside temperature.
2. Temperature throughout the building.
3. Outside pressures. These can be entered or calculated as described earlier.
4. Description of the flow network including flow coefficients and flow areas for all connections and the net air flows to each space due to the air conditioning system or due to a pressurization system.

The data above can be entered in either SI units or in engineering units. Appendix A contains a detailed description of the data input method.

In addition to reading data, this subroutine provides temperature and pressure data as well as a complete description of the flow network. This routine also calculates initial estimates of the hydrostatic pressure differences. When data is entered in engineering units the subroutine UNITS is called which converts all units to the SI system.

5.3 CORR Subroutine

This routine calculates adjusted flow coefficients for all flow paths using eq. (3.2). Two sets of these coefficients are calculated for each flow path to allow for flow in either direction.

5.4 INIT Subroutine

This routine calculates initial estimates of the building pressures by a technique used by Sander [1]. In this technique, mass flows are considered linear functions of differential pressure and therefore the flow equations can be expressed and solved in matrix form. In this estimate, shaft pressures are considered hydrostatic. The resulting pressures form a starting point for the iterative solution which follows.
Figure 1. Flow chart for main program
5.5 BLDGP Subroutine

The iterative solution for the building pressures and flows consists of the three subroutines BLDGP, SHAFTP and PZAD. The subroutine BLDGP operates on the building compartments sequentially. The sum of all the mass flows into compartment \( i \) is calculated. If the absolute value of this sum is less than a convergence limit then eq. (3.3) is considered satisfied and the computer proceeds to the next compartment or returns to the main program. However, if the absolute value of the sum is greater than the convergence limit, then an improved estimate of the pressure at compartment \( i \) is obtained by the regula falsi method [14]. When none of the pressures need to be modified this routine passes a convergence signal to the main program.

5.6 SHAFTP Subroutine

The structure of this routine is very similar to that of BLDGP except that it operates on shafts sequentially. The sum of all the mass flows into shaft \( i \) is calculated. If the absolute value of this sum is less than the convergence limit then eq. (3.4) is also considered satisfied and the computer proceeds to the next shaft or returns to the main program. However, if the absolute value of the sum is greater than the convergence limit, then improved estimates of the shaft pressure are calculated. This is done by changing the pressures at the bottom of the shaft and then recalculating the shaft pressure by eq. (3.5). Again the regula falsi method is used, and if none of the shaft pressures require modification a convergence signal is passed to the main program. It can be seen from figure 1 that if convergence is achieved in both BLDGP and SHAFTP, then the subroutine OUT will print the solution. Otherwise, the hydrostatic pressure differences are adjusted in the subroutine PZAD.

5.7 PZAD Subroutine

This routine calculates hydrostatic pressure differences by eq. (3.6) using the most recent pressure estimates.

5.8 OUT Subroutine

This routine outputs mass flows and pressures for the flow network as well as the differential pressures across each shaft. If the data input was in engineering units then appropriate variables are converted to the engineering system before output.

6. FUTURE DIRECTION

It is planned to use this computer program in a project at NBS to study the feasibility of protected elevators as a means of fire escape for handicapped individuals. Consideration is being given to further development of the program for use as a design tool. Also, a program may be developed for microcomputers which can be used interactively.
7. REFERENCES


Data input consists of the following elements:

1. Initial data
2. Building heights
3. Temperature profiles
4. Outside pressure profiles
5. Building data
6. Shaft data

Each of these input elements is described in detail in the following sections. Elements 1 through 6 are always required. In the following sections the input required for each of the six data elements is described in detail. Each block or group of blocks below represent an input card. Unless otherwise stated these cards are unformatted; that is, the numbers do not have to be placed in specific columns and integers can be written with or without decimal points. However, separate pieces of numerical data must be separated by one or more spaces. Examples of input data are provided in Appendix B.

1. Initial data

project title (col. 1-72)

outside temperature (°C, °F)  unit indication (1 for SI, 2 for Eng)  summary output (0 for none, or file number)

\[1\]The user must assign this file before program execution.
2. Building heights

\[ h(1), h(2), h(3), \ldots, h(i), \ldots, h(N_h) \]

If input parameter = 0, then heights for each building level are to be individually entered as follows:

\[ h(1), h(2), h(3), h(i), h(N_h) \]

where \( h(i) \) is the height of the center of level \( i \) above the ground (m, ft).

If input parameter = 1, then the following card must be entered.

\[ h(1), \text{ distance between floors (m, ft)} \]

3. Temperature profiles

no. of temperature profiles

For each temperature profile the following data must be supplied.

\begin{tabular}{cccc}
no. of temp. & level no. & temperature \( (^\circ C,^\circ F) \) & level no. & temperature \( (^\circ C,^\circ F) \) & level no. & temperature \( (^\circ C,^\circ F) \) \\
\end{tabular}
4. **Outside pressure profiles**

\[ N_{po} \]

no. of outside pressure profiles 

\[ \text{input parameter} \]

(either 0 or 1)

If the input parameter = 0, each outside pressure profile is entered as follows:

\[ P_o(1) \quad P_o(2) \quad P_o(3) \quad P_o(i) \quad P_o(N_h) \]

where \( P_o(i) \) is the outside pressure at the center of level \( i \).

If the input parameter = 1, the outside pressures are calculated and the following data are required.

\[ V_o \]

wind velocity (mph)

\[ h_o \]

height at which velocity is measured

\[ n \]

wind exponent

pressure coefficients for each pressure profile

\[ C_w(1) \quad C_w(2) \quad C_w(N_{po}) \]

5. **Building data**

\[ N_f \]

no. of levels (or floors)
All of the following data in this input element are supplied for each level, or consecutive groups of similar levels.

\[ I_1 \quad I_2 \quad N_{\text{com}} \]

Start \ing floor \quad \text{Ending floor} \quad \text{No. of compartments per floor}

(Floor data is entered in ascending order of levels or floors. When data is for only one level then \( I_1 = I_2 \), and the same number is supplied for both.)

For each compartment on a level the following data are supplied:

\[ N_{\text{CS}} \quad N_{\text{CA}} \quad N_{\text{CO}} \quad F_f \quad \text{Temperature profile number} \]

No. of connections to other compartments on the same level \quad No. of connections to compartments on the level above \quad No. of connections to the outside \quad \text{Net flow}^2 (\text{l/s, cfm})

For each connection between this compartment and another on the same floor the following data are required.

Other compartment number on the same level \quad C \quad A

flow coefficient \quad \text{flow area} \quad (\text{m}^2, \text{ft}^2)

For each connection between this compartment and one on the level above the following data are required.

\(^2\text{All net flows are at standard conditions of 21°C (70°F) and one atmosphere.}\)
Other compartment number on floor above

<table>
<thead>
<tr>
<th>C</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For each connection to the outside the following data are required.

outside pressure profile number

<table>
<thead>
<tr>
<th>C</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. Shaft data

no. of shafts

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
</table>

All of the following data in this input element are required for each shaft.

shaft title (col 1-20)

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
</table>

\[ C_s \]

shaft flow coefficient

bottom level of shaft
top level of shaft
temperature profile number

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>

Enter the following typical data which applies to each level of the shaft.

Exceptions can be entered later.
<table>
<thead>
<tr>
<th>no. of connections between typical level of shaft and outside</th>
<th>( F_f ) net flow into typical level of shaft (l/s, cfm)</th>
</tr>
</thead>
</table>

The connection data to the building for a typical level are required.

<table>
<thead>
<tr>
<th>compartment no. to which shaft is connected</th>
<th>( C ) flow coefficient</th>
<th>( A ) flow area (m², ft²)</th>
</tr>
</thead>
</table>

For each connection to the outside, the connection data for a typical floor are required.

<table>
<thead>
<tr>
<th>outside pressure profile</th>
<th>( C ) flow coefficient</th>
<th>( A ) flow area (m², ft²)</th>
</tr>
</thead>
</table>

The number of exceptions to the typical data is required.

<table>
<thead>
<tr>
<th>no. of exceptions</th>
</tr>
</thead>
</table>

All of the following data in this input element are required for each exception.

<table>
<thead>
<tr>
<th>exception type (1, 2 or 3)</th>
<th>level of shaft</th>
</tr>
</thead>
</table>
The next card depends on the exception type. For exception type = 1, the net flow into the floor of the shaft is defined.

\[
F_f \\
\text{net flow} \\
(1/\text{s, cfm})
\]

For exception type = 2, an exception to an outside connection for this shaft is defined.

<table>
<thead>
<tr>
<th>outside pressure profile number</th>
<th>C</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For exception type = 3, an exception to the connection between the shaft and the building is defined.

<table>
<thead>
<tr>
<th>compartment no. to which shaft is connected</th>
<th>C</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. Example 1

A ten story building with a pressurized stairwell and no vertical leakage within the building is heated to 70°F when the outside temperature is -20°F. The stairwell temperature is 60°F at the tenth floor and 50°F at the bottom floor. The stairwell is pressurized by a net 550 cfm\(^1\) per floor. The wind is 30 mph at a height of 30 ft and the wind exponent is 0.14. This building has connections to the outside in two directions. The wind pressure coefficients are 0.7 for the windward wall and -0.7 for the leeward wall. The flow areas are the same vertically and are listed in Table B1. The flow coefficient is taken to be 0.65 for all connections.

<table>
<thead>
<tr>
<th>Connection location</th>
<th>Area (ft(^2))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between stairwell &amp; building</td>
<td>0.42</td>
</tr>
<tr>
<td>Between building &amp; outside into the wind</td>
<td>0.75</td>
</tr>
<tr>
<td>Between building &amp; outside away from the wind</td>
<td>0.75</td>
</tr>
</tbody>
</table>

1.1 Data for Computer Input

\(\text{initial data} \{\text{TEN STORY BUILDING WITHOUT VERTICAL LEAKAGE} \}
\)

\(\text{building heights} \{10, 5, 1, 10\}
\)

\(\text{temperature profiles} \{2, 1, 1, 2, 1, 70, 50, 10, 60\}
\)

\(\text{outside pressure profiles} \{2, 1, 30, 30, 0.7, -0.7, 0.15\}
\)

\(^1\)At standard conditions of 21°C (70°F) and one atmosphere.
2. Example 2

This is a 10 story building which is 70°F inside. Outside the air temperature is -5°F and there is no wind. This building has a stairwell and an elevator. The flow areas which are generally the same vertically are listed in table B2 and the flow exponents are taken to be 0.5. The stairwell is pressurized by a net 550 cfm per floor. The elevator shaft has a 4 ft² vent to the outside at the top. On floors 2 through 10 the elevator lobby separated from the building by doors that automatically close in the event of a fire. The flow coefficient is taken as 0.65 in all connections.

