WATER RECYCLE SYSTEM SIMULATION

Project 3251

Report One
A Progress Report
to
MEMBERS OF THE INSTITUTE OF PAPER CHEMISTRY

June 15, 1977
THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

WATER RECYCLE SYSTEM SIMULATION

Project 3251

Report One

A Progress Report
to
MEMBERS OF THE INSTITUTE OF PAPER CHEMISTRY

June 15, 1977
## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUMMARY</td>
<td>1</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>3</td>
</tr>
<tr>
<td>OBJECTIVES</td>
<td>5</td>
</tr>
<tr>
<td>PHASE I - WORK PLAN</td>
<td>6</td>
</tr>
<tr>
<td>The Original SIMPAK Program</td>
<td>6</td>
</tr>
<tr>
<td>General Description</td>
<td>6</td>
</tr>
<tr>
<td>The SIMPAK Input</td>
<td>8</td>
</tr>
<tr>
<td>The SIMPAK Capability</td>
<td>10</td>
</tr>
<tr>
<td>The SIMPAK Output</td>
<td>16</td>
</tr>
<tr>
<td>The Revised SIMPAK Program</td>
<td>16</td>
</tr>
<tr>
<td>The CONF Subprogram</td>
<td>18</td>
</tr>
<tr>
<td>The SORT Subprogram</td>
<td>21</td>
</tr>
<tr>
<td>The Computed Results</td>
<td>23</td>
</tr>
<tr>
<td>PHASE II - WORK PLAN</td>
<td>28</td>
</tr>
<tr>
<td>The Board Mill</td>
<td>28</td>
</tr>
<tr>
<td>General Description of the Mill at York, PA</td>
<td>28</td>
</tr>
<tr>
<td>Operating Data for the Existing System</td>
<td>29</td>
</tr>
<tr>
<td>CONCLUSIONS</td>
<td>38</td>
</tr>
<tr>
<td>RECOMMENDATIONS</td>
<td>39</td>
</tr>
<tr>
<td>FUTURE WORK</td>
<td>40</td>
</tr>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>41</td>
</tr>
<tr>
<td>APPENDIX I. LISTING OF THE EXISTING SIMPAK PROGRAM</td>
<td>42</td>
</tr>
<tr>
<td>APPENDIX II. LISTING OF THE IMPROVED SIMPAK PROGRAM</td>
<td>58</td>
</tr>
<tr>
<td>APPENDIX III. LISTING OF EXISTING YORK MILL INPUT DATA</td>
<td>77</td>
</tr>
<tr>
<td>(INITIAL CONDITION)</td>
<td></td>
</tr>
</tbody>
</table>
This report covers work done on Phases I and II of Project 3251 entitled "Water Recycle System Simulation." The objective of Phase I was concerned with the major improvements in computational efficiency of an existing dynamic simulation package (SIMPAK) program for its economic use for analyzing water reuse alternatives in a board mill. Both original and revised SIMPAK programs were applied to a simple pulping and cleaning system to illustrate the use of SIMPAK. A comparison of the computed results in the simulation runs, using both the original and revised SIMPAK programs, indicated that the revised SIMPAK program can cut computer time by a factor of nine (9) over the original SIMPAK program with essentially no change in the results.

The purpose of Phase II was to perform the initial phase of implementation of the revised SIMPAK program in a selected board mill. Efforts made in Phase II included the selection of a board mill in York, Pennsylvania, collection of the board mill data such as water and fiber flows in the white water system, translation of the board mill process flow diagram into a system laid out in the SIMPAK schematic form, and the preparation of the input data for the SIMPAK system for future application studies. The determination of best system closure alternative is yet to be undertaken.

A review of SIMPAK vis a vis the needs of the industry was also undertaken. Based on this review and the similarity of many of the operations in the pulp and paper industry to those of the chemical industry, it was decided to terminate work on SIMPAK. The need for dynamic simulation of pulp and paper mills can best be
satisfied by obtaining a previously developed simulator from the chemical industry and adapting it to the pulp and paper industry. Routines developed for SIMPAK will be modified for this new simulation. The selection of which chemical process simulation is best suited for dynamic simulation studies at the Institute is in progress.
INTRODUCTION

The pulp and paper industry uses a large quantity of water of varying quality in almost every department of the mill from woodyards, through wet end, to finished products. The high cost or limited supply of process water can be an incentive for water recycling. Also, the stringent effluent guidelines by the Environmental Protection Agency will force the pulp and paper industry to make intensive reuse of water through effluent treatment processes, especially in-plant controls like internal process changes and recycling.

Despite the fact that the intensive reuse and recycle of process water has now become an important consideration in both pollution abatement and water utility, the question of when to implement water reuse and to what extent has not been yet articulated. Two dominant factors which control the extent to which recycling can be practiced are:

- Accumulation of dissolved solids
- Heat buildup

To enhance water recycling it is necessary to know the limiting concentration of dissolved material in water which can be utilized in a mill system, and to relate water of varying quality from different process steps to the points of usage. This can best be done by systems analysis.

On the basis of the systems analysis concept, a dynamic simulation package (SIMPAK) program was developed at The Institute of Paper Chemistry for a pulp and paper mill to determine how the system closure would affect the ultimate buildup in dissolved solids (DS) concentrations and how these concentrations would dynamically respond to the predictable variations and upsets. Because of its flexibility, SIMPAK can also provide the means for mills (1) to test the effect
of operating policies, control strategies or any internal changes without actually modifying the real prototype system and (2) to assess the alternatives for prompt decision making between two or more courses of action.

The existing SIMPAK program is still in its development stage; it can be improved to extend its effective application for different systems through various modifications. For example, the initial development of SIMPAK was designed to meet the following two goals: (1) the computer program would utilize only a few basic unit blocks or modules which would be put together in any desired manner to approximately describe an actual or contemplated production process or area; (2) each basic unit block on the SIMPAK schematic diagram, identified by "block number," would be so arbitrarily assigned that the order in which block interconnections are specified is unimportant. Thus, the original SIMPAK system consists of a set of mainline and subroutine programs which are assembled in simple block diagram form to simulate the mill water flow system. In achieving the second goal, however, the mainline program incorporates an iterative scheme of calculations which is easy to program on a computer but does a lot more work than theoretically should be needed. (Such a measure involved 10 times repeated calculations at each integration interval in order to guarantee that the intermediate variables were at their proper values.) Hence, the computer time of SIMPAK in its simulation runs can be minimized simply through the refinement of the computational scheme and the revised SIMPAK program can be further verified in a selected board mill.

This research program (Project 3251) on water recycle system simulation is designed in four phases. Each of these phases represents a logical step in refinement of the existing SIMPAK program to accomplish the water reuse and recycle objectives as described in the next section.
OBJECTIVES

The main objectives of Project 3251 are:

1. To improve the existing SIMPAK program for its economical use for analyzing water reuse alternatives in a board mill.

2. To demonstrate how the improved SIMPAK program can be applied to this board mill for predicting the rate and extent of dissolved solids buildup during the extensive reuse of process water.

Project 3251 is conveniently divided into four phases. This report describes Phases I and II of the following four-phase project originally planned to be carried out at The Institute of Paper Chemistry in cooperation with St. Regis Paper Company:

1. Phase I - The refinement of the original SIMPAK program to increase the computational efficiency of the computer program.

2. Phase II - The preliminary work for implementation of the revised SIMPAK program in a selected board mill for water reuse analysis.

3. Phase III - The verification of the revised SIMPAK program against this board mill data.

4. Phase IV - The application studies of the revised SIMPAK program in this board mill to various system closure alternatives.
PHASE I — WORK PLAN

In the development of the original SIMPAK program, the initial attention was directed toward the construction of a simulation model to represent an entire pulp and paper mill in the least complicated manner possible. Other factors such as program structuring and computational efficiency were not taken into consideration.

The primary objective of this first phase was concerned with major improvement of the original SIMPAK program to achieve computational efficiency in the simulation runs. The secondary objective was to illustrate how to apply the original and revised SIMPAK program to a typical pulp mill. A typical set of the actual mill data was also used for initial testing of the revised SIMPAK program on its functional operation. Finally, an estimate of the computing speed in the simulation runs was also made for the improved SIMPAK program.

THE ORIGINAL SIMPAK PROGRAM

General Description

SIMPAK is an acronym for simulation package program which was developed on a "systems analysis" concept for describing the dynamic response of volume, flow, fiber, and chemical additive concentrations throughout any production process or system. This imitation of the real mill system is accomplished by constructing a series of simple building blocks or modules which correspond directly to the same production units or which can be hooked up to correspond to a more complex production process. Such basic modules of SIMPAK are the tanks, separators, mixers, distribution manifolds, and the connecting pipes as defined in Fig. 1. Time delays and process controllers are the basic components of SIMPAK which can be inserted wherever necessary but will not be used in the example that follows.
Pipe or Connection

Mixing Point

Tank or Chest

Distribution Manifold

Separator (Screen, Cleaner, Decker, etc.)

Figure 1. Basic Modules of the SIMPAK Program
The only module requiring more explanation is the separator. The separation of a mixture of water, fiber, and dissolved (or suspended) solids is a very common unit operation in the pulp and paper industry. Many different types of equipment are used at different process points to achieve this operation. Types of equipment which perform such separations include screens, knotters, centrifugal cleaners, deckers, drainers, selectifiers, paper machine wires, flat boxes, suction couches, wet presses, savealls, filters, clarifiers, etc. The way in which each of these separation units operates upon water, fiber, and dissolved (or suspended) solids is, of course, different from unit to unit. This difference is simply taken care of in the specification of the water, fiber, and additive characteristics for each of the separators in any system being studied.

For most systems, detailed information on the separation characteristics of the units is not readily available, but reasonable values may be derived from existing mill data and operating experience. Should any particular separator's characteristics turn out to be critical to the overall operation, then it would be worthwhile to do the experimental work needed to define more exactly the separation characteristics of the unit. The importance of a unit's characteristics can be determined by sensitivity analysis.

The SIMPAK Input

The use of SIMPAK can best be illustrated by an example. As a starting point one must have a complete piping and flow diagram, and actual data on the flow, fiber, and DS content. This process flow diagram will be translated unit by unit into a system laid out in the SIMPAK schematic form. After each process unit is represented on the SIMPAK diagram, with all the interconnecting pipes, each unit and each pipe is given a serial number which identifies that unit in the following data input and output lists. Figure 2 shows the SIMPAK schematic...
Figure 2. SIMPAK Schematic of Sartell Mill
which represents the complete pulp mill, cleaning, deckers, and white water re-
use systems for the groundwood portion of the Sartell mill, Minnesota (St. Regis
Paper Company) and also the serial numbers for the individual units.

Each process unit in the system has its unique set of parameters which
must be determined. For instance, it is necessary to measure or estimate the
volume of each tank, the separation of each screen or cleaner, and the volume of
flow for each supply and sewer outlet. Thus, the procedure of the computer input
is reduced to specifying the basic modules of SIMPAK within the system. Figure 3
shows a typical set of the computer input card deck corresponding to Fig. 2 for
the complete pulp mill. The detailed description of the computer data input which
is useful in interpreting changes to the input data deck and also for the use of
the SIMPAK program by other personnel is given in Table I.

Table II shows the program listing of SIMPAK which consists of a main-
line program and a series of modular subroutines. The flow diagram of the SIMPAK
program is given in Fig. 4, and the details of this program are given in Appendix I.

SIMPAK Capability

SIMPAK can provide a calculated estimate of the dynamic response of the
system to any operating changes after the connections and characteristics of the
system have been specified. If changes in the system itself, such as repiping,
addition or removal of a tank, or any other change, were contemplated, then it is
a simple matter to revise the SIMPAK input data file to correspond to the changes
and to repeat the computer experiment. This predictive capability is especially
valuable where the contemplated changes are difficult and expensive to study directly
in the mill without disturbing machine productivity or product quality, or when
process equipment does not exist.
<table>
<thead>
<tr>
<th>TIME</th>
<th>TEMPERATURE</th>
<th>PRESSURE</th>
<th>CONCENTRATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>298.15</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.01</td>
<td>298.15</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.02</td>
<td>298.15</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.03</td>
<td>298.15</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.04</td>
<td>298.15</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.05</td>
<td>298.15</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.06</td>
<td>298.15</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.07</td>
<td>298.15</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.08</td>
<td>298.15</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.09</td>
<td>298.15</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.10</td>
<td>298.15</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.11</td>
<td>298.15</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.12</td>
<td>298.15</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.13</td>
<td>298.15</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.14</td>
<td>298.15</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Figure 3. Data for SIMPAK for Sartell Mill
<table>
<thead>
<tr>
<th>Card Group</th>
<th>Number of Cards</th>
<th>Card Column</th>
<th>Description</th>
<th>Variable Name</th>
<th>Format Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1-80</td>
<td>Title of the company name and/or the objective of work</td>
<td>NTITLE</td>
<td>20A4</td>
</tr>
<tr>
<td>2</td>
<td>Minimum=2</td>
<td>1-2</td>
<td>Total number of independent process groups</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-3</td>
<td>Any number of identifying cards, with 999 in first column in the given example</td>
<td>NGRP</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>1-3</td>
<td>Total number of mixers in one process group</td>
<td>NMIXG</td>
<td>13</td>
</tr>
<tr>
<td>4</td>
<td>1 or more</td>
<td>0-1</td>
<td>M, mixers matrix</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-4</td>
<td>The specified number of mixer</td>
<td>NM (KK,JJ)</td>
<td>1X</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5-6</td>
<td>Types of mixer</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>7-10</td>
<td>The outgoing pipe</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>11-13</td>
<td>Total number of incoming pipes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>14-17</td>
<td>The individual incoming pipes, maximum=10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(18-48)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>1-3</td>
<td>Total number of separators in one process group</td>
<td>NSEPJC</td>
<td>13</td>
</tr>
<tr>
<td>6</td>
<td>1 or more</td>
<td>0-1</td>
<td>S, separators matrix</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-4</td>
<td>The specified number of separator</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5-6</td>
<td>Types of separator</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>7-10</td>
<td>Incoming pipe number</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>11-14</td>
<td>Rejects pipe number</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>15-18</td>
<td>Accepts pipe number</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>19-24</td>
<td>Fractional retention of solids in rejects pipe</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>25-30</td>
<td>Fractional pass-through of flow volume to accepts pipe</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>31-36</td>
<td>Fractional sorbed additive on fiber</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>1-3</td>
<td>Total number of distributors</td>
<td>NDISTG</td>
<td>13</td>
</tr>
<tr>
<td>8</td>
<td>1 or more</td>
<td>0-1</td>
<td>D, distributors matrix</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-4</td>
<td>The specified distributor number</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5-6</td>
<td>Types of distributor</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>7-10</td>
<td>Incoming pipe number</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>11-13</td>
<td>Total number of outgoing pipes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>1-5</td>
<td>Individual outgoing pipe</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6-11</td>
<td>Individual outgoing pipe, maximum=9</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(12-59)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>1-5</td>
<td>Distributors matrix to store the fractional distribution number to each outgoing pipe</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6-11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(12-59)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>1-3</td>
<td>Total number of proportional controllers in one process group</td>
<td>NPCONG</td>
<td>13</td>
</tr>
</tbody>
</table>
### TABLE I (Continued)
SIMPAK INPUT DATA VARIABLES AND FORMAT

<table>
<thead>
<tr>
<th>Card Group</th>
<th>Number of Cards</th>
<th>Card Column</th>
<th>Description</th>
<th>Variable Name</th>
<th>Format</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>1 or more</td>
<td>0-1</td>
<td>C, controllers matrix (not given here)</td>
<td>NPC (KK,JJ)</td>
<td>1X</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-4</td>
<td>The specified number of controller</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5-6</td>
<td>Controller attached to tank or pipe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>7-10</td>
<td>The specified tank or pipe number</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>11-12</td>
<td>Types of interest in flows (in tank or pipe)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>13-15</td>
<td>Controller attached to tank or pipe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>16-20</td>
<td>The specified tank or pipe number</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>21-22</td>
<td>Types of interest in flows (in tank or pipe)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-10</td>
<td>Controllers matrix to store set point value and proportional gain</td>
<td>RFC (KK,JJ)</td>
<td>F10.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>11-19</td>
<td></td>
<td></td>
<td>F11.2</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>1</td>
<td>1-3</td>
<td>Total number of tanks in one process group</td>
<td>NTANKG</td>
<td>I3</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>1 or more</td>
<td>0-1</td>
<td>T, tanks matrix</td>
<td>NT (KK,JJ)</td>
<td>1X</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-4</td>
<td>The specified number of tanks</td>
<td></td>
<td>I3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5-6</td>
<td>Types of tank</td>
<td></td>
<td>I4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>7-10</td>
<td>Incoming pipe number</td>
<td></td>
<td>I4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>11-14</td>
<td>Outgoing pipe number</td>
<td></td>
<td>I4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>15-25</td>
<td>Tank volume</td>
<td>V (JT,JJ)</td>
<td>F10.2</td>
<td>gallons</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26-35</td>
<td>Mass of fiber</td>
<td>MF (JT,JJ)</td>
<td>F10.2</td>
<td>lb</td>
</tr>
<tr>
<td></td>
<td></td>
<td>36-45</td>
<td>Mass of additive</td>
<td>MA (JT,JJ)</td>
<td>F10.2</td>
<td>lb</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>1-3</td>
<td>Total number of pipes in one process group</td>
<td>NPIPE</td>
<td>I3</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>1 or more</td>
<td>1</td>
<td>The specified number of pipe</td>
<td>K</td>
<td>1X</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-4</td>
<td>Flow rate</td>
<td>Q (JT,K)</td>
<td>F10.2</td>
<td>gal/min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25-33</td>
<td>Mass flow rate of fiber</td>
<td>WF (JT,K)</td>
<td>F9.2</td>
<td>lb/min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>34-32</td>
<td>Mass flow rate of additive</td>
<td>WA (JT,K)</td>
<td>F9.2</td>
<td>lb/min</td>
</tr>
<tr>
<td>17</td>
<td>1</td>
<td>1</td>
<td>Total number of desired printed outputs</td>
<td>NOUT</td>
<td>I1</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>1</td>
<td>1</td>
<td>The outputs vector to store type of process units (e.g., tanks, pipes, etc.)</td>
<td>NPRINT 1 (JJ)</td>
<td>I1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-5</td>
<td>The outputs vector to store the specified number of the process units which are of interest</td>
<td>NPRINT 2 (JJ)</td>
<td>I4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6-7</td>
<td>The outputs vector to store the process variables such as volume, or flows</td>
<td>NPRINT 3 (JJ)</td>
<td>I2</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>1</td>
<td>1-10</td>
<td>Incremental time step</td>
<td>DTIME</td>
<td>F10.4</td>
<td>minutes</td>
</tr>
<tr>
<td>20</td>
<td>1</td>
<td>1-10</td>
<td>Desired print interval</td>
<td>DPRT</td>
<td>F10.4</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>1</td>
<td>1-10</td>
<td>Desired map interval</td>
<td>DMAP</td>
<td>F10.4</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>1</td>
<td>1-10</td>
<td>Total execution time</td>
<td>TFINAL</td>
<td>F10.4</td>
<td>minutes</td>
</tr>
<tr>
<td>Subroutines</td>
<td>Explanation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------</td>
<td>-------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. MIX</td>
<td>Mixes a maximum of 10 incoming flows to give 1 outgoing flow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. SEP</td>
<td>Splits an incoming flow into 2 outgoing flows</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. DIST</td>
<td>Distributes an incoming flow to a maximum of 10 outgoing flows</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. TANK</td>
<td>Calculates concentrations at each tank</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. PCON</td>
<td>Proportional controllers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. HCON</td>
<td>Half power controllers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. CONVAR</td>
<td>Selects the desired output variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. MAP</td>
<td>Displays flow at each pipe, fiber, additive and dissolved solids in tanks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. DECODE</td>
<td>Specifies the desired information to be printed out</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. NAVAL</td>
<td>Calculates time constants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. LINE</td>
<td>Prints the desired material stored in each tank in line array</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**TYPICAL INPUT DATA**

1. NTITLE
2. NGRP
3. NMIXG ...
... 22. TFINAL

**MAIN PROGRAM**

1. ITERATION
2. BOOKKEEPING

**OUTPUT RESULTS**

1. LINE — tabulated values of CONC
2. MAP — detailed listing of
   a) tank volumes
   b) fiber quantity
   c) solids accumulation
3. TAPE — line graph of dynamic response of selected concentration within the system

**SUBROUTINES FOR PROCESS CALCULATIONS**

1. TANK 2. PCON 3. MIX 4. SEP 5. DIST

---

Figure 4. SIMPAK Computer System
The SIMPAK Output

The results from the simulation are available in three main forms. The first is a tabulated value of the concentration or consistency at a number of selected points as a function of time. Normally this list is used to obtain a close, continuous look at the changes in concentration which occur at critical points within the mill system.

The second form of results is a detailed printout of the tank volume, fiber quantity, and solids accumulation at every single point within the whole mill system. This printout is normally produced less frequently during the simulation experiment and is used mainly as a check on the proper logic and operation of the entire simulation.

