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ARGONNE NATIONAL LABORATORY

ENERGY AND ENVIRONMENTAL SYSTEMS DIVISION

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ARGONNE NATIONAL LABORATORY
Argonne, Illinois 60439

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EVALUATION OF AVAILABLE COMPUTER PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

prepared by
Stone & Webster Management Consultants, Inc.
90 Broad Street
New York, New York 10004
for
Energy and Environmental Systems Division
Argonne National Laboratory
under Contract No. 31-109-38-4598

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INTRODUCTION

In an earlier phase of this study, Stone & Webster Management Consultants, Inc. conducted a survey of 82 engineering and consulting firms, government agencies, universities, trade associations, equipment manufacturers, and utilities - both domestic and foreign - to identify computer programs which would be useful in the analysis of district heating and cooling systems. The results of that survey were reported to Argonne National Laboratory on October 1, 1979.

Based upon that survey, four programs were selected for further tests and evaluations. Those programs are:

1. Hydraulic Distribution Network Analysis Program (Consumers)
2. Gas Steady-State System GASSS (Stoner)
3. Liquid Steady-State System LIQSS (Stoner)
4. SYNTHA III (SYNTHA)

Brief descriptions of each program, along with the names and addresses of the owners, are provided in Appendix A. The following manuals were used in the evaluation.

1. Hydraulic Distribution Network Analysis Program (Consumers)
2. Users Guide for Gas Steady-State (Stoner - GASSS)
3. Users Guide for Liquid Steady-State System (Stoner - LIQSS)
4. Instruction Manual for SYNTHA III (SYNTHA)

The purpose of this report is to present the results of the evaluation of those four programs. The evaluation was performed by actually running sample distribution systems on each program. A hot water system was tested using the Consumers program, the Stoner LIQSS program, and the SYNTHA

program. A steam system was tested using the Stoner GASSS program and the SYNTHA program. The Consumers Gas Company does not offer a program which will analyze a steam network.

The hot water system run for each program was abstracted from the results of a Department of Energy funded study conducted by Public Service Electric & Gas Company for a potential district heating system in northeastern New Jersey. These plans were reviewed and missing details supplied by Stone & Webster Engineering Corporation. Appendix B of this report contains the data for the hot water system. To facilitate this evaluation, only certain sections of the system were used. Inasmuch as the system included a trunk line with several branching networks, it was possible to consolidate whole branches into one single load without affecting the total flow requirements of the system. For the demonstration of the Consumers program and the Stoner program, the system was reduced to 232 nodes and 231 mains. For the demonstration of the SYNTHA program, the system was reduced to 108 nodes and 140 mains.

The three programs tested have the capability to accommodate larger networks than those which were analyzed. The limitations are as follows:

Consumers	-	4,000 nodes	-	4,000 mains
Stoner (LIQSS)	-	1,600 nodes	-	2,000 mains
SYNTHA	-	350 streams		

However, the time required to prepare data for such examples would have unnecessarily delayed this evaluation. By running these smaller cases, more time was available for the evaluation of each program.

Appendix C of this report contains the data for the steam distribution system. The steam system run for the Stoner and SYNTHA programs was based on data supplied by Indianapolis Power & Light for its existing steam

distribution system. This system contains 108 nodes and 140 mains with sources of differing pressures. As with the hot water system, it was necessary to modify this system for the evaluation of the SYNTHA program; only the high pressure system, a network containing 16 nodes and 20 mains, was tested for this program.

The two programs tested have the capability to accommodate larger networks than those which were analyzed. The limitations are as follows:

Stoner (GASSS)	-	10,000 nodes and mains
SYNTHA	-	350 streams

A set of criteria was established by which the programs could be evaluated. These criteria are discussed in detail in the following section. Where quantifiable, a ranking of each criterion was made on a form displayed on the Criteria Evaluation Form in this report. This form indicates the relative merits of each program under various criteria as established by Stone & Webster Management Consultants, Inc., and allows the reader to provide appropriate weights, or degree of significance, to each criterion. The result of applying these weights to the relative position of each program by individual criteria element allows for the derivation of a ranking which yields the most useful program for meeting the specific needs of each user.

DISCUSSION OF CRITERIA AND EVALUATION

This section contains a discussion of each criterion evaluated by Stone & Webster. These criteria were established with the aid of Argonne National Laboratory personnel during the course of this study. Where possible, the programs have been ranked either 1, 2, or 3 relative to each criterion, with the lowest number representing the highest evaluation. Where such a quantitative evaluation was not possible, this discussion should provide sufficient information to facilitate the choosing of one of the programs or identifying the need for further research.

It should be noted that this evaluation did not test all of the features available with each program, but considered only those aspects of each program which are currently available. If any program is selected for intensive use, it is likely that modifications or enhancements may be made which would remove inefficiencies or omissions which this evaluation may identify. The following discussion refers to the rankings established on the Criteria Evaluation Form in the following section of this report.

A. User Aspects: General Cost and Availability

1. Ability to Be Used in a Variety of Applications

Stoner's programs had the greatest general applicability, as they could be used for both steam and hot water systems with a minimum amount of data required. Consumers' program was applicable to hot water systems only. Neither of these programs could perform heat balances. SYNTHA's program must be modified by the user for each district heating application. This program calculates heat balances and has an integral capability for simulating boilers, turbines, and other components not required by the

analyses which were evaluated, but which are of importance to the overall evaluation of distribution heating/cooling systems. The rankings shown in the Criteria Evaluation Form refer to the relative general applicability of each program in performing an analysis of the sample system as viewed by Stone & Webster.

2. Cost

The cost of running each program including terminal connect time, data entry, execution time, and the printing of an output report was approximately \$50 to \$100. No significant differences are noted; however, the sample problems executed for the Stoner and Consumers programs contained greater numbers of nodes and mains than those executed for SYNTHA.

3. Means of Access

All programs are designed to accept data entered from the user's remote terminals and to be run from those terminals. For each program, data may also be prepared on cards and entered in batch mode from a card reader located at the vendor's establishment. For the Consumers and SYNTHA programs, data cards may also be prepared which will cause the program to be run in batch mode. The Stoner programs may be run only from a terminal.

B. Vendor Support

1. Time-sharing Services

All programs can be accessed through nationally known time-sharing networks:

Consumers - McDonnell Douglas Automation Co.

Stoner - National CSS, Inc.

SYNTHA - Cybernet

These firms have been found to provide adequate documentation about their respective systems, personnel to assist in the operation thereof, training in the use of their time-sharing networks, and related support. These services were not subject to evaluation, except to the extent that there were no system-oriented problems encountered during any phase of the testing.

2. System Responsiveness

In running a model, entering data, awaiting execution, and so forth, the user may encounter delays on the system. These delays, usually a result of competition between users for computer time, vary according to the hour of day and the day of the week, or month. The Stoner programs were run at various times during the business week without encountering any delays. The Consumers and SYNTHA programs were run on Fridays and encountered some delays. The ranking of these criteria is based on the assumption that each system has similar peak load conditions.

3. Problem Solving Assistance

Knowledgeable personnel were available to assist in solving problems related to the operation of each of the programs. Stoner has the largest full-time staff devoted entirely to the support of its programs and the use of its programs for analyses.

4. Output Mode

a. Terminal/Printer

All programs generate output either on a remote terminal or on a high-speed printer. The accessibility of the printer is dependent upon the user's location. Generally, printouts are delivered within 24 hours to users in major cities. If the programs are run by users of a printer-equipped data center (often the local offices

of the time-sharing vendor), output is available shortly after the conclusion of the terminal session.

b. Output Selection

With the Stoner programs, the user creates an output report file containing such standardized schedules as are required. The report file may then be edited or printed at the user's request. Printing of the output file is without regard to page control. Slightly less options are offered by Consumers' program, although schedules are printed on separate pages. The SYNTHA program prints only the complete standard report. All programs allow the creation of output data files which can be edited before display or printing. None of the programs were judged to have inadequate output. The ranking for this criteria, however, is based on the scope of options discussed in the preceding.

5. Documentation

Although the documentation for each program and system is complete, the users will require at least a brief training period before the documentation can be efficiently used.

C. Operations and Operating Procedures

1. Log-in Process

For each program the process of gaining access to the system was easy to employ. No difficulties were encountered with any of the programs. Various levels of security are available for the protection of data files.

2. Data Entry

a. Conversational Mode

The data by which the simulations are defined are, in all programs, entered in specific coded formats. Only the Stoner program prompts

the user to respond by giving instructions regarding the names of files to be used, stored, created, the number of iterations to be performed, the level of exceptions to be printed in output reports, and so on.

b. Format

(1) Pre-run Error Checking

All programs checked the input data and provided useful diagnostics when errors were encountered.

(2) Error Correction

In some cases the Stoner program attempts to correct input errors by using predetermined defaults. These attempts are clearly indicated. The Stoner programs also have available an integral data editing routine.

(3) Sensitivity Analyses

Sensitivity analyses can be run on all programs; however, only Stoner allows the user to suspend the operation of the program and make changes in the data. Consumers and SYNTHA each allow the modification of data through the use of "change cards" but this process requires that the new problems be run from the start.

(4) Batch Entry

All programs can use data files which are keypunched off-line and entered through card readers. Generally, batch decks must be edited prior to execution of the program. This is a relatively easy operation. The Consumers and SYNTHA programs can be run in batch mode. The Stoner program requires terminal control during execution.

c. Technical Level Required for Data Entry

No technical experience beyond the knowledge of terminal operation is required for the entry of data. Time-sharing vendors offer brief training courses in the efficient use of their systems for creating and editing data files. Setting up systems to be run requires engineering expertise.

The Consumers and Stoner programs use predefined functions to simulate operating characteristics (e.g., pressure drops), whereas the applicable function must be supplied by the user of the SYNTHA program. As such, the greatest level of engineering expertise is required in the setting up of the SYNTHA program.

d. Data Requirements

Each of the programs is concerned with the analysis of a system, not of that system's design. Consequently, the system and its components must first be carefully defined. The Consumers and Stoner programs can be directly encoded from engineering diagrams which provide the physical characteristics (e.g., length, diameter, flow, pressure) for each of the system's components. The SYNTHA program requires that some of the system's components be broken into subparts. A node, for example, may not have an associated load. The load must be treated as a separate component. Also, and dependent upon the component, a series of specially coded definitions must be entered. While all programs are relatively easy to encode, the additional data requirements of the SYNTHA program made data entry for it the most time-consuming of the three.