Table B2. Flow areas for example 2

<table>
<thead>
<tr>
<th>Connection location</th>
<th>Area (ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between stairwell &amp; building</td>
<td>0.42</td>
</tr>
<tr>
<td>Between building &amp; outside</td>
<td>1.5</td>
</tr>
<tr>
<td>Between elevator &amp; elevator lobby</td>
<td>0.65</td>
</tr>
<tr>
<td>Between elevator lobby &amp; building</td>
<td>0.55</td>
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</table>

2.1 Data for Computer Input

```
initial data
{-5  2  0}

building heights
{10  1}
{5  10}

temperature profile
{1  1  70}

outside pressure data
{1  1}
{0  1  1}
```
2.2 Example 2 Output

The output for example 2 case 1 (the data above not including modifications for Cases 2 and 3) is given in appendix C.
APPENDIX C. EXAMPLE OUTPUT
EXAMPLE OUTPUT

TEN STORY BUILDING WITH ELEVATOR

OUTSIDE TEMPERATURE  -5.0 F

<table>
<thead>
<tr>
<th>HEIGHT (FT)</th>
<th>TEMPERATURE PROFILES (DEG F)</th>
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<tr>
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<tr>
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<tr>
<td>45.00</td>
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<td>85.00</td>
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<tr>
<td>95.00</td>
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<table>
<thead>
<tr>
<th>HEIGHT (FT)</th>
<th>OUTSIDE PRESSURE PROFILES (IN H2O)</th>
</tr>
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<tbody>
<tr>
<td>5.00</td>
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<tr>
<td>15.00</td>
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<tr>
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<tr>
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THE FOLLOWING UNITS ARE USED FOR OUTPUT

FLOW IN CFM AT 70 DEG F AND 1 ATM
PRESSURE IN INCHES H2O
AREA IN FEET SQUARED
<table>
<thead>
<tr>
<th>FLOOR</th>
<th>COMPARTMENT</th>
<th>PRESSURE</th>
<th>TEMP PROFILE</th>
<th>FIXED FLOW</th>
<th>CONNECTION TO</th>
<th>DIFFERENTIAL PRESSURE</th>
<th>ADJUSTED FLOW COEFFICIENT</th>
<th>FLOW AREA</th>
<th>FLOW</th>
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<td>1694.</td>
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</table>
### Stairwell

**Temperature Profile 1**  
**Shaft Flow Coefficient**: 80000.

<table>
<thead>
<tr>
<th>Floor</th>
<th>Pressure</th>
<th>Fixed Flow</th>
<th>Connection to</th>
<th>Differential Pressure</th>
<th>Adjusted Flow Coefficient</th>
<th>Flow Area</th>
<th>Flow</th>
</tr>
</thead>
<tbody>
<tr>
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### Elevator

**Temperature Profile 1**  
**Shaft Flow Coefficient**: 2700000.

<table>
<thead>
<tr>
<th>Floor</th>
<th>Pressure</th>
<th>Fixed Flow</th>
<th>Connection to</th>
<th>Differential Pressure</th>
<th>Adjusted Flow Coefficient</th>
<th>Flow Area</th>
<th>Flow</th>
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#### Note

-1 NET
APPENDIX D. PROGRAM LISTING
MAIN PROGRAM

COMPUTER PROGRAM FOR AIR FLOW ANALYSIS IN BUILDINGS
SPECIFICALLY FOR ANALYSIS OF SMOKE CONTROL SYSTEMS

PROGRAM VARIABLES

AI LEAKAGE AREA OF INTERNAL CONNECTION
AO LEAKAGE AREA OF CONNECTION TO OUTSIDE
C FLOW COEFFICIENT BETWEEN BUILDING POINTS
CG FLOW COEFFICIENT TO OUTSIDE
CS FLOW COEFFICIENT OF SHAFT
E LIMIT WITHIN WHICH CONVERGENCE IS ACCEPTABLE
F NET FLOW INTO POINT I
FC FLOW BETWEEN INTERNAL POINTS
FF FIXED FLOW INTO POINT I
FD FLOW TO OUTSIDE
FSS NET FLOW INTO SHAFT IS
F T HEIGHT FROM GROUND TO MIDPOINT OF FLOOR
BUG OUTPUT VARIABLE
ICONV INTEGER USED IN SUBROUTINES BLDGP AND SHAFTP
IFLCCR FLOOR LEVEL WHERE POINT I IS LOCATED
IF POINTER TO TEMP PROFILE FOR POINT I
ITS POINTER TO TEMPERATURE PROFILE OF SHAFT
JC POINT NO. CONNECTED TO POINT I
JC DIRECTION OF OUTSIDE CONNECTION
N NO. OF BUILDING COMPARTMENTS
NC NO. OF INTERNAL POINTS CONNECTED TO POINT I
NCO NO. OF OUTSIDE CONNECTIONS
NFS1 BOTTOM FLOOR OF SHAFT
NFS2 TOP FLOOR OF SHAFT
N NO. OF FLOORS
NPC NO. OF OUTSIDE PRESSURE PROFILES
NS NO. OF SHIFTS
NS1 I VALUE FOR START OF SHAFT
NS2 I VALUE FOR END OF SHAFT
NT TOTAL NO. OF POINTS (BLDG AND SHAFT)
NTP NO. OF TEMPERATURE PROFILES
P PRESSURE AT POINT I
PO OUTSIDE PRESSURE PROFILES
PO OUTSIDE PRESSURE
PS PRESSURE PROFILE OF SHAFT - WORKSPACE
PZ PRESSURE DUE TO ELEVATION DIFFERENCE
T TEMPERATURE PROFILE ARRAY
TITLE PROJECT TITLE
TI TITLE SHAFT TITLE

PROGRAM PARAMETERS

MB MAX NO. OF BUILDING COMPARTMENTS
MM MAX NO. OF POINTS
MS MAX NO. OF SHAFTS
MC MAX NO. OF CONNECTIONS FOR ANY POINT
MPO MAX NO. OF OUTSIDE PRESSURE PROFILES
MTP MAX NO. OF TEMPERATURE PROFILES
MFL MAX NO. OF FLOORS
MAIN PROGRAM

PARAMETER (MM=140, MS=8, MC=9, MFC=2, MTP=2, MFL=25, MB=50)

COMMON NT, P(MM), C(MM, MC), NC(MM), JC(MM, MC), ITS(MS),
FC(MM, MC), PZ(MM, MC), PO(MM, MPO), CQ(MM, MPO), F(MM), PFL(MFP, MPO),
2 FP(MM), PO(MM, MPO), CS(MS), PS(MFL), NS1(MS), N2(MS),
3 FSS(MS), NS, NPO, ICONV, E, IBUG, Al(MM, MC), AO(MM, MPO), TITSM(MS, 5),
4 NT, T(MTP), IFLOOR(MM), T(MTP, MFL), NFS1(MS), NFS2(MS), IT(MB), NTP
5 ,NCC(MM), JOC(MM, MPO), TOUT

DOUBLE PRECISION P, P0, PS

COMMON /RUN/IRUN

DIMENSION B1(MM, MC), B2(MM, MPO)

NTER=5000
IRUN=1

CALL INPUT TO READ DATA

CALL INPUT

E=0.2
ICS=1

SAVE AI(I,J) IN B1(I,J) AND FIND
MAX VALUE OF AI(I,J)

AZZ=2
AMAX=0
DO 10 I=1, NT
DO 8 J=1, MC
B1(I,J)=AI(I,J)
IF(AI(I,J) .GT. AMAX)AMAX=AI(I,J)
8 CONTINUE
DO 9 J=1, MPO
DO 12 I=1, MC
IF(AI(I,J) .LT. 0.1) GO TO 12
AI(I,J)=AM*AI(I,J)+BB
12 CONTINUE
9 CONTINUE

ADJUST FOR LARGE VALUES OF FLOW AREA

IF(AMAX .LT. 0.3) GO TO 25
AZZ=1
AM=0.2/(AMAX-0.1)
BB=0.14(1.0-AM)
DO 15 I=1, NT
DO 12 J=1, MC
IF(AI(I,J) .LT. 0.1) GO TO 12
AI(I,J)=AM*AI(I,J)+BB
12 CONTINUE
DO 14 J=1, MPO
IF(AO(I,J) .LT. 0.1) GO TO 14
AO(I,J)=AM*AO(I,J)+BB
14 CONTINUE
15 CONTINUE

TEMPERATURE CORRECTION

CALL CCRR
MAIN PROGRAM

CALL INIT TO INITIALIZE PRESSURE ARRAY, P

CALL INIT

DO LCOF TO 30 IS ITERATIVE SOLUTION TO PRESSURE ARRAY

GO 30 ITER=1,NITER

CALL BLDGP TO SOLVE FOR BUILDING Pressures

CALL BLDGP
ICE=ICONV
IF(ICB .EQ. 0 .AND. ICS .EQ. 0) GO TO 40

CALL SHAFTP TO SOLVE FOR SHAFT PRESSURES

CALL SHAFTP
ICS=ICONV
IF(ICB .EQ. 0 .AND. ICS .EQ. 0) GO TO 40

CALL PZAD TO CALCULATE PZ TERMS

CALL PZAD
CONTINUE

IF ROUTINE FAILS TO CONVERGE IN NITER

ITERATIONS PRINT ERROR MESSAGE

WRITE(6,800)

CONTINUE
WRITE(6,801) ITER
IF(A2Z .EQ. 0.) GO TO 42
A2Z = 0.
DO 60 I=1,NT
DO 50 J=1,MC
50 AI(I,J)=B1(I,J)
DO 55 EE J=1,MPQ
55 AO(I,J)=B2(I,J)
60 CONTINUE

CALL CCRR
GO TO 24

CALL OUT TO OUTPUT SOLUTION

CALL OUT

WRITE(6,805)
STOP

FORMAT STATEMENTS

800 FORMAT(////5X,35(1H1)//5X,
+35HFAILURE OF MAIN PROGRAM TO CONVERGE //5X,35(1H1)//)
MAIN PROGRAM

801 FORMAT( 10X, IS, 5X, 11MITERATIONS  )
805 FORMAT(1E1)
END

SUBROUTINE INPUT.L,1
SUBROUTINE INPUT

&NBS*PLIBS SHOW A.INPUT

SUBROUTINE INPUT

THIS ROUTINE READS AND PRINTS DATA
AND Initializes PZ ARRAY

PARAMETER (MM=140, MS=8, MC=9, MFO=2, MTP=2, MFL=25, MB=50)
COMMON /PZ/ PGZ
COMMON /IO/TITLE(I), IUNIT, NCOMP(MFL), NCOMP(MFL)
COMMON N, P(MM), C(MM, MC), NC(MM), JC(MM, MC), ITS(MS),
F(MM), FG(MM, MPO), CS(NS), PS(MFL), NS1(MS), NS2(MS),
HC(MF), HFLOR(MM), T(MTP, MFL), NFS1(MS), NFS2(MS), IT(MB), NTP
DOUBLE PRECISION P, PG, PS
DIMENSION II(MF), TT(MF), PAR(7), CW(MPO), PH(MFL), NZZ(MM)
DATA PAR/* MM', ' MS*, ' MC', 'MFO', 'MTP', ' MFL', ' MB*/
IBUG=0

READ AND WRITE PROJECT TITLE

READ(5,600)(TITLE(I), I=1,18)
WRITE(6,601)(TITLE(I), I=1,18)

READ GENERAL DATA

TOOLT = OUTSIDE TEMPERATURE
IUNIT = 1 FOR SI UNITS
         = 2 FOR ENG UNITS
ICLT = 0 FOR NO SUMMARY OUTPUT
OTHERWISE IOUT IS FILE NO. TO
WHICH SUMMARY OUTPUT IS WRITTEN

READ(5,700)IOUT, IUNIT, IOUT
WRITE(6,411)IOUT, IUNIT, IOUT
IF(IUNIT .GT. 2 .OR. IUNIT .LT. 1) GO TO 105

READ HEIGTS
NN=0 FOR INPUT OF ALL HEIGTS
NN=1 FOR CALCULATION OF HEIGTS

READ(5,700)NH, NN
WRITE(6,412)NH, NN
IF(NF .LE. MFL) GO TO 89
IPAR=6
GO TO 110

9 IF(NH .LE. 1) GO TO 57
READ(5,700)(H(I), I=1,NH)
WRITE(6,413)(H(I), I=1,NH)
GO TO 99
57 READ(5,700)H(1), DH
WRITE(6,414)H(1), DH
GO 56 I=2,NH
SUBROUTINE INPUT