The third form of the results is a computer-plotted line graph of the dynamic response of selected concentrations within the system. This graph, produced in an off-line operation, is derived from a magnetic tape copy of the output results which is made during the simulation experiment itself. The user must develop his own program to retrieve the desired information from this magnetic tape copy for various application purposes. A plotting subroutine is not part of SIMPAK.

THE REVISED SIMPAK PROGRAM

The SIMPAK program was revised specifically to improve computational efficiency by cutting the computer simulation run time in the use of SIMPAK. This new SIMPAK contains two additional subroutines in addition to slightly modifying the computation section in the mainline program of the original SIMPAK to perform a simple operation which avoids repetitive calculations. The two new
subroutines are respectively called CONF and SORT. Table III lists the revised SIMPAK program, and the details of this new program are given in Appendix II.

**TABLE III**

THE REVISED SIMPAK COMPUTER PROGRAM

I. Modified Main Program

II. Subroutines

<table>
<thead>
<tr>
<th>No.</th>
<th>Subroutine</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>MIX</td>
<td>Mixes a maximum of 10 incoming flows to give 1 outgoing flow</td>
</tr>
<tr>
<td>2.</td>
<td>SEP</td>
<td>Splits an incoming flow into 2 outgoing flows</td>
</tr>
<tr>
<td>3.</td>
<td>DIST</td>
<td>Distributes an incoming flow to a maximum of 10 outgoing flows</td>
</tr>
<tr>
<td>4.</td>
<td>TANK</td>
<td>Calculates concentrations at each tank</td>
</tr>
<tr>
<td>5.</td>
<td>PCON</td>
<td>Proportional controllers</td>
</tr>
<tr>
<td>6.</td>
<td>HCON</td>
<td>Half power controllers</td>
</tr>
<tr>
<td>7.</td>
<td>CONVAR</td>
<td>Selects the desired output variables</td>
</tr>
<tr>
<td>8.</td>
<td>MAP</td>
<td>Displays flow at each pipe, fiber, additive and dissolved solids in tanks</td>
</tr>
<tr>
<td>9.</td>
<td>DECODE</td>
<td>Specifies the desired information to be pointed out</td>
</tr>
<tr>
<td>10.</td>
<td>NAVEL</td>
<td>Calculates time constants</td>
</tr>
<tr>
<td>11.</td>
<td>LINE</td>
<td>Prints the desired material stored in each tank in line array</td>
</tr>
</tbody>
</table>

III. New Subroutines

<table>
<thead>
<tr>
<th>No.</th>
<th>Subroutine</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONF</td>
<td>Specifies and prepares the SIMPAK configuration for order-sorting operation</td>
</tr>
<tr>
<td>2.</td>
<td>SORT</td>
<td>Determines the detailed sequence of the integrations and distributions among the basic modules of the SIMPAK system</td>
</tr>
</tbody>
</table>
The CONF Subprogram

The CONF subroutine provides a set of the SIMPAK configuration elements, plus a couple of special elements that the user can tailor to his particular needs. Table IV illustrates these elements, their language symbols, and descriptions of their functions.

<table>
<thead>
<tr>
<th>Elements</th>
<th>Language Symbols (Identifiers)</th>
<th>Descriptions</th>
<th>Identification Numbers (or Coding)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanks</td>
<td>T1, T2, ...</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Separators</td>
<td>S1, S2, ...</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Distributors</td>
<td>D1, D2, ...</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Mixers</td>
<td>M1, M2, ...</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Constants</td>
<td>C1, C2, ...</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Holds</td>
<td>H1, H2, ...</td>
<td></td>
<td>6</td>
</tr>
</tbody>
</table>

The CONF subprogram is an abbreviation of the SIMPAK configuration which is used herein to describe the structure of the simulation block diagrams expressed in terms of language symbols as defined in Table IV. Thus, the user can use the same SIMPAK diagram derived from the process flow diagram, showing the interconnections among the elements required to implement his model. For example, Fig. 5 depicts the same Sartell pulp mill as shown in Fig. 2 except that two special language symbols were added. The inputs (Logs, Fresh Water, and Tracer Injection) are represented as the constant elements, C1, C2, C3, and C4. The hold elements,
Figure 5. Schematic of Sartell Mill for Revised SIMPAK Program
H1 and H2, needed so break closed loops were inserted between Separator 009 and Mixer 009, and between Separator 006 and Mixer 011 in Fig. 5.

Translation of the SIMPAK configuration as shown in Fig. 5 into a computer program involves the use of configuration statements which define the interconnections among the basic modular blocks and specify the desired functional operation. These configuration statements can be prepared in any order. A fixed format simplifies the routine task of preparing the necessary input card deck either using punched cards or entering directly through the keyboard. Figure 6 contains detailed information about the language statements expressed in terms of numbers and shows one of the possible arrangements of configuration elements which can be made to correspond to the SIMPAK configuration of Fig. 5. The correct sequencing of the calculations is automatically performed by a sorting routine.

A few words concerning the array of numbers as shown in Fig. 6 may be in order. Each line of Fig. 6 represents an input data card which contains three parts of information. The first part contains a SIMPAK configuration element in serial number which can be arbitrarily specified. The second part includes five associated incoming elements in serial number. (Only mixer elements can have more than five incoming elements. Should any element contain more than five incoming elements, then either the element must be split in two or more new elements to reduce the number of incoming elements, or the CONF subprogram can be slightly modified to provide enough room for the additional elements.) The last part contains the identification number (ID) indicating the type of modular elements and its sequence number. For example, tanks and separators have their corresponding ID Numbers 4 and 2.
<table>
<thead>
<tr>
<th>Serial No.</th>
<th>Incoming Element Serial Numbers</th>
<th>ID No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>23</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>24</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>25</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>28</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>29</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>32</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>20</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>26</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>33</td>
<td>4</td>
</tr>
<tr>
<td>13</td>
<td>34</td>
<td>5</td>
</tr>
<tr>
<td>14</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>15</td>
<td>31</td>
<td>7</td>
</tr>
<tr>
<td>16</td>
<td>30</td>
<td>8</td>
</tr>
<tr>
<td>17</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>18</td>
<td>17</td>
<td>1</td>
</tr>
<tr>
<td>19</td>
<td>35</td>
<td>2</td>
</tr>
<tr>
<td>20</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>21</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>22</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>23</td>
<td>20</td>
<td>6</td>
</tr>
<tr>
<td>24</td>
<td>22</td>
<td>7</td>
</tr>
<tr>
<td>25</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>26</td>
<td>22</td>
<td>9</td>
</tr>
<tr>
<td>27</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>28</td>
<td>18</td>
<td>2</td>
</tr>
<tr>
<td>29</td>
<td>22</td>
<td>3</td>
</tr>
<tr>
<td>30</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>31</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>32</td>
<td>22</td>
<td>6</td>
</tr>
<tr>
<td>33</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>34</td>
<td>37</td>
<td>8</td>
</tr>
<tr>
<td>35</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>36</td>
<td>19</td>
<td>10</td>
</tr>
<tr>
<td>37</td>
<td>41</td>
<td>11</td>
</tr>
<tr>
<td>38</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>39</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>40</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>41</td>
<td>13</td>
<td>15</td>
</tr>
</tbody>
</table>

**Figure 6.** SIMPAK Configuration Data for Sartell Mill Simulation (For Description See Text)

The **SORT Subprogram**

The SORT program defines the proper order for processing the modular blocks by means of a sorting algorithm. No modular block is allowed to be processed until updated values of its input variables are available. If the sorting algorithm indicates an improperly specified configuration, the program produces a diagnostic message. The most common cause for a sort error is the
existence of an algebraic loop. This is a closed pathway in the simulation diagram that does not include a tank module. A special element called Hold (H) provided in the program must then be used to break the loop. Such a situation was encountered while testing the improved SIMPAK program in a simple cleaning and pulping system as shown in Fig. 5.

To mechanize the sorting process requires an advanced programming technique. However, the basic concept behind the sorting scheme is rather simple and can be briefly described in what follows.

At each integration interval, it is assumed that constants or inputs (the known inlets of fresh water and chemical additives or given outlets of sewer and other discharges) and the outputs of tank modules are available. A tank module is one in which the current output depends only on past values of the input and output. Using these constants and tank outputs, it is possible to process one or more other modules such as mixers, or separators, or distributors. These outputs then become available as inputs to additional modules. If the SIMPAK configuration is consistent, the logical sequencing of processing all the modular blocks can be determined in accordance with the sorting diagram, and all the blocks would carry sequential numbers to be processed in the modified mainline program.

In essence, the sorting procedure begins with repeating a line-by-line search from top to bottom of the SIMPAK configuration of Fig. 6 for the second part of information to check if all the associated incoming elements are known. (Initially only tanks and constants are assumed to be known.) Any element which has all its incoming elements available will be displaced to the top of the configuration map (Fig. 6) and assigned an ordinal number. This element now
becomes available as an input to other unordered elements which must be repeatedly checked. Such a search process will continue until all the configuration elements are completely identified with proper ordinal numbers.

THE COMPUTED RESULTS

The revised SIMPAK program has been tested and run for a simple pulping system at Sartell, Minnesota as shown in Fig. 2. The purpose of doing this was twofold. First, it would provide the assurance that all portions of the program modified are reasonably debugged. Second, it would provide a base for estimating the computing speed of both the original and revised SIMPAK program.

To run the new version of SIMPAK requires a set of input data as given in Fig. 3. In addition to these data, an additional set of data, Fig. 6, which is prepared on the basis of Fig. 5, is needed to order the calculations.

The example problem tested was to study the dynamic behavior of the pulping system in response to the bromide ion injection at the pipeline P61 into the knotter accept tank T3, as shown in Fig. 2. The integration time step taken was 0.1 minute and the final simulation time was terminated at 200 minutes. The computer printouts were given at every 100th minute.

The partial listings of the computed results, using both the original and revised SIMPAK programs, are given in Tables V, VI, VII, and VIII. Although Tables V and VII show little difference in the dynamic change of bromine concentration level accumulated in each of seven (7) tanks, the revised SIMPAK program has cut the computer simulation time by a factor of nine over the existing SIMPAK program.
<table>
<thead>
<tr>
<th>Time, min</th>
<th>Tank 1</th>
<th>Tank 2</th>
<th>Tank 3</th>
<th>Tank 4</th>
<th>Tank 5</th>
<th>Tank 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>5.0</td>
<td>0.12</td>
<td>0.00</td>
<td>0.19</td>
<td>0.17</td>
<td>0.19</td>
<td>0.39</td>
</tr>
<tr>
<td>10.0</td>
<td>0.43</td>
<td>0.02</td>
<td>0.24</td>
<td>0.25</td>
<td>0.27</td>
<td>0.67</td>
</tr>
<tr>
<td>15.0</td>
<td>0.71</td>
<td>0.04</td>
<td>0.30</td>
<td>0.32</td>
<td>0.34</td>
<td>0.90</td>
</tr>
<tr>
<td>20.0</td>
<td>0.97</td>
<td>0.05</td>
<td>0.34</td>
<td>0.39</td>
<td>0.40</td>
<td>1.10</td>
</tr>
<tr>
<td>25.0</td>
<td>1.20</td>
<td>0.07</td>
<td>0.38</td>
<td>0.44</td>
<td>0.46</td>
<td>1.28</td>
</tr>
<tr>
<td>30.0</td>
<td>1.40</td>
<td>0.09</td>
<td>0.42</td>
<td>0.50</td>
<td>0.51</td>
<td>1.44</td>
</tr>
<tr>
<td>35.0</td>
<td>1.57</td>
<td>0.10</td>
<td>0.45</td>
<td>0.54</td>
<td>0.56</td>
<td>1.59</td>
</tr>
<tr>
<td>40.0</td>
<td>1.73</td>
<td>0.11</td>
<td>0.48</td>
<td>0.58</td>
<td>0.60</td>
<td>1.71</td>
</tr>
<tr>
<td>45.0</td>
<td>1.87</td>
<td>0.12</td>
<td>0.50</td>
<td>0.62</td>
<td>0.63</td>
<td>1.82</td>
</tr>
<tr>
<td>50.0</td>
<td>1.99</td>
<td>0.13</td>
<td>0.53</td>
<td>0.65</td>
<td>0.66</td>
<td>1.92</td>
</tr>
<tr>
<td>55.0</td>
<td>2.10</td>
<td>0.14</td>
<td>0.55</td>
<td>0.68</td>
<td>0.69</td>
<td>2.01</td>
</tr>
<tr>
<td>60.0</td>
<td>2.20</td>
<td>0.15</td>
<td>0.56</td>
<td>0.70</td>
<td>0.72</td>
<td>2.09</td>
</tr>
<tr>
<td>65.0</td>
<td>2.29</td>
<td>0.16</td>
<td>0.58</td>
<td>0.72</td>
<td>0.74</td>
<td>2.16</td>
</tr>
<tr>
<td>70.0</td>
<td>2.36</td>
<td>0.16</td>
<td>0.59</td>
<td>0.74</td>
<td>0.76</td>
<td>2.22</td>
</tr>
<tr>
<td>75.0</td>
<td>2.43</td>
<td>0.17</td>
<td>0.60</td>
<td>0.76</td>
<td>0.77</td>
<td>2.27</td>
</tr>
<tr>
<td>80.0</td>
<td>2.49</td>
<td>0.17</td>
<td>0.62</td>
<td>0.77</td>
<td>0.79</td>
<td>2.32</td>
</tr>
<tr>
<td>85.0</td>
<td>2.54</td>
<td>0.18</td>
<td>0.62</td>
<td>0.79</td>
<td>0.80</td>
<td>2.36</td>
</tr>
<tr>
<td>90.0</td>
<td>2.59</td>
<td>0.18</td>
<td>0.63</td>
<td>0.80</td>
<td>0.82</td>
<td>2.40</td>
</tr>
<tr>
<td>95.0</td>
<td>2.63</td>
<td>0.18</td>
<td>0.64</td>
<td>0.81</td>
<td>0.83</td>
<td>2.43</td>
</tr>
<tr>
<td>100.0</td>
<td>2.67</td>
<td>0.19</td>
<td>0.65</td>
<td>0.82</td>
<td>0.84</td>
<td>2.46</td>
</tr>
</tbody>
</table>

Table V: Bromine Buildup in the Tanks Using Original Program
### TABLE VI

**FINAL SIMULATION RESULTS USING ORIGINAL PROGRAM**

SIMPAK FOR ST. REGIS, SARTEL. BROMINE INJECTION EXPERIMENT  
FULL VARIABLE MAP AT TIME = 199.9999

<table>
<thead>
<tr>
<th>THERE ARE 61 PIPES</th>
<th>FLOW RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>298.00</td>
<td>18.00</td>
</tr>
<tr>
<td>396.46</td>
<td>2627.00</td>
</tr>
<tr>
<td>83.00</td>
<td>1284.72</td>
</tr>
<tr>
<td>396.78</td>
<td>365.83</td>
</tr>
<tr>
<td>2102.42</td>
<td>3210.66</td>
</tr>
<tr>
<td>158.56</td>
<td>26.96</td>
</tr>
<tr>
<td></td>
<td>106.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MASS FLOW RATE OF FIBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
</tr>
<tr>
<td>0.1</td>
</tr>
<tr>
<td>0.2</td>
</tr>
<tr>
<td>0.3</td>
</tr>
<tr>
<td>0.4</td>
</tr>
<tr>
<td>0.5</td>
</tr>
<tr>
<td>0.6</td>
</tr>
<tr>
<td>0.7</td>
</tr>
<tr>
<td>0.8</td>
</tr>
<tr>
<td>0.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MASS FLOW RATE OF ADDITIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
</tr>
<tr>
<td>0.1</td>
</tr>
<tr>
<td>0.2</td>
</tr>
<tr>
<td>0.3</td>
</tr>
<tr>
<td>0.4</td>
</tr>
<tr>
<td>0.5</td>
</tr>
<tr>
<td>0.6</td>
</tr>
<tr>
<td>0.7</td>
</tr>
<tr>
<td>0.8</td>
</tr>
<tr>
<td>0.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>THERE ARE 7 TANKS</th>
<th>VOLUME</th>
</tr>
</thead>
<tbody>
<tr>
<td>8500.00</td>
<td>500.00</td>
</tr>
<tr>
<td>1500.00</td>
<td>1500.00</td>
</tr>
<tr>
<td>2000.00</td>
<td>2000.00</td>
</tr>
<tr>
<td>2000.00</td>
<td>2000.00</td>
</tr>
<tr>
<td>6000.00</td>
<td>6000.00</td>
</tr>
<tr>
<td>5220.00</td>
<td>5220.00</td>
</tr>
<tr>
<td>616.21</td>
<td>31.85</td>
</tr>
<tr>
<td>112.02</td>
<td>100.47</td>
</tr>
<tr>
<td>292.05</td>
<td>22.28</td>
</tr>
<tr>
<td>2.93</td>
<td>0.21</td>
</tr>
<tr>
<td>0.69</td>
<td>0.88</td>
</tr>
<tr>
<td>0.90</td>
<td>2.67</td>
</tr>
<tr>
<td>2.09</td>
<td></td>
</tr>
<tr>
<td>Time, min</td>
<td>Tank 1</td>
</tr>
<tr>
<td>----------</td>
<td>--------</td>
</tr>
<tr>
<td>5.0</td>
<td>0.10</td>
</tr>
<tr>
<td>10.0</td>
<td>0.39</td>
</tr>
<tr>
<td>15.0</td>
<td>0.67</td>
</tr>
<tr>
<td>20.0</td>
<td>0.91</td>
</tr>
<tr>
<td>25.0</td>
<td>1.14</td>
</tr>
<tr>
<td>30.0</td>
<td>1.33</td>
</tr>
<tr>
<td>35.0</td>
<td>1.51</td>
</tr>
<tr>
<td>40.0</td>
<td>1.67</td>
</tr>
<tr>
<td>45.0</td>
<td>1.80</td>
</tr>
<tr>
<td>50.0</td>
<td>1.93</td>
</tr>
<tr>
<td>55.0</td>
<td>2.04</td>
</tr>
<tr>
<td>60.0</td>
<td>2.14</td>
</tr>
<tr>
<td>65.0</td>
<td>2.23</td>
</tr>
<tr>
<td>70.0</td>
<td>2.31</td>
</tr>
<tr>
<td>75.0</td>
<td>2.38</td>
</tr>
<tr>
<td>80.0</td>
<td>2.44</td>
</tr>
<tr>
<td>85.0</td>
<td>2.50</td>
</tr>
<tr>
<td>90.0</td>
<td>2.55</td>
</tr>
<tr>
<td>95.0</td>
<td>2.59</td>
</tr>
<tr>
<td>100.0</td>
<td>2.63</td>
</tr>
</tbody>
</table>
### Table VIII

**Final Simulation Results Using Revised Program**

<table>
<thead>
<tr>
<th>Full Variable</th>
<th>Mass Flow Rate of Additive</th>
<th>Mass Flow Rate of Fiber</th>
<th>Mass Flow Rate of Stalk</th>
<th>Mass Flow Rate of Additive</th>
<th>Mass Flow Rate of Fiber</th>
<th>Mass Flow Rate of Stalk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.53</td>
<td>0.50</td>
<td>0.52</td>
<td>0.48</td>
<td>0.87</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td>0.124</td>
<td>0.126</td>
<td>0.128</td>
<td>0.124</td>
<td>0.128</td>
<td>0.128</td>
</tr>
<tr>
<td></td>
<td>0.129</td>
<td>0.129</td>
<td>0.129</td>
<td>0.129</td>
<td>0.129</td>
<td>0.129</td>
</tr>
<tr>
<td></td>
<td>0.130</td>
<td>0.130</td>
<td>0.130</td>
<td>0.130</td>
<td>0.130</td>
<td>0.130</td>
</tr>
<tr>
<td></td>
<td>0.131</td>
<td>0.131</td>
<td>0.131</td>
<td>0.131</td>
<td>0.131</td>
<td>0.131</td>
</tr>
<tr>
<td></td>
<td>0.132</td>
<td>0.132</td>
<td>0.132</td>
<td>0.132</td>
<td>0.132</td>
<td>0.132</td>
</tr>
<tr>
<td></td>
<td>0.133</td>
<td>0.133</td>
<td>0.133</td>
<td>0.133</td>
<td>0.133</td>
<td>0.133</td>
</tr>
<tr>
<td></td>
<td>0.134</td>
<td>0.134</td>
<td>0.134</td>
<td>0.134</td>
<td>0.134</td>
<td>0.134</td>
</tr>
</tbody>
</table>

*Note: The table continues with similar data for other variables.*
PHASE II - WORK PLAN

The second phase of this project involved the preliminary work necessary for a practical application of the improved SIMPAK program to a selected board mill for water reuse analysis. The work to have been completed in this phase was the following:

(1) Selection of a typical board mill
(2) Initial review of this board mill water system
(3) Collection of the mill material balance data
(4) Translation of the mill water flow diagram into the SIMPAK schematic diagram
(5) Preparation of a typical set of input data deck for SIMPAK computing purposes.

A medium-sized board mill with at least a moderate degree of water recycle was the criterion for the choice of a board mill for the application study of the revised SIMPAK program. The reasons for this are two. First, most board mills are the medium size. Second, a moderate degree of water reuse systems would generate enough information for various simulation studies.