3. Running the Program - Time Required

a. Data Preparation

For the Consumers or Stoner programs, the encoding of data describing a network of 100 to 500 nodes requires 1 to 2 man-days. This assumes the prior preparation of engineering diagrams. The SYNTHA program requires more detailed input; the time for encoding data describing a network of 10 to 100 nodes may require 1 to 2 man-days.

b. Data Entry

The entering of data describing a network of 100 to 500 nodes requires approximately one man-day, including proofreading and a normal number of corrections. This assumes the entrance of data at a terminal by someone who is skilled in typing, or the entrance of data by cards using a skilled keypunch operator.

c. Execution Time

All programs can be run during a terminal session of five minutes or less. This includes execution of the program, as well as the normal interactive delay of time-sharing systems. The Consumers and Stoner programs are immediately available to users, whereas the SYNTHA program is maintained on an off-line tape. This necessitates a short delay while an operator at the vendor's computer center mounts the required tape. It is possible for frequent users of the SYNTHA program to negotiate with SYNTHA for on-line storage of the program. The time required for entering data is the same for all programs, and is, of course, a result of the amount of data to be entered. In general, however, the greater amount of data required by the SYNTHA program will necessitate more input time than is needed for either the Consumers or Stoner programs.

d. Receipt of Output

Printouts are available shortly after the conclusion of the program's execution. Delivery times vary due to printing speed (at terminals and printers) and delivery schedules when printers are located away from the user's location. No significant variation was experienced, however, with the three programs evaluated.

D. Technical Representation

1. Components

a. Valves

The Stoner programs compute the appropriate pressure drop across the valves depending on the flow rate. The SYNTHA program is capable of representing shutoff valves and control valves. The former will either prevent any flow from passing through the valve or pass on any flow established upstream to the valve. The latter is used to establish the priorities and flow limits on alternate flow sources.

The Consumers program does not consider valves directly; however, pressure drops associated with such devices can be simulated using equivalent feet of piping.

b. Pressure Regulators

The Stoner and SYNTHA programs allow the use of pressure regulators for steam and hot water systems, the Consumers program does not.

c. Pumps

All of the programs consider pumps for the analyses of hot water distribution systems. The Stoner programs use pump curves which describe the head or pressure produced versus discharged. The pump

represented in the SYNTHA program establishes the output to input pressure ratio. Similar to the Stoner programs, the head/flow curve is used by the Consumers program to represent the pump characteristics.

2. Flow Characteristics

a. Pressure

All of the programs allow the user to vary pressure and/or to solve for pressure.

b. Heat Losses

The Consumers and Stoner programs require that the temperature be known at the sources. The SYNTHA program allows the user to vary temperatures and/or to solve for it at any point along the system.

c. Flow Rates and Direction

All of the programs allow the user to vary flow rates and direction and/or to solve for them.

3. Pipe Characteristics

a. Nominal and Inside Diameter

The Consumers and Stoner programs require the input of inside diameter. Consumers allows for the use of a table of nominal and inside diameters. SYNTHA does not normally consider this characteristic; however, as all functions are user-supplied, users may supply data and a function defining the characteristic.

b. Material

Friction factors can be used with the Consumers and Stoner programs. Consumers provides a set of factors relative to various piping materials. SYNTHA allows the user to supply data and a function defining the material.

c. Insulation

Only SYNTHA considers heat loss and, therefore, the thickness of pipe insulation and related loss of heat.

4. Input Data Allowed

a. Nodes

Consumers allows for the input of load data at nodes. There may be up to four inflow/outflow streams at each node. Data may be entered for pressure and flows may be combined at any node.

Stoner allows the input of load data at nodes. There may be an unlimited number of inflow/outflow streams at each node. Data may be entered for pressure and flow. Loads and flows may be combined at any node.

SYNTHA requires the input of load data end points, a special kind of node. There may be up to three inflow/outflow streams at each node. Data may be entered for pressure, temperature and flow. Loads and flow may not be combined at any node.

b. Mains

Consumers and Stoner allows the input of diameter, length, evaluation, friction factors, and flow along mains.

SYNTHA allows the user to supply tables to calculate specific items related to various characteristics of mains. The inclusion of any characteristic, however, is optional and not required for the program's operation.

c. Other

Calculations for SYNTHA are generally dependent upon input data which are user-supplied. This limits the quick usefulness of the program

inasmuch as a greater amount of data must be generated and input to the program. Conversely, this data requirement allows the user maximum flexibility in the use of the model to solve specific problems. Tables of properties of saturated steam and water are also included in the program.

5. Solution Techniques

a. Flow Equations Used

Consumers - hot water - Hazen - Williams

Stoner - hot water - Darcy - Weisbach

Hazen - Williams

Manning

- steam - Municipal steam system (based on the
Fundamental Steam Equation)

SYNTHA - Equations are those which the user provides.

b. Iterations

The number of iterations to be performed is user-specified in the Stoner program. If a solution has not been obtained after a specified number of iterations, the user is told the number of elements out of tolerance, given the option of seeing the status of those elements, and asked the number of additional iterations, if any, to be performed. In the Consumers and SYNTHA programs, the user has no control over the number of iterations to be performed. All programs allow the user to specify the allowable tolerance to be used in computing the solution.

c. Accuracy

The following tables illustrate the accuracy of the Stoner & Consumers programs in calculating the flow rate along the mains (selected for illustration), as compared with manual checking provided the pressures at each end of the mains are balanced.

Hot Water SystemStoner Program (Hazen - William Equation)

<u>Node</u>	<u>Node</u>	<u>Diameter</u> (Inches)	<u>Length</u> (Feet)	<u>Flow Rate</u>	
				<u>Program</u>	<u>Check</u>
				----- (GPM) -----	
1	43	18	5250	877.87	881.61
126	127	3	300	288.20	289.46
131	132	1	60	4.60	4.61
1107	1108	1	60	(0.05)(1)	0.004

Note: (1) Tolerance level met, balance assumed.

Consumers Program (Hazen - William Equation)

<u>Node</u>	<u>Node</u>	<u>Diameter</u> (Inches)	<u>Length</u> (Feet)	<u>Flow Rate</u>	
				<u>Program</u>	<u>Check</u>
				----- (GPM) -----	
1	43	18	5250	877.88	881.61
126	127	3	300	288.20	289.46
131	132	1	60	4.60	4.41
1107	1108	1	60	0.004	0.004

Steam SystemStoner Program (Municipal Steam System Equation)

<u>Node</u>	<u>Node</u>	<u>Diameter</u> (Inches)	<u>Length</u> (Feet)	<u>Flow Rate</u>	
				<u>Program</u>	<u>Check</u>
				----- (GPM) -----	
99	124	12	440	(36.23)	(36.02)
AA	165T	16	3000	106.58	106.57
30	32	6	370	0.37	0.37

There are no specific equations encoded in the SYNTHA program. However, the calculation of flows, pressures, and/or temperatures was carried out by means of schedule components, i.e., a table in which the user specifies the results of a desired flow equation. Extensive table look-ups were used in balancing the system. Nevertheless, the procedure has been proven to be accurate in the program testing.

6. Output

a. Report Organization

All output reports give useful details describing the run of the problem from input through execution. Output from the Stoner program is without regard to page control.

b. Input Image

Files containing input data can be listed for all programs. Actual card images are automatically provided by SYNTHA. This is particularly useful in correcting errors resulting from misaligned data entries.

E. Economic Aspect

None of the programs evaluated performed an economic feasibility analysis. The only program which deals with cost information is the Consumers program. It is limited to an accumulation of first cost. Optimization routines are not available in any of the programs tested, although each owner indicated a willingness to make specified modifications or to perform optimization analysis. As such, economic aspects were not evaluated.

ARGONNE NATIONAL LABORATORY
EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEM
CRITERIA EVALUATION FORM

		A			B					C																D												
		User Aspects			Vendor Support					Operation																Technical Representation												
		1	2	3	1	2	3	4a	4b	5	1	2a	2b1	2b2	2b3	2b4	2c	2d	3a	3b	3c	3d	1a	1b	1c	2a	2b	2c	3a	3b	3c	4a	4b	5a	5b	5c	6a	6b
		Ability to be Used in a Variety of Applications	Cost	Means of Access	Time-sharing Service	System Responsiveness	Problem-solving Assistance	Output (Terminal/Printer)	Output Selection	Documentation	Log-in	Data Entry—Conversational	Pre-run Error Checking	Error Correction	Sensitivity Analysis	Batch Entry	Tech. Level of Users	Data Requirements	Data Preparation	Running: Data Entry	Execution	Receipt of Output	Valves	Pressure Regulators	Pumps	Flow-Pressure	Flow-Heat Loss	Flow-Rates and Direction	Pipe—Diameter	Pipe—Material	Pipe—Insulation	Input Data—Nodes	Input Data—Mains	Flow Equations	Iterations	Accuracy	Output Report Organization	Input Image
Stone & Webster Ranking	Consumers	2	1	1	1	1	1	1	2	1	1	2	1	2	2	1	1	1	1	1	1	1	2	NA	1	1	2	1	1	1	NA	2	1	1	2	1	1	2
	Stoner Programs	1	1	2	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	2	1	2	2	NA	1	1	1	1	1	2	2
	SYNTHA	3	1	1	1	1	1	1	3	1	1	2	1	2	2	1	1	2	2	2	1	1	1	1	1	1	1	1	2	2	1	3	2	1	2	1	2	1
Criteria Weighting																																						
Adjusted Rankings	Consumers																																					
	Stoner Programs																																					
	SYNTHA																																					

The programs have been ranked by Stone & Webster either 1, 2, or 3 relative to each criterion with the lowest number representing the highest evaluation.

NA = Not Applicable

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APPENDIXES

APPENDIX A

APPENDIX A

Description of the programs which were evaluated in this study:

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Consumers	1
Stoner - GASSS	4
Stoner - LIQSS	8
SYNTHA	12

CONSUMERS GAS COMPANY

HYDRAULIC DISTRIBUTION NETWORK ANALYSIS PROGRAMS

Abstract

The Network Analysis Program calculates the flows and pressures in a network of known pipe sizes for any specified load conditions. The program is available in versions of different capacity, the programs handling larger networks requiring more computer storage.

Program Features

A. Objectives

The program is intended to aid in the following:

- . System simulation.

B. Program Capacity

- . Up to 4,000 nodes, 4,000 branches, 50 sources, and 1,600 loops can be handled by the largest analysis program.
- . The programs use Imperial units.

C. Configurations Analyzed

- . Networks with branches, trees, and loops can be analyzed.

D. Components of Distribution System

- . Pressure regulators and reservoirs are represented as sources (pressure constant within specified flow limits, variable outside this range).
- . Branches (defined by length, diameter, efficiency, material).
- . Loads (specified at input).
- . Pumps (specified by points on the Head/Flow curve).

E. Flow Equations

- . Hazen-Williams.
- . Other equations can be made available.

F. Type of Flow Analyzed

- . Pressurized flow in closed conduits.

G. Type of Media Carried

- . Any liquid.

H. Thermal Transfer

- . Heat loss is not considered.

I. Economic Analysis

The cost estimate of the designed network is calculated on the basis of lengths, diameters, and unit costs.