IM=I-1
S8 T(I)=T(IM)+DH
C
C READ TEMPERATURE PROFILES
C
S9 READ(5,700)NTP
WRITE(6,415)NTP
IF(NTP LE. MTP)GO TO S0
IPAR=5
GO TC 110
S0 DO 3 IF=1,NTP
READ(5,700)NNN,(II(J),TT(J),J=1,NNN)
WRITE(6,416)NNN,(II(J),TT(J),J=1,NNN)
IF(NNN .GT. 1)GO TO 2
CO 1 IFF=1,NH
1 T(IP,IFF)=TT(1)
GO TC 3
2 J=1
JP1=2
DO 4 IFF=1,NH
T(IP,IFF)=TT(J)+(TT(JP1)-TT(J))*((IFF-II(J))/(II(JP1)-II(J)))
IF(IFF NE. II(JP1))GO TC 4
IF(JF1 EQ. NNN)GO TO 4
J=JP1
JP1=J+1
4 CONTINUE
C
C READ OUTSIDE PRESSURE PROFILES
C NN=0 FOR INPUT OF ALL PRESSURES
C NN=1 FOR CALCULATION BY POWER LAW
C
S1 READ(5,700)NP0,NN
WRITE(6,417)NP0,NN
IF(NPO LE. MPO)GO TO S1
IPAR=4
GO TC 110
S1 IF(NN .EQ. 1)GO TO S1
C
C READ ALL OUTSIDE PressURES
C
S1 READ(5,700)PGZ,(PFO(J,I),J=1,NP0)
WRITE(6,418)PGZ,(PFO(J,I),J=1,NP0)
GO TC 85
C
C CALCULATE OUTSIDE PressURES
C PATMCS IS ATMOSPHERIC PRESSURE (PA)
C
S1 READ(5,700)VW,H,W,XW,(CW(I),I=1,NPO)
WRITE(6,419)VW,H,W,XW,(CW(I),I=1,NPO)
IF(ILNIT .EQ. 1)VW=VW*.2778
IF(ILNIT .EQ. 2)VW=VW*.4470
PATMCS=101325*
TOR=180+273*
IF(ILNIT .EQ. 2)TOR=(TOUT+460.)/1.8
PVA=176.4*VW*VW/TOC

32
SUBROUTINE INPUT

Z = -0.03417/TOO
IF(INIT .EQ. 2) Z = 0.3048*Z
CWM = C(W(1))
IF(NFO .EQ. 1) GO TO 212
DO 211 I = 1, NPO
IF(C(W(I)) .LT. CWM) CWM = C(W(I))
211 CONTINUE
IF(NFQ .EQ. 1) GO TO 212
DO 211 I = 1, NPO
CWM = C(W(I))
211 CONTINUE
PGZ = PATMOS*EXP(H(NH)**Z) + CW*M*PV*A*C*(H(NH)/HW)**(2.*XW)) - 100.
CONTINUE
DO 212 I = 1, NPO
PGZ = PATMOS*EXP(H(I)**Z)
212 CONTINUE

BUILDING DATA INPUT

NFLS = NO. OF FLOORS IN BUILDING
IF1 = LOWER FLOOR IN SERIES OF SIMILAR FLOORS
IF2 = UPPER FLOOR IN SERIES OF SIMILAR FLOORS
NCC = NO. OF COMPARTMENTS PER FLOOR
NZ = NO. OF CONNECTIONS TO COMPARTMENTS ON SAME FLOOR
NA = NO. OF CONNECTIONS TO COMPARTMENTS ON FLOOR ABOVE

I = 0
SNCCMP(1) = 0.
READ(5,700)NFLS
WRITE(6,420)NFLS
IF(NFLS .GT. NH) GO TO 106
7 READ(5,700)IF1, IF2, NOC
WRITE(6,400)IF1, IF2, NOC
IF(IF1 .GT. IF2) GO TO 107
NCOMF(IF1) = NOC
IFP = IF1 + 1
SNCCMP(IFP) = SNCCMP(IF1) + NOC
CO = 1C IZ = 1, NOC
I = I + 1
READ(5,700)NZ, NA, NNO, FF(I), IT(I)
WRITE(6,401)NZ, NA, NNO, FF(I), IT(I)
NZZ(I) = NZ
NN = N + NA
IF(NC(I) = IF1)
IF(NA .LE. M) GO TO 111
IPAR = 3
GO TO 110
111 IF(NFQ .LE. MPO) GO TO 112
IPAR = 4
GO TO 110
112 IF(IT(I) .GT. NTP .OR. IT(I) .LT. 1) GO TO 102
NC(I) = NN
IF(NZ .EQ. 0) GO TO 63

INPUT CONNECTIONS TO COMPARTMENTS ON SAME FLOOR
READ(5,700)JC(I,J), C(I,J), AI(I,J), J = 1, NZ
WRITE(6,402)
WRITE(6,403)(JC(I,J), C(I,J), AI(I,J), J = 1, NZ)
SUBROUTINE INPUT

CQ 62 J=1,NZ

62 JC(I,J)=JC(I,J)+SNCMP(IF1)

63 IF(NA .EQ. 0)GO TO 2

C

INPUT CONNECTIONS TO COMPARTMENTS ON FLOOR ABOVE

C

NP=NZ+1
READ(5,700)(JC(I,J),C(I,J),AI(I,J),J=NP,NN)
WRITE(6,404)
WRITE(6,403)(JC(I,J),C(I,J),AI(I,J),J=NP,NN)

66 JC(I,J)=JC(I,J)+SNCMP(IF1)+SNCCMP

E

IF(NNO .EQ. 0)GO TO 10

C

INPUT CONNECTION TO OUTSIDE

C

READ(5,700)(JOC(I,J),CQ(I,J),AO(I,J),J=1,NNO)
WRITE(6,405)
WRITE(6,403)(JOC(I,J),CQ(I,J),AO(I,J),J=1,NNO)
CQ 9 JJ=1,NNO
J=JOC(I,J)

5 FCQ(I,J)=FPQ(IF1,J)

10 CONTINUE

IF(IF1 .NE. IF2)GO TO 11
IF(IF1 .EQ. NFLS)GO TO 20
GO TO 19

C

ASIGN DATA FOR FLOORS SIMILAR TO FLOOR IF1

C

11 IFP=IF1+1
CQ 17 IFF=IFP,IF2
SNCMP(IFP)=NOC
IFFP=IFF+1
SNCMP(IFPP)=SNCMP(IFP)+NOC
CQ 16 ZZ=1,NOC
I=I+1
I1=I+2+SNCMP(IF1)
IFLCCR(I)=IFF
FF(I)=FF(I1)
IT(I)=IT(I1)
NN=NCC(I1)
NOC=NCC(I1)
NC(I)=NN
NCC(I)=NNO
IF(IFP .NE. NFLS)GO TO 23
NN=NZZ(I1)
NC(I)=NN

23 IF(NN .EQ. 0)GO TO 14
DQ 12 J=1,NN
C(I,J)=C(I1,J)
AI(I,J)=AI(I1,J)
JC(I,J)=JC(I,J)+SNCMP(IF1)-SNCMP(IF1)

12 CONTINUE

14 IF(NNO .EQ. 0)GO TO 16
DQ 15 J=1,NNO
JOC(I,J)=JOC(I1,JJ)
J=JOC(I,JJ)

34
SUBROUTINE INPUT

CQ(I,JJ)=CO(I1,JJ)
AQ(I,JJ)=AO(I1,JJ)

15 FQ(I,JJ)=PFQ(IFF,J)
16 CONTINUE
17 CONTINUE
18 IF(IF2 .EQ. NFSL) GO TO 20
19 CONTINUE
20 N=I
N2=N
IF(N .LE. MB) GO TO 114
IPAR=7
GO TO 110

C
C S-AFT DATA INPUT
C
114 REAC(5,700)NS
IF(NS .LE. MS) GO TO 113
IPAR=2
GO TO 110
113 DO 1 CO IS=1,NS
REAC(5,603)(TITSH(IS,I)*I=1,5)
WRITE(6,406)(TITSH(IS,I)*I=1,5)
REAC(5,700)CS(IS),NFS1(IS),NFS2(IS),ITS(IS)
WRITE(6,407)CS(IS),NFS1(IS),NFS2(IS),ITS(IS)
N1=N2+1
N2=N1+NFS2(IS)-NFS1(IS)
NS1(IS)=N1
NS2(IS)=N2
IFF=NFS1(IS)-1
REAC(5,700)NNO,FFF,JCP,CC,AA
WRITE(6,408)NNC,FFF,JCP,CC,AA
IF(NNO .EQ. 0) GO TO 21
REAC(5,700)(JOC(N1,J),CO(N1,J),AO(N1,J),J=1,NNO)
WRITE(6,403)(JOC(N1,J),CC(N1,J),AO(N1,J),J=1,NNO)

21 DO 24 I=N1,N2
NC(I)=1
NCO(I)=NNO
IFF=IFF+1
IF(Name(I))==IFF
IF(IF .GT. NFSL) GO TO 25
FF(I)==FFF
IF(JCP .GT. NCOMP(IFF)) GO TO 25
JC(I,1)=JCP+NCOMP(IFF)
C(I,1)=CC
AI(I,1)=AA
26 IF(NNO .EQ. 0) GO TO 24
CO 22 J=1,NNO
JJ=JCC(N1,J)
FQ(I,J)=PFQ(IFF,JJ)
JOC(I,J)=JJ
CO(I,J)=CO(N1,J)

22 AO(I,J)=AO(N1,J)
GO TO 24
25 NC(I)=0
GO TO 26
24 CONTINUE
C
SUBROUTINE INPUT

C    EXCEPTIONS TO GENERAL SHAFT INPUT
C    NNN = NO. OF EXCEPTIONS
C    KE = 1 FOR FF EXCEPTION
C    KE = 2 FOR OUTSIDE CONNECTION
C    KE = 3 FOR INTERNAL CONNECTION
C
READ(5,700) NNN
IF(NNN .EQ. 0) GO TO 100
DO 69 IK=1,NNN
READ(5,700) KE, IFF
WRITE(6,409) KE, IFF
I=NS1(IS)+IFF-NFS1(IS)
IF(KE .EQ. 1) GO TO 41
IF(KE .EQ. 2) GO TO 42
IF(KE .EQ. 3) GO TO 51
GO TO 104
41 READ(5,700) FF(I)
WRITE(6,410) FF(I)
GO TO 69
42 READ(5,700) J, CCC, AAO
WRITE(6,405)
WRITE(6,403) J, CCC, AAO
NNC=NC(1)
IF(NNC .EQ. 0) GO TO 44
DO 42 K=1,NNC
IF(KE .EQ. 1) GO TO 41
IF(KE .EQ. 2) GO TO 42
IF(KE .EQ. 3) GO TO 51
CONTINUE
44 NJC=NNC+1
NC(1)=NJC
47 PO(I,NJG)=PO(I,IFF,J)
JC(I,NJG)=J
CC(I,NJG)=CCC
AO(I,NJG)=AAO
GO TO 69
46 NJO = K
KK=K+1
IF (CC .NE. 0) GO TO 47
NJG=NC-1
NC(1)=NJG
IF(NJG .EQ. 0) GO TO 69
DO 49 K=KK,NNC
IF(JC(I,K) .EQ. J) GO TO 55
CONTINUE
IF(KE .EQ. 1) GO TO 41
IF(KE .EQ. 2) GO TO 42
IF(KE .EQ. 3) GO TO 51
READ(5,700) JCP, CC, AA
WRITE(6,402)
WRITE(6,403) JCP, CC, AA
J=JCF+SNCOMP(IFF)
NN=NC(1)
IF(NN .EQ. 0) GO TO 53
DO 52 K=1,NN
IF(JC(I,K) .EQ. J) GO TO 55
CONTINUE
IF(CCC .NE. 0) GO TO 53
WRITE(6,520) IS, KE, IFF
SUBROUTINE INPUT

GO TO 69
NJ=N+1
NC(I)=NJ
JC(I,NJ)=J
CI(I,NJ)=CC
AI(I,NJ)=AA
GO TO 69
NJ=K
KK=K+1
IF(AA .NE. 0.) GO TO 54
NJ=NJ-1
NC(I)=NJ
IF(NJ .EQ. 0.) GO TO 69
CO 61 K=KK,NN
KM=K-1
JC(I,KM)=JC(I,K)
CI(I,KM)=CI(I,K)
61 AI(I,KM)=AI(I,K)
69 CONTINUE
100 CONTINUE
NT=2
IF(NT .LE. MM) GO TO 160
IPAR=1
GO TO 110

C PRINT OUTSIDE TEMPERATURE

160 WRITE(6,601)(TITLE(I),I=1,12)
IF(IUNIT .EQ. 1) WRITE(6,800)TOUT
IF(IUNIT .EQ. 2) WRITE(6,500)TOUT
IF(IUNIT .EQ. 2) TOUT=(TOUT-32.)/1.8
TOUT=TOUT+273.