Based on the above criterion, the St. Regis board mill at York, Pennsylvania was selected for this study. This board mill has a rather complex water flow system because of its high degree of system closure and is described below.

THE BOARD MILL

General Description of the Mill at York, PA

The mill at York is an integrated board mill which has three (3) hydraulic pulpers to pulp waste paper (carton, news and mixed), one cylinder board and two
fourdrinier machines to produce 364 tons per day of paper and paperboard. At the
time of our study approximately 275 gallons per minute of fresh water were enter-
ing the mill and a similar quantity was being passed to the various outlets either
with product, or through evaporation in dryers, and sump and sewers for treatment
and landfill. This represents approximately 1100 gallons of fresh water usage
for each ton of paper produced.

The layout for the entire mill is shown in Fig. 7 using the SIMPAK symbols
for the tanks, mixers, distributors, and separators (see Fig. 1). For better under-
standing of the mill system, the flow diagram (Fig. 7) has been divided into six
detailed segments (D-1 through D-6) and separately shown in Fig. 7a through 7f.
The details of the SIMPAK symbols can be obtained by referring to the input speci-
fications in Appendix III, page 77.

The description of the entire board mill (Fig. 7) involves 62 major
tanks, 72 mixing or blending points, 50 separators of various types, 31 distribu-
tors, and 332 pipeline connections. The high degree of water recycle and inter-
dependence of the existing mill system are quite apparent in the detailed layout
which represents the York mill's present operating arrangement. The details of
the process flow diagram were identified and reviewed jointly by technical experts
from the York mill, the St. Regis Technical Center, and The Institute of Paper
Chemistry.

Operating Data for the Existing System

Based on extensive flow, consistency, and concentration measurements
by the mill technical staff at York, a typical set of material balance data
was synthesized and supplied by the St. Regis research staff for initial steady
state flow rates and fiber consistencies throughout the entire board mill.
Figure 7d. Schematic of St. Regis Board Mill at York, PA.
Figure 7f. Schematic of St. Regis Board Mill at York, PA
(Dissolved solids distribution within the system will be supplied at the time when simulation runs for various practical application studies are to be made.) These data were further checked and used by the Institute staff to determine the proper parameters for each of the individual components in the SIMPAK system. The parameters, as well as the water and fiber flow rates, are given in detail in the input data deck (Appendix III) for the initial steady state condition.
CONCLUSIONS

1. The original SIMPAK program has been revised to improve computational efficiency in the simulation runs.

2. The revised program has been tested and run on a small pulping system at Sartell, Minnesota in order to provide assurance that the improved model is workable and reasonably correct for the system under both the steady state and dynamic conditions.

3. A comparison of the computed results in the simulation runs, using both the original and revised SIMPAK programs indicated that the revised SIMPAK program can speed up the calculations by a factor of nine over the earlier SIMPAK program.
RECOMMENDATIONS

On the basis of the present work covering Phases I and II, the following avenues may be included for further studies to accomplish the ultimate goal of SIMPAK applications.

1. The prediction of the steady state and dynamic response of process water systems is a necessary part of decision making on the use or reuse of process water within a mill. Hence, it would be useful to make computer runs on the York board mill to demonstrate the capability and applicability of the revised SIMPAK program to such problems. The computed results would be compared with the actual data.

2. Once the revised SIMPAK program has been verified against actual board mill data, it can be readily used to study water quality parameters from various parts of the mill or at various points within the mill during the intensive recycling simulation. Evaluation of the predicted results based on varying water route systems will immediately lead to one of the best reroute alternatives to achieve the internal mill closure objectives.

3. An additional task would be the exercise of the revised model to determine the sensitivity and dynamics of additive retention in the system as a function of the degree to which the additive is adsorbed on the pulp fibers.

4. Further modifications to include fiber fines as a separate item or to include the several types of pulp separately are also possible.
FUTURE WORK

The work done in Phases I and II of this project and the work done in earlier projects have demonstrated the need for dynamic simulation of mill water systems. These simulation efforts have demonstrated that SIMPAK has the ability to predict the transient behavior of both fiber and dissolved solids in mill water systems. These studies have also indicated that it would be desirable to simulate the behavior of more components in the water system. Additionally, it would be desirable to simulate the behavior of many of the processes in a mill at a greater level of detail than presently incorporated into SIMPAK. For these reasons SIMPAK has been very carefully reviewed. This review was focused on the ability of SIMPAK to be easily expanded to incorporate more processes and components. Other dynamic simulators were also evaluated to compare simulation methodologies.

Based on this review, it has been concluded that the large effort necessary to expand SIMPAK to become a full mill simulation package could be avoided by obtaining the master control program from an already developed simulation package. The Institute would then concentrate its efforts on adopting existing SIMPAK subroutines and developing new subroutines for the new master control program. Several possible candidates for this new master control program are under consideration; all of them have undergone extensive development in the chemical industry.

The expanded simulation capability will be checked using the large database that has been accumulated for use with SIMPAK. The increased simulation capability will then be used to study mechanisms to control the pulping and papermaking process to achieve a more uniform product, to develop optional water reuse strategies, and to study the influence of upsets on mill processes, including waste treatment facilities.
ACKNOWLEDGMENTS

We are very grateful to Messrs. Robert Roscoe and James Hulbert of St. Regis Paper Company for their active participation in the mill system definition, experimentation, and mill data collection and analysis necessary for this work. We also want to thank Dr. Delmar Raymond, West Nyack, New York and the people at York, St. Regis Paper Company, for their cooperation in this study.

THE INSTITUTE OF PAPER CHEMISTRY

James Y. Hung
Research Fellow

Peter E. Parker
Research Fellow

Approved by

Hardev S. Dugal
Director
Division of Industrial & Environmental Systems
APPENDIX I

LISTING OF THE EXISTING SIMPAK PROGRAM

This appendix contains a listing of the original SIMPAK program (main-line and subroutines) used for the pulping system simulation.
SIMPAK MAINLINE FOR SIMULATION OF MILL WATER SYSTEMS

ROBERT A. HOLM THE INSTITUTE OF PAPER CHEMISTRY

COPYRIGHT 11 MAR 73

MODIFIED FOR TAPE OR DISK OUTPUT 12/28/73 J Y HUNG

DIMENSION Q(2,400),WF(2,400),WA(2,400)

DIMENSION V(2,75),MF(2,75),MA(2,75),NT(4,75)

DIMENSION NM(14,100)

DIMENSION NO(14,50),RD(10,50)

DIMENSION NPC(17,50),RPG(2,50)

DIMENSION NPR(17),NPR(217),NPRT(17),NIITLE(20)

INTEGER CRD,PRT,PCN,A(17,8)

REAL MF,MA

COMMON Q,WF,WA,V,MF,MA

THESE DIMENSION VARIABLES ARE INPUT TO THE CALL SUBRoutines FOR

EACH MIXER, SEPARATOR, DISTRIBUTOR, CONTROLLER, AND TANK. MAXIMUM

DIMENSION CAN BE CHANGED TO FIT THE SYSTEM TO BE SIMULATED ON

COMPUTER MEMORY AVAILABLE, CAN PUT IN REPEATED CALLS WITH

EXPLICIT STATEMENT OF EACH INPUT CONNECTION IN PLACE OF THESE

MATRICES. Q,WF,WA,V,MF,MA MUST REMAIN VECTORS, HOWEVER

CALL WHEN

CRD= 5

PRT= 6

PCN= 7

ZERO ALL DATA POSITIONS

DO 15 KK=1,2

DO 1 JJ=1,200

Q(JJ)=0.0

WF(KK, JJ)=0.0

MA(KK, JJ)=0.0

1 CONTINUE

DO 2 JJ=1,75

V(KK, JJ)=0.0

MF(KK, JJ)=0.0

MA(KK, JJ)=0.0

2 CONTINUE

15 CONTINUE

NMIX=0

NPSEP=0

NUMST=0

NPON=0

NTANK=0

NPipe=0

J= 1

K= 2

ITER= 5

ITER SETS THE NUMBER OF ITERATIONS IN THE RELAXATION PROEDURE

AND MUST BE AN EVEN NUMBER EQUAL TO OR GREATER THAN THE LARGEST

NUMBER OF NON-TANK ELEMENTS IN ANY BRANCH OF THE SYSTEM

READ(CRD,1001) NIITLE

1001 FORMAT(2044)

INPUT FULL SYSTEM CONFIGURATION AND PARAMETERS

THE SYSTEM MAY BE GROUPED INTO FUNCTIONAL AREAS OR BLOCKS

AND NUMBER OF IDENTIFYING CARDS (WITH 999 IN FIRST THREE COLUMNS

MAY BE INSERTED BEFORE EACH SET OF MIXERS TO IDENTIFY THAT BLOCK

EACH BLOCK MUST CONTAIN MIX,SEP,DIST,PCON,TANK, AND PIPE COUNTS

WITH SOME COUNTS ZEROS IF THAT SORT OF UNIT IS NOT IN USED IN THAT

1004 FORMAT(12)

READ(CRD,1004) NGRP

DO 50 NG=1,NGRP

51 READ(CRD,1000) NMIXG

IF(NMIXG=999) 52,51

1000 FORMAT(13)

52 NMIX=NMIX+1

NMIX=NMIX+NMIXG

IF(NMIXG)1021,1021,1020

1020 DO 1006 JJ=NMIX,NMIX

...
READ(CRD,1007) (N*(KK, JJ), KK=1,14)
1006 CONTINUE
1007 FORMAT (I13, 12, I4, 13, 1014)
   C
1021 READ(CRD,1000) NSCPG
   NSSEP=NSCPG+1
   NSSEP=NSCPG+NSSEP
   IF(NSSEP.GT.1023, 1024)
1022 DO 1005 JJ=NSSEP, NSSEP
   READ(CRD,1008) (NS(KK, JJ), KK=1, 3), (RS(KK, JJ), KK=1, 3)
1008 FORMAT (I13, 12, 314, 3F6.3)
1005 CONTINUE
   C
1023 READ(CRD,1000) NDISTG
   NSDJS=NDIST+1
   NDIST=NDIST+NDIST
   IF(NDIST.GT.1024)
1024 DO 1011 JJ=NSDJS, NDIST
   READ(CRD,1012) (NS(KK, JJ), KK=1, 4)
1012 FORMAT (I13, 12, I4, 13)
1016 FORMAT (I5, 916)
1017 FORMAT (5, 3, 9F6.3)
1011 CONTINUE
1025 READ(CRD,1000) NPCONG
   NSCON=NPCONG+1
   NPCONG=NPCONG+NPCONG
   IF(NPCONG.GT.1027, 1027)
1026 DO 1018 JJ=NSCON, NPCONG
   READ(CRD,1019) (NPC(KK, JJ), KK=1, 7), (RPC(KK, JJ), KK=1, 2)
1019 FORMAT (I13, 12, 12, 14, 12, 1F10.2, F9.2)
1018 CONTINUE
1027 READ(CRD,1000) NTANKG
   NSTAN=NTANK+1
   NTANK=NTANK+NTANK
   IF(NTANK.GT.1029, 1029, 1028)
1028 DO 1030 JJ=NSTAN, NTANK
   READ(CRD,1031) (NT(KK, JJ), KK=1, 4), V(JT, JJ), MF(JT, JJ), MA(JT, JJ)
1031 FORMAT (I13, 12, 214, 12, 3F10.2)
1030 CONTINUE
1029 READ(CRD,1000) NPIPEG
   NSPI=NPIPEG+1
   NPIPEG=NPIPEG+NPIPEG
   IF(NPIPEG.GT.1033, 1033, 1032)
1033 WRITE(PR6, 1034)
   1034 FORMAT ('WHY ARE THERE NO PIPES...')
   GO TO 1035
1032 DO 1035 JJ=NSPI, NPIPEG
   READ(CRD,1036) (RJ(JT, K), W(JT, K), W(JT, K)
1036 FORMAT (I13, 12, 214, 12, 2F9.2)
1035 CONTINUE
50 CONTINUE
   C
   UNTIL ALL GROUPS HAVE BEEN READ
   C
   END OF SYSTEM INPUT
   C
   SET NUMBER OF DESIRED PRINTED OUTPUTS AND THEIR IDENTIFY
   READ(CRD,1013) NOUT
1013 FORMAT (I11)
   DO 1014 JJ=1, NOUT
   READ(CRD,1015) NPRINT(JJ), NPRINT(JJ), NPRINT(JJ), (A(JJ, K), K=1, 8)
1015 FORMAT (I14, 12, 8A4)
1014 CONTINUE
   C
   SET TIME STEP, PRINT INTERVAL, MAP INTERVAL, AND END POINT
   READ(CRD,1010) DTIME
   READ(CRD,1010) DMAP
   READ(CRD,1010) DFINAL
1010 FORMAT (F10.4
   DPRINT=(DPRINT/DTIME)+0.5
   NPRINT=(DPRINT/DMAP)+0.5
   NSTOP=(DFINAL/DMAP)+0.5
   TIME=0.0
1003 WRITE(PRT,1003) NTITLE
1010 WRITE(PRT,1010) DTIME,DPRT,DMAP,TFINAL
3000 FORMAT(1H,2X,TIME,'=',F10.4,/,3X,'DPRT =',F10.4,/,1X,'DMAP =',F10.4,/,3X,'TFINAL =',F10.4)
1002 FORMAT(1H,'(OUTPUT CODES ARE *.7(3,14,12))')
C WRITE TO TAPE N ITEMS AND OUTPUT CODES
C NTAPE=NSTOP=NPRT
C NWRITE(1,9001) NOUT,NTAPE
9001 FORMAT(8AX)
C DO 170 J=1,NOUT
170 CALL(E1,19002) NPRT1(J),NPRT2(J),NPRT3(J),(A(J,K),K=1,8)
9002 FORMAT(3A4/8A4)
C SET ALL VARIABLES EQUAL FOR PRESENT TIME AND TIME + DTIME.
C THIS WILL COVER ALL CONSTANT INPUTS FOR CONTINUED CALCULATIONS
C AND ANY THAT ARE NOT CONSTANT WILL SIMPLY BE OVERLAI
C DO 18 JJ=1,200
18 CONTINUE
C GO TO 35
36 CONTINUE
C INITIAL STATE VECTOR OF TANK VOLUMES
C JT= 1
C KT= 2
C INIT= 3
CALL MAP(NPIPE,NTANK,PRT,-1.0,NTITLE,JT)
GO TO 35
C START THE SYSTEM AT PROPER EQUILIBRIUM FOR ARBITRARY
C MAIN RETURN POINT
C DO 12 LLL=1,NSTOP
C DO 7 KK=1,NNAP
C DO 3 JJJ=1,NPRT
C IF(NTANK) 33,33,32
C CALL TANK(J,JT,NT,J,KJ,DTIME,NT,J,J,KJ,KT)
C CALL MAP(NPIPE,NTANK,PRT,0.0,NTITLE,JT)
C 33 CONTINUE
C THIS IS AN APPROXIMATE REPLACEMENT FOR DETAILED SEQUENCING OF
C SYSTEM NETWORK ELEMENTS BY SUCCESSIVE RELAXATION OF ALL NON-
C C STORAGE ELEMENTS IN THE SYSTEM
C IF(NPCON) 30,30,29
C CALL PCON(J,NPC(2,J),RPC(1,J),JT,NTANK,NT)
C 31 CONTINUE
C CALL MAP(NPIPE,NTANK,PRT,31.0,NTITLE,KT)
C 30 IF(NMIX) 21,21,20
C CALL MIX(J,NMIX,J,K,JK,KT)
C 22 CONTINUE
C CALL MAP(NPIPE,NTANK,PRT,22.0,NTITLE,KT)
C 21 IF(NSEP) 24,24,23
C CALL SEP(J,NSEP,J,K,JK,KT)
C 25 CONTINUE
C CALL MAP(NPIPE,NTANK,PRT,25.0,NTITLE,KT)
C 24 IF(NDIST) 38,38,26
26 DO 28 J=1,NDIST
28 CONTINUE
29 CALL DIST(J,ND(2,J),RD(1,J),JT,KT)
C
30 CALL MAP(NPIPE,NTANK,PRT,28.0,NTITLE,KT)
31 IF(JT-11 16,16,17
32 JT= 2
33 KT= 1
34 GO TO 27
35 JT= 1
36 KT= 2
37 CONTINUE
38 IF(INIT-1) 36,36,37
C
39 CONTINUE
40 RNDT=JJJ+NPRT*(KKK-1)+NMAP*NPRT*(LLL-1)
41 TIME=TIME*RNDT
42 CONTINUE
43 CALL LINE(TIME,NOUT,NPRT1,NPRT2,NPRT3,PRT,JT)
44 CONTINUE
45 CALL MAP(NPIPE,NTANK,PRT,TIME,NTITLE,KT)
46 CONTINUE
47 CALL NAVAL(NT,NTANK,PRT)
C
48 WRITE(PCH,998) NTANK
998 FORMAT(3=,180)
999 FORMAT(3=,10PES)
DO 1037 J=1,NTANK
1037 WRITE(PCH,1038) (NT(K,J),K=1,4),V(1,J),MF(1,J),MA(1,J)
1039 CONTINUE
1038 FORMAT(15,1,12,2I4,3F10.2)
1039 WRITE(PCH,999) NPIPE
DO 1039 J=1,NPIPE
1040 WRITE(PCH,1040) J,Q(1,J),WF(1,J),WA(1,J)
1041 CONTINUE
1040 FORMAT(*P*,13,F10.2,2F9.2)
C
END THE TAPE FILE
END FILE 1
CALL EXIT
END
SUBROUTINE MIX(J,IN,JT,KT)
DIMENSION Q(2,400),WF(2,400),WA(2,400)
DIMENSION V(2,75),MF(2,75),MA(2,75)
INTEGER IN(3)
REAL MF,MA
COMMON Q,WF,WA,V,MF,MA
C TYPE SPECIFIES WHICH THINGS MAY CHANGE FOR THIS SIMULATION
C (1)EVERYTHING (2)FIBER AND ADDITIVE, BUT NOT FLOW (3)ADDITIVE ONLY
C ITS ACCURACY. For initial tests at constant flow, type=2
C
TYPE=IN(1)
OUT=IN(2)
N=IN(3)
K=N+3
GO TO (1,2,3),TYPE

1 DD=0.0
DO 4 JJ=4,K
KQ=IN(JJ)
DD=DD+Q(JT,KQ)
4 CONTINUE
Q(1,KT,OUT)=DD

2 WFD=0.0
ADD UP TOTAL FIBER RATE
DO 5 JJ=4,K
KK=IN(JJ)
WFD=WFD+WF(JT,KK)
5 CONTINUE
WFI(KT,OUT)=WFD

3 WAD=0.0
ADD UP TOTAL ADDITIVE RATE
DO 6 JJ=4,K
KK=IN(JJ)
WAD=WAD+WA(JT,KK)
6 CONTINUE
WA(KT,OUT)=WAD
RETURN
END
SUBROUTINE SEP(J,N,R,KT,KT)
DIMENSION Q(2,400),WF(2,400),WA(2,400)
DIMENSION V(2,75),MF(2,75),MA(2,75)
DIMENSION N(4),R(3)
INTEGER IN,REJ,ACC,TYPE
REAL MF,MA
REAL KF
COMMON Q,WF,WA,V,MA
C ROBERT A. HOLM, THE INSTITUTE OF PAPER CHEMISTRY, COPYRIGHT 1973
C NOTE THAT RF IS FRACTIONAL RETENTION OF SOLIDS IN REJECTS LINE
C AND AQ IS FRACTIONAL PASS-THRU OF FLOW VOLUME TO ACCEPTS LINE
C TYPE SHOWS WHETHER FIBER RATES (TYPE 1) OR VOLUMETRIC FLOWS (TYPE
C 2) ARE CONSTANT, OR ALL ARE VARIABLE (TYPE 1)
C FOR INITIAL TESTS, TYPE=2
C TYPE=N(1)
C IN=N(2)
C REJ=N(3)
C ACC=N(4)
C RF=R(1)
C AQ=R(2)
C KF=R(3)
C GO TO (1,2,3),TYPE
C CALCULATE VOLUMETRIC FLOW SEPARATION
1 Q(KT,REJ)=Q(JT,IN)*(1.0-AQ)
Q(KT,ACC)=Q(JT,IN)-Q(KT,REJ)
C CALCULATE FIBER MASS FLOW SEPARATION
2 WF(KT,REJ)=WF(JT,IN)*RE
WF(KT,ACC)=WF(JT,IN)-WF(KT,REJ)
C CALCULATE BALANCE OF ADDITIVE SOLUBLE AND NOT ABSORBED, KF=0.0
3 DENOM=Q(JT,IN)*KF*WF(JT,IN)
IF(DENOM) 8,6,7
7 CAW=WA(JT,IN)/DENOM
WAF=KF*CAW
GO TO 9
8 WAF=0.0
C CALCULATE TOTAL DISSOLVED AND SORBED ADDITIVE LEAVING AT EACH PIPE
9 WA(KT,REJ)=Q(KT,REJ)*CAW+WF(KT,REJ)*WAF
WA(KT,ACC)=Q(KT,ACC)*CAW+WF(KT,ACC)*WAF
RETURN
END
SUBROUTINE DIST(J,NQ,QF,JT,KT)
DIMENSION Q1(2,400),WF(2,400),WA(2,400)
DIMENSION V(2,75),MF(2,75),MA(2,75)
DIMENSION NQ(13),QF(10)
INTEGER OUT,TYPE
REAL MF,MA
COMMON 0,WF,WA,V,PF,MA
C ROBERT A. HOLM, THE INSTITUTE OF PAPER CHEMISTRY, COPYRIGHT 1973
C TYPE SIGNIFIES VARIABLE ADDITIVE (3), VARIABLE ADDITIVE AND
C FIBER (2), OR VARIABLE ADDITIVE, FIBER, AND FLOW (1)
C FOR INITIAL TESTS, FLOWS ARE CONSTANT SO (2) SHOULD BE USED
C TYPE=NQ(1)
IN=NQ(2)
N=NQ(3)
K=N+3
GO TO (1,2,3),TYPE
C CALCULATE FLOW DISTRIBUTION
C NOTE THAT ALL TEN VALUES OF OUT MUST BE
C FILLED IN (WITH ZEROS IF NECESSARY)
1 DO 4 JJ=4,K
L=JJ-3
KK= NQ(JJ)
Q(KT,KK)=QF(L)*Q(JT,IN)
4 CONTINUE
C CALCULATE FIBER DISTRIBUTION
2 IF(Q(JT,IN)) 8,8,7
7 CF=WF(JT,IN)/Q(JT,IN)
GO TO 9
8 CF=0.0
9 DO 5 JJ=4,K
KK= NQ(JJ)
WF(KT,KK)=Q(KT,KK)*CF
5 CONTINUE
C CALCULATE ADDITIVE DISTRIBUTION
3 IF(Q(JT,IN)) 11,11,10
10 CA=MA(JT,IN)/Q(JT,IN)
GO TO 12
11 CA=0.0
12 DO 6 JJ=4,K
KK= NQ(JJ)
WA(KT,KK)=Q(KT,KK)*CA
6 CONTINUE
RETURN
END
SUBROUTINE PCON(J,NC,R,IT,KT,NTANK,NT)
DIMENSION Q(2,400),MF(2,400),MA(2,400)
DIMENSION VI(2,25),MF(2,15),MA(2,15)
DIMENSION NC(6),R(21,NI(4,75))
REAL MF,MA
COMMON Q,MF,MA,V,NI,H