J. Computer Configurations

- . Several IBM configurations, potentially any machine with a FORTRAN compiler.
- . Core requirements for the design and analysis programs are approximately as follows: 1,000-branch analysis program, 118K bytes; 4,000-branch analysis program, 216K.

K. Language

- . FORTRAN.

L. Data Input Mode

- . Card, tape, or CRT.

M. Output Mode

- . Hard copy or CRT.

N. Input Data

Input to the program includes: network identification, convergence criterion, physical properties of the gas flow equation to be used, pipe sizes, node loads and elevations, lengths of connecting branches, source pressures and flow limits, pump performance curves, modifications to the basic program specified.

0. Output Data

The program output consists of several reports, as follows:

- . Input listings with diagnostic messages.
- . Processing log indicating the completion of various stages of the program.
- . Program results showing pressure tabulation, flow tabulation and cost tabulation.
- . Pump lead/flow graphs.
- . Modification data.

Author(s) - Consumers Gas Company.

Owner(s) - Consumers Gas Company.

Availability - The programs are available in versions of different capacity and different units, as noted previously.

Cost - Purchase: Negotiable.

Person Contacted and Address

Mr. Peter Harper
Manager, Consulting Services
Consumers Gas Company
P.O. Box 650
Scarborough, Ontario, Canada MIK5E3

(416) 492-5000

List of Users - Many users through McDonnell Douglas Automation Co.

STONER ASSOCIATES GASSS

Abstract

The Gas Steady-state System (GASSS) Service determines the balanced steady-state pressure-flow relationship for an isothermal gas system (natural gas, steam, and so on) composed of pipelines, compressors, and regulators. The program uses modern equation solving techniques to provide fast convergence of the model equations.

Both high-pressure and low-pressure distribution systems can be modeled by the program. The program also supports a new concept of network analysis for natural gas systems having variable specific gravity and Btu content, allowing the user to balance gas network based on the therm rate loading as opposed to the standard or historical volumetric rate loading.

The GASSS Service also provides the ability to solve dry saturated steam flow models. A fundamental steam flow equation has been developed that is intended primarily for district heating system analysis.

The GASSS Service has the capability of performing sensitivity analyses on the balanced model, which provide approximate answers as to how much the unknown would vary for a given change in one of the fixed value parameters.

The GASSS Service may also be used in conjunction with the Facility Optimization Program (FOP) for the calculation of the least cost of new facilities.

The Service is designed to serve the modeling interests of natural gas production, transmission and distribution companies, municipal steam systems, and other gas systems.

Program Features

A. Objectives

The program is designed for use in an engineering planning as well as an operating environment with the following objectives:

- . Preliminary and detailed feasibility.
- . Preliminary and final design.
- . System simulation.

B. Program Capacity

- . Up to 10,000 nodes and mains (including devices) can be accommodated. It is expected that ultimately 30,000 elements can be accommodated by the program.
- . Both English and metric units can be used.
- . Six significant digits are obtained for input and output data.

C. Configurations Analyzed

Systems with branches, trees, and loops can be analyzed.

D. Components of Distribution System

- . Pipelines.
- . Compressors.
- . Fisher, Grove, Reliance regulators.
- . Fourth-degree polynomial horsepower per million curve.

E. Flow Equations

- . Panhandle A.
- . Panhandle B.
- . Weymouth.
- . Spitzglass.
- . Fundamental equations.
- . Theoretical horsepower equation.

- . Centrifugal compressor equation.

- . Storage field equation.

F. Type of Flow Analyzed

- . Pressurized flow in closed conduits.

G. Type of Media Carried

- . Isothermal gas (natural gas, steam, air, and other gases).

H. Thermal Transfer

Heat loss is not considered in this program.

I. Economic Analysis

This program may be used in conjunction with the FOP to calculate the least cost of new facilities. FOP is essentially a gradient optimization procedure which calculates the least costs by minimizing the square of source flows from various sources.

The economic parameters used by FOP are inputted by the users.

J. Computer Configuration

- . IBM or IBM compatible system.

- . Core requirement varies with the size of the case analyzed. For example, a case with 1,000 nodes requires 400K bytes plus 72K bytes supervisor.

K. Language

The program is written mostly in FORTRAN (IBM) with a small amount in ASSEMBLER.

L. Data Input Mode

- . Card or CRT.

M. Output Mode

- . Hard copy or CRT.

N. Input Data

The input data for GASSS is of the following three major categories.

- . System variables and execution controls.
- . Node connecting element data.
- . Node data.

O. Output Data

The following is available for output:

- . Value of unknown node flows.
- . The sum of system loads.
- . The nth largest node residuals.
- . The nth highest node pressures.
- . The nth lowest node pressures.
- . The n NCES (node connecting elements) with highest squared loss per mile.
- . The volume of linepack for all pipes in the system.
- . Zero flow nodes (nodes having more than one attached NCE, which are sinks of the system).

Sensitivity analysis computations for a balanced system can be initiated by the user.

Author(s) - Stoner Associates.

Owner(s) - Stoner Associates.

Availability - Readily available on National CSS, Inc. time-sharing systems.

Cost - Purchase: Use is available on a surcharge basis.

Person Contacted and Address

Dr. Michael A. Stoner, President
Stoner Associates, Inc.
P.O. Box 86
Carlisle, Pennsylvania 17013

(717) 243-9212

List of Users

- . Baltimore Gas & Electric Company
- . Bay State Gas Company
- . Brooklyn Union Gas Company
- . Columbia Gas System
- . Commonwealth Gas Company
- . The Consolidated Edison Company of New York
- . Consumers Power Company
- . Delmarva Power & Light Company
- . Pacific Gas & Electric Company
- . Southern California Gas Company
- . Union Gas Limited
- . Washington Gas Light Company

STONER ASSOCIATES LIQSS

Abstract

The Liquid Steady-state System (LIQSS) Service determines the balanced steady-state head-flow relationship for a liquid network composed of pipelines, pumps, and valves. The program utilizes modern techniques to provide fast convergence of model equations, and is capable of modeling networks having different liquids in different parts of the system. A high degree of flexibility is provided for formulating and solving unknowns. Given a specific pressure response, for example, pipe diameters, pump horsepower, and valve settings can be determined.

The LIQSS Service has the capability of performing sensitivity analyses on the balanced model, which provide approximate answers to how much the unknowns would vary for a given change in one of the fixed value parameters.

The Service is designed to serve the modeling interests of water distribution companies, petroleum pipeline companies, petrochemical and industrial piping systems complexes, and other liquid piping systems.

Program Features

A. Objectives

The Service is designed for use in an engineering planning as well as an operating environment for the following objectives:

- . Preliminary and detailed feasibility.
- . Preliminary and final design.
- . System simulation.

B. Program Capacity

- . Up to 1,600 nodes and 2,000 mains (including devices) can be accommodated.
- . Units of input and output are in both English and metric systems.
- . Six significant digits are obtained for input and output data.

C. Configurations Analyzed

Systems with branches, trees, and loops can be analyzed.

D. Components of Distribution System

- . Pump horsepower.
- . Pump curve tabular data.
- . Valve regulator.
- . Check valve.
- . Forced flow.
- . Velocity head loss, representing elbows and tees, for example.

E. Flow Equations

- . Darcy-Weisbach Pipeline.
- . Hazen-Williams.
- . Mannings equation.

F. Type of Flow Analyzed

- . Pressurized flow in closed conduits.

G. Type of Media Carried

- . Any single liquid (water, oil, and so on).
- . Multiple liquid system.

H. Thermal Transfer

Heat loss is not considered in the program.

I. Computer Configuration

- . IBM or IBM compatible system.
- . Core requirement varies with the size of the case analyzed. As an example, a case with 1,000 nodes requires 400K bytes plus 72K bytes supervisor.

J. Language

The program is written mostly in FORTRAN (IBM) with a small amount in ASSEMBLER.

K. Data Input Mode

- . Card or CRT.

L. Output Mode

- . Hard copy or CRT.

M. Input Data

The input data for LIQSS is of the following three major categories:

- . System variables and execution controls.
- . Node connecting element data.
- . Node data.

N. Output Data

A summary of the following is available:

- . Value of unknown node flows.
- . The sum of system loads.
- . The nth largest node residuals.
- . The nth highest node pressures and hydraulic grade lines.
- . The nth lowest node pressure and hydraulic grade lines.
- . The n NCES (node connecting elements) with highest head loss per foot.
- . Zero flow nodes (nodes having more than one attached NCE which are sinks of the system).

Also available is the capacity to perform a sensitivity analysis on the model equations, which have just been balanced.

Author(s) - Stoner Associates.

Owner(s) - Stoner Associates.

Availability - Readily available on National CSS, Inc. time-sharing systems.

Cost - Purchase: Use is available on a surcharge basis.

Person to Contact and Address

Dr. Michael A. Stoner, President
Stoner Associates, Inc.
P.O. Box 86
Carlisle, Pennsylvania 17013

(717) 243-9212

List of Users

- . Transco
- . LOVACA.
- . Brown and Root, Inc.
- . Duke Power Company
- . Fluor Ocean Services
- . Greeley and Hansen
- . Miller Engineering
- . Penfield & Smith Engineers, Inc.

SYNTHA CORPORATION SYNTHA III

Abstract

SYNTHA III Program is developed to aid in the design and performance analysis of cogeneration power plants and process utility systems in the chemical process industry. This program has been used to design and evaluate oil refineries, paper mills, and so on.

Program Features

A. Objectives

The program is intended to aid in the following:

- . Preliminary and detailed feasibility.
- . Preliminary and final design.
- . System simulation.

B. Program Capacity

- . Up to 350 streams can be accommodated.
- . English units are used.
- . Seven digits, not including the decimal point, are obtained.

C. Configurations Analyzed

Systems with branches, trees, and loops can be analyzed.

D. Components of Distribution System

Capability has been provided to represent any combination of elements, with or without return.

E. Flow Equations

There is no restriction on the use of mathematical modeling. Calculations are performed extensively on table basis.

F. Type of Flow Analyzed

- . Pressurized flow in closed conduits.

G. Type of Media Carried

- . Steam and water (with ASME properties).
- . Natural gas.
- . Others including air, H_2S , H_2O , N_2 , O_2 , H_2 , CO_2 , CO , SO_2 , and ash.

H. Thermal Transfer

Heat loss associated with radiant efficiency can be inputted by user.

I. Economic Analysis

The optimization subroutine minimizes the overall cost of the system by varying the heat exchanger sizes. The economic parameters are inputted by the user.

J. Computer Configurations

- . CDC 6400, 6600, 7600 or IBM 360, 370.
- . Core requirement is 500K for IBM or 250K for CDC 6600.

K. Language

- . FORTRAN.

L. Data Input Mode

- . Card.

M. Output Mode

- . Hard copy.