C PRINT HEIGHT AND TEMPERATURE PROFILES

IF(IUNIT .EQ. 1) WRITE(6,811)(IP,IP=1,NTP)
IF(IUNIT .EQ. 2) WRITE(6,511)(IP,IP=1,NTP)
WRITE(6,813)
CO 33 IFF=1,NH
30 WRITE(6,812)H(IFF),(T(IF,IFF),IP=1,NTP)

C CONVERT TEMPERATURES TO DEG K

DO 33 IFF=1,NH
CO 33 IF=1,NTP
IF(IUNIT .EQ. 2) T(IP,IFF)=(T(IP,IFF)-32.)/1.8
33 T(IP,IFF)=T(IP,IFF)+273.

C PRINT OUTSIDE PRESSURE PROFILES

IF(IUNIT .EQ. 1) GO TO 79
WRITE(6,514)(IP,IP=1,NPC)
WRITE(6,813)
CQ 76 JF=1,NH
CQ 77 J=1,NPO
77 PF0(IFF,J)=PF0(IFF,J)/248.8
WRITE(6,515)H(IFF),(PF0(IFF),J=1,NPO)
CQ 7E J=1,NPO
SUBROUTINE INPUT

78  PFC(IFF,J)=PFO(IFF,J)*24E.8
76  CONTINUE
79  GO TO 63

WRITE(6,814)(IP,IP=1,NPO)
WRITE(6,813)
DO 31 IFF=1,NM
WRITE(6,815)M(IFF),(PFO(IFF,J),J=1,NPO)
31  CONTINUE

C C CORRECT FOR CONNECTIONS ONLY INPUTED ONCE
C
63  DO 66 I=1,NT
   NN=NC(I)
   IF(NN.EQ.0)GO TO 60
   DO 56 JJ=1,NN
   J=JC(I,JJ)
   IF(J.EQ.0)GO TO 58
   NNJ=NC(J)
   IF(NNJ.EQ.0)GO TO 57
   DO 56 IA=1,NNJ
   IF(JC(J,IA).EQ.I)GO TO 58
56  CONTINUE
57  NNJ=NNJ+1
   IF(NNJ.LE.MC)GO TO 55
   IPAR=3
   GO TO 110
59  NC(J)=NNJ
   JC(J,NNJ)=I
   CJ(J,NNJ)=C(I,JJ)
   AI(J,NNJ)=AI(I,JJ)
   IF(J.GT.N.OR.I.GT.N)GO TO 58
   PZ(J,NNJ)=-PZ(I,JJ)
58  CONTINUE
60  CONTINUE
C C CORRECT UNITS
C
67  DO 40 I=1,N
   NN=NC(I)
   IF(NN.EQ.0)GO TO 40
   IA=I1(I)
   IFJ=IFLOR(I)
   DO 36 JJ=1,NN
   J=JC(I,JJ)
   IFJ=IFLOR(J)
   IF(IFI.EQ.0)IFJ)GO TO 38
   IB=IT(J)
   TEMPA=0.5*(T(I,IFI)+T(IB,IFJ))
   PZ(I,JJ)=3462.*(H(IFJ)-H(IFI))/TEMPA
38  CONTINUE
40  CONTINUE
C C INITIALIZE PZ FOR SHAFTS
C
SUBROUTINE INPUT

DC EC IS=1, NS
NI=NI1(IS)
N2=NI2(IS)-1
ITT=ITS(IS)
DO 4E I=HI1, N2
IFI=IFLOR(I)
IFJ=IFI+1
TEMPA=0.5*(T(ITT,IFI)+T(ITT,IFJ))
PZ(I,1)=2462.*(H(IFJ)-H(IFI))/TEMPA
45 CONTINUE
50 CONTINUE
C
C CHECK SHAFT CONNECTIONS
C
DO 240 IS=1, NS
NI=NI1(IS)
N2=NI2(IS)
DO 239 I=NI1, N2
NN=NC(I)
IF(NF .EQ. 0) GO TO 239
DO 226 J=1, NN
JJ=JC(I, J)
IF(IFLOR(I) .NE. IFLOOR(JJ)) GO TO 103
236 CONTINUE
239 CONTINUE
240 CONTINUE
RETURN
C
C DIAGNOSTIC OUTPUT
C
102 WRITE(6,902)I, IT(I)
GO TC 109
103 WRITE(6,903)
GO TC 109
104 WRITE(6,904)
GO TC 109
105 WRITE(6,905)
GO TC 109
106 WRITE(6,906)
GO TC 109
107 WRITE(6,907)
GO TC 109
110 WRITE(6,510)PAR(IPAR)
C
C PRINT CORRECTED BUILDING DATA
C
109 WRITE(6,540)
DO 7C I=1, N
NN=NC(I)
IF(NF .GT. 0) GO TO 180
WRITE(6,541)I, IFLOOR(I), IT(I), FF(I)
GO TC 182
180 WRITE(6,542)I, IFLOOR(I), IT(I), FF(I), JC(I, 1), C(I, 1), AI(I, 1)
IF(NF .EQ. 1) GO TO 182
WRITE(6,543)JC(I, J), C(I, J), AI(I, J), J=2, NN
182 NNC=KCC(I)
IF(NNC .EQ. 0) GO TC 70
SUBROUTINE INPUT

WRITE(6,544) (JC(I), CO(I), AO(I), J=1, NNO)
CONTINUE
C
PRINT CORRECTED SHAFT INPUT DATA
C
DO 80 IC=1, NS
WRITE(6,816) (TITSH(IS), IS=I, I=1, 5)
WRITE(6,806) IS, CS(IS), ITS(IS)
N1=N1(IS)
N2=N2(IS)
WRITE(6,807)
CO 75 =N1, N2
N=S(NC(I))
IF(NH.GT. 0) GO TO 72
WRITE(6,801) FLCOR(I), FF(I)
GO TO 74
72 WRITE(6,808) FLCOR(I), FF(I), JC(I), C(I)
IF(NH.EQ. 1) GO TO 74
WRITE(6,809) (JC(I), J=1, J=2, NN)
74 NC=S(CC(I))
IF(NH.EQ. 0) GO TO 75
WRITE(6,810) (JC(I), J=1, J=1, NNO)
CONTINUE
STOP
C
FORMAT STATEMENTS
C
400 FORMAT(5X,5HIF1 =, I3, 7H, IF2 =, I3, 7H, NOC =, I3)
401 FORMAT(5X,4MNZ =, I3, 6H NA =, I3, 7H, NNO =, I3, 6H, FF =, F8.1,
+ 7H, IT =, I3)
402 FORMAT(5X,25HCOUNT ON SAME FLOOR )
403 FORMAT(5X,3HJ =, I3, 5H, C =, F10.3, 5H, A =, F9.4)
404 FORMAT(5X,25HCOUNT ON FLOOR ABOVE )
405 FORMAT(5X,25HCOUNT ON OUTSIDE )
406 FORMAT(5X,5AAP)
407 FORMAT(5X,4NCS =, F9.1, 8H, NFS1 =, I3, 8H, NFS2 =, I3, 7H, ITS =, I3)
408 FORMAT(5X,5MNNO =, I3, 7H, FFF =, F8.1, 5H, J =, I3, 5H, C =, F10.3,
+ 5H, A =, F9.4)
409 FORMAT(5X,4MKE =, I3, 7H, IFF =, I3)
410 FORMAT(5X,4HFF =, F8.1)
411 FORMAT(5X,6HOUT =, F6.0, 5H, IUNIT =, I3, 8H, IOUT =, I3)
412 FORMAT(5X,4MNH =, I3, 6H, NN =, I3)
413 FORMAT(5X,7HEIGHTS /(10F6.2))
414 FORMAT(5X,6MHC =, F8.2, 6H, DM =, F8.2)
415 FORMAT(5X,5MNP =, I3)
416 FORMAT(5X,20HTEMPERATURE PROFILE /I5,(10I4,5H*))
417 FORMAT(5X,5MNPQ =, I3, 6H, NN =, I3)
418 FORMAT(5X,5MPGZ =, F12.1/17MPRESSURE PROFILE /(10F12.1))
419 FORMAT(5X,4HVW =, F6.1, 6H, HW =, F6.1, 6H, XW =, F4.2, 6H, CW =,
+ (10F4.2))
420 FORMAT(5X,6HMFLS =, I3)
500 FORMAT(///5X,20HOUTSIDE TEMPERATURE ,F6.1, 2H F)
511 FORMAT( ///5X,6HEIGHT,5X,29HTEMPERATURE PROFILES (DEG F) / + 7X,5HT, 3X,1916)
514 FORMAT(///5X,6HEIGHT ,5X,26HOUTSIDE PRESSURE PROFILES
1 11+ (IN H2O) /7X,2HT, 3X,8110)
515 FORMAT(F11.2,3X,8F10.3)
SUBROUTINE INPUT

120 FORMAT(//5X.15F14.3I12.F14.3I
10X,8F14.2,F15.4)
10X.26HFLOW
STOPPED

10X.3HAREA

10X.4F4.2

20X.3F1.2

40X.4HHEIGHT

10X.4F10.2

50X.4F10.2

60X.4F10.2

70X.4F10.2

80X.4F10.2

90X.4F10.2

100X.4F10.2

110X.4F10.2

120X.4F10.2

130X.4F10.2

140X.4F10.2

150X.4F10.2

160X.4F10.2

170X.4F10.2

180X.4F10.2

190X.4F10.2

200X.4F10.2

210X.4F10.2

220X.4F10.2

230X.4F10.2

240X.4F10.2

250X.4F10.2

260X.4F10.2

270X.4F10.2

280X.4F10.2

290X.4F10.2

300X.4F10.2

310X.4F10.2

SUBROUTINE CORR.L1
SUBROUTINE CORR

&NBS*PLIBS.SPCW INCOR
SUBROUTINE CORR
C
C THIS ROUTINE CALCULATES ADJUSTED FLOW COEFFICIENTS
C (C1,C2,C1,C02)
C
PARAMETER (MM=140,MS=8,MC=9,MFC=2,MTP=2,MFL=25,MB=50)
CCOMCN /CORR/C1(MM,MC),C2(MM,MC),C01(MM,MPO),C02(MM,MPO)
CCOMCN NT, P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
  FF(MM),FO(MM,MPO),CS(MS),PS(MFL,MPO),NS1(MS),NS2(MS),
  FSS(MS),N,NS,NPO,ICONV,E,IBUG,AI(MM,MC),AO(MM,MPO),TITSH(MS,5),
  NF,F(MFL),IFLOOR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
CCOELE PRECISION P,F0,PS
CO 12 I=1,NT
C
COFRECT C
C
PATMC5=101325,
BB=1000.*SQRT(2.*PATM5/287.)/1.2
NN=NC(I)
IF(I .LT. N)GO TO 1
IP=IT(I)
GO TO 4
1 CO 2 IS=1,NS
IF(I .LE. NS2(IS) .AND. I .GT. NS1(IS))GO TO 3
2 CONTINUE
WRITE(*,700)
STOP
3 IP=IT(IS)
4 IFF=IFLOOR(I)
T1=T(IF,IFF)
IF(NN .EQ. 0)GO TO 10
CO 9 J=1,NN
JJ=JC(I,J)
C1(I,J)=BB+C(I,J)*AI(I,J)/SQRT(T1)
IF(JJ .GT. N)GO TO 5
IP=IT(JJ)
GO TO 8
5 CO 6 IS=1,NS
IF(JJ .LE. NS2(IS) .AND. JJ .GT. NS1(IS))GO TO 7
6 CONTINUE
WRITE(*,700)
STOP
7 IP=ITS(IS)
8 IFF=IFLOOR(JJ)
T2=T(IP,IFF)
C2(I,J)=BB+C(I,J)*AI(I,J)/SQRT(T2)
9 CONTINUE
C
COFRECT CO
C
10 NNC=NC(I)
IF(NNC .EQ. 0)GO TO 12
CO 11 J=1,NNC
C01(I,J)=BB*CG(I,J)*AO(I,J)/SQRT(T1)
42
SUBROUTINE CORR