C ROBERT A. HOLT, THE INSTITUTE OF PAPER CHEMISTRY, COPYRIGHT 1973
C THIS IS A SIMPLE PROPORTIONAL CONTROLLER WITH SELECTIBLE INPUT
C AND OUTPUT. THE FIRST PARAMETER (M) OR (N) SHOWS WHETHER THE
C SENSOR IS ON A TANK (1) OR A PIPE (2) AND THE SECOND PARAMETER
C SHOWS WHICH VARIABLE IS SENSED OR CONTROLLED. FOR THE TANK
C THE VARIABLES ARE V (1), MF (2), OR MA (3) WHILE FOR THE PIPE
C THEY ARE Q (1), WF (2), OR WA (3)
C FOR THE ITERATIVE RELAXATION VERSION OF SIMPAK, STATE OF SYSTEM
C CONTROL IS ALWAYS USED FOR V,MF,MA WHILE RELAXING VALUES (IT,KT)
C ARE USED FOR THE INTERMEDIATE VARIABLES Q,WF,WA
M1=NC(1)
M=NC(2)
M2=NC(3)
N1=NC(4)
N=NC(5)
N2=NC(6)
SET=R(I)
GAIN=R(I)

C LOCATE PROPER INPUT
CV=CONVAR(M1,M2,IT)

C CALCULATE PRESENT VALUE OF ERROR
ERROR=SET-CV

C CALCULATE CONTROLLER OUTPUT
VC=GAIN*ERROR

C VARIABLE TO BE CONTROLLED RESTRICTED TO POSITIVE VALUES
IF(VC)19,19,20

19 VC=0.0
20 GOTO (11,10),N1
21 OUTPUT VARIABLE IS IN A TANK
10 GOTO (12,13,14),N2
22 VI(N1)=VC
23 GOTO 18
12 VI(N1)=VC
13 VI(N1)=VC
14 IV(N1)=VC
15 GOTO 18
16 MF(KT,NI)=VC
17 GOTO 18
18 CONTINUE
19 OUTPUT IS IN A PIPE
11 GOTO (15,16,17),N2
20 CONTROLED VARIABLE IS FLOW RATE
15 Q(KT,NI)=VC
21 GOTO 18
16 WF(KT,NI)=VC
22 GOTO 18
21 CONTROLED VARIABLE IS MASS RATE OF FIBER
16 WF(KT,NI)=VC
22 GOTO 18
17 CONTROLED VARIABLE IS MASS RATE OF ADDITIVE
18 CONTINUE
21 CONTINUE
22 CONTINUE
23 RETURN

END

DO 7 JTank=1,NTank
NOut=MT(4,JTank)
IF(VJ(JTank)) 21,21,22
21 CF=0.0
CA=0.0
GOTO 23
22 CF=MF(JTank)/VI(JTank)
CA=MA(JTank)/VI(JTank)
23 WF(KT,NOut)=QK(T,NOut)*CF
VAL(KT,NOut)=QK(T,NOut)*CA
7 CONTINUE
RETURN
END
SUBROUTINE TANK(JTANK,TYPE,DTIME,IN,OUT,VT,KT)
DIMENSION Q(2,400),WF(2,400),WA(2,400)
DIMENSION V(2,75),MF(2,75),MA(2,75)
INTEGER IN,OUT,TYPE
REAL MF,MA
COMMON Q,WF,WA,V,MA

C ROBERT A. HULM, THE INSTITUTE OF PAPER CHEMISTRY, COPYRIGHT 11MAR73
C TYPE CHOOSES WHETHER VOLUME IS VARIABLE (1) OR CONSTANT (2)
C A SIMPLE LINEAR EXTRAPOLATION OF RATES IS USED.

C IF(V(JT,JTANK)) 4,4,3
3 WF(JT,OUT)=Q(JT,OUT)*MF(JT,JTANK)/V(JT,JTANK)
   WA(JT,OUT)=Q(JT,OUT)*MA(JT,JTANK)/V(JT,JTANK)
   GO TO 5
4 WF(KT,OUT)=0.0
   WA(KT,OUT)=0.0
5 GO TO (1,2), TYPE
1 V(KT,JTANK)=V(JT,JTANK)+DTIME*(Q(JT,IN)-Q(JT,OUT))
2 MF(KT,JTANK)=MF(JT,JTANK)+DTIME*(WF(JT,IN)-WF(JT,OUT))
   MA(KT,JTANK)=MA(JT,JTANK)+DTIME*(WA(JT,IN)-WA(JT,OUT))
   IF(V(KT,JTANK)) 6,7,7
6 V(KT,JTANK)=0.0
7 IF(MF(KT,JTANK)) 8,9,9
8 MF(KT,JTANK)=0.0
9 IF(MA(KT,JTANK)) 10,11,11
10 MA(KT,JTANK)=0.0
11 CONTINUE

C CALCULATE NEW OUTPUT FLOWS OF FIBER AND ADDITIVE FOR THIS STATE
   WF(KT,OUT)=Q(JT,OUT)*MF(JT,JTANK)/V(JT,JTANK)
   WA(KT,OUT)=Q(JT,OUT)*MA(JT,JTANK)/V(JT,JTANK)

C RETURN NEW VALUES OF V,MF,MA TO STATE VECTOR SIDE OF ARRAY
   V(JT,JTANK)=V(KT,JTANK)
   MF(JT,JTANK)=MF(KT,JTANK)
   MA(JT,JTANK)=MA(KT,JTANK)
   WF(JT,OUT)=WF(KT,OUT)
   WA(JT,OUT)=WA(KT,OUT)
RETURN
END
FUNCTION CONVAR(N1,N2,JT)
DIMENSION Q(2,400),WF(2,400),WA(2,400)
DIMENSION V(2,75),MF(2,75),MA(2,75)
REAL MF,MA
COMMON Q,WF,WA,V,MF,MA
C THIS ROUTINE SELECTS THE PROPER VARIABLE FROM VECTOR ARRAYS FOR
C INPUT AND OUTPUT IN RESPONSE TO A TWO-DIGIT CODE
C 1,1 1,2 1,3 ARE FLOW, FIBER RATE, ADDITIVE RATE FOR PIPES
C 2,1 2,2 2,3 ARE FIBER VOLUME, FIBER STORED, ADDITIVE STORED IN TANKS
C THE SINGLE REAL VALUE OF THE VARIABLE SELECTED IS RETURNED TO THE
C MAINLINE PROGRAM FOR ITERATIVE RELAXATION. JT=1 FOR V,MF,MA
C IS USED ALWAYS, WHILE THE RELAXING VALUES OF Q,WF,WA (JT=JT) ARE
C COPYRIGHT ROBERT A. HOLM THE INSTITUTE OF PAPER CHEMISTRY 12MAR73
GO TO (1,2,N1)
1 GO TO (3,4,5),N2
2 CONVAR=Q(JT,N)
3 RETURN
4 CONVAR=WF(JT,N)
5 RETURN
6 CONVAR=WA(JT,N)
7 RETURN
GO TO (6,7,8),N2
8 CONVAR=V(JT,N)
9 RETURN
10 END
C THESE VALUES USE THE PRESENT STATE VECTOR FOR THE SYSTEM
C CONSISTENTLY IN THE DETERMINATION OF THE VALUE OF THE CONTROL
C VARIABLE TO BE USED
C RETURN
7 CONVAR=MF(1,N)
8 RETURN
9 CONVAR=MA(1,N)
10 RETURN
END
5450
5460
5470
5480
5490
5500
5510
5520
5530
5540
5550
5560
5570
5580
5590
5600
5610
5620
5630
5640
5650
5660
5670
5680
5690
5700
5710
5720
5730
5740
5750
5760
5770
5780
SUBROUTINE MAP(NPIPE,NTANK,PRT,TIME,NTITLE,JT)
DIMENSION NTITLE(20)
DIMENSION Q(2,400),WF(2,400),WA(2,400)
DIMENSION VI(2,75),MF(2,75),MA(2,75)
INTEGER PRT
REAL MF,MA
COMMON Q,WF,WA,V,MF,MA

C THIS OUTPUT PROGRAM TABULATES THE VARIABLE OUTPUTS OF EVERY
C TANK AND PIPE IN THE SYSTEM FOR OCCASIONAL INSPECTION DURING
C A SIMULATION RUN AND AT THE BEGINNING AND END OF EACH SIMULATION
C COPYRIGHT ROBERT A. HOLM THE INSTITUTE OF PAPER CHEMISTRY 12MAR73
WRITE (PRT,100)
100 FORMAT(I11) WRITE(PRT,112) NTITLE
112 FORMAT(I10,20X) WRITE(PRT,101) TIME
101 FORMAT(I1H,'FULL VARIABLE MAP AT TIME=',F10.4)
WRITE(PRT,107)
107 FORMAT(I1H,'THERE ARE',I6,'X','PIPES') WRITE(PRT,109)
109 FORMAT(I1H,'FLOW RATE') WRITE(PRT,104) (Q(JT,JJ),JJ=1,NPIPE)
WRITE(PRT,110)
110 FORMAT(I1H,'MASS FLOW RATE OF FIBER') WRITE(PRT,104) (WF(JT,JJ),JJ=1,NPIPE)
WRITE(PRT,111)
111 FORMAT(I1H,'MASS FLOW RATE OF ADDITIVE') WRITE(PRT,104) (WA(JT,JJ),JJ=1,NPIPE)
WRITE(PRT,107)
107 FORMAT(I1H) WRITE(PRT,102) NTANK
102 FORMAT(I1H,'THERE ARE',I6,'X','TANKS') WRITE(PRT,103)
103 FORMAT(I1H,'VOLUME') WRITE(PRT,104) (VIJJ,JJ=1,NTANK)
104 FORMAT(I1H,'OF FIBER STORED') WRITE(PRT,104) (MF(JT,JJ),JJ=1,NTANK)
WRITE(PRT,105)
105 FORMAT(I1H,'OF ADDITIVE STORED') WRITE(PRT,104) (MA(JT,JJ),JJ=1,NTANK)
WRITE(PRT,100) RETURN
END
SUBROUTINE HCQNL,J,NC,R,KT,NTANK,NT)
DIMENSION Q(2,400),WF(2,400),MA(2,400)
DIMENSION VI(2,75),MF(2,75),MA(2,75)
DIMENSION NC(6),R(2),NT(4,75)
REAL MF,MA
COMMON O,MF,MA,V,PF,MA
SEE SUBROUTINE PCLN IN SIMPAK FOR ADDITIONAL EXPLANATIONS
M1=NC(1)
M2=NC(2)
N1=NC(4)
N=NC(5)
N2=NC(6)
SET=R(1)
SSOUT=R(2)

THIS IS A NONLINEAR (HALF POWER OR SQUARE ROOT) CONTROLLER. THE
OUTPUT IS CALCULATED TO VARY WITH THE SQUARE ROOT OF THE ABSOLUTE
VALUE OF THE INPUT. THE NORMAL USE IS TO CALCULATE A TANK OUTPUT
FLOW WHICH IS PROPORTIONAL TO THE SQUARE ROOT OF THE TANK VOLUME
AND SIMULATING AN OUTPUT WEIR, VALVE, OR PIPE UNDER TURBULENT
FLOW. IF THE TANK HAS AN OVERFLOWWEIR OR STANDPIPE, ONLY THE
ACTIVE VOLUME SHOULD BE COUNTED IN THE VALUE OF 'SET'.

SHOULD BE AS FOLLOWS...
M1=2
M=INPUT NO.
N2=1
N=OUTPUT FLOW NO.

LOCATE PROPER INPUT
CV=CONVAR(M1,M,M2,JT)
CALCULATE CONTROLLER OUTPUT
VC=SET#1(CV/SSOUT)**0.5

NOW LOCATE PROPER OUTPUT
GO TO (11,10),N1
GO TO (12,13,14),N2

M1=NC(1)
M2=NC(2)
N1=NC(4)
N=NC(5)
N2=NC(6)
SET=R(1)
SSOUT=R(2)

20 GO TO (11,10),N1
10 GO TO (12,13,14),N2
FUNCTION DECODE(N1,N2,JT)
DIMENSION Q(2,400),WF(2,400),WA(2,400)
DIMENSION V(2,75),MF(2,75),MA(2,75)
REAL MF,MA
COMMON Q,WF,WA,V,KF,MA
 THIS ROUTINE SELECTS THE PROPER VARIABLE FROM VECTOR ARRAYS FOR
 INPUT AND OUTPUT IN RESPONSE TO A TWO-DIGIT CODE
 C & 1,2 1,1 ARE FLOW, FIBER RATE, ADDITIVE RATE FOR PIPES
 C & 2,1 2,2, 2,3 ARE VOLUME, FIBER STORED, ADDITIVE STORED IN TANKS
 C & THE SINGLE REAL VALUE OF THE VARIABLE SELECTED IS RETURNED TO THE
 C MAINLINE PROGRAM
 C COPYRIGHT ROBERT A. HOLM THE INSTITUTE OF PAPER CHEMISTRY 12MAR73
1 GO TO (1,2),N1
 1 GO TO (3,4,5),N2
 3 DECODE=Q(JT,N)
 4 DECODE=WF(JT,N)
 5 DECODE=WA(JT,N)
 2 GO TO (6,7,8),N2
 6 DECODE=V(JT,N)
 7 DECODE=MF(JT,N)
 8 DECODE=MA(JT,N)
 RETURN
END
SUBROUTINE NAEL(NT,NTANK,PRT)
C SUBROUTINE FOR TABULATING TIME CONSTANTS FOR SIMPAK SIMULATOR
C ROBERT A. HOLM COPYRIGHT (C) JULY 25, 1973
DIMENSION Q(2,400),WF(2,400),WA(2,400)
DIMENSION V(2,75),MF(2,75),MA(2,75),NT(4,75)
INTEGER CRD,PRT,PCH
REAL MF,MA
COMMON Q,WF,WA,V,MF,MA
INTEGER IN,OUT
WRITE(PRT,101)
101 FORMAT(1X,'TIME CONSTANTS FOR IN, OUT, AND NET FLOWS')
WRITE(PRT,102)
102 FORMAT(1X,'1X,TANK,3X,IN,2X,OUT,8X,IN,7X,OUT,12X,NET')
DO 1 JJ=1,NTANK
   IF(V(1,JJ)) 2,2,3
5 TCIN= 0.0
   TCOUT= 0.0
   TCNET= 0.0
   GO TO 4
2 IN= NT(3,JJ)
   OUT= NT(4,JJ)
   TCIN= V(1,JJ)/Q(1,IN)
   TCOUT= V(1,JJ)/Q(1,OUT)
   TCNET= V(1,JJ)/(Q(1,OUT)-Q(1,IN))
4 WRITE(PRT,103) JJ,IN,OUT,TCIN,TCOUT,TCNET
103 FORMAT(1H,315,2F10.5,F15.5)
1 CONTINUE
WRITE(PRT,100)
100 FORMAT(1H1)
RETURN
END
SUBROUTINE LINE(TIME,NOUT,NPR1,NPR2,NPR3,PRT, JT)
DIMENSION NPR1(1),NPR2(1),NPR3(1),VAR(7)
DIMENSION Q(2,400),WF(2,400),MA(2,400)
DIMENSION V(2,75),MF(2,75),MA(2,75)
INTEGER PRT
REAL MF,MA
COMMON Q,WF,MA,V,WF,MA
C THIS SUBROUTINE LIGANES THE Selected Seven VARIABLES FOR OUTPUT AN
C PRINTS THEM IN SEVEN COLUMN FORMAT WITH TIME IN THE LEADING EIGHTH
C COLUMN THE INSTITUTE OF PAPER CHEMISTRY (C) & A HOLM 12 MAR
C CHECK FOR NOUT .GT. 7
IF(NOUT-7) 101,101,102
101 FORMAT('MORE THAN 7 OUTPUTS, JOB TERMINATED')
 CALL EXIT
102 WRITE(6,9001)
 DO 1 JJ=1,NOUT
  VAR(JJ)=DECODENPR1(JJ),NPR2(JJ),NPR3(JJ),JT
  CONTINUE
 WRITE(PRT,100) TIME,(VAR(JJ),JJ=1,NOUT)
 WRITE(1,9002) TIME,(VAR(JJ),JJ=1,NOUT)
9002 FORMAT(20A4)
C NO MORE THAN SEVEN VARIABLES CAN BE PRINTED
100 FORMAT(1H,F10.1,F10.2)
RETURN
END
APPENDIX II

LISTING OF THE IMPROVED SIMPAK PROGRAM

This appendix contains a listing of the revised SIMPAK program (main-line and subroutines) used in the Sartell mill (fine paper) system.
SIMPAK MAINLINE FOR SIMULATION OF MILL WATER SYSTEMS
ROBERT A. HOLM THE INSTITUTE OF PAPER CHEMISTRY
COPYRIGHT 11 MAR 73
SIMPAK IS STILL IN THE DEVELOPMENT PHASE--CODING IS NOT
GUARANTEED TO WORK ON MACHINES OTHER THAN THE IBM 360/44
USING THE RAX OPERATING SYSTEM
PLEASE REPORT ANY CODING ERRORS TO PETE PARKER AT THE INSTITUTE
OF PAPER CHEMISTRY, APPLETON, WISCONSIN 414-734-9251
MODIFIED FOR TAPE OR DISK OUTPUT 12/28/73 J Y HUNG
SPECIAL TAPE OR DISK OUTPUT IS WRITTEN TO DEVICE I
OTHER DEVICES ARE STANDARD
READER=5 PRINTER=6 PUNCH=7
DIMENSION Q(2,400),MF(2,400),WA(2,400)
DIMENSION V(2,75),MF(2,75),MA(2,75),NT(4,75)
DIMENSION NM(14,100)
DIMENSION NS(5,50),RS(5,50)
DIMENSION ND(14,5),RO(10,50)
DIMENSION NPC(7,50),NPC(12,50)
DIMENSION NPT(7),NPRT(7),NPRT(7),NTITLE(20)
INTEGER CRD,PRT,PCN,A1(7,8)
REAL MF,MA
COMMON Q,MF,WA,A,V,MA
COMMON MTRX(50,7),IDQR(50),IDLA(5),INTG(20),MTRX(50),MTRX(50)
COMMON NL,PX,NCON,NEQ,NOQ,NOA
THESE DIMENSION VARIABLES ARE INPUT TO THE CALL ROUTINES FOR
EACH MIXER, SEPARATOR, DISTRIBUTOR, CONTROLLER, AND TANK.
MAXIMUM
DIMENSION CAN BE CHANGED TO FIT THE SYSTEM TO BE SIMULATED OR
COMPUTER MEMORY AVAILABLE. CAN PUT IN REPEATED CALLS WITH
EXPLICIT STATEMENT OF EACH INPUT CONNECTION IN PLACE OF THESE
MATRICES. Q,MF,WA,A,V,MA MUST REMAIN VECTORS, HOWEVER
CALL WHEN
CRD= 5
PRT= 6
PCN= 2
ZERO ALL DATA POSITIONS
DO 15 KK=1,2
DO 1 JJ=1,400
Q(KK, JJ)=0.0
MF(KK, JJ)=0.0
WA(KK, JJ)=0.0
1 CONTINUE
DO 2 JJ=1,75
V(KK, JJ)=0.0
MF(KK, JJ)=0.0
WA(KK, JJ)=0.0
2 CONTINUE
15 CONTINUE
READ(CRD,1001) NTITLE,1004 FORMAT(20A4)
READ(CRD,1004) NGRP,1004 FORMAT(12)
DO 50 N=1,NGRP
C
CHECK FOR 999 COMMENT CARDS PRECEDING MIXER IDENTIFICATION