N. Input Data

- . The process flow or piping diagram (in numerical form).
- . Individual steam, heat, and power requirements for each user.
- . Engineering component performance data such as: pump, boiler, and fan efficiencies; turbine extraction flow limits; generator fixed

and variable losses; gas and fuel constituents for use in calculating heating value and products of combustion. Radiation efficiency of all heat transfer components, plus desired approach or exit temperature differences.

- . Optional flow limitations for the selected primary, secondary, and tertiary steam sources for each header (such as turbine extraction and letdown flows) for use by Syntha III in balancing the header entrance flows with the header steam requirements.

O. Output Data

- . The flow, pressure, temperature, enthalpy, and entropy of all water, steam, and gas streams. The composition and liquid/vapor ratio are shown for each gas stream.
- . The individual engineering performance data for each component such as: rpm, efficiency, horsepower, kw, heat transfer, heating value, fuel requirements, pressure ratio.
- . The Overall System Performance Summary provides:
 - . Total Fuel Flow, thousands of pounds per hour; Equivalent Fuel Heat, Other Heat Added, and Total Heat Requirements in millions of Btu's per hour.
 - . Total Generator Output, Total Motor Requirements, Total Electric Loads, Net Plant Generation in Mw.
 - . Horsepower Provided, Horsepower Required, and Net Plant Horsepower.

Author(s) - David W. Hutchinson.

Owner(s) - SYNTHA Corporation.

Availability - Readily available on Cybernet time-sharing system.

Cost - Purchase: Negotiable.

Person Contacted and Address

David W. Hutchinson, President
SYNTHA Corporation
51 W. Putnam
Greenwich, Connecticut 06830

(203) 869-2703

List of Users

- . Pullman-Kellogg
- . Georgia Pacific
- . Rust Engineering Company
- . DuPont
- . ALCOA.

APPENDIX B

APPENDIX B: SAMPLE HOT WATER SYSTEM

For the evaluation of the SYNTHA program, the sample system listed on the following pages was condensed to include only those nodes and branches indicated by the asterisk.

HOT WATER SYSTEM FOR CONSUMERS AND STONER

SYNTHA HOT WATER SYSTEM

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE HOT WATER SYSTEM

BRANCH MAIN DATA

<u>Node No.</u>	<u>Node No.</u>	<u>Length (Feet)</u>	<u>Diameter (Inches)</u>
0	1	500	30 *
1	3	7,700	30 *
3	4	5,570	30 *
4	5	5,300	24 *
5	6	2,270	18 *
6	7	2,700	16 *
7	8	4,770	16 *
8	9	4,600	14 *
9	10	4,230	14
10	11	1,800	12
11	12	3,600	6
12	13	720	6
13	14	750	4
14	1144	90	2
1144	1145	60	1
1145	1146	60	1

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EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE HOT WATER SYSTEM

BRANCH MAIN DATA

<u>Node No.</u>	<u>Node No.</u>	<u>Length (Feet)</u>	<u>Diameter (Inches)</u>
1146	1147	60	1
14	568	90	2
568	569	60	1
569	570	60	1
570	571	60	1
14	15	300	3
15	1272	90	2
1272	1273	60	2
1273	1274	60	2
1274	1275	60	1
1275	1276	60	1
15	696	90	2
696	697	60	1
697	698	60	1
698	699	60	1
699	700	60	1
15	16	300	3
16	408	90	2
408	409	60	2
409	410	60	2
410	411	60	1
411	412	60	1
16	984	90	2
984	985	60	2
985	986	60	2

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EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE HOT WATER SYSTEM

BRANCH MAIN DATA

<u>Node No.</u>	<u>Node No.</u>	<u>Length (Feet)</u>	<u>Diameter (Inches)</u>
986	987	60	1
987	988	60	1
16	17	300	2
17	18	90	2
18	19	60	1
19	20	60	1
20	21	60	1
17	856	90	2
856	857	60	1
857	858	60	1
858	859	60	1
6	97	4330	12 *
97	121	500	10
121	122	1800	10
122	123	3600	6
123	124	720	6
124	125	750	4
125	1184	90	2
1184	1185	60	1
1185	1186	60	1
1186	1187	60	1
125	608	90	2
608	609	60	1

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE HOT WATER SYSTEM

BRANCH MAIN DATA

<u>Node No.</u>	<u>Node No.</u>	<u>Length (Feet)</u>	<u>Diameter (Inches)</u>
609	610	60	1
610	611	60	1
125	126	300	3
126	1322	90	2
1322	1323	60	2
1323	1324	60	2
1324	1325	60	1
1325	1326	60	1
126	746	90	2
746	747	60	2
747	748	60	2
748	749	60	1
749	750	60	1
126	127	300	3
127	458	90	2
458	459	60	2
459	460	60	2
460	461	60	1
461	462	60	1
127	1034	90	2
1034	1035	60	2
1035	1036	60	2
1036	1037	60	1
1037	1038	60	1

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EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE HOT WATER SYSTEM

BRANCH MAIN DATA

<u>Node No.</u>	<u>Node No.</u>	<u>Length (Feet)</u>	<u>Diameter (Inches)</u>
127	128	300	2
128	129	90	2
129	130	60	1
130	131	60	1
131	132	60	1
128	896	90	2
896	897	60	1
897	898	60	1
898	899	60	1
4	294	500	12
294	295	1800	10
295	296	3600	6
296	297	720	6
297	298	750	4
298	1208	90	2
1208	1209	60	1
1209	1210	60	1
1210	1211	60	1
298	632	90	2
632	633	60	1
633	634	60	1

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE HOT WATER SYSTEM

BRANCH MAIN DATA

<u>Node No.</u>	<u>Node No.</u>	<u>Length (Feet)</u>	<u>Diameter (Inches)</u>
634	635	60	1
298	299	300	3
299	1352	90	2
1352	1353	90	2
1353	1354	90	2
1354	1355	60	1
1355	1356	60	1
299	776	90	2
776	777	60	2
777	778	60	2
778	779	60	1
779	780	60	1
299	300	300	3
300	488	90	2
488	489	60	2
489	490	60	2
490	491	60	1
491	492	60	1
300	1064	90	2
1064	1065	60	2
1065	1066	60	2
1066	1067	60	1
1067	1068	60	1

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EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE HOT WATER SYSTEM

BRANCH MAIN DATA

<u>Node No.</u>	<u>Node No.</u>	<u>Length (Feet)</u>	<u>Diameter (Inches)</u>
300	301	300	2
301	302	90	2
302	303	60	1
303	304	60	1
304	305	60	1
301	920	90	2
920	921	60	1
921	922	60	1
922	923	60	1
1	43	5250	18 *
43	44	2125	14 *
44	71	800	8 *
71	72	4700	8
72	73	720	8
73	74	720	6
74	76	30	4
76	77	300	3
77	78	300	3
78	79	300	2
76	1264	90	2
1264	1265	60	1
1265	1266	60	1
1266	1267	60	1

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EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE HOT WATER SYSTEM

BRANCH MAIN DATA

<u>Node No.</u>	<u>Node No.</u>	<u>Length (Feet)</u>	<u>Diameter (Inches)</u>
76	688	90	2
688	689	60	1
689	690	60	1
690	691	60	1
77	1422	90	2
1422	1423	60	2
1423	1424	60	2
1424	1425	60	1
1425	1426	60	1
77	846	90	2
846	847	60	2
847	848	60	2
848	849	60	1
849	850	60	1
78	558	90	2
558	559	60	2
559	560	60	2
560	561	60	1
561	562	60	1
78	1134	90	2
1134	1135	60	2
1135	1136	60	2
1136	1137	60	1
1137	1138	60	1

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE HOT WATER SYSTEM

BRANCH MAIN DATA

<u>Node No.</u>	<u>Node No.</u>	<u>Length (Feet)</u>	<u>Diameter (Inches)</u>
79	80	90	2
80	81	60	1
81	82	60	1
82	83	60	1
79	976	90	2
976	977	60	1
977	978	60	1
978	979	60	1
44	45	5625	12 *
45	146	2500	8
146	147	720	8
147	148	720	6
148	149	30	4
149	1240	90	2
1240	1241	60	1
1241	1242	60	1
1242	1243	60	1
149	664	90	2
664	665	60	1
665	666	60	1
666	667	60	1
149	150	300	3
150	1392	90	2

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE HOT WATER SYSTEM

BRANCH MAIN DATA

<u>Node No.</u>	<u>Node No.</u>	<u>Length (Feet)</u>	<u>Diameter (Inches)</u>
1392	1393	60	2
1393	1394	60	2
1394	1395	60	1
1395	1396	60	1
150	816	90	2
816	817	60	2
817	818	60	2
818	819	60	1
819	820	60	1
150	151	300	3
151	528	90	2
528	529	60	2
529	530	60	2
530	531	60	1
531	532	60	1
151	1104	90	2
1104	1105	60	2
1105	1106	60	2
1106	1107	60	1
1107	1108	60	1
151	152	300	2
152	153	90	2
153	154	60	1
154	155	60	1
155	156	60	1

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE HOT WATER SYSTEM

BRANCH MAIN DATA

<u>Node No.</u>	<u>Node No.</u>	<u>Length (Feet)</u>	<u>Diameter (Inches)</u>
152	952	90	2
952	953	60	1
953	954	60	1
954	955	60	1

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE HOT WATER SYSTEM

NODE DATA

<u>Node No.</u>	<u>Load (GPM)</u>
1	25.7 *
3	20.3 *
4	12.8 *
5	9.0 *
6	7.5 *
7	4.4 *
8	3.8 *
9	3.0 *
10	2.4
11	1.9
12	.5
13	.3
14	.2
15	15.1
16	85.2
17	28.4
18	14.2
19	11.4
20	8.6
21	5.6
1144	14.2
1145	11.4
1146	8.6

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE HOT WATER SYSTEM

NODE DATA

<u>Node No.</u>	<u>Load (GPM)</u>
1147	5.6
568	14.2
569	11.4
570	8.6
571	5.6
1272	26.2
1273	22.8
1274	17.1
1275	11.4
1276	5.7
696	28.4
697	22.8
698	17.1
699	11.4
700	5.7
408	1.7
409	1.4
410	0
411	0.7
412	0.3
984	28.4
985	22.8
986	17.1
987	11.4
988	5.7

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE HOT WATER SYSTEM

NODE DATA

<u>Node No.</u>	<u>Load (GPM)</u>
856	14.2
857	11.4
858	8.6
859	5.6
97	3.1 *
121	1.6
122	1.2
123	.4
124	.3
125	.1
1184	11.4
1185	9.1
1186	6.8
1187	4.6
608	11.4
609	9.1
610	6.8
611	4.6
125	.1
126	.1
127	68.4
128	22.8
129	11.4
130	9.1
131	6.8
132	4.6