C02(I,J)=BB*C0(I,J)*AC(I,J)/SQRT(TOUT)
11 CONTINUE
12 CONTINUE
RETURN

700 FORMAT(//'PROGRAM STOPPED IN SUBROUTINE CORR //)
END

SUBROUTINE INIT.L.1
THIS ROUTINE Initializes THE PRESSURE ARRAY

PARAMETER (MM=140, MS=8, MC=9, MP=2, MFL=25, MB=50)
PARAMETER (MBP=MB+1)
COMMON /CORR/C1(MM, MC), C2(MM, MC), CO1(MM, MP), CO2(MM, MP),
NT, P(MM), C(MM, MC), NC(MM), JC(MM, MC), ITS(MS),
1 FC(MM, MC), PZ(MM, MC), PC(MM, MFC), CO(MM, MP), F1(MM), PF0(MFL, MP),
2 FF(MM), FC(MM, MP), CS(MS), PS(MFL), NS1(MS), NS2(MS),
3 FSS(MS), N, NS, NPO, ICCNV, E, IEUG, AI(MM, MC), AQ(MM, MP), TITSH(MS, 5),
4 NH, T(MFL), IFLOC(MM), T(MTP, MFL), NFS1(MS), NFS2(MS), IT(MB), NTP
5, NCC(MM), JOC(MM, MFC), TOUT
DOULE PRECISION F, FC, FS
DIMENSION SC(MS), SCO(MS)
COMMON /MAT/A(ME, MEP), XX(MB), NNN
DOULE PRECISION A, XX

CALCULATE AVERAGE OUTSIDE PRESSURE

SUM=C,
CO IC J=1, NPO
CC IC I=1, NH
SUM=SUM+PF0(I, J)
FA=SLM/(NPO*NH)
THE CO LOOP TO STATEMENT 30 ESTIMATES SHAFT PRESSURES
DO 30 IS=1, NS
CALCULATE SHAFT PRESSURE DIFFERENCE, DP
SUM=C,
SUMN=0.
N1=NS1(IS)
N2=NS2(IS)
DO 16 I=N1, N2
SUM=SUM+FF(I)
N=NCC(I)
IF(N .EQ. 0) GO TO 16
DO 15 J=1, N
SUMN=SUMN+C(I, J)
15 CONTINUE
SC(IS)=SUMN
16 NCC=NCC(I)
IF(NCC .EQ. 0) GO TO 16
DO 17 J=1, NNN
SUMN=SUMN+C01(I, J)
17 CONTINUE
SCO(IS)=SUMN-SC(IS)

CONTINUE
SUBROUTINE INIT

CP2=SUM/SUMN
SIGN=1.
IF(CP2 .LT. 0.)SIGN=-1.
DP=SIGN*(SIGN*CP2)**2

CALCULATE AVERAGE TEMP OF SHAFT

SUM=C.
IP=ITS(IS)
DO 20 I=N1,N2
IFF=I.FLOC(I)
20 SUM=SUM+T(IP,IFF)
TA=SLM/(N2-N1+1)

ESTIMATE PRESSURE AT BOTTOM OF SHAFT, PBOT

HH=0.5*(M(NH)-H(1))+H(1)
NF1=FS1(IS)
PBOT=P+DP+3462.*((HH-H(NF1))/TA)

ESTIMATE OTHER SHAFT PRESSURES

P(N1)=PBOT
NM=N2-1
DO 24 I=N1,NM
IP1=I+1
24 P(IP1)=P(I)-PZ(I,1)
30 CONTINUE

ENC OF SHAFT PRESSURE ESTIMATES

SET UP MATRIX FOR BUILDING COMPARTMENTS

NP1=I+1
DO 50 I=1,N
NN=N(NC(I))
SUMII=0.
SUMNF=0.
IF(NH .EQ. 0.)GO TO 42
DO 40 JJ=1,NN
J=JC(I,JJ)
IF(J .GT. N)GO TO 34
A(I,J)=C1(I,JJ)
SUMII=SUMII-C1(I,JJ)
SUMNF=SUMNF-C1(I,JJ)*PZ(I,JJ)
GO TO 40
34 SUMII=SUMII-C1(I,JJ)
SUMNF=SUMNF-C1(I,JJ)*P(J)
40 CONTINUE
42 NNC=KCC(I)
IF(NK .EQ. 0.)GO TO 46
DO 46 K=1,NNO
SUMII=SUMII-C01(I,K)
45 SLUN=SUMNF-C01(I,K)*PG(I,K)
46 A(I,K)=SUMII
A(I,NF1)=SUMNF-FF(I)
50 CONTINUE
SUBROUTINE INIT

C WRITE MATRIX
C
IF(IEUG .EQ. 0) GO TO 84
WRITE(6,802)
GO TO 82
I=1,N

82 WRITE(6,803)(A(I,J),J=1,NP1)
C
CALL ROUTINE TO SOLVE FOR INITIAL BUILDING PRESSURES
C
84 CALL SMEQ
C
OUTPUT INITIAL PRESSURES
C
IF(IEUG .EQ. 0) GO TO 85
WRITE(6,800)
WRITE(6,801)(I,XX(I),I=1,N)
NN=NS1(I)
WRITE(6,801)(I,P(I),I=NN,NT)
C
ASSIGN BUILDING PRESSURES
C
89 DO SC I=1,N
90 P(I)=XX(I)
RETURN
800 FORMAT(/8(6X,1HI,4X,3HP )/)
801 FORMAT(8(I7,F7.1))
802 FORMAT(/10X,20H MATRICE COEFFICIENTS )/
803 FORMAT(10X,11F11.1)
END

&DG,P

SUBROUTINE BLDGP.L.1

46
SUBROUTINE BLDGP

PARAMETER (MM=140, MS=8, MC=9, MPC=2, MTP=2, MFL=25, MB=50)
COMMON NT, P(MM), C(MM, MC), NC(MM), JCC(MM, MC), ITS(MS),
1 FC(MM, MC), PZ(MM, MC), PO(MM, MPO), F(MM), PFO(MFL, MPO),
2 FF(MM), FO(MM, MPO), CS(MS), PS(MFL), NS1(MS), NS2(MS),
3 FSS(MS), N, N1, NPO, ICONV, E, IBUG, AI(MM, MC), AO(MM, MPO), TITSH(MS, 5),
4 NF, F(MFL), IFLOOR(MM), T(MTP, MFL), NFS1(MS), NFS2(MS), IT(MB), NTP
5 , NCC(MM), JCC(MM, MFC), TOUT
COUPLE PRECISION P, PZ, PO, PI
IF(IEUG .GT. 0) WRITE(6, 806)
ITM=100
ICONV=0
CO 15 I=1, N
CALCULATE NET FLOW ,FI, INTO POINT I
FI=PFLCW(I, P(I))
CHECK MAGNITUDE OF FI
IF(AES(FI) .LT. E) GO TO 15
ICCNV=ICCNV+1
SET UP PARAMETERS FOR ITERATION
CP=1.0
IPHASE=1
CPI=C.
EE=0.2*ABS(FI)
IF(EE .LT. E) EE=E
SIGN=1
IF(FI .LT. 0.) SIGN=-1
IK=0
IF(IEUG .GT. 0) WRITE(6, 802)
ITERATION TO REDUCE MAGNITUDE OF FN
IK=IK+1
NEW ESTIMATE OF PRESSURE , PI, AT POINT I
PI=P(I)+SIGN*OP
CALCULATE NET FLOW ,FN, INTO POINT I USING PI
FN=PFLCW(I, PI)
IF(IEUG .GT. 0) WRITE(6, 804) I, IK, FI, FN, FP, DPI, DP, DPP, PI, I PHASE
CHECK MAGNITUDE OF FN
IF(AES(FN) .LT. EE) GO TO 10
CHECK NUMBER OF ITERATIONS
IF(IK .GT. ITM) GO TO 25
CHECK PHASE
SUBROUTINE ELDGP

IF(IFHASE .EQ. 2) GO TO 6

C CHECK FOR TRANSITION FROM PHASE 1 TO PHASE 2
IF(FI*FN .LT. 0.) GO TO 4

C PHASE 1
CPI=CF
CP=5*0*DP
FI=FN
GO TO 2

C PHASE 2
IPHASE=2
GO TO 9

C NEW CP BETWEEN DPI AND DP
CPP=CP
FP=FN
CP=DFI+(CPP-DPI)*FI/(FI-FN)
GO TO 2

C NEW CP BETWEEN CP AND DFP
FP=FN
DPI=CP
DF=DFI+(CPP-DPI)*FN/(FN-FP)
GO TO 2

10 P(I)=P I
15 CONTINUE

C RETURN
25 WRITE(*,800)
STOP

C FORMAT STATEMENTS
C
800 FORMAT(///10X,20(1H*),/10X,22HEXCESSIVE ITERATIONS /)
+ 10X,8+IN BLDGP //10X,20(1H*)//////)
802 FORMAT(///11X,1HI,2X,2HIT,12X,2HFI,13X,2HFN,13X,2HFP,12X,3HDP1,
+13X,2+CP,12X,3FDP,13X,2HPI,3X,5HPHASE /)
804 FORMAT(8X,214,3E15.4,4F15.6,15)
806 FORMAT( //10X,6HBLDGP )
END
SUBROUTINE SHAFTP

@BS*PLIES$SHOW A.SHAP TP

SUCRTINE SHAP TP

THI S F CTINE CALCULATES STEADY ST AE PRESSURES
FOR SHAP TS

PARAMETER (MM=140, MS=8, MC=9, MFC=2, MTP=2, MFL=25, MB=50)
CMMCN NT, F(MM), C(MM, MC), NC(MM), JC(MM, MC), ITS(MS),
1 FC(MM, MC), PZ(MM, MC), PG(MM, MPO), CO(MM, MPO), F(MM), PFO(MFL, MPO),
2 FF(MM), FO(MM, MPO), CS(MS), PS(MFL), NS1(MS), NS2(MS),
3 FES(MS), N, NS, NPO, ICCNV, IEBUG, AI(MM, MC), AO(MM, MPO), TITSH(MS, 5),
4 NP, P(MFL), IFLCCTR(MM), T(MTP, MFL), NFS1(MS), NFS2(MS), IT(MB), NTP
5 NC(MM), JOC(MM, MPO), TOUT