51 READ(CRD,1000) NMIXG
IF(NMIXG=999) 52,51,51

1000 FORMAT(I3)
52 NMIX=NMIX+1
NMIX=NMIX+NMIXG
IF(NMIXG)1021,1021,1020

1020 DO 1006 JJ=NSMIX,NMIX
READ(CRD,1007) (NK,JJ),KK=1,14)
1006 CONTINUE
1007 FORMAT(Ix,13,12,14,13,1014)

1008 READ(CRD,1000) VSEP
NSSEP=NSSEP+1
IF(NSSEP)1023,1023,1022
1022 DO 1005 JJ=NSSEP,NSSEP
READ(CRD,1008) (NS[KK,JJ],KK=1,5),(RS[KK,JJ],KK=1,3)
1008 CONTINUE

1023 READ(CRD,1000) NDISTG
NSCON=NSCON+1
NDIST=NDIST+NDISTG
IF(NDIST)1025,1025,1024
1024 DO 1011 JJ=NSCON,NSCON
READ(CRD,1012) (NL[KK,JJ],KK=1,4)
1012 CONTINUE
1016 FORMAT(I5,916)
READ(CRD,1017) (RD[KK,JJ],KK=1,10)

1017 FORMAT(F5.3,9F6.3)

1011 CONTINUE

1025 READ(CRD,1000) NPECONG
NSCON=NPECONG+1
NPECONG=NPECONG+1
IF(NPECONG)1027,1027,1026
1026 DO 1018 JJ=NSCON,NSCON
READ(CRD,1019) (NPC[KK,JJ],KK=1,7),(RPC[KK,JJ],KK=1,2)
1019 CONTINUE
1018 FORMAT(Ix,13,2(13,12,12),F10,2,F9.2)

1027 READ(CRD,1000) NTKNG
NSTAN=NSTAN+1
NSTAN=NSTAN+NTKNG
IF(NTKNG)1029,1029,1028
1028 DO 1030 JJ=NSTAN,NTKNG
READ(CRD,1031) (NI[KK,JJ],KK=1,4),(v[JT,JJ],MF[JT,JJ],MA[JT,JJ])
1031 CONTINUE
1030 FORMAT(Ix,13,12,214,3F10,2)

1029 READ(CRD,1000) NPipeG
NSPIPE=NSPIPE+1
NPipeC=NPipeC+NPipeG
IF(NPipeC)1033,1033,1032
1033 WRITE(PRT,1034)
1034 FORMAT(15,‘WHY ARE THERE NO PIPES...‘)
1035 CONTINUE
1032 DO 1035 JJ=NSPIPE,NSPIPE
READ(CRD,1036) K,G(JT,K),MF(JT,K),MA(JT,K)
1036 CONTINUE
1035 FORMAT(Ix,13,F10,2,F9,2)

C 50 CONTINUE
C UNTIL ALL GROUPS HAVE BEEN READ
C END OF SYSTEM INPUT
C SET NUMBER OF DESIRED PRINTED OUTPUTS AND THEIR IDENTITY

1013 FORMAT(I3)
DO 1014 JJ=1,NOUT
READ(CRD,1015) NPRTJ(JJ),NPRT2(JJ),NPRT3(JJ),(AJJ,K),K=1,8
1015 CONTINUE
1014 CONTINUE
1016 FORMAT(I14,12,8A)

C SET TIME STEP, PRINT INTERVAL, MAP INTERVAL, AND END POINT
READ(CRD,1010) DTME
READ(CRD,1010) DPRT
READ(CRD,1010) DMAP
READ(CRD,1010) TFNL
1010 FORMAT(F10.4)
NPRT=(DPRT/DTIME)+0.5
NMAP=(DMAP/DPRT)+0.5
NSTP=(TFNL/DMAP)+0.5
TIME=0.0
WRITE(PRT,1003) NITLE
1003 FORMAT(1H,20A4)
WRITE(PRT,3000) TIME,DPRT,DMAP,TFNL
3000 FORMAT(1H,2X,1D TIME=,F8.4,/,3X,*DPRT =,F8.4,/,1
3X,*DMAP =,F8.4,/,3X,*TFNL =,F8.4)
WRITE(PRT,1002) (NPRT(J),NPRT2(J),NPRT3(J),A(J,K),K=1,8)
1002 FORMAT(3A4/8A4)
C WRITE TO TAPE N ITEMS AND OUTPUT CODES
NTAPE=NSTOP*NMAP
WRITE(1,9001) NOUT,NTAPE
9001 FORMAT(8A4)
DO 170 J=1,NOUT
170 WRITE(1,9002) NPRT1(J),NPRT2(J),NPRT3(J),A(J,K),K=1,8
9002 FORMAT(3A4/8A4)
C SET ALL VARIABLES EQUAL FOR PRESENT TIME AND TIME + DTIME.
C THIS WILL COVER ALL CONSTANT INPUTS FOR CONTINUED CALCULATIONS
C AND ANY THAT ARE NOT CONSTANT WILL SIMPLY BE OVERLAPPED
DO 18 JJ=1,NPIPE
Q(J)=Q(J,1)
W(J)=W(J,1)
18 CONTINUE
DO 19 JJ=1,NANK
V(J)=V(J,1)
M(J)=M(J,1)
19 CONTINUE
CALL CONF
CALL SORT
C START THE SYSTEM AT PROPER EQUILIBRIUM FOR ARBITRARY
C INITIAL STATE VECTOR OF TANK VOLUMES
INIT=1
CALL MAP(NPIPE,NTANK,PRT,-1.0,NTITLE,JT)
GOTO 35
36 CONTINUE
C INIT=2
CALL MAP(NPIPE,NTANK,PRT,0.0,NTITLE,JT)
C CALL NADEL(NT,NTANK,PRT)
C MAIN RETURN POINT
DO 12 LLL=1,NSTOP
DO 7 KKK=1,NMAP
DO 3 JJJ=1,NPRT
3 CONTINUE
DO 29 J=1,NTANK
D(J)=D(N(1),J)
CALL TANK(J,NT(J),DTIME,NT(3,J),NT(4,J),JT,KT)
34 CONTINUE
35 NEXT=NCOND
33 I=ORDR(NEXT)
J=MTMX(NEXT,T)
ITYPE=MTM1(NEXT)
GO TO (25,28,29,30,30,30),ITYPE
30 CONTINUE
GO TO 20
29 CALL DIST(J,ND(2,J),RD(1,J),JT,KT)
GO TO 20
28 CALL SEP(J,NS(2,J),RS(1,J),JT,KT)
GO TO 20
25 CALL MIX(J,NM(2,J),JT,KT)
20 IF(NEXT=NL) 21,22,23
21 NEXT=NEXT+1
GO TO 33
23 CONTINUE
C KTR=KTR+1
C IF(KTR-1) 38,32,38
   CALL MAP(NPIPE,NTANK,PRT,34.0,NTITLE,JT)
C
   38 IF(JT-1) 16,16,17
      JT= 2
      KT= 1
      GO TO 27
      JT= 1
      KT= 2
C 27 CONTINUE
   IF(INIT-1) 36,36,37
   37 CONTINUE
C
   RNDT=1JJ*NPRT*(KKK-1)+NMAP*NPRT*(LLL-1)
   TIME=TIME*RNDT
C 3 CONTINUE
   IF(JT-1) 301,300,301
   CALL LINE(TIME,NOUT,NPRT1,NPRT2,NPRT3,PRT,JT)
   GO TO 7
   301 CALL LINE(TIME,NOUT,NPRT1,NPRT2,NPRT3,PRT,KT)
   7 CONTINUE
   IF(JT-1) 306,305,306
   CALL MAP(NPIPE,NTANK,PRT,TIME,NTITLE,JT)
   GO TO 12
   306 CALL MAP(NPIPE,NTANK,PRT,TIME,NTITLE,KT)
   12 CONTINUE
C
   CALL NAVAL(NT,NTANK,PRT)
   WRITE(PCH,998) NTANK
   998 FORMAT(3I4) TANKS)
   CALL NAVAL(NT,NTANK,PRT)
   WRITE(PCH,998) NTANK
   998 FORMAT(3I4) TANKS)
   DO 1037 J=1,NTANK
      WRITE(PCH,1038) INT(K,J),K=1,4),V(1,J),MF(1,J),MA(1,J)
   1037 CONTINUE
   FORMAT(13,4 TANKS)
   WRITE(PCH,1038) INT(K,J),K=1,4),V(1,J),MF(1,J),MA(1,J)
   1038 CONTINUE
   WRITE(PCH,1040) J,Q(1,J),WF(1,J),WA(1,J)
   1039 CONTINUE
   WRITE(PCH,1040) J,Q(1,J),WF(1,J),WA(1,J)
   1040 CONTINUE
C END THE TAPE FILE
C END FILE 1
C CALL EXIT
C
SUBROUTINE MIX(JN, JT, KT)
DIMENSION Q(12*400), WF(2*400), WA(2*400)
DIMENSION V(2*75), MF(2*75), MA(2*75)
DIMENSION IN(13)
INTEGER OUT, N, IN, TYPE
REAL WF, MA
COMMON Q, WF, WA, V, MF, MA
COMMON MTRX(50, 7), LURD(50), IDLA(5), INTG(20), MTRX1(50), MTRX7(50)
COMMON NBLK, NLIST, CON, NEXT, NEQ, NOD
C
ROBERT A. HOLM, THE INSTITUTE OF PAPER CHEMISTRY, COPYRIGHT 1973
C
(1) TYPE SPECIFIES WHICH THINGS MAY CHANGE FOR THIS SIMULATION
C
(2) SKIPPING CALCULATIONS SHOULD SPEED UP THE CALCULATION AND IMPROVE
C
ITS ACCURACY. FOR INITIAL TESTS AT CONSTANT FLOW, TYPE=2
C
TYPE=IN(1)
OUT=IN(2)
N=IN(3)
K=N+3
C
TESTING
C
WRITE(6, 100) (IN(JJ), JJ=1, 13)
C
100 FORMAT(1X, 'INS = ', 13I5)
GO TO (1, 2, 3), TYPE
C
ADD UP TOTAL FLOW
1 QD=0.0
DO 4 JJ=1, 13
QD=QD+Q(JJ)
4 CONTINUE
QD=QD+QD
RETURN
END
C
ADD UP TOTAL FIBER RATE
2 WFD=0.0
DO 5 JJ=1, 13
WFD=WFD+WF(JJ)
5 CONTINUE
WFD=QD+WF
RETURN
END
C
ADD UP TOTAL ADDITIVE RATE
3 WAD=0.0
DO 6 JJ=1, 13
WAD=WAD+WA(JJ)
6 CONTINUE
WA=WAD
RETURN
END
C
WRITE(6, 101) QD(QD/10.2), WF(WF/10.2), MA(MA/10.2)
C
101 FORMAT(1X, 'QD= ', 1F10.2, 'WF= ', 1F10.2, 'MA= ', 1F10.2)
RETURN
END
SUBROUTINE SEP(J,N,R,JT,KT)
DIMENSION Q(2,400),W(2,400),MA(2,400)
DIMENSION V(2,75),MF(2,75),MA(2,75)
DIMENSION N(4),R(13)
INTEGER IN,RE,JACC,ACC,TYPE
REAL MF,MA
REAL KF
COMMON Q,MF,WA,V,MA
COMMON MTRX(50,7),IDRSA(50),INTG(20),MTRX(100),MTRX(700)
COMMON NBLK,LIST,NCUN,NEXT,NEQ,NOI
C
ROBERT A. HOLM, THE INSTITUTE OF PAPER CHEMISTRY, COPYRIGHT 1973
C
NOTE THAT RF IS FRACTIONAL RETENTION OF SOLIDS IN REJECTS' LINE
C
AND AQ IS FRACTIONAL PASS-THRU OF FLOW VOLUME TO ACCEPTS' LINE
C
C
TYPE SHOWS WHETHER FIBER RATES (TYPE 3) OR VOLUMETRIC FLOWS (TYPE 2)
ARE CONSTANT. IF ALL ARE VARIABLE (TYPE 1)
FOR INITIAL TESTS, TYPE=2
TYPE=N(1)
IN=N(2)
RE=N(3)
ACC=N(4)
R=1(1)
AQ=R(2)
KF=R(3)

100 FORMAT(15,4X,4I5,3F10.2)
GO TO (1,2,3),TYPE
C
1 CALCULATE VOLUMETRIC FLOW SEPARATION
Q(1,J,JT)=Q(JT,IN)*(1.0-AQ)
Q(1,J,ACC)=Q(JT,IN)-Q(1,J,REJ)
C
2 CALCULATE FIBER MASS FLOW SEPARATION
WF(J,JT,IN)=WF(JT,JN)*RF
WF(J,ACC)=WF(JT,JN)-WF(JT,REJ)

3 CALCULATE BALANCE OF ADDITIVE SORED ON FIBER
(E PERFECTLY SOLUBLE AND NOT ABSORBED, KF=0.0
IF(DENOM) 8,8,7
7 CAM=WAF(JT,IN)/DENOM
WAF=KF*CAM
GO TO 9
C
8 CAM=0.0
WAF=0.0
GO TO 3
C
9 CALCULATE TOTAL DISSOLVED AND SOURED ADDITIVE LEAVING AT EACH PIPE
WAF(JT,ACC)=WAF(JT,REJ)*CAM+WF(JT,REJ)*WAF
WAF(JT,ACC)=Q(KT,ACC)*CAM+WF(KT,ACC)*WAF
C
10 FORMAT(15,4X,4I5,3F10.2)
WRITE(6,101) Q(KT,REJ),Q(KT,ACC)
C101 FORMAT(15,1X,11F10.2)
RETURN
END
SUBROUTINE DIST(J,NQ,QF,JT,KT)
DIMENSION Q(2,400),MF(2,400),MA(2,400)
DIMENSION V(2,75),MF(2,75),MA(2,75)
INTEGER NQ(13),QF(10)

REAL MF,MA,
COMMON MTRX(50,7),IDولا(50),INTG(20),MTRX1(50),MTRX7(50)
COMMON NBLK,NLIST,NCN,NEXT,NEQ,NOD

C ROBERT A. HOLM, THE INSTITUTE OF PAPER CHEMISTRY, COPYRIGHT1973
C TYPE SIGNIFIES VARIABLE ADDITIVE (3), VARIABLE ADDITIVE AND
C FIBER (2), OR VARIABLE ADDITIVE, FIBER, AND FLOW (1)
C FOR INITIAL TESTS, FLOWS ARE CONSTANT SO (2) SHOULD BE USED
C
C TYPE=NQ(1)
IN=NQ(2)
N=NQ(3)
K=N+3

C WRITE6,100) (NQ(JJ),JJ=1,13)
C FORMAT(*,10,135)
C WRITE6,101) QF(I),II=1,10)
C FORMAT(*,10,F6.2)
GO TO (1,2,3),TYPE
C
C CALCULATE FLOW DISTRIBUTION
C NOTE THAT ALL TEN VALUES OF OUT MUST BE
C FILLED IN (WITH ZEROS IF NECESSARY)
C 1 DD 4 JJ=4,K
C L=JJ-3
C QF(KT,KK)=QF(L)*Q(JT,IN)
C WRITE6,102) Q(KT,KK)
C FORMAT(*,10,F6.2)
C 4 CONTINUE
C
C CALCULATE FIBER DISTRIBUTION
2 IFQ(JT,IN)) B,6,7
1 CF=WF(JT,IN)/Q(JT,IN)
GO TO 9
8 CF=0.0
9 DD 5 JJ=4,K
C MF(KT,KK)=QF(KT,KK)*CF
C 5 CONTINUE
C
C CALCULATE ADDITIVE DISTRIBUTION
3 IFQ(JT,IN)) I,11,10
C CA=MA(JT,IN)/Q(JT,IN)
GO TO 12
11 CA=0.0
12 DD 6 JJ=4,K
C WA(KT,KK)=QF(KT,KK)*CA
C 6 CONTINUE
RETURN
END
SUBROUTINE PCON(J, NC, R, JT, KT, NTANK, NT)

DIMENSION Q(12,400), W(2,400), WA(2,400)

DIMENSION VC(12,75), MF(2,75), MAI(2,75)

DIMENSION NC(6), R(12), NT(4, 75)

REAL MF, MA, WA, V, MF, MA

COMMON MTRX(50,71), ORDR(50), IDLA(5), INTEG(20), MTRX1(50), MTRX7(50)

COMMON NBLK, NLIST, CONV, NEX, NEO, NOD

This is a simple proportional controller with selectable input

AND OUTPUT. THE FIRST PARAMETER (M1 OR N1) SHOWS WHETHER THE
SENSOR IS ON A TANK (1) OR A PIPE (2) AND THE SECOND PARAMETER
SHOWS WHICH VARIABLE IS SENSORED OR CONTROLLED. FOR THE TANK
THE VARIABLES ARE V (1), MF (2), OR MA (3) WHILE FOR THE PIPE
THEY ARE Q (1), W (2), OR WA (3).

FOR THE ITERATIVE RELAXATION VERSION OF SIMPAK, STATE OF SYSTEM
ITM=1) IS ALWAYS USED FOR V, MF, MA, WHILE RELAXING VALUES (JT, KT)
ARE USED FOR THE INTERMEDIATE VARIABLES Q, W, MA.

M1=NC(1)

M=NC(2)

M2=NC(3)

N1=NC(4)

N=NC(5)

N2=NC(6)

SET=R(1)

GAIN=R(2)

LOCATE PROPER INPUT

CV=CONVAR(M1, M2, JT)

LOCATE PROPER OUTPUT

C

20 GO TO (11, 10) N1

C

OUTPUT VARIABLE IS IN A TANK

10 GO TO (12, 13, 14) N2

C

CONTROLLED VARIABLE IS VOLUME (NOT USUALLY CONTROLLED DIRECTLY)

11 V(1, N)=VC

GO TO 18

C

CONTROLLED VARIABLE IS MASS OF FIBER IN TANK

12 MF(1, N)=VC

GO TO 18

C

CONTROLLED VARIABLE IS MASS OF ADDITIVE IN TANK

13 MA(1, N)=VC

GO TO 18

C

OUTPUT IS IN A PIPE

14 W(1, 16, 17, N2)

C

CONTROLLED VARIABLE IS FLOW RATE

15 QI(K, N)=VC

GO TO 19

C

CONTROLLED VARIABLE IS MASS RATE OF FIBER

16 WFKT(N)=VC

GO TO 18

C

CONTROLLED VARIABLE IS MASS RATE OF ADDITIVE

17 WAINT(N)=VC

C

CONTINUE

C

BRING ALL FIBER AND ADDITIVE FLOWS OUT OF TANKS UP TO DATE

C

BEFORE RETURN TO MAINLINE

DO 7 JTANK=1, NTANK

NOUT=NT(4, JTANK)

IF (V, JT, JTANK) 21, 21, 22

10 CF=0.0

GO TO 23

7 CONTINUE

RETURN

END

5100

5140

5150

5160

5170

5180

5190

5200

5210

5220

5230

5240

5250

5260

5270

5280

5290

5300
SUBROUTINE TANK(JTANK, TYPE, DTIME, IN, OUT, JT, KT)
DIMENSION QJ(2,400), WJ(2,400), MAJ(2,400)
DIMENSION VI(2,75), MF(2,75), MA(2,75)
INTEGER IN, OUT, TYPE
REAL MF, MA
COMMON MTRX(50,7), IQORDR(50), IDLA(5), INTG(20), MTRX1(50), MTRX7(50)
COMMON NBLK, NLIST, NCON, NEXT, NEQ, NOD
C TYPE CHOOSES WHETHER VOLUME IS VARIABLE (1) OR CONSTANT (2)
C A SIMPLE LINEAR EXTRAPOLATION OF RATES IS USED.
C
IF(V(JT,JTANK)) 4,4,3
3 WF(JT,OUT) = Q(JT,OUT) + MF(JT,JTANK)/(VI(JT,JTANK))
WA(JT,OUT) = Q(JT,OUT) + MA(JT,JTANK)/(VI(JT,JTANK))
GO TO 5
4 WF(KT,OUT) = 0.0
WA(KT,OUT) = 0.0
5 GO TO 1,2, TYPE
1 V(KT,JTANK) = V(JT,JTANK) + DTIE*(Q(JT,IN) - Q(JT,OUT))
2 MF(KT,JTANK) = MF(JT,JTANK) + DTIE*(MF(JT,IN) - MF(JT,OUT))
MA(KT,JTANK) = MA(JT,JTANK) + DTIE*(MA(JT,IN) - MA(JT,OUT))
IF(V(KT,JTANK)) 6,7,7
6 V(KT,JTANK) = 0.0
7 IF(MF(KT,JTANK)) 8,9,9
8 MF(KT,JTANK) = 0.0
9 IF(MA(KT,JTANK)) 10,11,11
10 MA(KT,JTANK) = 0.0
11 CONTINUE
C
CALCULATE NEW OUTPUT FLOWS OF FIBER AND ADDITIVE FOR THIS STATE
WF(KT,OUT) = Q(JT,OUT) + MF(KT,JTANK)/(VI(JT,JTANK))
WA(KT,OUT) = Q(JT,OUT) + MA(KT,JTANK)/(VI(JT,JTANK))
C
RETURN NEW VALUES OF V, MF, MA TO STATE VECTOR SIDE OF ARRAY
V(JT,JTANK) = V(KT,JTANK)
MF(JT,JTANK) = MF(KT,JTANK)
MA(JT,JTANK) = MA(KT,JTANK)
WF(JT,OUT) = WF(KT,OUT)
WA(JT,OUT) = WA(KT,OUT)
RETURN
END