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE HOT WATER SYSTEM

NODE DATA

<u>Node No.</u>	<u>Load (GPM)</u>
1322	22.8
1323	18.2
1324	13.7
1325	9.1
1326	4.6
746	22.8
747	18.2
748	13.7
749	9.1
750	4.6
458	22.8
459	16.8
460	12.6
461	8.4
462	4.2
1034	22.8
1035	18.2
1036	13.7
1037	9.1
1038	4.6
896	11.4
897	9.1
898	6.8
899	4.6

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE HOT WATER SYSTEM

NODE DATA

<u>Node No.</u>	<u>Load (GPM)</u>
294	2.5
295	1.9
296	.5
297	.4
298	.2
1208	14.7
1209	11.7
1210	8.8
1211	5.9
632	14.7
633	11.7
634	8.8
635	5.9
1352	29.4
1353	25.6
1354	17.7
1355	11.8
1356	5.9
776	29.4
777	25.6
778	17.7
779	11.8
780	5.9

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE HOT WATER SYSTEM

NODE DATA

<u>Node No.</u>	<u>Load (GPM)</u>
299	.1
300	88.2
488	29.4
489	23.6
490	17.7
491	11.8
492	5.9
1064	29.4
1065	23.6
1066	17.7
1067	11.8
1068	5.9
301	29.4
302	14.7
303	11.7
304	8.8
305	5.9
920	14.7
921	11.7
922	8.8
923	5.9
43	5.4 *
44	3.6 *
45	2.3 *

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE HOT WATER SYSTEM

NODE DATA

<u>Node No.</u>	<u>Load (GPM)</u>
71	1.3 *
72	.9
73	.6
74	.3
76	.1
77	.1
78	79.4
79	24.8
1264	12.4
1265	0.0
1266	7.5
1267	5.0
688	12.4
689	0.0
690	7.5
691	0.0
1422	24.8
1423	19.8
1424	14.9
1425	9.9
1426	4.9
846	24.8
847	19.8
848	14.9
849	9.9

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE HOT WATER SYSTEM

NODE DATA

<u>Node</u> <u>No.</u>	<u>Load</u> <u>(GPM)</u>
558	24.8
559	19.8
560	14.9
561	9.8
562	4.9
1134	24.8
1135	19.8
1136	14.9
1137	9.8
1138	4.9
80	12.4
81	0.0
82	7.5
83	0.0
976	12.4
977	0.0
978	7.5
979	0.0
146	.7
147	.5
148	.2
149	.1
150	.1
151	60.6
152	20.2

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE HOT WATER SYSTEM

NODE DATA

<u>Node No.</u>	<u>Load (GPM)</u>
153	10.1
154	0.0
155	6.1
156	0.0
1240	10.1
1241	0.0
1242	6.1
1243	0.0
664	10.1
665	8.0
666	6.1
667	0.0
1392	20.2
1393	16.2
1394	12.1
1395	8.1
1396	0.0
816	20.2
817	16.2
181	12.1
819	8.1
820	0.0

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE HOT WATER SYSTEM

NODE DATA

<u>Node No.</u>	<u>Load (GPM)</u>
528	20.2
529	14.8
530	11.1
531	7.4
532	3.7
1104	20.2
1105	16.2
1106	12.1
1107	8.1
1108	0
952	10.1
953	0
954	6.1
955	0

APPENDIX C

APPENDIX C - SAMPLE STEAM SYSTEM

For the evaluation of the SYNTHA program, the sample system listed on the following pages was condensed to include only those nodes and branches indicated by the asterisk.

HIGH PRESSURE
STEAM SYSTEM FOR STONER

— High Pressure
.... Low Pressure

LOW PRESSURE STEAM SYSTEM FOR STONER

SYNTHA STEAM SYSTEM

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE STEAM SYSTEM

Branch Main Data			
Node Name		Diameter (Inches)	Length (Feet)
From	To		
7	1	10	3,450
1	2	8	200
2	3	8	1,150
3	4	8	1,650
4	5	8	375
2	8	8	300
8	9	4	1,150
9	3	6	300
9	11	4	1,500
11	4	6	540
8	12	8	300
12	13	6	3,250
12	16	8	400
16	17	6	3,250
16	19	8	420
19	20	4	1,710
20	21	6	1,490
19	24	8	400
24	25	4	1,710
25	26	6	1,490
5	6	16	240
6	7	16	225
13	14	16	175
51	5	16	200
17	13	12	380
21	17	12	400
26	21	8	390
26	28	8	430
44	7	20	650
51	14	16	270
14	36	8	2,100
36	37	8	470
37	5	8	1,900

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE STEAM SYSTEM

Branch Main Data			
Node Name		Diameter (Inches)	Length (Feet)
From	To		
39	40	12	750
47	44	12	2,700
40	6	12	1,500
28	29	4	1,150
29	30	6	460
30	26	4	1,050
30	32	6	370
32	21	4	1,050
17	35	8	1,110
35	144	6	2,500
50	39	8	720
48	39	12	2,720
48	42	20	720
42	43	12	2,100
43	47	12	280
59	48	18	740
145	49	8	630
49	50	8	1,170
142	59	18	440
148	142	18	700
144	143	18	1,140
145	59	8	490
145	142	12	910
143	148	16	420
42	68	8	1,280
42	62	12	730
48	63	12	610
61	67	20	480
62	61	20	525
62	63	20	465
63	64	12	1,030
70	67	24	250
68	61	12	510

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE STEAM SYSTEM

Branch Main Data			
Node Name		Diameter (Inches)	Length (Feet)
From	To		
70	72	20	760
64	71	10	750
72	71	20	420
63	74	12	1,070
71	90	20	510
69	94	30	1,180
PWLO	69	30	1,120
94	129	20	920
95	94	24	1,050
95	70	24	500
99	124	12	440
117	99	10	200
72	117	12	530
98	123	8	300
103	105	12	500
123	103	12	400
107	105	12	520
106	103	6	580
106	107	6	550
116	98	12	380
117	116	3	70
123	122	10	80
142	60	12	740
79	58	10	500
74	60	12	220
74	75	12	1,060
75	101	12	720
60	78	12	800
78	79	10	760
80	58	8	780
81	80	8	750
90	101	20	100
75	81	8	860

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE STEAM SYSTEM

Branch Main Data			
Node Name		Diameter (Inches)	Length (Feet)
From	To		
101	102	12	350
102	107	10	210
81	113	8	520
107	113	8	520
58	120	12	960
73	115	12	300
115	87	12	70
87	118	20	10
108	111	16	120
111	87	20	390
105	73	15	250
113	115	6	480
118	121	20	1,050
120	121	16	620
118	140	20	550
140	141	20	900
PKLO	56	24	1,200
89	141	10	60
129	124	20	440
110	128	4	60
122	125	18	410
124	122	20	200
125	108	20	420
128	127	8	220
141	128	20	280
129	133	20	470
133	56	24	850
133	137	12	470
137	134	12	500
134	56	16	1,030
136	89	8	190
137	136	10	320
89	110	8	300

ARGONNE NATIONAL LABORATORY
EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE STEAM SYSTEM

Branch Main Data			
<u>Node Name</u>		<u>Diameter</u> (Inches)	<u>Length</u> (Feet)
<u>From</u>	<u>To</u>		
134	127	16	560
PKHI	BB	20	3,000*
BB	CC	12	430*
BB	AA	18	6,100*
CC	N. St	12	2,560*
AA	16 St	16	3,000*
16 St	51	Regulator	
N. St	42	Regulator	

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE STEAM SYSTEM

Node Data		
<u>Node Name</u>	<u>Pressure (Psig)</u>	<u>Flow (Mlb/H)</u>
1		-9.60
2		-1.95
3		-4.00
4		-3.30
5		-2.00
6		-6.95
7		-9.55
8		-0.45
9		-0.45
11		-1.25
12		-1.80
13		-2.15
14		-7.00
16		-0.90
17		-5.40
19		-0.10
20		-0.20
21		-0.50
24		-0.70
25		-1.00
26		-0.95
28		-1.25
29		-2.15
30		-0.55
32		-2.10
35		-6.00
36		-6.95
37		-1.95
39		-8.10
40		-8.30
42	11.00	-12.60
43		-22.00
44		-7.70

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE STEAM SYSTEM

<u>Node Data</u>		
<u>Node</u> <u>Name</u>	<u>Pressure</u> (Psig)	<u>Flow</u> (Mlb/H)
47		-3.45
48		-8.40
49		-9.85
50		-6.40
51	11.00	-1.15
56		-3.80
58		-4.10
59		-0.20
60		-5.50
61		-3.55
62		-2.65
63		-18.30
64		-38.05
67		-1.15
68		-5.85
69		-1.90
70		-0.50
71		-14.25
72		-16.60
73		-4.20
74		-13.60
75		-14.95
78		-14.95
79		-4.45
80		-3.05
81		-7.00
87		-2.05
89		-2.45
90		-2.70
94		-12.80
95		-10.30
98		-3.30
99		-2.30

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE STEAM SYSTEM

Node Data		
<u>Node</u> <u>Name</u>	<u>Pressure</u> (Psig)	<u>Flow</u> (Mlb/H)
101		-15.25
102		-4.20
103		-9.30
105		-13.50
106		-9.05
107		16.95
108		-3.65
110		-2.45
111		-2.05
113		-8.65
115		-1.15
116		-8.75
117		-18.65
118		-23.60
120		-10.80
121		-3.75
122		-11.15
123		-6.00
124		-21.05
125		-12.25
127		-13.05
128		0.0
129		-19.65
133		-0.10
134		-9.10
136		-1.20
137		-2.35
140		-9.75
141		-9.70
142		-3.05
143		-6.80
144		-2.65
145		-7.30

ARGONNE NATIONAL LABORATORY

EVALUATION OF AVAILABLE PROGRAMS FOR
DISTRICT HEATING/COOLING DISTRIBUTION SYSTEMS

SAMPLE STEAM SYSTEM

<u>Node Data</u>		
<u>Node</u> <u>Name</u>	<u>Pressure</u> <u>(Psig)</u>	<u>Flow</u> <u>(Mlb/H)</u>
148		-6.20
PWLO	24.40	
PKLO	25.00	
PKHI	220.00*	
AA		-59.00*
BB		-12.00*
CC		-11.00*
16 St		0.0*
N. St		0.0*

APPENDIX D

APPENDIX D

Samples of input and output.

HYDRAULIC NETWORK DESIGN

PAGE- 4

NETWORK NO.

HJT WATER ANALYSIS

LEG CARDS

RUN NO.