DOLELE PRECISION P, PG, PS, PI
IF(IEUG .GT. 0) WRITE(6, E06)
ITM=100
ICCNV=0
DO IE = I, NS

CALCULATE NET FLOW, FI, INTO POINT I
N1=N51(I)
FI=SFLCW(I, P(N1))

CHECK MAGNITUDE OF FI
IF(AES(FI) .LT. E) GO TO 15
ICCNV=ICCNV+1

SET LP PARAMETERS FOR ITERATION
DP=1.0
IP=0
EE=0
SIGN=1

IF(FI .LT. 0.) SIGN=-1
IF(IEUG .GT. 0) WRITE(6, E02)

ITERATION TO REDUCE MAGNITUDE OF FN
IK=IK+1

NEW ESTIMATE OF PRESSURE, PI, AT BOTTOM OF SHAFT I
PI=F(N1)+SIGN*DP

CALCULATE NET FLOW, FN, INTO SHAFT I USING PI
FN=SFLOW(1, PI)
IF(IEUG .GT. 0) WRITE(6, E04) I, IK, FI, FN, FP, DPI, DP, DPP, PI, IPHASE

CHECK MAGNITUDE OF FN
IF(AES(FN) .LT. EE) GO TO 10

CHECK NUMBER OF ITERATIONS
IF(IK .GT. ITM) GO TO 25

CHECK PHASE

49
SUBROUTINE SHAFTP

IF(IF*ASE .EQ. 2) GO TO 6

C CHECK FOR TRANSITION FROM PHASE 1 TO PHASE 2
IF(FI*FN .LT. 0.) GO TO 4

C PHASE 1
CP=CP
FI=FI
GO TO 2

C PHASE 2
4IPHASE=2
GO TO 5

C IF(FI*FN .GT. 0.) GO TO 8

C NEW CP BETWEEN DPI AND DP
5CPP=CP
FP=FN
DP=DFI+(CPP-DPI)*FI/(FI-FN)
GO TO 2

C NEW CP BETWEEN DP AND DPP
6FI=FI
CP=CP
DP=CFI+(DPP-DPI)*FN/(FN-FP)
GO TO 2

10 N2=N2+2(I)
GO 11 IF=N1,N2
11 IF=IF+1-N1
15 CONTINUE
C RETURN
25 WRITE(6,800)
STOP
C FORMAT STATEMENTS
C 800 FORMAT(///10X,2O(1H*))/\(10X,22\)EXCESSIVE ITERATIONS /
+ 10X,9+IN SHAFTP ///10X,2O(1H*)///)
802 FORMAT(///11X,1H1,2X,2HIT,12X,2HFI,13X,2HFN,13X,2HFPI,12X,3HDP1, 
+13X,2HDP,12X,3HDP1,13X,2HFN,13X,5MHASE /)
804 FORMAT(8X,2I4,3E15.4,4F15.6,E15)
806 FORMAT( ///10X,6HSHAFTP)
END

TODG,P SUBROUTINE PZAD .L.1
SUBROUTINE PZAD

THIS ROUTINE CORRECTS PZ TERMS FOR PRESSURE

PARAMETER (MM=140, MS=8, MC=9, MFC=2, MTP=2, MFL=25, MB=50)
COMMON NT, P(MM), C(MM, MC), NC(MM), JC(MM, MC), ITS(MS),
1 FC(MM, MC), PZ(MM, MC), PG(MM, MPO), CD(MM, MPO), FI(MM), PFO(MFL, MPO),
2 FF(MM), FO(MM, MPO), CS(MS), PS(MFL), NS1(MS), NS2(MS),
3 FS(MS), N, NS, NPO, ICONV, E, IBUG, AI(MM, MC), A0(MM, MPO), TITSH(MS, 5),
4 NH, P (MFL), IFLOC(MM), T(MTP, MFL), NF1(MS), NF2(MS), IT(MB), NTP
5, NC(MM), JDC(MM, MPO), TOUT

COMMON /PZ/, PGZ

DOUBLE PRECISION P, FO, PS

IF (IEUG .NE. 0) GO TO 1
WRITE(6,800)
DC 2 I=1,N
NN=NC(I)
IF (NN .EQ. 0) GO TO 2
WRITE(6,801)(I,J,PZ(I,J),J=1,NN)
CONTINUE
NP1=I+1
WRITE(6,802)(IL,PZ(IL,1),IL=NP1,NT)

1 DC 1C=1,N
NN=NC(I)
IF (NN .EQ. 0) GO TO 10
IA=IT(1)
IFI=IFLOC(1)
DO 6 JJ=1,NN
J=JC(I,JJ)
IFJ=IFLOC(J)
IFI .EQ. IFJ) GO TO 8
IE=IT(J)
TEMPA=0.5*(T(IA,IFI)+T(IE,IFJ))
FAVE=0.5*(P(I)+P(J))+PGZ
PZ(I,JJ)=(0.03416*PAVE/TEMPA)*H(IFJ)-H(IFI))

CONTINUE
10 CONTINUE

60 FORMAT(/10X,3HPZ(I2,6H,1),F12.4)
601 FORMAT(/10X,HHADJUSTED PZ/)
12 FORMAT(/10X,3HPZ(I2,6H,1),F12.4)
602 FORMAT(10X,10MINITIAL PZ/)
603 FORMAT(10X,11HADJLISTED PZ/)

RETURN
SUBROUTINE OUT

THIS ROUTINE OUTPUTS FLOWS AND DIFFERENTIAL PRESSURES
FOR ALL SHAFTS AND BUILDING COMPARTMENTS

PARAMETER (MM=140, MS=8, MC=9, MFC=2, MTP=2, MFL=25, MB=50)
COMMON /CORR/C1(MM,MC), C2(MM,MC), C01(MM,MPO), CO2(MM,MPO)
COMMON /IO/TITLE(18), IDROUT, IUNIT, NCOMP(MFL), SNCOMP(MFL)
COMMON NT, P(MM), C(MM, MC), NC(MM), JC(MM, MC), ITS(MS),
1 FC(MM, MC), PZ(MM, MC), PO(MM, MPO), F(MM), PFQ(MFL, MPO),
2 FF(MS), FC(MM, MPO), CS(MS), FS(MFL), NS1(MS), NS2(MS),
3 FSS(MS) .NS1(MS).NS2(MS),
4 NT, FC(MFL), IFLOOR(MM), T(T(MTP, MFL), NFS1(MS), NFS2(MS), IT(ME), NTP
5 NCC(MM), JOC(MM, MFC), TOUT

INTEGER COM

ILUNIT = 1 FOR SI UNITS
ILUNIT = 2 FOR ENG UNITS
WHEN ILUNIT = 2 GO TO 100
IF(ILUNIT .EQ. 2) GO TO 100

BUILDING COMPARTMENT OUTPUT

I=0
IL=0
WRITE(6,800)(TITLE(I), I=1,18)
DO 30 IFF=1, NM
NN=NCMP(IFF)
IF(NNN .EQ. 0) GO TO 30
DO 25 IC=1, NNN
I=I+1
NN=NC(I)
NCC=NCC(I)
IL=IL+NN+NN+2
IF(IL .LT. 51) GO TO 2
WRITE(6,800)(TITLE(I), I=1,18)
IL=NN+NN+2
2 IF(NN .GT. 0) GO TO 3
WRITE(6,801) IFF, IC, P(I), IT(I), FF(I)
GO TO 21
3 DO 20 J=1, NN
JJ=JC(I,J)
DP=F(JJ)-P(I)+PZ(I,J)
CC=C2(I,J)
IF(DF .LT. 0.) CC=C1(I,J)
IF(JJ .LE. N) GO TO 10
DO 5 IS=1, NS
IF(JJ .GE. NS1(IS) .AND. JJ .LE. NS2(IS)) GO TO 6
CONTINUE
5 CONTINUE
6 IF(J .GE. T) 1 GO TO 7
WRITE(6,801) IFF, IC, P(I), IT(I), FF(I), (TITSH(IS,K), K=1,5)
+ DF, CC, AI(I,J), FC(I,J)
GO TO 20
SUBROUTINE CUT

7 WRITE(*,603)(TITSH(IS,K),K=1,5),DP,CC,AIL(I,J),FC(I,J)
GO TO 20
10 IF(J .LT. 1)GO TO 12
WRITE(*,804)IFF,IC,P(I),IT(I),FF(I),CMM,DP,CC,AIL(I,1),FC(I,1)
GO TO 20
12 WRITE(*,805)IFF,COM,DP,CC,AIL(I,J),FC(I,J)
20 CONTINUE
21 IF(NNO .EQ. 0)GO TO 29
DO 23 J=1,NNO
   JJ=JCC(I,J)
   CP=PC(I,J)-P(I)
   CC=CC2(I,J)
   IF(DP .LT. 0.)CC=CC1(I,J)
23 WRITE(*,806)JJ,DP,CC,AO(I,J),FC(I,J)
29 CONTINUE
WRITE(*,900)
C
S#AF1 OUTPUT
C
DO 32 IS=1,NS
   N1=NS1(IS)
   N2=NS2(IS)
32 WRITE(*,614)(TITLE(I),I=1,18)
WRITE(*,808)(TITSH(IS,K),K=1,5),ITS(IS),CS(IS)
CC 5C I=N1,N2
   NN=NCC(I)
   IF(NN .GT. 0)GO TO 35
   WRITE(*,809)IFLOOR(I),P(I),FF(I)
   GO TO 41
35 DO 42 J=1,NN
   JJ=JCC(I,J)
   CP=PC(JJ)-P(I)
   CC=CC2(I,J)
   IF(DP .LT. 0.)CC=CC1(I,J)
   IF=IFLORC(JJ)
   CMM=JJ-SNCOMP(IFJ)
   IF(J .GT. 1)GO TO 36
   WRITE(*,810)IFLOOR(I),P(I),FF(I),IFJ,CMM,DP,CC,AIL(I,1),FC(I,1)
   GO TO 40
36 WRITE(*,811)IFJ,CCM,DP,CC,AIL(I,J),FC(I,J)
40 CONTINUE
41 NCC=NCC(I)
   IF(NNO .EQ. 0)GO TO 50
   DO 46 J=1,NNO
      JJ=JCC(I,J)
      CP=PC(I,J)-P(I)
      CC=CC2(I,J)
      IF(DP .LT. 0.)CC=CC1(I,J)
46 WRITE(*,812)JJ,DP,CC,AO(I,J),FC(I,J)
50 CONTINUE
WRITE(*,813)FSS(IS)
WRITE(*,500)
60 CONTINUE
GO TO 165
C
SUBROUTINE OUT