Members of The Institute of Paper Chemistry
Project 3251

Page 67
Report One
FUNCTION CONVAR(N1,N2,N1,N2,JT)
DIMENSION Q(2,400), I,J(2,400), MA(2,400)
DIMENSION V(2,75), NF(2,75), MA(2,75)
REAL MF, MA
COMMON Q, I,J(2,400), MA(2,400), V(2,400)
COMMON A(3), N1ST, NCON, NEXT, NDF, NDD

THIS ROUTINE SELECTS THE PROPER VARIABLE FROM VECTOR ARRAYS FOR
INPUT AND OUTPUT IN RESPONSE TO A TWO-DIGIT CODE
C
C. 1 1 1 2 1 3 ARE FLOW, FIBER RATE, ADDITIVE RATE FOR PIPES
C. 2, 2 1 2 2 3 ARE VOLUME, FIBER STORED, ADDITIVE STORED IN TANKS
C. THE SINGLE REAL VALUE OF THE VARIABLE SELECTED IS RETURNED TO THE
C. MAINLINE PROGRAM FOR ITERATIVE RELAXATION, JT=1 FOR V, MF, MA
C. IS USED ALWAYS, WHILE THE RELAXING VALUES OF Q, NF, WA (JT=JT) ARE
C. USED
C
COPYRIGHT ROBERT A. HOLM THF INSTITUTE OF PAPER CHEMISTRY 12MAR73
GO TO (1,2), N1
1 GO TO (3,4,5), N2
3 CONVAR=Q(JT,N1)
RETURN
4 CONVAR=I(JT,N1)
RETURN
5 CONVAR=J(JT,N1)
RETURN
2 GO TO (6,7,8), N2
6 CONVAR=V(J1,N1)
RETURN
7 CONVAR=MF(J1,N1)
RETURN
8 CONVAR=MA(J1,N1)
RETURN
END
SUBROUTINE MAP(NPIPE,NTANK,PRT,TIME,NTITLE,JT)
DIMENSION NTITLE(20)
DIMENSION Q(2,400),WF(2,400),WA(2,400)
DIMENSION V(2,75),MF(2,75),MA(2,75)
INTEGER PRT
REAL MF,MA
COMMON Q,WF,WA,V,MF,MA
COMMON MTRX(50,7),IDOR(50),IDLA(5),INTG(20),MTRX1(50),MTRX7(50)
COMMON NBLK,NLST,NCON,NEXT,NEQ,NOD

C THIS OUTPUT PROGRAM TABULATES THE VARIABLE OUTPUTS OF EVERY
C TANK AND PIPE IN THE SYSTEM FOR OCCASIONAL INSPECTION DURING
C A SIMULATION RUN AND AT THE BEGINNING AND END OF EACH SIMULATION
C
COPYRIGHT ROBERT A. HOLM THE INSTITUTE OF PAPER CHEMISTRY 12MAR73

WRITE (PRT,100)
100 FORMAT(1H1)
WRITE(PRT,112) NTITLE
112 FORMAT(1H0,20A4)
WRITE(PRT,101) TIME
101 FORMAT(1H, 'FULL VARIABLE MAP AT TIME=',F10.4)
WRITE(PRT,107)
WRITE(PRT,108) NPIPE
108 FORMAT(1H, 'THERE ARE ',16,2X,'PIPES')
WRITE(PRT,109)
109 FORMAT(1H, 'FLOW RATE')
WRITE (PRT,104) (Q(JT,JJ),JJ=1,NPIPE)
WRITE(PRT,110)
WRITE(PRT,111)
110 FORMAT(1H, 'MASS FLOW RATE OF FIBER')
WRITE (PRT,104) (MF(JT,JJ),JJ=1,NPIPE)
WRITE(PRT,111)
111 FORMAT(1H, 'MASS FLOW RATE OF ADDITIVE')
WRITE (PRT,104) (MA(JT,JJ),JJ=1,NPIPE)
WRITE(PRT,107)
107 FORMAT(1H )
WRITE (PRT,102) NTANK
102 FORMAT(1H, 'THERE ARE ',16,2X,'TANKS')
WRITE (PRT,103)
103 FORMAT(1H, 'VOLUME')
WRITE (PRT,104) (V(JT,JJ),JJ=1,NTANK)
104 FORMAT(1H, 'VOLUME')
WRITE (PRT,105)
105 FORMAT(1H, 'MASS OF FIBER STORED')
WRITE (PRT,104) (MF(JT,JJ),JJ=1,NTANK)
WRITE (PRT,106)
106 FORMAT(1H, 'MASS OF ADDITIVE STORED')
WRITE (PRT,104) (MA(JT,JJ),JJ=1,NTANK)
WRITE(PRT,100)
100 FORMAT(1H )
RETURN
END
SUBROUTINE HCONE(J, NC, R, JT, NT, NK, NTANK, NT)
DIMENSION Q(1, 2, 400, 400), M(J, 2, 400), MA(2, 400)
DIMENSION V(2, 75, 2, 75), MA(2, 75)
DIMENSION NC(6, 12, 2, 75, 1, 75)
REAL MF, MA
COMMON Q, MF, WA, V, MA
COMMON NRX(5, 7), IDOR(50), IDLA(5), INTG(20), MTRX(50), MTRX(50)
COMMON NLK, NLST, NC, NNX, NEQ, NOD
SEE SUBROUTINE PCHN IN SIMPAK FOR ADDITIONAL EXPLANATIONS
C
M1=NC(1)
N1=NC(2)
M2=NC(3)
N2=NC(4)
M3=NC(5)
N3=NC(6)
SET=N1(1)
SSOUT=N1(12)
C
THIS IS A NONLINEAR (HALF POWER OR SQUARE ROOT) CONTROLLER. THE
OUTPUT IS CALCULATED TO VARY WITH THE SQUARE ROOT OF THE ABSOLUTE
VALUE OF THE INPUT. THE NORMAL USE IS TO CALCULATE A TANK OUTPUT
FLOW WHICH IS PROPORTIONAL TO THE SQUARE ROOT OF THE TANK VOLUME
THUS SIMULATING AN OUTPUT WEIR, VALVE, OR PIPE UNDER TURBULENT
FLOW. IF THE TANK HAS AN OVERFLOW WIER OR STANDPIPE, ONLY THE
ACTIVE VOLUME SHOULD BE COUNTED IN THE VALUE OF 'SET'.
FOR THE NORMAL USE (TANK HYDRAULICS) THE VARIABLE SELECTORS
SHOULD BE AS FOLLOWS...
M1=2 M=TANK NO.
M2=1 N=OUTPUT FLOW N0.
N2=1
C
LOCATE PROPER INPT
CV=CONVAR(M1, M2, JT)
C
CALCULATE CONTROLLER OUTPUT
VC=SET*(CV/SSOUT)**0.5
C
NOW LOCATE PROPER OUTPUT
20 GO TO (11, 10, N1)
10 GO TO (12, 13, 14, N2)
12 V1(N1)=VC
13 MF(V1(N1)=VC
14 MA(V1(N1)=VC
15 Q(KT, N)=CV
16 MF(Q(KT, N)=VC
17 WA(KT, N)=VC
18 CONTINUE
DO 7 JTK=1, NTANK
7 NOUT=NT(4, JTK)
7 IF(V1(JT, JTK), 16, 17, 18)
16 CF=0.0
17 CA=0.0
18 GO TO 23
21 CF=MF(JT, JTK)/V(JT, JTK)
22 CA=MA(JT, JTK)/V(JT, JTK)
23 W(KT, NOUT)=Q(KT, NOUT)*CF
W(KT, NOUT)=Q(KT, NOUT)*CA
7 CONTINUE
RETURN
END
FUNCTION DECODE(N1,N2,J1)
DIMENSION Q(2,400),WF(2,400),WA(2,400)
DIMENSION V(2,75),MF(2,75),MA(2,75)
REAL MF,MA
COMMON Q,WF,WA,V,WF,MA
COMMON MIXX(50,7),IDOR(50),IDA(5),INTG(20),MTRX1(50),MTRX2(50)
COMMON NBLK,NNST,SCON,NEXT,SEQ,NOD
C
C THIS ROUTINE SELECTS THE PROPER VARIABLE FROM VECTOR ARRAYS FOR
C INPUT AND OUTPUT IN RESPONSE TO A TWO-DIGIT CODE
C
C 1,1 1,2 1,3 ARE FLOW, FIBER RATE, ADDITIVE RATE FOR PIPES
C 2,1 2,2 2,3 ARE VOLUME, FIBER STORED, ADDITIVE STORED IN TANKS
C
C THE SINGLE REAL VALUE OF THE VARIABLE SELECTED IS RETURNED TO THE
C MAINLINE PROGRAM
C
COPYRIGHT ROBERT A. HOLM THE INSTITUTE OF PAPER CHEMISTRY 12MAR73
GO TO (1,2),N1
1 GO TO (3,4,5),N2
3 DECODE=Q(J1,N)
RETURN
4 DECODE=WF(J1,N)
RETURN
5 DECODE=WA(J1,N)
RETURN
2 GO TO (6,7,8),N2
6 DECODE=V(J1,N)
RETURN
7 DECODE=MF(J1,N)
RETURN
R DECODE=MA(J1,N)
RETURN
END
SUBROUTINE NAVEL(NT, NTANK, PRT)
C
SUBROUTINE FOR TABULATING TIME CONSTANTS FOR SIMPAK SIMULATOR

C
ROBERT A. HOLM  COPYRIGHT (C) JULY 25, 1973
DIMENSION Q(2,401),WF(2,401),WA(2,401)
DIMENSION V(2,75),MF(2,75),MA(2,75),NT(4,75)
INTEGER CRD,PRT,PCH
REAL MF,MA
COMMON Q,WF,WA,V,MA
COMMON MTRX(50,7),IORDR(50),IDL(5),INTG(20),MTRX(50),MTRX(50)
COMMON NULX,NUXT,N,NCUN,NEXT,NEQ,NOD
INTEGER INOUT
WRITE(PRT,101)
101 FORMAT(1H8,'TIME CONSTANS FOR IN, OUT, AND NET FLOW')
WRITE(PRT,102)
102 FORMAT(1H11,'1X,TANK*,3X,IN*,2X,OUT*,8X,IN*,7X,OUT*,12X,NET*)
DO 1 JJ=1,NTANK
IF(V(1 JJ)) 2,2,3
2 TCIN= 0,0
TOUT= 0,0
TCNET= 0,0
GO TO 4
3 IN= NT(3, JJ)
OUT= NT(4, JJ)
TCIN= V(1 JJ)/Q(IN)
TOUT= V(1 JJ)/Q(OUT)
TCNET= V(1 JJ)/Q(OUT)-Q(IN)
WRITE(PRT,103) JJ, IN, OUT, TCIN, TOUT, TCNET
103 FORMAT(1H11, '315,2F10.5,F15.5')
1 CONTINUE
WRITE(PRT,100)
100 FORMAT(1H11)
RETURN
END
SUBROUTINE LINE(TIME,NOUT,NPRT1,NPRT2,NPRT3,PRT,JT)
DIMENSION NPRT1(1),NPRT2(1),NPRT3(1),VARI(7)
DIMENSION Q(2,400),MF(2,400),WA(2,400)
DIMENSION V(2,75),NF(2,75),MA(2,75)
INTEGER PRT
REAL MF,WA
COMMON Q,MF,WA,V,P,FA
COMMON M,B(50,7),ID,A(50),DB(5),INTG(20),MTRX1(50),MTRX7(50)
COMMON NBLK,NLIST,NCON,NEXI,NEQ,NOD
C THIS SUBROUTINE LOCATES THE SELECTED SEVEN VARIABLES FOR OUTPUT AN
C PRINTS THEM IN SEVEN COLUMN FORMAT WITH TIME IN THE LEADING EIGHTH
C COLUMN THE INSTITUTE OF PAPER CHEMISTRY (C) R A HOLM 12 MAR
C CHECK FOR NOUT .GT. 7
C IF(NOUT-7) 101,101,102
1001 FORMAT(11 MORE THAN 7 OUTPUTS, JOB TERMINATED*)
CALL EKII
101 DO I JJ=1,NOUT
VAR(IJJ)=DECODE(NPRT1(JJ),NPRT2(JJ),NPRT3(JJ),JT)
1 CONTINUE
WRITE(PRT,100) TIME,(VAR(IJJ),JJ=1,NOUT)
WRITE(1,9002) TIME,(VAR(I),I=1,NOUT)
9002 FORMAT(20A4)
C NO MORE THAN SEVEN VARIABLES CAN BE PRINTED
100 FORMAT(IH,F10.1,F10.2)
RETURN
END
SUBROUTINE CONF
C
C CARD ENTRY FOR CONFIGURATION
C
JAMES Y. HUNG MARCH, 31, 1975
C
DIMENSION Q(2,400), WF(2,400), WA(2,400)
C
DIMENSION V(2,75), MF(2,75), MA(2,75)
C
REAL MF, MA
C
COMMON Q, WF, WA, V, MF, MA
COMMON MTRX(50,7), IDRDL(50), IDLA(5), INTG(20), MTRX1(50), MTRX7(50)
C
COMMON NBLK, NLIST, NCON, NEXT, NEQ, NOD
C
NBLK=0
C
10 READ(5,202) I,J,K,L,M,N,KLAS,ID
202 FORMAT(I8,5)
C
IF(I) 150, 200, 100
C
30 WRITE(6,203) I,J,K,L,M,N,KLAS,ID
203 FORMAT(1X,8I5)
C
GO TO 10
C
100 CONTINUE
C
IF(MTRX(I,J)) 148, 148, 147
147 WRITE(6,207)
207 FORMAT(1X, 'PREVIOUS SPECIFICATION DELETED ')
C
148 MTRX(I,J)=KLAS
C
MTRX(I,J)=KLAS
MTRX(I,J)=K
MTRX(I,J)=L
MTRX(I,J)=M
MTRX(I,J)=N
MTRX(I,J)=ID
MTRX(I,J)=ID
NBLK=NBLK+1
C
GO TO 30
C
30 WRITE(6,205) I
205 FORMAT(1X, 'THE SPECIFICATION FOR BLOCK ' , I5, ' IS INCORRECT')
C
CALL EXIT
C
EXIT FROM THIS SUBROUTINE
C
200 CONTINUE
C
RETURN
C
END
SUBROUTINE SORT

FIRST PREPARE FOR SORT OPERATION

TEST FOR INTEGRAL & INPUT ELEMENTS

JAMES Y. HUNG MARCH 31 1975

DIMENSION Q(2,600),MF(2,400),WA(2,400)

DIMENSION V(2,75),MF(2,75),MA(2,75)

REAL MF,MA

COMMON Q,WF,WA,V,WF,MA

COMMON MTRX(50,7),IOORDR(50),IDLA(5),INTG(20),MTRX1(50),MTRX7(50)

COMMON NBLK,NLIST,NCON,NEXT,NEQ,NOD

NOD=0

NEQ=0

NCON=1

IERK=2

C FORMAT(1, 7, 15)

D 11 I=1, NBLK

WRITE(6,199) 1,(MTRX(I,J), J=1, 6)

IF(MTRX(I,1)) 11, 1, 12

C DELAY ELEMENT

12 IF(MTRX(I,1)- 6 ) 14,13,14

13 NOD=NOD+1

IDLA(NOD) = 1

GO TO 25

C CONTINUE

14 IF(MTRX(I,4)-) 18,17,18

17 NEQ=NEQ+1

INTG(NEQ)=1

GO TO 25

C CONTINUE

18 IF(MTRX(I,1)-5 ) 20,19,20

19 IOORDR(NCON) =

MTRX(NCON,7)-MTRX7(I)

MTRX1(NCON)=MTRX(I,1)

NCON=NCON+1

GO TO 26

C CONTINUE

20 SET ELEMENT IDENTIFIER NEGATIVE UNTIL AFTER SORTING

C 25 MTRX(I,1)=MTRX(I,1)

26 CONTINUE

DO 27 M=2, 6

IF(LTEST ) 27,27,29

20 FORDNT( IX,13,100,1371)

28 WRITE(6,200) LTEST, 1

27 CONTINUE

C 11 CONTINUE

C PERFORM SORT OPERATION

C 50 DO 50 N=NCON,NBLK

51 IOORDR(N)=0

C 60 NLIST=NCON-1

61 DO 51 I=1, NBLK

IF(MTRX(I,1)) 52,51,51

C 52 CONTINUE

DO 55 M=2, 6

LTEST=LAB5(MTRX(I,M))

IF(LTEST) 53,55,55

C 53 CONTINUE

IF(NOD) 54,54,56

55 DO 57 N=1,NOD

IF(LTEST=IDLA(N)) 57,55,57

C 54 CONTINUE

C 56 DO 58 N=1,NEQ

IF(LTEST=INTG(N)) 58,55,58

C 58 CONTINUE

C 59 DO 59 N=1,NLIST

IF(LTEST=IOORDR(N)) 59,55,59

C 60 CONTINUE

GO TO 51

C 55 CONTINUE

C 61 NLIST = NLIST + 1

IOORDR(NLIST) = 1
MTRX(NLIST,7)=MTRX7(I)
MTRX(I,NLIST)=ABS(MTRX(I,1))
MTRX(I,1) = - MTRX(I,1)
GO TO 60
51 CONTINUE
C
C SORT TEST
C
DO 65 I=1,NBLK
IF(MTRX(I,1)) 66,66,66
ERR=1
66 MTRX(I,1) = - MTRX(I,1)
WRITE(6,201) I
201 FORMAT(IX,*SORT FAILURE - BLOCK *1,14)
NLIST = NLIST + 1
IFOR(NLIST) = I
GO TO 60
65 CONTINUE
C
GO TO (67,68),NERK
C
UNSUCCESSFUL SORT
67 CALL EXIT
C
SUCCESSFUL SORT
68 WRITE(6,202) NBLK,NLIST,NCON,NEXT,NEQ,NDD
WRITE(6,203) (FOR(NJ),MTRX(NJ,7),MTRX(NJ,1),NJ=1,NBLK)
202 FORMAT(IX,615)
203 FORMAT(IX,315)
69 RETURN
END
APPENDIX III

LISTING OF EXISTING YORK MILL INPUT DATA
(INITIAL CONDITION)

This appendix contains a listing of the input data for the York mill
(board) at the initial steady state condition.
SIMPAC FOR YORK BOARD MILL (ST. REGIS PAPER COMPANY)