0

PASS NO. 1

NETWK
NO.CARD
NO.LOW
NODEHIGH
NODELENGTH
FEETNOM
DIAMHAZEN
WILLIAMS

MAT

CHAR
TYPECARD
CODE

-----ERRORS-----

1000

1

500

30

100

0

L

1

3

7700

30

100

0

L

3

4

5570

30

100

0

L

4

5

5330

24

100

1

L

5

6

2270

18

100

0

L

6

7

2700

16

100

0

L

7

8

4770

16

100

0

L

8

9

4600

14

100

0

L

9

10

4230

14

100

0

L

10

11

1800

12

100

0

L

11

12

3600

6

100

0

L

12

13

720

6

100

0

L

13

14

750

4

100

0

L

14

1144

90

2

100

0

L

1144

1145

60

1

100

0

L

1145

1146

60

1

100

0

L

1146

1147

60

1

100

0

L

14

568

90

2

100

0

L

568

569

60

1

100

0

L

569

570

60

1

100

0

L

570

571

60

1

100

0

L

14

15

300

3

100

0

L

15

1272

90

2

100

0

L

1272

1273

60

2

100

0

L

1273

1274

60

2

100

0

L

1274

1275

60

1

100

0

L

1275

1276

60

1

100

0

L

15

696

90

2

100

0

L

696

697

60

1

100

0

L

697

698

60

1

100

0

L

698

699

60

1

100

0

L

699

700

60

1

100

0

L

15

16

300

3

100

0

L

16

408

90

2

100

0

L

408

409

60

2

100

0

L

409

410

60

2

100

0

L

410

411

60

1

100

0

L

411

412

60

1

100

0

L

16

584

90

2

100

0

L

584

585

60

2

100

0

L

985

586

60

2

100

0

L

986

987

60

1

100

0

L

987

588

60

1

100

0

L

16

17

300

2

100

0

L

17

18

90

2

100

0

L

18

19

60

1

100

0

L

19

20

60

1

100

0

L

20

21

60

1

100

0

L

17

E56

90

2

100

0

L

356

E57

60

1

100

0

L

CONSUMERS

HYDRAULIC NETWORK DESIGN

PAGE- 9

NETWORK NO.

HOT WATER ANALYSIS

LOAD CARDS

RUN NO.

0

PASS NO. 1

NETWK NO.	CARD NO.	NO. ELEVATION (FEET)	IF NOT DESIGN MIN
-----------	----------	----------------------	-------------------

LOAD ON CARD	PERCENT CODE
--------------	--------------

LOAD USED

CARD CODE

-----REMARKS & ERRORS-----

1	1	25.709	0	25.709	Q
3	1	20.299	0	20.299	Q
4	1	12.794	0	12.794	Q
5	1	8.978	0	8.978	Q
6	1	7.458	0	7.458	Q
7	1	4.350	0	4.350	Q
8	1	3.820	0	3.820	Q
9	1	2.956	0	2.956	Q
10	1	2.380	0	2.380	Q
11	1	1.890	0	1.890	Q
12	1	0.510	0	0.510	Q
13	1	0.340	0	0.340	Q
14	1	0.170	0	0.170	Q
15	1	0.142	0	0.142	Q
16	1	85.200	0	85.200	Q
17	1	28.400	0	28.400	Q
18	1	14.200	0	14.200	Q
19	1	11.400	0	11.400	Q
20	1	8.600	0	8.600	Q
21	1	5.600	0	5.600	Q
1144	1	14.200	0	14.200	Q
1145	1	11.400	0	11.400	Q
1146	1	8.600	0	8.600	Q
1147	1	5.600	0	5.600	Q
568	1	14.200	0	14.200	Q
569	1	11.400	0	11.400	Q
570	1	8.600	0	8.600	Q
571	1	5.600	0	5.600	Q
1272	1	26.200	0	26.200	Q
1273	1	22.800	0	22.800	Q
1274	1	17.100	0	17.100	Q
1275	1	11.400	0	11.400	Q
1276	1	5.700	0	5.700	Q
696	1	28.400	0	28.400	Q
697	1	22.800	0	22.800	Q
698	1	17.100	0	17.100	Q
699	1	11.400	0	11.400	Q
700	1	5.700	0	5.700	Q
408	1	1.700	0	1.700	Q
409	1	1.400	0	1.400	Q
410	1	0.001	0	0.001	Q
411	1	0.700	1	0.700	Q
412	1	0.300	1	0.300	Q
934	1	28.400	0	28.400	Q
935	1	22.800	0	22.800	Q
936	1	17.100	0	17.100	Q
937	1	11.400	0	11.400	Q
938	1	5.700	0	5.700	Q
336	1	14.200	0	14.200	Q
337	1	11.400	0	11.400	Q

HYDRAULIC NETWORK DESIGN

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NETWRK NO.

HOT WATER ANALYSIS

NODE TABULATION

RUN NO.

0

PASS NO. 1

A			B			C			D		
NO.	LOAD	PRESSURE	NO.	LOAD	PRESSURE	NO.	LOAD	PRESSURE	NO.	LOAD	PRESSURE
1	25.739	999.938	3	20.299	999.501	4	12.794	999.191	5	8.978	998.832
6	7.451	998.220	7	4.350	997.834	8	3.820	997.161	9	2.956	995.935
10	2.330	994.818	11	1.890	993.820	12	0.510	935.828	13	0.340	924.250
14	0.170	837.472	15	0.142	733.195	16	85.200	689.329	17	28.400	473.045
18	14.200	462.810	19	11.400	441.081	20	8.600	433.778	21	5.600	432.471
43	5.401	998.924	44	3.614	997.544	45	2.265	995.844	71	1.349	994.877
72	0.894	979.286	73	0.596	976.906	74	0.298	967.267	76	0.149	964.376
77	0.124	864.453	78	79.400	817.753	79	24.800	734.098	80	12.400	731.255
81	0.010	729.004	82	7.500	726.759	83	0.005	726.759	97	3.108	996.127
121	1.642	995.546	122	1.231	993.468	123	0.411	943.695	124	0.274	933.756
125	0.274	859.250	126	0.114	765.944	127	68.400	720.486	128	22.800	576.739
129	11.400	569.942	130	9.100	555.537	131	6.800	550.672	132	4.600	549.764
146	0.720	990.461	147	0.486	988.917	148	0.243	982.660	149	0.121	980.784
150	0.101	918.953	151	60.600	889.717	152	20.200	832.519	153	10.100	830.575
154	0.034	829.040	155	6.100	827.508	156	0.004	827.508	294	2.460	998.798
295	1.933	995.380	296	0.528	913.575	297	0.352	897.239	298	0.176	774.778
299	0.147	620.680	300	88.200	546.112	301	29.400	316.302	302	14.700	305.440
303	11.700	282.439	304	8.800	274.653	305	5.900	273.214	408	1.700	689.176
409	1.400	689.138	410	0.001	689.131	411	0.700	689.077	412	0.300	689.071
458	22.800	655.267	459	16.800	687.730	460	12.600	684.800	461	8.400	678.946
462	4.200	678.179	488	29.400	501.315	489	23.600	487.180	490	17.700	481.686
491	11.800	470.708	492	5.900	469.269	528	20.200	869.695	529	14.800	863.733
530	11.100	861.416	531	7.400	856.785	532	3.700	856.178	558	24.800	785.352
559	19.800	775.175	560	14.900	771.230	561	9.800	763.444	562	4.900	762.423
568	14.200	827.237	569	11.400	805.509	570	8.600	798.205	571	5.600	796.899

HYDRAULIC NETWORK DESIGN

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NETWORK NO.

HOT WATER ANALYSIS

LEG TABULATION

RUN NO.

0

PASS NO.