BUILDING DATA OUTPUT FOR IUNIT = 2

C
I=0
IL=0
WRITE(6,800)(TITLE(I),I=1,18)
C0 130 IFF=1,NH
NN=NCCM(F(I))
IF(NN .EQ. 0)GO TO 130
C0 129 IC=1,NNN
I=I+1
FF=F(I)/0.4719
PIII=P(I)/248.8
FFF=FFF(I)/0.4719
NN=NC(I)
NLC=NCO(F)
IL=IL+NN+NNO+2
IF(IL .LT. 51)GO TO 102
WRITE(6,800)(TITLE(I),I=1,18)
IL=NN+NNO+2
102 IF(NN .GT. 0)GO TO 103
WRITE(6,601)IFF,IC,PIII,IT(I),FFF
GO TO 121
103 C0 120 J=1,NN
FCCC=FC(I,J)/0.4719
JJ=JC(F)
DP=(F(JJ)-P(I)+PZ(I,J))/248.8
AAI=AI(I,J)/0.0929
CC=C2(I,J)
IF(DF .LT. 0.)CC=C1(I,J)
CC=CC*33.43
IF(JJ .LE. NS(I))GO TO 100
DO 105 IS=1,NS
IF(JJ .GE. NS1(IS) orr AND. JJ .LE. NS2(IS))GO TO 106
CONTINUE
105 CONTINUE
106 IF(J .GT. 1)GO TO 107
WRITE(6,602)IFF,IC,PIII,IT(I),FFF,(TITSH(I,S,K),K=1,5)
+ ,DP,CC,AAI,FCCC
GO TC 120
107 WRITE(6,603)(TITSH(I,S,K),K=1,5),DP,CC,AAI,FCCC
GO TC 120
110 IF(J=1)FLOR(J)
CO=J-JC(SI
IF(J .LT. 1)GO TO 112
WRITE(6,604)IFF,IC,PIII,IT(I),FFF ,IFJ,COM,DP,CC,AAI,FCCC
GO TC 120
112 WRITE(6,605)IFF,CO,DP,CC,AAI,FCCC
CONTINUE
121 IF(NNG .EQ. 0)GO TO 125
C0 123 J=1,NNO
F0C=F0(I,J)/0.4719
JJ=JC(F)
DP=(FC(I,J)-P(I))/248.8
AAI=AC(I,J)/0.0929
CC=C2(I,J)
IF(DF .LT. 0.)CC=C01(I,J)
CC=CC*33.43
123 WRITE(6,606)JJ,DP,CC,AAI,F0C
129 WRITE(6,807)FI
SUBROUTINE OUT

130 CONTINUE
WRITE(6,901)

C
SHAFT OUTPUT FOR IUNIT = 2

C
DO 160 IS=1,NS
CSS=CS(IS)/0.02992
FFI=FFS(IS)/0.4719
N1=NS(I)
N2=NS2(IS)
132 WRITE(6,814)(TITLE(I),I=1,18)
WRITE(6,800)(TITSH(IS,K),K=1,5),ITS(IS),CSS
DO 150 I=N1,N2
FFF=FF(I)/0.4719
PIII=P(I)/248.8
NN=NC(I)
IF(NN .GT. 0)GO TO 135
WRITE(6,609)IFLOOR(I),PIII,FFF
135 GC 141
DO 140 J=1,NN
FCCC=FC(I,J)/0.4719
JJ=JC(I,J)
DP=(F(JJ)-P(I))/248.8
AAI=AI(I,J)/0.0929
CC=C2(I,J)
IF(CF .LT. 0.)CC=C1(I,J)
CC=CC*33.43
IFJ=IFLOCR(JJ)
CG=JJ-SNCOMP(IFJ)
IF(J .LT. 1)GO TO 136
WRITE(6,610)IFLOOR(I),PIII,FFF,IFJ,COM,DP,CC,AAI,FCCC
140 CONTINUE
136 WRITE(6,611)IFJ,COM,DP,CC,AAI,FCCC
140 CONTINUE
141 NNC=NCO(I)
IF(NNO .EQ. 0.)GO TO 150
C 146 J=1,NNO
FOC=FO(I,J)/0.4719
JJ=JC(I,J)
CP=(FO(I,J)-P(I))/248.8
AAO=AO(I,J)/0.0529
CC=C2(I,J)
IF(CF .LT. 0.)CC=CO1(I,J)
CC=CC*33.43
146 WRITE(6,612)JJ,DP,CC,AAO,FOC
150 CONTINUE
WRITE(6,813)FFI
WRITE(6,501)
160 CONTINUE

C
SUMMARY OUTPUT
C USER INSERTS WRITE STATEMENTS TO FILE IOUT
C
165 CONTINUE
RETURN
C
FCFMAT STATEMENTS
SUBROUTINE OUT

C

01 FORMAT (/4X,I3,110,F13.3,I8,F12.0)
03 FORMAT (53X,5A4,F14.3,F15.0,F10.3,F11.1)
04 FORMAT (/4X,I3,110,F13.3,18,F12.0,3X,5HFLOR,I3,12H COMPARTMENT,I3,1
. F11.3,F15.0,F10.3,F11.1)
05 FORMAT (53X,5HFLOR,I3,12H COMPARTMENT,I3,F11.3,F15.0,F10.3,F11.1)
06 FORMAT (53X,17HOUTSIDE DIRECTION,I3,F14.3,F15.0,F10.3,F11.1)
07 FORMAT (4X,I3,F10.3,F11.0,3X,5HFLOR,I3,12H COMPARTMENT,I3,F11.3,1
. F15.0,F10.3,F11.1)
08 FORMAT (31X,5HFLOR,I3,12H COMPARTMENT,I3,F11.3,F15.0,F10.3,F11.1)
09 FORMAT (31X,17HOUTSIDE DIRECTION,I3,F14.3,F15.0,F10.3,F11.1)
10 FORMAT (13X,F8.1,4H NET)
11 FORMAT (11X,F8.1,4H NET)
12 FORMAT (11X,F8.1,4H NET)
13 FORMAT (4X,I3,F10.1,F11.0)
14 FORMAT (4X,I3,F10.1,F11.0)
15 FORMAT (31X,5HFLOR,I3,12H COMPARTMENT,I3,F11.1,F15.1,F10.4,F11.1)
16 FORMAT (31X,17HOUTSIDE DIRECTION,I3,F14.1,F15.1,F10.4,F11.1)
17 FORMAT (93X,F8.1,4H NET)
18 FORMAT (13X,F8.1,4H NET)
19 FORMAT (13X,F8.1,4H NET)
20 FORMAT (/15X,'THE FOLLOWING UNITS ARE USED FOR OUTPUT')
21 FORMAT (/15X,'FLOW IN CFM AT 70 DEG F AND 1 ATM')
22 FORMAT (/15X,'PRESSURE IN PASCALS*/5X,'AREA IN METERS SQUARED')
23 FORMAT (/15X,'THE FOLLOWING UNITS ARE USED FOR OUTPUT')
24 FORMAT (/15X,'FLOW IN CFM AT 70 DEG F AND 1 ATM')
25 FORMAT (/15X,'PRESSURE IN INCHS H-20'/5X,'AREA IN FEET SQUARED')
END

8HDG,P SUGEROUTINE UNITS,L,1
SUBROUTINE UNITS

&NBS*PLIE*SHOW A. UNITS
SUBROUTINE UNITS
C

THIS ROUTINE CONVERTS VARIABLES H, FF, AI, AO, CS TO SI UNITS
C
C
PARAMETER (MM=140, MS=8, MC=9, MFC=2, MTP=2, MFL=25, MB=50)
COMMON NT, P(MM), C(MM, MC), NC(MM), JC(MM, MC), ITS(MS),
1 FC(MM, MC), PZ(MM, MC), FO(MM, MPO), CO(MM, MPO), F(MM), PFO(MFL, MPO),
2 FF(MM), FO(MM, MPO), CS(MS), PS(MFL), NS1(MS), NS2(MS),
3 FES(MS), NS, NSP, ICONV, E, IBUG, AI(MM, MC), AO(MM, MPO), TITSH(MS, S),
4 NH, T(FFL), IFLOCR(MM), T(MTP, MFL), NFS1(MS), NFS2(MS), IT(MB), NTP
5, NCC(MM), JOC(MM, MPO), TOUT
DO DOUBLE PRECISION P, P0, P5
DIMENSION B(5)
CATA B/0.3048, 248.6, 0.4719, 0.02992, 0.0929/
DO 10 I=1, NH
10 1(I)=H(I)*B(1)
DO 20 I=1, NT
FF(I)=FF(I)*B(3)
DO 16 J=1, MC
AI(I,J)=AI(I, J)*B(5)
16 CONTINUE
DO 18 J=1, MPO
AO(I,J)=AO(I, J)*B(5)
18 CONTINUE
DO 22 I=1, NS
CS(I)=CS(I)*B(4)
22 CONTINUE
RETURN
END

&FDG,P
SUBROUTINE SMEQ*L.1
SUBROUTINE SIMEG

C CLESKY'S METHOD OF SOLUTION OF SIMULTANEOUS LINEAR ALGEBRIC EQUATIONS

PARAMETER (MM=140, MS=8, MC=9, MFC=2, MTP=2, MFL=25, MB=50)
PARAMETER (MBF=MB+1)
COMMON /MAT/ A(MB,MBP), X(MB), N
NPI=MB+1
ZERO=1.0E-35
K=0

SEE IF A(1,1) IS ZERO
IF SC ADD ANOTHER ROW TO ROW 1
IF (AES(A(1,1)) .GT. ZERO) GO TO 40
DO 31 I=2, N
IF (A(I,1) .NE. 0.) GO TO 32
31 CONTINUE
12 WRITE(6,804) K
STCF
32 CC 33 J=1, NPI
33 A(1,J)=A(1,J)+A(I,J)

CALCULATE UPPER AND LOWER TRIANGULAR MATRICES OVER ORIG MATRIX A

40 AA=A(1,1)
CO 2 J=2, NPI
2 A(1,J)=A(1,J)/AA
DO 10 I=2, N
K=K+1
CO 6 J=1, I
6 X(J)=A(I,J)

STORE A(I,1) ... A(I,1) IN X ARRAY
IN CASE NEW A(I,1) IS ZERO ROW I CAN BE RECALCULATED

4 CO 5 J=1, I
5 X(J)=A(I,J)
K=K+1
CO 10 J=2, NPI
IF (J .GT. I) GO TO 8
JM1=-1
AA=0.
CO 3 IR=1, JM1
3 AA=AA+A(I,IR)*A(IR,J)
A(I,J)=A(I,J)-AA

CHECK IF A(I,1) IS ZERO
IF SC MULTIPLY OLD ROW 1 BY 2.

IF (I .NE. J) GO TO 10
IF (AES(A(I,I)) .GT. ZERO) GO TO 10
DO 6 JJ=1, I
6 A(IJJ)=X(JJ)
DO 7 JJ=1, NPI

7

58
SUBROUTINE SIMEQ

7 A(I,J)=2.*A(I,J)
   IF(K.GT.3)GO TO 12
   GO TO 4
8 IM1=I-1
   AA=0.
   DO 9 IR=1,IM1
9   AA=AA+A(I,IR)*A(IR,J)
   A(I,J)=(A(I,J)-AA)/A(I,I)
10 CONTINUE
C
C     END OF CALCULATION OF TRIANGULAR MATRICES
C
C EACKWARD SUBSTITUTION
C
X(N)=A(N,NP1)
   DO 2 C II=2,N
   AA=0.
   I=NP1-II
   IP1=I+1
   DO 1E J=IP1,N
15   AA=AA+A(I,J)*X(J)
20   X(I)=A(I,NP1)-AA
C
804 FORMAT(///10X,1XPROGRAM FAILURE ,I3///)  
END

&CGF,P      FUNCTION FLOW.L,1
FUNCTION FLOW

FUNCTION FLOW(PI,PJ,PZ,C)
DOUBLE PRECISION PI,PJ

C THIS FUNCTION CALCULATES FLOWS BETWEEN TWO POINTS

C IF(C .LT. 0.001)GO TO 10
CP=PJ-PI+PZ
SIGN=1.0
IF(DP .LT. 0.0)SIGN=-1.
FLCW=SIGN*C*SQRT(SIGN*DP)
RETURN

10 FLOW=0.0
RETURN
END

FUNCTION PFLOW.L.1
FUNCTION PFLOW

INBS*PLIES*SFLOW A.PFLOW

FUNCTION PFLOW(I,PI)