<table>
<thead>
<tr>
<th>MIXFRS</th>
<th>CTN</th>
<th>TANK</th>
<th>YIELD</th>
<th>PERCENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>M001</td>
<td>003</td>
<td>C2</td>
<td>001</td>
<td>002</td>
</tr>
<tr>
<td>M002</td>
<td>004</td>
<td>C2</td>
<td>003</td>
<td>005</td>
</tr>
<tr>
<td>M003</td>
<td>009</td>
<td>C2</td>
<td>007</td>
<td>010</td>
</tr>
<tr>
<td>M004</td>
<td>012</td>
<td>C3</td>
<td>009</td>
<td>011</td>
</tr>
<tr>
<td>M005</td>
<td>038</td>
<td>C2</td>
<td>039</td>
<td>040</td>
</tr>
<tr>
<td>M006</td>
<td>039</td>
<td>C2</td>
<td>041</td>
<td>042</td>
</tr>
<tr>
<td>M007</td>
<td>043</td>
<td>C2</td>
<td>026</td>
<td>044</td>
</tr>
<tr>
<td>M008</td>
<td>051</td>
<td>C2</td>
<td>052</td>
<td>053</td>
</tr>
<tr>
<td>M009</td>
<td>054</td>
<td>C2</td>
<td>053</td>
<td>054</td>
</tr>
<tr>
<td>M010</td>
<td>054</td>
<td>C2</td>
<td>023</td>
<td>055</td>
</tr>
<tr>
<td>M011</td>
<td>054</td>
<td>C2</td>
<td>047</td>
<td>048</td>
</tr>
<tr>
<td>M012</td>
<td>048</td>
<td>C2</td>
<td>015</td>
<td>049</td>
</tr>
<tr>
<td>M013</td>
<td>017</td>
<td>C2</td>
<td>016</td>
<td>018</td>
</tr>
<tr>
<td>M014</td>
<td>069</td>
<td>C2</td>
<td>062</td>
<td>070</td>
</tr>
<tr>
<td>M015</td>
<td>074</td>
<td>C6</td>
<td>025</td>
<td>031</td>
</tr>
<tr>
<td>M016</td>
<td>067</td>
<td>C2</td>
<td>061</td>
<td>066</td>
</tr>
<tr>
<td>M017</td>
<td>058</td>
<td>C3</td>
<td>008</td>
<td>056</td>
</tr>
<tr>
<td>M018</td>
<td>080</td>
<td>C2</td>
<td>078</td>
<td>079</td>
</tr>
<tr>
<td>M019</td>
<td>083</td>
<td>C2</td>
<td>081</td>
<td>082</td>
</tr>
<tr>
<td>M020</td>
<td>085</td>
<td>C3</td>
<td>083</td>
<td>084</td>
</tr>
<tr>
<td>M021</td>
<td>090</td>
<td>C3</td>
<td>087</td>
<td>089</td>
</tr>
<tr>
<td>M022</td>
<td>095</td>
<td>C2</td>
<td>093</td>
<td>056</td>
</tr>
<tr>
<td>M023</td>
<td>126</td>
<td>C2</td>
<td>094</td>
<td>125</td>
</tr>
<tr>
<td>M024</td>
<td>128</td>
<td>C2</td>
<td>126</td>
<td>127</td>
</tr>
<tr>
<td>M025</td>
<td>133</td>
<td>C6</td>
<td>097</td>
<td>131</td>
</tr>
<tr>
<td>M026</td>
<td>140</td>
<td>C3</td>
<td>137</td>
<td>139</td>
</tr>
<tr>
<td>M027</td>
<td>144</td>
<td>C3</td>
<td>088</td>
<td>119</td>
</tr>
<tr>
<td>M028</td>
<td>148</td>
<td>C2</td>
<td>149</td>
<td>146</td>
</tr>
<tr>
<td>M029</td>
<td>104</td>
<td>C2</td>
<td>102</td>
<td>103</td>
</tr>
<tr>
<td>M030</td>
<td>108</td>
<td>C2</td>
<td>106</td>
<td>107</td>
</tr>
<tr>
<td>M031</td>
<td>139</td>
<td>C2</td>
<td>110</td>
<td>150</td>
</tr>
<tr>
<td>M032</td>
<td>112</td>
<td>C2</td>
<td>111</td>
<td>113</td>
</tr>
<tr>
<td>M033</td>
<td>116</td>
<td>C2</td>
<td>114</td>
<td>115</td>
</tr>
<tr>
<td>M034</td>
<td>118</td>
<td>C2</td>
<td>116</td>
<td>117</td>
</tr>
<tr>
<td>M035</td>
<td>122</td>
<td>C3</td>
<td>120</td>
<td>121</td>
</tr>
<tr>
<td>M036</td>
<td>152</td>
<td>C2</td>
<td>151</td>
<td>153</td>
</tr>
<tr>
<td>M037</td>
<td>156</td>
<td>C3</td>
<td>154</td>
<td>155</td>
</tr>
<tr>
<td>M038</td>
<td>160</td>
<td>C3</td>
<td>158</td>
<td>159</td>
</tr>
<tr>
<td>M039</td>
<td>161</td>
<td>C2</td>
<td>186</td>
<td>187</td>
</tr>
<tr>
<td>M040</td>
<td>183</td>
<td>C2</td>
<td>163</td>
<td>182</td>
</tr>
<tr>
<td>M041</td>
<td>165</td>
<td>C2</td>
<td>162</td>
<td>164</td>
</tr>
<tr>
<td>M042</td>
<td>193</td>
<td>C2</td>
<td>192</td>
<td>194</td>
</tr>
<tr>
<td>M043</td>
<td>191</td>
<td>C4</td>
<td>173</td>
<td>188</td>
</tr>
<tr>
<td>M044</td>
<td>073</td>
<td>C3</td>
<td>172</td>
<td>176</td>
</tr>
<tr>
<td>M045</td>
<td>224</td>
<td>C2</td>
<td>223</td>
<td>225</td>
</tr>
<tr>
<td>M046</td>
<td>198</td>
<td>C3</td>
<td>035</td>
<td>196</td>
</tr>
<tr>
<td>M047</td>
<td>197</td>
<td>C2</td>
<td>233</td>
<td>234</td>
</tr>
<tr>
<td>M048</td>
<td>205</td>
<td>C2</td>
<td>213</td>
<td>214</td>
</tr>
<tr>
<td>M049</td>
<td>204</td>
<td>C3</td>
<td>202</td>
<td>263</td>
</tr>
<tr>
<td>M050</td>
<td>231</td>
<td>C2</td>
<td>219</td>
<td>230</td>
</tr>
<tr>
<td>M051</td>
<td>217</td>
<td>C2</td>
<td>216</td>
<td>218</td>
</tr>
<tr>
<td>M052</td>
<td>260</td>
<td>C2</td>
<td>257</td>
<td>259</td>
</tr>
<tr>
<td>5040</td>
<td>1</td>
<td>264</td>
<td>268</td>
<td>267</td>
</tr>
<tr>
<td>5041</td>
<td>1</td>
<td>290</td>
<td>291</td>
<td>292</td>
</tr>
<tr>
<td>5042</td>
<td>1</td>
<td>292</td>
<td>293</td>
<td>294</td>
</tr>
<tr>
<td>5043</td>
<td>1</td>
<td>294</td>
<td>295</td>
<td>296</td>
</tr>
<tr>
<td>5044</td>
<td>1</td>
<td>299</td>
<td>300</td>
<td>301</td>
</tr>
<tr>
<td>5045</td>
<td>1</td>
<td>311</td>
<td>312</td>
<td>304</td>
</tr>
<tr>
<td>5046</td>
<td>1</td>
<td>305</td>
<td>307</td>
<td>306</td>
</tr>
<tr>
<td>5047</td>
<td>1</td>
<td>306</td>
<td>309</td>
<td>308</td>
</tr>
<tr>
<td>5048</td>
<td>1</td>
<td>308</td>
<td>314</td>
<td>313</td>
</tr>
<tr>
<td>5049</td>
<td>1</td>
<td>317</td>
<td>319</td>
<td>318</td>
</tr>
<tr>
<td>5050</td>
<td>1</td>
<td>319</td>
<td>321</td>
<td>320</td>
</tr>
</tbody>
</table>

| 5051 | 1 | 037 | 02 | 0.882 | 0.117 | 0.000 | 0.000 |
| 5052 | 1 | 006 | C2 | 0.978 | 0.022 | 0.000 | 0.000 |
| 5053 | 1 | 050 | 02 | 0.077 | 0.008 | 0.000 | 0.000 |
| 5054 | 1 | 047 | 049 | 0.057 | 0.943 | 0.000 | 0.000 |
| 5055 | 1 | 024 | C2 | 0.026 | 0.027 | 0.000 | 0.000 |
| 5056 | 1 | 056 | 02 | 0.040 | 0.960 | 0.000 | 0.000 |
| 5057 | 1 | 061 | 02 | 0.447 | 0.553 | 0.000 | 0.000 |
| 5058 | 1 | 068 | 02 | 0.764 | 0.736 | 0.000 | 0.000 |
| 5059 | 1 | 060 | 05 | 0.319 | 0.220 | 0.000 | 0.000 |
| 5060 | 1 | 033 | 02 | 0.036 | 0.035 | 0.000 | 0.000 |
| 5061 | 1 | 090 | 02 | 0.948 | 0.052 | 0.000 | 0.000 |
| 5062 | 1 | 092 | 02 | 0.515 | 0.485 | 0.000 | 0.000 |
| 5063 | 1 | 100 | 02 | 0.408 | 0.092 | 0.000 | 0.000 |
| 5064 | 1 | 136 | 02 | 0.986 | 0.994 | 0.000 | 0.000 |
| 5065 | 1 | 138 | 02 | 0.342 | 0.658 | 0.000 | 0.000 |
| 5066 | 1 | 129 | 07 | 0.010 | 0.258 | 0.019 | 0.000 |
| 5067 | 1 | 143 | 04 | 0.449 | 0.032 | 0.064 | 0.455 |
| 5068 | 1 | 109 | 02 | 0.175 | 0.021 | 0.096 | 0.313 |

**DISTRIBUTORS**

<p>| 0001 | 1 | 037 | 02 | 0.882 | 0.117 | 0.000 | 0.000 |
| 0002 | 1 | 006 | C2 | 0.978 | 0.022 | 0.000 | 0.000 |
| 0003 | 1 | 050 | 02 | 0.077 | 0.008 | 0.000 | 0.000 |
| 0004 | 1 | 024 | C2 | 0.026 | 0.027 | 0.000 | 0.000 |
| 0005 | 1 | 056 | 02 | 0.040 | 0.960 | 0.000 | 0.000 |
| 0006 | 1 | 068 | 02 | 0.447 | 0.553 | 0.000 | 0.000 |
| 0007 | 1 | 060 | 05 | 0.319 | 0.220 | 0.000 | 0.000 |
| 0008 | 1 | 033 | 02 | 0.036 | 0.035 | 0.000 | 0.000 |
| 0009 | 1 | 090 | 02 | 0.948 | 0.052 | 0.000 | 0.000 |
| 0010 | 1 | 092 | 02 | 0.515 | 0.485 | 0.000 | 0.000 |
| 0011 | 1 | 100 | 02 | 0.408 | 0.092 | 0.000 | 0.000 |
| 0012 | 1 | 136 | 02 | 0.986 | 0.994 | 0.000 | 0.000 |
| 0013 | 1 | 138 | 02 | 0.342 | 0.658 | 0.000 | 0.000 |
| 0014 | 1 | 129 | 07 | 0.010 | 0.258 | 0.019 | 0.000 |
| 0015 | 1 | 143 | 04 | 0.449 | 0.032 | 0.064 | 0.455 |
| 0016 | 1 | 109 | 02 | 0.175 | 0.021 | 0.096 | 0.313 |</p>
<table>
<thead>
<tr>
<th>Data</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>0017</td>
<td>1 167 02</td>
</tr>
<tr>
<td>159</td>
<td>188</td>
</tr>
<tr>
<td>0.476</td>
<td>0.524 0.000 0.000 0.000 0.000 0.000 0.000 0.000</td>
</tr>
<tr>
<td>0018</td>
<td>1 171 02</td>
</tr>
<tr>
<td>173</td>
<td>174</td>
</tr>
<tr>
<td>0.006</td>
<td>0.994 0.000 0.000 0.000 0.000 0.000 0.000</td>
</tr>
<tr>
<td>0019</td>
<td>1 179 02</td>
</tr>
<tr>
<td>180</td>
<td>181</td>
</tr>
<tr>
<td>0.914</td>
<td>0.086 0.000 0.000 0.000 0.000 0.000 0.000</td>
</tr>
<tr>
<td>0020</td>
<td>1 215 C3</td>
</tr>
<tr>
<td>042</td>
<td>151 232</td>
</tr>
<tr>
<td>0.867</td>
<td>0.129 0.004 0.000 0.000 0.000 0.000 0.000</td>
</tr>
<tr>
<td>0021</td>
<td>1 200 C2</td>
</tr>
<tr>
<td>201</td>
<td>202</td>
</tr>
<tr>
<td>0.248</td>
<td>0.202 0.000 0.000 0.000 0.000 0.000 0.000</td>
</tr>
<tr>
<td>0022</td>
<td>1 227 02</td>
</tr>
<tr>
<td>225</td>
<td>226</td>
</tr>
<tr>
<td>0.660</td>
<td>0.160 0.000 0.000 0.000 0.000 0.000 0.000</td>
</tr>
<tr>
<td>0023</td>
<td>1 229 02</td>
</tr>
<tr>
<td>218</td>
<td>228</td>
</tr>
<tr>
<td>0.208</td>
<td>0.392 0.000 0.000 0.000 0.000 0.000 0.000</td>
</tr>
<tr>
<td>0024</td>
<td>1 256 02</td>
</tr>
<tr>
<td>257</td>
<td>258</td>
</tr>
<tr>
<td>0.708</td>
<td>0.292 0.000 0.000 0.000 0.000 0.000 0.000</td>
</tr>
<tr>
<td>0025</td>
<td>1 256 02</td>
</tr>
<tr>
<td>248</td>
<td>255</td>
</tr>
<tr>
<td>0.543</td>
<td>0.457 0.000 0.000 0.000 0.000 0.000 0.000</td>
</tr>
<tr>
<td>0026</td>
<td>1 278 03</td>
</tr>
<tr>
<td>001</td>
<td>234 266</td>
</tr>
<tr>
<td>0.012</td>
<td>0.443 0.545 0.000 0.000 0.000 0.000 0.000</td>
</tr>
<tr>
<td>0027</td>
<td>1 274 03</td>
</tr>
<tr>
<td>052</td>
<td>214 275</td>
</tr>
<tr>
<td>0.622</td>
<td>0.258 0.120 0.000 0.000 0.000 0.000 0.000</td>
</tr>
<tr>
<td>0028</td>
<td>1 281 C5</td>
</tr>
<tr>
<td>235</td>
<td>265 282 283 284</td>
</tr>
<tr>
<td>0.418</td>
<td>0.226 0.176 0.057 0.123 0.000 0.000 0.000</td>
</tr>
<tr>
<td>0029</td>
<td>1 331 02</td>
</tr>
<tr>
<td>279</td>
<td>323</td>
</tr>
<tr>
<td>0.384</td>
<td>0.616 0.000 0.000 0.000 0.000 0.000 0.000</td>
</tr>
<tr>
<td>0030</td>
<td>1 327 02</td>
</tr>
<tr>
<td>316</td>
<td>328</td>
</tr>
<tr>
<td>0.618</td>
<td>0.382 0.006 0.000 0.000 0.000 0.000 0.000</td>
</tr>
<tr>
<td>0031</td>
<td>1 332 C2</td>
</tr>
<tr>
<td>302</td>
<td>329</td>
</tr>
<tr>
<td>0.795</td>
<td>0.205 0.000 0.000 0.000 0.000 0.000 0.000</td>
</tr>
</tbody>
</table>