1

A							B						
LOW	HIGH	DIAMETER	FLOW	VELOCITY	COST	LEG	LOW	HIGH	DIAMETER	FLOW	VELOCITY	COST	LEG
NODE	NODE	CODE F/P	IN GPM	FPS	DOLLARS	TYPE	NODE	NODE	CODE F/P	IN GPM	FPS	DOLLARS	TYPE
300	301	2 F	111.600	11.408	0		301	302	2 F	41.100	4.201	0	
301	920	2 F	41.100	4.201	0		302	303	1 F	26.400	10.794	0	
303	304	1 F	14.700	6.010	0		304	305	1 F	5.900	2.412	0	
408	409	2 F	2.401	0.245	0		409	410	2 F	1.001	0.102	0	
410	411	1 F	1.000	0.409	0		411	412	1 F	0.300	0.123	0	
458	459	2 F	42.000	4.293	0		459	460	2 F	25.200	2.576	0	
460	461	1 F	12.600	5.152	0		461	462	1 F	4.200	1.717	0	
483	489	2 F	59.000	6.031	0		489	490	2 F	35.400	3.619	0	
490	491	1 F	17.700	7.237	0		491	492	1 F	5.900	2.412	0	
528	529	2 F	37.000	3.782	0		529	530	2 F	22.200	2.269	0	
530	531	1 F	11.100	4.539	0		531	532	1 F	3.700	1.513	0	
558	559	2 F	49.400	5.050	0		559	560	2 F	29.600	3.026	0	
560	561	1 F	14.700	6.010	0		561	562	1 F	4.900	2.003	0	
568	569	1 F	25.600	10.467	0		569	570	1 F	14.200	5.806	0	
570	571	1 F	5.600	2.290	0		608	609	1 F	20.500	8.382	0	
609	610	1 F	11.400	4.661	0		610	611	1 F	4.600	1.881	0	
632	633	1 F	26.400	10.794	0		633	634	1 F	14.700	6.010	0	
634	635	1 F	5.900	2.412	0		664	665	1 F	14.104	5.767	0	
665	666	1 F	6.104	2.496	0		666	667	1 F	0.004	0.002	0	
688	689	1 F	7.515	3.073	0		689	690	1 F	7.505	3.069	0	
690	691	1 F	0.005	0.002	0		696	697	1 F	57.000	23.306	0	
697	698	1 F	34.200	13.984	0		698	699	1 F	17.100	6.992	0	
699	700	1 F	5.700	2.331	0		746	747	2 F	45.600	4.661	0	
747	748	2 F	27.400	2.801	0		748	749	1 F	13.700	5.602	0	
749	750	1 F	4.600	1.881	0		776	777	2 F	61.000	6.235	0	

```

      00000000      A      SSSSSSSS SSSSSSSS SSSSSSSS
      0          0      A A      S      S      S
      G          G      A A      S      S      S
      G          G      A A      S      S      S
      0      00000      AAAAAAAAAA SSSSSSSS SSSSSSSS SSSSSSSS
      G          G      A A      S      S      S
      G          G      A A      S      S      S
      G          G      A A      S      S      S
      00000000      A      SSSSSSSS SSSSSSSS SSSSSSSS

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A PROGRAM FOR MODELING STEADY STATE FLOW IN GAS TRANSPORTATION SYSTEMS
 GASSS IS A PROPRIETARY PROGRAM OF STONER ASSOCIATES INC.,
 CARLISLE, PENNA 17013 -- 717 243-9212

RUN ON: 10/19/79 AT 16.37.49

DATA PREPARATION OUTPUT FOR GASSS
 PROBLEM TITLE

SAMPLE STEAM SYSTEM -- HIGH AND LOW PRESSURES

RUN ON: 10/19/79 AT 16.37.49

FLOW UNITS USED MLB/HR
 PIPELINE LENGTH UNIT FFET
 SUPER COMPRESSIBILITY ON OR OFF SUPOFF
 BASE PRESSURE 14.46
 BASE TEMP 452.0
 GAS GRAVITY 0.6000
 GAS TEMPERATURE 800.0
 PRESSURE UNIT PSIG
 DEFAULT EFFICIENCY 1.000
 DEFAULT FRIC FAC. 0.0200
 DEFAULT ROUGHNESS 0.00015
 ABS VISCOSITY 0.0000100
 REYNOLDS NO. FRICTION SWITCH 0

PRESSURE 0.100
 NODE FLOW(UNITS GIVEN ABOVE) 0.1000
 PIPE DIAMETER INCHES 0.050
 COMPRESSOR HP AND/OR RPM 10.00
 VALVE CONVEYANCE K 1.000
 STORAGE FIELD WELLS 0.10

MAX NO. OF ITERATIONS 5

SYSTEM DESCRIPTION DATA

NCE NUM	FROM NODE	TO NODE	ELEMENT TYPE	ELEMENT DATA X1	X2	X3	X4	X5
1	7	1	FS	10.00	3450.00	0.020	.1500E-03	1.000
2	1	2	FS	8.00	200.00	0.020	.1500E-03	1.000
3	2	3	FS	8.00	1150.00	0.020	.1500E-03	1.000
4	3	4	FS	8.00	1550.00	0.020	.1500E-03	1.000
5	4	5	FS	8.00	375.00	0.020	.1500E-03	1.000
6	2	8	FS	8.00	300.00	0.020	.1500E-03	1.000
7	8	9	FS	4.00	1150.00	0.020	.1500E-03	1.000
8	9	3	FS	6.00	300.00	0.020	.1500E-03	1.000
9	9	11	FS	4.00	1500.00	0.020	.1500E-03	1.000
10	11	4	FS	6.00	540.00	0.020	.1500E-03	1.000
11	8	12	FS	8.00	300.00	0.020	.1500E-03	1.000
12	12	13	FS	6.00	3250.00	0.020	.1500E-03	1.000
13	12	16	FS	8.00	400.00	0.020	.1500E-03	1.000
14	16	17	FS	6.00	3250.00	0.020	.1500E-03	1.000
15	16	19	FS	8.00	420.00	0.020	.1500E-03	1.000
16	19	20	FS	4.00	1710.00	0.020	.1500E-03	1.000
17	20	21	FS	6.00	1490.00	0.020	.1500E-03	1.000
18	19	24	FS	8.00	400.00	0.020	.1500E-03	1.000
19	24	25	FS	4.00	1710.00	0.020	.1500E-03	1.000
20	25	26	FS	6.00	1490.00	0.020	.1500E-03	1.000
21	5	6	FS	16.00	240.00	0.020	.1500E-03	1.000
22	6	7	FS	16.00	225.00	0.020	.1500E-03	1.000
23	13	14	FS	16.00	175.00	0.020	.1500E-03	1.000
24	51	5	FS	16.00	200.00	0.020	.1500E-03	1.000
25	17	13	FS	12.00	380.00	0.020	.1500E-03	1.000
26	21	17	FS	12.00	400.00	0.020	.1500E-03	1.000
27	26	21	FS	8.00	390.00	0.020	.1500E-03	1.000
28	26	28	FS	8.00	430.00	0.020	.1500E-03	1.000
29	44	7	FS	20.00	650.00	0.020	.1500E-03	1.000
30	51	14	FS	16.00	270.00	0.020	.1500E-03	1.000
31	14	36	FS	8.00	2100.00	0.020	.1500E-03	1.000
32	36	37	FS	8.00	470.00	0.020	.1500E-03	1.000
33	37	5	FS	8.00	1900.00	0.020	.1500E-03	1.000
34	39	40	FS	12.00	750.00	0.020	.1500E-03	1.000
35	47	44	FS	12.00	2700.00	0.020	.1500E-03	1.000
36	40	6	FS	12.00	1500.00	0.020	.1500E-03	1.000
37	28	29	FS	4.00	1150.00	0.020	.1500E-03	1.000
38	29	30	FS	6.00	460.00	0.020	.1500E-03	1.000
39	30	26	FS	4.00	1050.00	0.020	.1500E-03	1.000
40	30	32	FS	6.00	370.00	0.020	.1500E-03	1.000
41	32	21	FS	4.00	1050.00	0.020	.1500E-03	1.000
42	17	35	FS	8.00	1110.00	0.020	.1500E-03	1.000
43	35	144	FS	6.00	2500.00	0.020	.1500E-03	1.000
44	50	39	FS	8.00	720.00	0.020	.1500E-03	1.000
45	48	30	FS	12.00	2700.00	0.020	.1500E-03	1.000

129	124	133	94
133	56	137	120
134	56	127	137
136	89	137	
137	134	136	133
140	141	118	
141	128	140	89
142	59	60	148 145
143	148	144	
144	143	35	
145	49	142	59
148	142	143	

NODE INPUT DATA

NODE NAME	PRES PSIG	FLOW MLB/H
1	11.00 S	-9.60
2	11.00 S	-1.95
3	11.00 S	-4.00
4	11.00 S	-3.30
5	11.00 S	-2.00
6	11.00 S	-6.95
7	11.00 S	-9.55
8	11.00 S	-0.45
9	11.00 S	-0.45
11	11.00 S	-1.25
12	11.00 S	-1.80
13	11.00 S	-2.15
14	11.00 S	-7.00
16	11.00 S	-0.90
17	11.00 S	-5.40
19	11.00 S	-0.10
20	11.00 S	-0.20
21	11.00 S	-0.50
24	11.00 S	-0.70
25	11.00 S	-1.00
26	11.00 S	-0.95
28	11.00 S	-1.25
29	11.00 S	-2.15
30	11.00 S	-0.55
32	11.00 S	-2.10
35	11.00 S	-6.00
36	11.00 S	-6.95
37	11.00 S	-1.95
39	11.00 S	-8.10
40	11.00 S	-8.30
42	11.00	-12.60
43	11.00 S	-22.00
44	11.00 S	-7.70
47	11.00 S	-3.45
48	11.00 S	-8.40
49	11.00 S	-9.85
50	11.00 S	-6.40
51	11.00	-1.15
56	11.00 S	-3.80
58	11.00 S	-4.10
59	11.00 S	-0.20
60	11.00 S	-5.50
61	11.00 S	-3.55

108 NODES
140 NCES
2 UNKNOWN NCES
103 UNKNOWN PRES
3 UNKNOWN FLOWS

SUM OF INPUT DATA LOADS = -758.69 MLB/
SUM OF INPUT DATA SUPPLIES = 753.00 MLB/

DATA PREPARATION COMPLETED FOR RUN

SAMPLE STEAM SYSTEM -- HIGH AND LOW PRESSURES

FULL NCE RESULTS FOR:
SAMPLE STEAM SYSTEM -- HIGH AND LOW PRESSURES
RUN ON 10/19/79 AT 16.37.49

FROM	TO	F-P	T-P	TYPE	MLB/H	PARAM.	REMARKS
N.ST	42	218.S	11.	FIS	0.23	1.0	
PKHI	88	220.S	218.S	FS	185.93	20.000 RN=	3947536.F=0.0097
PKLO	56	25.	22.S	FS	233.64	24.000 RN=	4133749.F=0.0096
PWLO	69	24.	23.S	FS	339.13	30.000 RN=	4800183.F=0.0094
16ST	51	210.S	11.	FIS	105.58	475.2	**CB>MAX 100.0
1	2	8.S	8.S	FS	-1.78	8.000 RN=	94407.F=0.0183
2	3	8.S	8.S	FS	-1.47	8.000 RN=	78167.F=0.0191
2	8	8.S	8.S	FS	-2.26	8.000 RN=	119743.F=0.0175
3	4	8.S	10.S	FS	-5.31	8.000 RN=	281600.F=0.0148
4	5	10.S	10.S	FS	-10.62	8.000 RN=	563666.F=0.0132
5	6	10.S	10.S	FS	50.39	16.000 RN=	1327256.F=0.0114
6	7	10.S	10.S	FS	33.55	16.000 RN=	890306.F=0.0121
7	1	10.S	8.S	FS	7.82	10.000 RN=	332119.F=0.0144
8	9	8.S	8.S	FS	-0.15	4.000 RN=	15584.F=0.0276
8	12	8.S	8.S	FS	-2.56	8.000 RN=	135836.F=0.0170
9	3	8.S	8.S	FS	0.17	6.000 RN=	11839.F=0.0296
9	11	8.S	9.S	FS	-0.76	4.000 RN=	81116.F=0.0190
AA	16ST	212.S	210.S	FS	106.58	16.000 RN=	2828604.F=0.0102
BB	AA	218.S	212.S	FS	165.58	18.000 RN=	3906163.F=0.0098