C
TC
 THIS FUNCTION CALCULATES NET FLOWS INTO POINT I
C
C
PARAMETER (MM=140, MS=5, MC=9, MFC=2, MTP=2, MFL=25, MB=50)
COMMNC /CORR/C1(MM,MC),C2(MM,MC),CO1(MM,MPO),CO2(MM,MPO)
COMMNC NT, P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
1 FC(MM,MC),PZ(MM,MC),PC(MM,MPC),CO(MM,MPO),F4(MM),PFM(F(MFL,MPO),
2 FF(MM),FO(MM,MPO),CS(MS),PS(MFL),NS1(MS),NS2(MS),
3 FSS(MS),N,NS,NFO,ICO,NV,E,IEUG,Al(MM,MC),AO(MM,MPO),ITSH(MS,S),
4 NT,IF(MFL),IFLOOR(MM),IT(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
5 ,NC(MM),JOC(M,MP),TOUT
DQUELE PRECISION P,PO,PS,PI
NN=NC(I)
SUM=0.
IF(NN .EQ. 0) GO TO 3
C0 1 JJ=1,NN
J=JC(I,JJ)
CC=C1(I,JJ)
IF(PI .LT. P(JJ))CC=C2(I,JJ)
PZZ=FZ(I,JJ)
IF(I .LT. N)PZZ=0.
FC(I,JJ)=FLOW(PI,P(JJ),PZZ,CC)
1 SUM=SUM+FC(I,JJ)
3 NNC=NC(I)
IF(NNO .EQ. 0) GO TO 4
C0 2 K=1,NNO
CC=C1(I,K)
IF(PI .LT. PO(I,K))CC=C2(I,K)
F0(I,K)=FLOW(PI,PO(I,K),0,CC)
2 SUM=SUM+F0(I,K)
4 FLFLOW=SUM+FF(I)
IF(I .LE. N)FF(I)=SUM+FF(I)
RETURN
ENC

ENDG, P

FUNCTION SFLOW.L,1
FUNCTION SFLOW

C C
C THIS ROUTINE CALCULATES NET FLOW INTO A SHAFT AND
C SHAFT PRESSURE PROFILE
C C
C PARAMETER (MM=140, NS=8, MC=9, MPC=2, MTP=2, MFL=25, MB=50)
C COMM NC NT, P(MM), C(MM, MC), NC(MM), JC(MM, MC), ITS(MS),
1 FC(MM, MC), PZ(MM, MC), PO(MM, MPO), CO(MM, MPO), F(MM), PFO(MFL, MPO),
2 FF(MM, MPO), PS(MFL), NS1(NS), NS2(MS),
3 FF(MS), NS, NPO, ICCNV, EIBUG, AI(MM, MC), AO(MM, MPO), TITSH(MS, S),
4 NTP, T(MFL), IFLOCOR(MM), T(MTP, MFL), NFS1(MS), NFS2(MS), IT(MB), NTP
5, NC(MM), JGC(MN, MFC), TOUT
C COULE E PRECISION P, PO, PS, PI
IF(IEUG .GT. 1) WRITE(6, 800) IS
SUM=C. 
N1=N S1(IS)
N2=N S2(IS)
FS(1)=PI
FUP=C. 
CSS=CS(IS)
DO 10 I=N1, N2
II=I+1-N1
FLO=FFLOW(I, PS(II))
FUP=FLC+FUP
SUM=SUM+FLO
IF(I , EQ. N2) GC TO 5
IIPI=II+1
SIGN=1.
IF(FLP .GT. 0.) SIGN=-1. 
FS(IIPI)=PS(II)-PZ(I, I)+SIGN*FUP*FUP/(CSS*CSS)
5 IF(IEUG .GT. 1) WRITE(6, 801) I, II, PS(II), FLO, FUP, SUM
10 CONTINUE
FS(IS)=SUM
SFL0%=SUM
RETFLN
C C
C FCR#AT STATEMENTS
C
E00 FORMAT(///5X,17HFLCW - SHAFT NO , IS/) 
E01 FORMAT(5X, 3H1 = I3, 5X, 4HII = I3, 5X, 4HPS = , 
+ E15.7, 5X, 5HFLC = E10.4, 5X, 5HFUP = E10.4, 5X, 5HSUM = E10.4/) 
END

&ERKPT PRINTS
**FEDERAL INFORMATION PROCESSING STANDARD SOFTWARE SUMMARY**

<table>
<thead>
<tr>
<th>01. Summary date</th>
<th>02. Summary prepared by (Name and Phone)</th>
<th>03. Summary action</th>
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<tr>
<td></td>
<td>John Klote 921-3387</td>
<td></td>
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<tr>
<th>04. Software date</th>
<th>05. Software title</th>
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<tr>
<td>2/05/28</td>
<td>A Computer Program for Analysis of Smoke Control Systems</td>
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<th>06. Short title</th>
<th>07. Internal Software ID</th>
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<th>09. Processing mode</th>
<th>10. Application area</th>
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<tbody>
<tr>
<td>Automated Data System</td>
<td>Interactive</td>
<td>General</td>
</tr>
<tr>
<td>Computer Program</td>
<td></td>
<td>Management/</td>
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<tr>
<td>Subroutine/Module</td>
<td>Combination</td>
<td>Business</td>
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<th>11. Submitting organization and address</th>
<th>12. Technical contact(s) and phone</th>
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<tr>
<td>Suppression &amp; Extinguishment Group</td>
<td>John Klote 921-3387</td>
</tr>
<tr>
<td>Center for Fire Research</td>
<td></td>
</tr>
<tr>
<td>National Bureau of Standards</td>
<td></td>
</tr>
<tr>
<td>Washington, D.C. 20234</td>
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</table>

13. Narrative

Pressurized stairwells and pressurized elevators can be used as a means of providing a smoke free exit route during fire situations. This computer program analyzes systems intended to pressurize stairwells and elevator shafts.

14. Keywords

Air movement; computer programs; egress; elevator shafts; escape means; modeling; pressurization; simulating; smoke control; stairwells

15. Computer manufacturer and model

Univac 1100/82

16. Computer operating system

ANSI FORTRAN

17. Programming language(s)

18. Number of source program statements

1756

19. Computer memory requirements

20. Tape drives

21. Disk/Drum units

22. Terminals

23. Other operational requirements

24. Software availability

Available Limited In-house only

25. Documentation availability

Available Inadequate In-house only

26. FOR SUBMITTING ORGANIZATION USE

Available
INSTRUCTIONS

01. Summary Date. Enter date summary prepared. Use Year, Month, Day format: YYMMDD.

02. Summary Prepared By. Enter name and phone number (including area code) of individual who prepared this summary.

03. Summary Action. Mark the appropriate box for new summary, replacement summary or deletion of summary. If this software summary is a replacement, enter under “Previous Internal Software ID” the internal software identification as reported in item 07 of the original summary, and enter the new internal software identification in item 07 of this form; complete all other items as for a new summary. If a software summary is to be deleted, enter under “Previous Internal Software ID” the internal software identification as reported in item 07 of the original summary; complete only items 01, 02, 03 and 11 on this form.

04. Software Date. Enter date software was completed or last updated. Use Year, Month, Day format: YYMMDD.

05. Software Title. Make title as descriptive as possible.

06. Short Title. (Optional) Enter commonly used abbreviation or acronym which identifies the software.

07. Internal Software ID. Enter a unique identification number or code.

08. Software Type. Mark the appropriate box for an Automated Data System (set of computer programs), Computer Program, or Subroutine/Module, whichever best describes the software.

09. Processing Mode. Mark the appropriate box for an Interactive, Batch, or Combination mode, whichever best describes the software.

10. Application Area.
   General: Mark the appropriate box which best describes the general area of application from among:
   - Computer Systems Support/Utility
   - Process Control
   - Management/Business
   - Scientific/Engineering
   - Other

   Specific: Specify the sub-area of application; e.g.; "COBOL optimizer" if the general area is "Computer Systems Support/Utility"; "Payroll" if the general area is "Management/Business"; etc. Elaborate here if the general area is "Other."

11. Submitting Organization and Address. Identify the organization responsible for the software as completely as possible, to the Branch or Division level, but including Agency, Department (Bureau/Administration), Service, Corporation, Commission, or Council. Fill in complete mailing address, including mail code, street address, city, state, and ZIP code.

12. Technical Contact(s) and Phone: Enter person(s) or office(s) to be contacted for technical information on subject matter and/or operational aspects of software. Include telephone area code. Provide organization name and mailing address, if different from that in item 11.

13. Narrative. Describe concisely the problem addressed and methods of solution. Include significant factors such as special operating system modifications, security concerns, relationships to other software, input and output media, virtual memory requirements, and unique hardware features. Cite references, if appropriate.

14. Keywords. List significant words or phrases which reflect the functions, applications and features of the software. Separate entries with semicolons.

15. Computer Manufacturer and Model. Identify mainframe computer(s) on which software is operational.

16. Computer Operating System. Enter name, number, and release under which software is operating. Identify enhancements in the Narrative (item 13).

17. Programming Language(s). Identify the language(s) in which the software is written, including version; e.g., ANSI COBOL, FORTRAN V, SIMSCRIPT II.5, SLEUTH II.

18. Number of Source Program Statements. Include statements in this software, separate macros, called subroutines, etc.

19. Computer Memory Requirements. Enter minimum internal memory necessary to execute software, exclusive of memory required for the operating system. Specify words, bytes, characters, etc., and number of bits per unit. Identify virtual memory requirements in the Narrative (item 13).

20. Tape Drives. Identify number needed to operate software. Specify, if critical, manufacturer, model, tracks, recording density, etc.

21. Disk/Drum Units. Identify number and size (in same units as "Memory");—item 19 needed to operate software. Specify, if critical, manufacturer, model, etc.

22. Terminals. Identify number of terminals required. Specify, if critical, type, speed, character set, screen/line size, etc.

23. Other Operational Requirements. Identify peripheral devices, support software, or related equipment not indicated above, e.g., optical character devices, facsimile, computer-output microfilm, graphic plotters.

24. Software Availability. Mark the appropriate box which best describes the software availability from among: Available to the Public, Limited Availability (e.g.: for government use only), and For-In-house Use Only. If the software is "Available", include a mail or phone contact point, as well as the price and form in which the software is available, if possible.

25. Documentation Availability. Mark the appropriate box which best describes the documentation availability from among: Available to the Public, Inadequate for Distribution, and For-In-house Use Only. If documentation is "Available", include a mail or phone contact point, as well as the price and form in which the documentation is available, if possible. If documentation is presently "Inadequate", show the expected availability date.

26. For Submitting Organization Use. This area is provided for the use of the organization submitting this summary. It may contain any information deemed useful for internal operation.
1. PUBLICATION OR REPORT NO.  
NBSIR 82-2512


3. Publication Date  
June 1982

4. TITLE AND SUBTITLE  
A COMPUTER PROGRAM FOR ANALYSIS OF SMOKE CONTROL SYSTEMS

5. AUTHOR(S)  
John H. Klote

6. PERFORMING ORGANIZATION (If joint or other than NBS, see instructions)  
NATIONAL BUREAU OF STANDARDS  
DEPARTMENT OF COMMERCE  
WASHINGTON, D.C. 20234

7. Contract/Grant No.  

8. Type of Report & Period Covered  
Final Report

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (Street, City, State, ZIP)  
Department of Health and Human Services  
Washington, D.C. 20201

10. SUPPLEMENTARY NOTES  
☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)  
This paper describes a computer program developed to analyze systems intended to control smoke in building fires. These systems include pressurized stairwells, pressurized elevator shafts, zone smoke control systems, and pressurized corridors. This program calculates air flows and differential pressures throughout a building in which a smoke control system is operating. The basic assumptions and limitations of the program are also discussed. The appendices contain a program listing and examples.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)  
Air movement; computer programs; egress; elevator shafts; escape means; modeling; pressurization; simulation; smoke control; stairwells

13. AVAILABILITY  
☐ Unlimted  
☐ For Official Distribution. Do Not Release to NTIS
☐ Order From National Technical Information Service (NTIS), Springfield, VA. 22161

14. NO. OF PRINTED PAGES  
69

15. Price  