**Controllers**

** Tanks**

<table>
<thead>
<tr>
<th>Data</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td>2 004 006 5000.00 0.00 0.00 TANK VOLUME ASSUMED</td>
</tr>
<tr>
<td>002</td>
<td>2 012 014 5000.00 0.00 0.00 DITTO</td>
</tr>
<tr>
<td>003</td>
<td>2 017 019 5000.00 0.00 0.00 DITTO</td>
</tr>
<tr>
<td>004</td>
<td>2 021 070 5000.00 0.00 0.00 DITTO</td>
</tr>
<tr>
<td>005</td>
<td>2 069 065 5000.00 0.00 0.00 DITTO</td>
</tr>
<tr>
<td>006</td>
<td>2 067 068 5000.00 0.00 0.00 DITTO</td>
</tr>
<tr>
<td>007</td>
<td>2 060 059 5000.00 0.00 0.00 TANK VOLUME ASSUMED</td>
</tr>
<tr>
<td>008</td>
<td>2 038 037 5000.00 0.00 0.00 DITTO</td>
</tr>
<tr>
<td>009</td>
<td>2 043 040 5000.00 0.00 0.00 DITTO</td>
</tr>
<tr>
<td>010</td>
<td>2 051 050 5000.00 0.00 0.00 DITTO</td>
</tr>
<tr>
<td>011</td>
<td>2 074 075 5000.00 0.00 0.00 DITTO</td>
</tr>
<tr>
<td>012</td>
<td>2 036 076 5000.00 0.00 0.00 DITTO</td>
</tr>
<tr>
<td>013</td>
<td>2 076 077 5000.00 0.00 0.00 DITTO</td>
</tr>
<tr>
<td>Code</td>
<td>Value</td>
</tr>
<tr>
<td>------</td>
<td>-------</td>
</tr>
<tr>
<td>T014</td>
<td>2 077 078</td>
</tr>
<tr>
<td>T015</td>
<td>2 080 081</td>
</tr>
<tr>
<td>T016</td>
<td>2 144 145</td>
</tr>
<tr>
<td>T017</td>
<td>2 141 143</td>
</tr>
<tr>
<td>T018</td>
<td>2 128 129</td>
</tr>
<tr>
<td>T019</td>
<td>2 133 136</td>
</tr>
<tr>
<td>T020</td>
<td>2 104 105</td>
</tr>
<tr>
<td>T021</td>
<td>2 105 106</td>
</tr>
<tr>
<td>T022</td>
<td>2 108 109</td>
</tr>
<tr>
<td>T023</td>
<td>2 112 114</td>
</tr>
<tr>
<td>T024</td>
<td>2 152 154</td>
</tr>
<tr>
<td>T025</td>
<td>2 156 158</td>
</tr>
<tr>
<td>T026</td>
<td>2 183 184</td>
</tr>
<tr>
<td>T027</td>
<td>2 165 166</td>
</tr>
<tr>
<td>T028</td>
<td>2 193 195</td>
</tr>
<tr>
<td>T029</td>
<td>2 169 194</td>
</tr>
<tr>
<td>T030</td>
<td>2 224 231</td>
</tr>
<tr>
<td>T031</td>
<td>2 204 206</td>
</tr>
<tr>
<td>T032</td>
<td>2 212 213</td>
</tr>
<tr>
<td>T033</td>
<td>2 211 216</td>
</tr>
<tr>
<td>T034</td>
<td>2 231 229</td>
</tr>
<tr>
<td>T035</td>
<td>2 228 227</td>
</tr>
<tr>
<td>T036</td>
<td>2 222 230</td>
</tr>
<tr>
<td>T037</td>
<td>2 221 223</td>
</tr>
<tr>
<td>T038</td>
<td>2 260 041</td>
</tr>
<tr>
<td>T039</td>
<td>2 238 239</td>
</tr>
<tr>
<td>T040</td>
<td>2 245 237</td>
</tr>
<tr>
<td>T041</td>
<td>2 244 246</td>
</tr>
<tr>
<td>T042</td>
<td>2 255 256</td>
</tr>
<tr>
<td>T043</td>
<td>2 253 254</td>
</tr>
<tr>
<td>T044</td>
<td>2 251 259</td>
</tr>
<tr>
<td>T045</td>
<td>2 262 263</td>
</tr>
<tr>
<td>T046</td>
<td>2 267 269</td>
</tr>
<tr>
<td>T047</td>
<td>2 272 274</td>
</tr>
<tr>
<td>T048</td>
<td>2 280 281</td>
</tr>
<tr>
<td>T049</td>
<td>2 277 278</td>
</tr>
<tr>
<td>T050</td>
<td>2 286 287</td>
</tr>
<tr>
<td>T051</td>
<td>2 288 290</td>
</tr>
<tr>
<td>T052</td>
<td>2 297 289</td>
</tr>
<tr>
<td>T053</td>
<td>2 295 153</td>
</tr>
<tr>
<td>T054</td>
<td>2 310 311</td>
</tr>
<tr>
<td>T055</td>
<td>2 303 305</td>
</tr>
<tr>
<td>T056</td>
<td>2 313 312</td>
</tr>
<tr>
<td>T057</td>
<td>2 314 315</td>
</tr>
<tr>
<td>T058</td>
<td>2 321 322</td>
</tr>
<tr>
<td>T059</td>
<td>2 324 103</td>
</tr>
<tr>
<td>T060</td>
<td>2 320 325</td>
</tr>
<tr>
<td>T061</td>
<td>2 326 327</td>
</tr>
<tr>
<td>T062</td>
<td>2 330 331</td>
</tr>
<tr>
<td>332 PIPES</td>
<td></td>
</tr>
<tr>
<td>P001</td>
<td>26.14</td>
</tr>
<tr>
<td>P002</td>
<td>1173.89</td>
</tr>
<tr>
<td>P003</td>
<td>1200.00</td>
</tr>
<tr>
<td>P004</td>
<td>1366.40</td>
</tr>
<tr>
<td>P005</td>
<td>166.37</td>
</tr>
<tr>
<td>P006</td>
<td>1366.40</td>
</tr>
<tr>
<td>P007</td>
<td>1336.10</td>
</tr>
<tr>
<td>P008</td>
<td>30.30</td>
</tr>
<tr>
<td>P009</td>
<td>1514.80</td>
</tr>
<tr>
<td>P010</td>
<td>178.70</td>
</tr>
<tr>
<td>Item</td>
<td>Value1</td>
</tr>
<tr>
<td>------</td>
<td>--------</td>
</tr>
<tr>
<td>P011</td>
<td>2290.99</td>
</tr>
<tr>
<td>P012</td>
<td>5828.70</td>
</tr>
<tr>
<td>P013</td>
<td>2022.91</td>
</tr>
<tr>
<td>P014</td>
<td>5828.70</td>
</tr>
<tr>
<td>P015</td>
<td>812.00</td>
</tr>
<tr>
<td>P016</td>
<td>5016.70</td>
</tr>
<tr>
<td>P017</td>
<td>5036.70</td>
</tr>
<tr>
<td>P018</td>
<td>20.00</td>
</tr>
<tr>
<td>P019</td>
<td>5036.70</td>
</tr>
<tr>
<td>P020</td>
<td>666.70</td>
</tr>
<tr>
<td>P021</td>
<td>4370.00</td>
</tr>
<tr>
<td>P022</td>
<td>484.50</td>
</tr>
<tr>
<td>P023</td>
<td>182.20</td>
</tr>
<tr>
<td>P024</td>
<td>171.64</td>
</tr>
<tr>
<td>P025</td>
<td>10.56</td>
</tr>
<tr>
<td>P026</td>
<td>6.75</td>
</tr>
<tr>
<td>P027</td>
<td>164.85</td>
</tr>
<tr>
<td>P028</td>
<td>76.47</td>
</tr>
<tr>
<td>P029</td>
<td>88.38</td>
</tr>
<tr>
<td>P030</td>
<td>75.92</td>
</tr>
<tr>
<td>P031</td>
<td>12.46</td>
</tr>
<tr>
<td>P032</td>
<td>74.57</td>
</tr>
<tr>
<td>P033</td>
<td>1.35</td>
</tr>
<tr>
<td>P034</td>
<td>1.28</td>
</tr>
<tr>
<td>P035</td>
<td>0.07</td>
</tr>
<tr>
<td>P036</td>
<td>157.20</td>
</tr>
<tr>
<td>P037</td>
<td>1331.09</td>
</tr>
<tr>
<td>P038</td>
<td>1331.09</td>
</tr>
<tr>
<td>P039</td>
<td>1200.97</td>
</tr>
<tr>
<td>P040</td>
<td>130.12</td>
</tr>
<tr>
<td>P041</td>
<td>281.60</td>
</tr>
<tr>
<td>P042</td>
<td>919.37</td>
</tr>
<tr>
<td>P043</td>
<td>130.12</td>
</tr>
<tr>
<td>P044</td>
<td>123.33</td>
</tr>
<tr>
<td>P045</td>
<td>0.01</td>
</tr>
<tr>
<td>P046</td>
<td>2291.00</td>
</tr>
<tr>
<td>P047</td>
<td>84.00</td>
</tr>
<tr>
<td>P048</td>
<td>2207.00</td>
</tr>
<tr>
<td>P049</td>
<td>1395.00</td>
</tr>
<tr>
<td>P050</td>
<td>1479.00</td>
</tr>
<tr>
<td>P051</td>
<td>1479.00</td>
</tr>
<tr>
<td>P052</td>
<td>904.03</td>
</tr>
<tr>
<td>P053</td>
<td>574.97</td>
</tr>
<tr>
<td>P054</td>
<td>498.50</td>
</tr>
<tr>
<td>P055</td>
<td>146.00</td>
</tr>
<tr>
<td>P056</td>
<td>17.00</td>
</tr>
<tr>
<td>P057</td>
<td>679.10</td>
</tr>
<tr>
<td>P058</td>
<td>726.40</td>
</tr>
<tr>
<td>P059</td>
<td>560.03</td>
</tr>
<tr>
<td>P060</td>
<td>560.03</td>
</tr>
<tr>
<td>P061</td>
<td>70.00</td>
</tr>
<tr>
<td>P062</td>
<td>156.00</td>
</tr>
<tr>
<td>P063</td>
<td>32.00</td>
</tr>
<tr>
<td>P064</td>
<td>1893.99</td>
</tr>
<tr>
<td>P065</td>
<td>4526.00</td>
</tr>
<tr>
<td>P066</td>
<td>2503.09</td>
</tr>
<tr>
<td>P067</td>
<td>2573.09</td>
</tr>
<tr>
<td>P068</td>
<td>2573.09</td>
</tr>
<tr>
<td>P069</td>
<td>4526.00</td>
</tr>
<tr>
<td>P070</td>
<td>4370.00</td>
</tr>
<tr>
<td>P071</td>
<td>24.00</td>
</tr>
<tr>
<td>P072</td>
<td>39.00</td>
</tr>
<tr>
<td>P073</td>
<td>116.96</td>
</tr>
<tr>
<td>P074</td>
<td>234.98</td>
</tr>
<tr>
<td>P075</td>
<td>234.98</td>
</tr>
<tr>
<td>P076</td>
<td>157.20</td>
</tr>
<tr>
<td>P077</td>
<td>157.20</td>
</tr>
<tr>
<td>P078</td>
<td>157.20</td>
</tr>
<tr>
<td>P079</td>
<td>41.38</td>
</tr>
<tr>
<td>P080</td>
<td>198.58</td>
</tr>
<tr>
<td>P081</td>
<td>198.58</td>
</tr>
<tr>
<td>P082</td>
<td>1301.62</td>
</tr>
<tr>
<td>P083</td>
<td>1500.00</td>
</tr>
<tr>
<td>P084</td>
<td>140.00</td>
</tr>
<tr>
<td>P085</td>
<td>2667.74</td>
</tr>
<tr>
<td>P086</td>
<td>1027.74</td>
</tr>
<tr>
<td>P087</td>
<td>2505.94</td>
</tr>
<tr>
<td>P088</td>
<td>161.80</td>
</tr>
<tr>
<td>P089</td>
<td>10.00</td>
</tr>
<tr>
<td>P090</td>
<td>2525.94</td>
</tr>
<tr>
<td>P091</td>
<td>10.00</td>
</tr>
<tr>
<td>P092</td>
<td>1224.52</td>
</tr>
<tr>
<td>P093</td>
<td>19.70</td>
</tr>
<tr>
<td>P094</td>
<td>1204.82</td>
</tr>
<tr>
<td>P095</td>
<td>58.97</td>
</tr>
<tr>
<td>P096</td>
<td>38.37</td>
</tr>
<tr>
<td>P097</td>
<td>50.57</td>
</tr>
<tr>
<td>P098</td>
<td>7.50</td>
</tr>
<tr>
<td>P099</td>
<td>6.74</td>
</tr>
<tr>
<td>P100</td>
<td>0.76</td>
</tr>
<tr>
<td>P101</td>
<td>0.69</td>
</tr>
<tr>
<td>P102</td>
<td>0.07</td>
</tr>
<tr>
<td>P103</td>
<td>195.87</td>
</tr>
<tr>
<td>P104</td>
<td>195.94</td>
</tr>
<tr>
<td>P105</td>
<td>195.94</td>
</tr>
<tr>
<td>P106</td>
<td>195.94</td>
</tr>
<tr>
<td>P107</td>
<td>96.00</td>
</tr>
<tr>
<td>P108</td>
<td>291.94</td>
</tr>
<tr>
<td>P109</td>
<td>291.94</td>
</tr>
<tr>
<td>P110</td>
<td>1.72</td>
</tr>
<tr>
<td>P111</td>
<td>290.22</td>
</tr>
<tr>
<td>P112</td>
<td>364.85</td>
</tr>
<tr>
<td>P113</td>
<td>74.63</td>
</tr>
<tr>
<td>P114</td>
<td>364.85</td>
</tr>
<tr>
<td>P115</td>
<td>2400.00</td>
</tr>
<tr>
<td>P116</td>
<td>2764.85</td>
</tr>
<tr>
<td>P117</td>
<td>2177.64</td>
</tr>
<tr>
<td>P118</td>
<td>4942.49</td>
</tr>
<tr>
<td>P119</td>
<td>194.00</td>
</tr>
<tr>
<td>P120</td>
<td>4748.49</td>
</tr>
<tr>
<td>P121</td>
<td>20.00</td>
</tr>
<tr>
<td>P122</td>
<td>4788.49</td>
</tr>
<tr>
<td>P123</td>
<td>20.00</td>
</tr>
<tr>
<td>P124</td>
<td>2388.49</td>
</tr>
<tr>
<td>P125</td>
<td>2350.12</td>
</tr>
<tr>
<td>P126</td>
<td>3554.94</td>
</tr>
<tr>
<td>P127</td>
<td>421.70</td>
</tr>
<tr>
<td>P128</td>
<td>3976.64</td>
</tr>
<tr>
<td>P129</td>
<td>3976.60</td>
</tr>
<tr>
<td>P130</td>
<td>494.97</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>P131</td>
<td>142.00</td>
</tr>
<tr>
<td>P132</td>
<td>5.00</td>
</tr>
<tr>
<td>P133</td>
<td>862.52</td>
</tr>
<tr>
<td>P134</td>
<td>15.00</td>
</tr>
<tr>
<td>P135</td>
<td>156.98</td>
</tr>
<tr>
<td>P136</td>
<td>862.52</td>
</tr>
<tr>
<td>P137</td>
<td>295.00</td>
</tr>
<tr>
<td>P138</td>
<td>567.52</td>
</tr>
<tr>
<td>P139</td>
<td>18.00</td>
</tr>
<tr>
<td>P140</td>
<td>330.00</td>
</tr>
<tr>
<td>P141</td>
<td>312.00</td>
</tr>
<tr>
<td>P142</td>
<td>18.00</td>
</tr>
<tr>
<td>P143</td>
<td>332.00</td>
</tr>
<tr>
<td>P144</td>
<td>373.80</td>
</tr>
<tr>
<td>P145</td>
<td>373.80</td>
</tr>
<tr>
<td>P146</td>
<td>373.70</td>
</tr>
<tr>
<td>P147</td>
<td>0.10</td>
</tr>
<tr>
<td>P148</td>
<td>517.70</td>
</tr>
<tr>
<td>P149</td>
<td>144.00</td>
</tr>
<tr>
<td>P150</td>
<td>16.28</td>
</tr>
<tr>
<td>P151</td>
<td>136.60</td>
</tr>
<tr>
<td>P152</td>
<td>247.83</td>
</tr>
<tr>
<td>P153</td>
<td>111.23</td>
</tr>
<tr>
<td>P154</td>
<td>247.83</td>
</tr>
<tr>
<td>P155</td>
<td>60.00</td>
</tr>
<tr>
<td>P156</td>
<td>326.00</td>
</tr>
<tr>
<td>P157</td>
<td>18.17</td>
</tr>
<tr>
<td>P158</td>
<td>326.00</td>
</tr>
<tr>
<td>P159</td>
<td>496.84</td>
</tr>
<tr>
<td>P160</td>
<td>1712.00</td>
</tr>
<tr>
<td>P161</td>
<td>891.28</td>
</tr>
<tr>
<td>P162</td>
<td>1224.13</td>
</tr>
<tr>
<td>P163</td>
<td>487.99</td>
</tr>
<tr>
<td>P164</td>
<td>30.00</td>
</tr>
<tr>
<td>P165</td>
<td>1254.13</td>
</tr>
<tr>
<td>P166</td>
<td>1254.13</td>
</tr>
<tr>
<td>P167</td>
<td>1039.70</td>
</tr>
<tr>
<td>P168</td>
<td>214.43</td>
</tr>
<tr>
<td>P169</td>
<td>166.32</td>
</tr>
<tr>
<td>P170</td>
<td>48.11</td>
</tr>
<tr>
<td>P171</td>
<td>43.51</td>
</tr>
<tr>
<td>P172</td>
<td>4.60</td>
</tr>
<tr>
<td>P173</td>
<td>0.27</td>
</tr>
<tr>
<td>P174</td>
<td>43.24</td>
</tr>
<tr>
<td>P175</td>
<td>15.88</td>
</tr>
<tr>
<td>P176</td>
<td>27.36</td>
</tr>
<tr>
<td>P177</td>
<td>85.00</td>
</tr>
<tr>
<td>P178</td>
<td>15.30</td>
</tr>
<tr>
<td>P179</td>
<td>0.58</td>
</tr>
<tr>
<td>P180</td>
<td>0.53</td>
</tr>
<tr>
<td>P181</td>
<td>0.05</td>
</tr>
<tr>
<td>P182</td>
<td>277.30</td>
</tr>
<tr>
<td>P183</td>
<td>765.29</td>
</tr>
<tr>
<td>P184</td>
<td>765.29</td>
</tr>
<tr>
<td>P185</td>
<td>0.01</td>
</tr>
<tr>
<td>P186</td>
<td>765.28</td>
</tr>
<tr>
<td>P187</td>
<td>126.00</td>
</tr>
<tr>
<td>P188</td>
<td>544.86</td>
</tr>
<tr>
<td>P189</td>
<td>224.00</td>
</tr>
<tr>
<td>P190</td>
<td>10.00</td>
</tr>
<tr>
<td>P191</td>
<td>779.13</td>
</tr>
<tr>
<td>P192</td>
<td>719.13</td>
</tr>
<tr>
<td>P193</td>
<td>885.45</td>
</tr>
<tr>
<td>P194</td>
<td>166.32</td>
</tr>
<tr>
<td>P195</td>
<td>885.45</td>
</tr>
<tr>
<td>P196</td>
<td>9.00</td>
</tr>
<tr>
<td>P197</td>
<td>1102.88</td>
</tr>
<tr>
<td>P198</td>
<td>1111.95</td>
</tr>
<tr>
<td>P199</td>
<td>0.35</td>
</tr>
<tr>
<td>P200</td>
<td>1111.60</td>
</tr>
<tr>
<td>P201</td>
<td>275.80</td>
</tr>
<tr>
<td>P202</td>
<td>835.80</td>
</tr>
<tr>
<td>P203</td>
<td>617.80</td>
</tr>
<tr>
<td>P204</td>
<td>4964.24</td>
</tr>
<tr>
<td>P205</td>
<td>3510.64</td>
</tr>
<tr>
<td>P206</td>
<td>4964.24</td>
</tr>
<tr>
<td>P207</td>
<td>3510.64</td>
</tr>
<tr>
<td>P208</td>
<td>4964.20</td>
</tr>
<tr>
<td>P209</td>
<td>618.00</td>
</tr>
<tr>
<td>P210</td>
<td>4346.20</td>
</tr>
<tr>
<td>P211</td>
<td>1211.20</td>
</tr>
<tr>
<td>P212</td>
<td>3135.00</td>
</tr>
<tr>
<td>P213</td>
<td>3135.00</td>
</tr>
<tr>
<td>P214</td>
<td>375.64</td>
</tr>
<tr>
<td>P215</td>
<td>1060.23</td>
</tr>
<tr>
<td>P216</td>
<td>1211.20</td>
</tr>
<tr>
<td>P217</td>
<td>2884.80</td>
</tr>
<tr>
<td>P218</td>
<td>1673.60</td>
</tr>
<tr>
<td>P219</td>
<td>2562.64</td>
</tr>
<tr>
<td>P220</td>
<td>322.16</td>
</tr>
<tr>
<td>P221</td>
<td>131.80</td>
</tr>
<tr>
<td>P222</td>
<td>190.36</td>
</tr>
<tr>
<td>P223</td>
<td>131.80</td>
</tr>
<tr>
<td>P224</td>
<td>1060.23</td>
</tr>
<tr>
<td>P225</td>
<td>928.43</td>
</tr>
<tr>
<td>P226</td>
<td>150.97</td>
</tr>
<tr>
<td>P227</td>
<td>1079.40</td>
</tr>
<tr>
<td>P228</td>
<td>1079.40</td>
</tr>
<tr>
<td>P229</td>
<td>2753.00</td>
</tr>
<tr>
<td>P230</td>
<td>190.36</td>
</tr>
<tr>
<td>P231</td>
<td>2753.00</td>
</tr>
<tr>
<td>P232</td>
<td>4.26</td>
</tr>
<tr>
<td>P233</td>
<td>150.88</td>
</tr>
<tr>
<td>P234</td>
<td>952.00</td>
</tr>
<tr>
<td>P235</td>
<td>281.11</td>
</tr>
<tr>
<td>P236</td>
<td>1118.11</td>
</tr>
<tr>
<td>P237</td>
<td>837.00</td>
</tr>
<tr>
<td>P238</td>
<td>1393.91</td>
</tr>
<tr>
<td>P239</td>
<td>1393.91</td>
</tr>
<tr>
<td>P240</td>
<td>0.01</td>
</tr>
<tr>
<td>P241</td>
<td>1393.90</td>
</tr>
<tr>
<td>P242</td>
<td>171.00</td>
</tr>
<tr>
<td>P243</td>
<td>1222.90</td>
</tr>
<tr>
<td>P244</td>
<td>385.90</td>
</tr>
<tr>
<td>P245</td>
<td>837.00</td>
</tr>
<tr>
<td>P246</td>
<td>385.90</td>
</tr>
<tr>
<td>P247</td>
<td>810.90</td>
</tr>
<tr>
<td>P248</td>
<td>425.00</td>
</tr>
<tr>
<td>P249</td>
<td>90.55</td>
</tr>
<tr>
<td>P250</td>
<td>720.35</td>
</tr>
</tbody>
</table>
Members of The Institute of Paper Chemistry
Project 3251

| P251 | 720.35  | 0.00  | 0.00  |
| P252 | 28.80   | 61.79 | 0.00  |
| P253 | 61.75   | 0.00  | 0.00  |
| P254 | 782.10  | 0.00  | 0.00  |
| P255 | 397.10  | 0.00  | 0.00  |
| P256 | 397.10  | 0.00  | 0.00  |
| P257 | 292.80  | 0.00  | 0.00  |
| P258 | 104.30  | 0.00  | 0.00  |
| P259 | 28.80   | 61.79 | 0.00  |
| P260 | 281.60  | 61.79 | 0.00  |
| P261 | 281.60  | 61.79 | 0.00  |
| P262 | 261.31  | 0.00  | 0.00  |
| P263 | 261.31  | 0.00  | 0.00  |
| P264 | 1584.29 | 73.79 | 0.00  |
| P265 | 151.86  | 0.00  | 0.00  |
| P266 | 1171.12 | 23.79 | 0.00  |
| P267 | 1438.41 | 0.00  | 0.00  |
| P268 | 145.88  | 23.79 | 0.00  |
| P269 | 1438.41 | 0.00  | 0.00  |
| P270 | 1459.67 | 0.83  | 0.00  |
| P271 | 17.06   | 0.00  | 0.00  |
| P272 | 1544.67 | 0.00  | 0.00  |
| P273 | 5.00    | 0.83  | 0.00  |
| P274 | 1544.67 | 0.00  | 0.00  |
| P275 | 175.00  | 0.00  | 0.00  |
| P276 | 17.00   | 0.00  | 0.00  |
| P277 | 2149.26 | 31.14 | 0.00  |
| P278 | 2149.26 | 31.14 | 0.00  |
| P279 | 104.30  | 0.00  | 0.00  |
| P280 | 671.82  | 0.00  | 0.00  |
| P281 | 671.82  | 0.00  | 0.00  |
| P282 | 118.10  | 0.00  | 0.00  |
| P283 | 38.04   | 0.00  | 0.00  |
| P284 | 82.71   | 0.00  | 0.00  |
| P285 | 1.10    | 30.80 | 0.00  |
| P286 | 119.20  | 30.80 | 0.00  |
| P287 | 119.20  | 30.80 | 0.00  |
| P288 | 609.01  | 30.80 | 0.00  |
| P289 | 489.81  | 0.00  | 0.00  |
| P290 | 609.01  | 30.80 | 0.00  |
| P291 | 0.01    | 0.01  | 0.00  |
| P292 | 609.01  | 30.80 | 0.00  |
| P293 | 489.81  | 0.00  | 0.00  |
| P294 | 565.00  | 27.88 | 0.00  |
| P295 | 111.23  | 27.88 | 0.00  |
| P296 | 451.77  | 0.00  | 0.00  |
| P297 | 489.81  | 0.00  | 0.00  |
| P298 | 0.72    | 20.60 | 0.00  |
| P299 | 88.48   | 22.11 | 0.00  |
| P300 | 0.17    | 0.17  | 0.00  |
| P301 | 83.31   | 21.94 | 0.00  |
| P302 | 403.63  | 0.00  | 0.00  |
| P303 | 802.41  | 41.82 | 0.00  |
| P304 | 315.47  | 19.88 | 0.00  |
| P305 | 802.41  | 41.82 | 0.00  |
| P306 | 802.41  | 41.82 | 0.00  |
| P307 | 0.01    | 0.00  | 0.00  |
| P308 | 703.80  | 35.55 | 0.00  |
| P309 | 98.60   | 6.25  | 0.00  |
| P310 | 315.60  | 20.00 | 0.00  |
P311  315.60  20.00  0.00  
P312  0.13  0.12  0.00  
P313  508.00  0.00  0.00  
P314  195.80  35.55  0.00  
P315  195.80  35.55  0.00  
P316  270.70  0.00  0.00  
P317  466.50  35.55  0.00  
P318  414.40  0.00  0.00  
P319  52.10  35.55  0.00  
P320  23.70  0.00  0.00  
P321  28.40  35.55  0.00  
P322  28.40  35.55  0.00  
P323  167.47  0.00  0.00  
P324  195.87  35.55  0.00  
P325  23.70  0.00  0.00  
P326  438.10  0.00  0.00  
P327  438.10  0.00  0.00  
P328  167.40  0.00  0.00  
P329  104.37  0.00  0.00  
P330  271.77  0.00  0.00  
P331  271.77  0.00  0.00  
P332  167.47  0.00  0.00  

7 OUTPUTS FOR STEADY-STATE FLOW INITIAL RUN
1  001 1 
1  002 1 
1  003 1 
1  004 1 
1  005 1 
1  006 1 
1  007 1 

0.10000 DTIME 
100.00000 OPRT 
200.00000 DMAP 
400.00000 TFINAL 

/END CARD READ, JOB TERMINATED