BA	CC	218.S	218.S	FS	8.35	12.000 RN=	295362.F=0.0147
CC	N.ST	218.S	218.S	FS	-2.65	12.000 RN=	93889.F=0.0183
11	4	9.S	10.S	FS	-2.01	6.000 RN=	142542.F=0.0169
12	13	8.S	11.S	FS	-2.46	6.000 RN=	173959.F=0.0163
12	16	8.S	8.S	FS	-1.90	8.000 RN=	100907.F=0.0181
13	14	11.S	11.S	FS	-26.52	16.000 RN=	703945.F=0.0126
14	36	11.S	10.S	FS	4.73	8.000 RN=	251198.F=0.0152
16	17	8.S	10.S	FS	-2.11	6.000 RN=	149352.F=0.0168
16	19	8.S	8.S	FS	-0.69	8.000 RN=	36777.F=0.0225
17	13	10.S	11.S	FS	-21.92	12.000 RN=	775534.F=0.0124
17	35	10.S	10.S	FS	4.22	8.000 RN=	223749.F=0.0155
19	20	8.S	10.S	FS	-0.89	4.000 RN=	94431.F=0.0184
19	24	8.S	8.S	FS	0.10	8.000 RN=	5139.F=0.0372
20	21	10.S	10.S	FS	-1.09	6.000 RN=	77109.F=0.0191
21	17	10.S	10.S	FS	-10.19	12.000 RN=	340609.F=0.0141
24	25	8.S	9.S	FS	-0.60	4.000 RN=	63826.F=0.0200
25	26	9.S	10.S	FS	-1.60	6.000 RN=	113324.F=0.0177
26	28	10.S	10.S	FS	2.73	8.000 RN=	144948.F=0.0168
26	21	10.S	10.S	FS	-6.86	8.000 RN=	364193.F=0.0142
28	29	10.S	7.S	FS	1.48	4.000 RN=	157220.F=0.0167
29	30	7.S	7.S	FS	-0.67	4.000 RN=	17420.F=0.0212

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L      I      OOOOO      SSSSSSSS      SSSSSSSS
L      I      O      O      S      S
L      I      O      O      S      S
L      I      O      O      SSSSSSS      SSSSSSS
L      I      O      O      O      S      S
L      I      O      O      O      S      S
L      I      O      O      SSSSSSS      SSSSSSS
LLLLLLLLL I      OOOOO      SSSSSSSS      SSSSSSS

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A PROGRAM FOR MODELING STEADY STATE FLOW IN LIQUID PIPING SYSTEMS.
LIQSS IS A PROPRIETARY PROGRAM OF STONER ASSOCIATES INC.,
CARLISLE, PENNA 17013 -- 717 243-9212
LIQSS IS A TRADEMARK OF STONER ASSOCIATES INC.

RU# DN# 11/27/79 AT 13.33.03

1 DATA PREPARATION OUTPUT FOR LIQSS
PROBLEM TITLE

SAMPLE HOT WATER SYSTEM

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THE FLOW UNITS FOR THIS SYSTEM ARE      GPM
THE SPECIFIC GRAVITY RELATIVE TO WATER(62.4) IS  1.0000
THE VISCOSITY OF THE LIQUID IN FT-SQ/SEC      0.0000100
THE DEFAULT VALUE FOR DARCY-WEISBACH FRICTION FACTOR      0.020
THE DEFAULT VALUE FOR THE HAZEN-WILLIAMS COEFFICIENT      100.0
THE DEFAULT VALUE FOR PIPE ROUGHNESS (FEET)      0.00100
THE LENGTH UNIT IS FEET

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DARCY-WEISBACH FRICTION FACTORS WILL BE DETERMINED
AS A FUNCTION OF REYNOLDS NO.

•• SOLUTION TOLERANCES ••

PRESSURE (PSI) 0.050
NODE FLOW, FLOW UNIT PRINTED ABOVE 0.0500
PIPE DIAMETER-INCHES 0.050
PUMP HORSEPOWER AND/OR RPM 0.50
VALVE FLOW AREA, SQ. INCHES 0.0500

SYSTEM DESCRIPTION DATA

NCE NUM	FROM NODE	TO NODE	ELEMENT TYPE	X1	X2	X3	X4	X5
1	1000	1	HW	30.00	500.00	100.000	0.0	0.0
2	1	3	HW	30.00	7700.00	100.000	0.0	0.0
3	3	4	HW	30.00	5570.00	100.000	0.0	0.0
4	4	5	HW	24.00	5330.00	100.000	0.0	0.0
5	5	6	HW	10.00	2270.00	100.000	0.0	0.0
6	6	7	HW	16.00	2700.00	100.000	0.0	0.0
7	7	8	HW	16.00	4770.00	100.000	0.0	0.0
8	8	9	HW	14.00	4600.00	100.000	0.0	0.0
9	9	10	HW	14.00	4230.00	100.000	0.0	0.0
10	10	11	HW	12.00	1800.00	100.000	0.0	0.0
11	11	12	HW	6.00	3600.00	100.000	0.0	0.0
12	12	13	HW	6.00	720.00	100.000	0.0	0.0
13	13	14	HW	6.00	750.00	100.000	0.0	0.0
14	14	1144	HW	2.00	90.00	100.000	0.0	0.0
15	1144	1145	HW	1.00	60.00	100.000	0.0	0.0
16	1145	1146	HW	1.00	60.00	100.000	0.0	0.0
17	1146	1147	HW	1.00	60.00	100.000	0.0	0.0
18	14	568	HW	2.00	90.00	100.000	0.0	0.0
19	568	569	HW	1.00	60.00	100.000	0.0	0.0
20	569	570	HW	1.00	60.00	100.000	0.0	0.0
21	570	571	HW	1.00	60.00	100.000	0.0	0.0
22	14	15	HW	3.00	300.00	100.000	0.0	0.0
23	15	1272	HW	2.00	90.00	100.000	0.0	0.0
24	1272	1273	HW	2.00	60.00	100.000	0.0	0.0
25	1273	1274	HW	2.00	60.00	100.000	0.0	0.0
26	1274	1275	HW	1.00	60.00	100.000	0.0	0.0
27	1275	1276	HW	1.00	60.00	100.000	0.0	0.0
28	15	696	HW	2.00	90.00	100.000	0.0	0.0
29	696	697	HW	1.00	60.00	100.000	0.0	0.0
30	697	698	HW	1.00	60.00	100.000	0.0	0.0
31	698	699	HW	1.00	60.00	100.000	0.0	0.0
32	699	700	HW	1.00	60.00	100.000	0.0	0.0
33	15	16	HW	3.00	300.00	100.000	0.0	0.0
34	16	408	HW	2.00	90.00	100.000	0.0	0.0

NODE INPUT DATA

NODE NAME	ELEV FEET	PHES PSIG	FLOW GPM
1	1.0	100.00 S	-25.71
3	1.0	100.00 S	-20.30
4	1.0	100.00 S	-12.79
5	1.0	100.00 S	-8.98
6	1.0	100.00 S	-7.46
7	1.0	100.00 S	-4.35
8	1.0	100.00 S	-3.82
9	1.0	100.00 S	-2.96
10	1.0	100.00 S	-2.38
11	1.0	100.00 S	-1.89
12	1.0	100.00 S	-0.51
13	1.0	100.00 S	-0.34
14	1.0	100.00 S	-0.17
15	1.0	100.00 S	-0.14
16	1.0	100.00 S	-85.20
17	1.0	100.00 S	-28.40
18	1.0	100.00 S	-14.20
19	1.0	100.00 S	-11.40
20	1.0	100.00 S	-8.60
21	1.0	100.00 S	-5.60
1144	1.0	100.00 S	-14.20
1145	1.0	100.00 S	-11.40
1146	1.0	100.00 S	-8.60
1147	1.0	100.00 S	-5.60
568	1.0	100.00 S	-14.20
569	1.0	100.00 S	-11.40
570	1.0	100.00 S	-8.60
571	1.0	100.00 S	-5.60
1272	1.0	100.00 S	-26.20
1273	1.0	100.00 S	-22.80
1274	1.0	100.00 S	-17.10
1275	1.0	100.00 S	-11.40
1276	1.0	100.00 S	-5.70
696	1.0	100.00 S	-28.40
697	1.0	100.00 S	-22.80
698	1.0	100.00 S	-17.10
699	1.0	100.00 S	-11.40
700	1.0	100.00 S	-5.70
408	1.0	100.00 S	-1.70
409	1.0	100.00 S	-1.40
410	1.0	100.00 S	-0.00
411	1.0	100.00 S	-0.70
412	1.0	100.00 S	-0.30
984	1.0	100.00 S	-28.40
985	1.0	100.00 S	-22.80
986	1.0	100.00 S	-17.10
987	1.0	100.00 S	-11.40
988	1.0	100.00 S	-5.70
856	1.0	100.00 S	-14.20

818	1.0	100.00 S	-12.10
819	1.0	100.00 S	-3.10
820	1.0	100.00 S	-0.00
528	1.0	100.00 S	-20.20
529	1.0	100.00 S	-14.80
530	1.0	100.00 S	-11.10
531	1.0	100.00 S	-7.40
532	1.0	100.00 S	-3.70
1104	1.0	100.00 S	-20.20
1105	1.0	100.00 S	-14.20
1106	1.0	100.00 S	-12.10
1107	1.0	100.00 S	-8.10
1108	1.0	100.00 S	-6.00
952	1.0	100.00 S	-10.10
953	1.0	100.00 S	-0.01
954	1.0	100.00 S	-6.10
955	1.0	100.00 S	-0.00
1000	1.0	1000.00	0.0 S

*** PROBLEM SUMMARY ***

232 NODES
231 NCES
0 UNKNOWN NCES
231 UNKNOWN PRES
1 UNKNOWN FLOWS

SUM OF INPUT DATA LOADS = -2641.46 GPM
SUM OF INPUT DATA SUPPLYS = 0.0 GPM

DATA PREPARATION COMPLETED FOR RUN

SAMPLE HOT WATER SYSTEM

FULL NCE RESULTS FOR:
SAMPLE HOT WATER SYSTEM
RUN ON 11/27/79 AT 13.39.03

FROM	TO	F-P	T-P	TYPE	GPM	PARAM.	REMARKS
1	43	1000.S	999.S	HW	877.872	10.000 H/CL	0.0450 V 1.1
1	3	1000.S	999.S	HW	1738.189	30.000 H/CL	0.0132 V 0.8
10	11	995.S	994.S	HW	533.965	12.000 H/CL	0.1290 V 1.5
1000	1	1000.	1000.S	HW	2641.636	30.000 H/CL	0.0297 V 1.2
1034	1035	711.S	709.S	HW	45.601	2.000 H/CL	8.3515 V 4.7
1035	1036	709.S	708.S	HW	27.401	2.000 H/CL	3.2518 V 2.8
1036	1037	708.S	701.S	HW	13.700	1.000 H/CL	26.3484 V 5.6
1037	1038	701.S	701.S	HW	4.600	1.000 H/CL	3.4912 V 1.9
1064	1065	531.S	528.S	HW	59.000	2.000 H/CL	13.4568 V 6.0

1065	1066	529.S	526.S	HW	35.391	2.000	H/CL	5.2227	V	3.6
1066	1067	526.S	515.S	HW	17.700	1.000	H/CL	42.3424	V	7.2
1067	1068	515.S	514.S	HW	5.899	1.000	H/CL	5.5335	V	2.4
11	12	994.S	935.S	HW	532.062	6.000	H/CL	3.7490	V	6.0
1104	1105	884.S	883.S	HW	36.406	2.000	H/CL	5.5035	V	3.7
1105	1106	883.S	882.S	HW	20.200	2.000	H/CL	1.8499	V	2.1
1106	1107	882.S	880.S	HW	8.104	1.000	H/CL	9.9656	V	3.3
1107	1108	880.S	880.S	HW	-0.054	1.000	H/CL	-0.0009	V	-0.0
1134	1135	808.S	806.S	HW	49.399	2.000	H/CL	9.6849	V	5.0
1135	1136	806.S	805.S	HW	29.599	2.000	H/CL	3.7513	V	3.0
1136	1137	805.S	797.S	HW	14.700	1.000	H/CL	30.0208	V	6.0
1137	1138	797.S	796.S	HW	4.900	1.000	H/CL	3.9250	V	2.0
1144	1145	834.S	812.S	HW	25.600	1.000	H/CL	83.8623	V	10.5
1145	1146	812.S	804.S	HW	14.200	1.000	H/CL	28.1569	V	5.8
1146	1147	804.S	803.S	HW	5.600	1.000	H/CL	5.0265	V	2.3
1184	1185	856.S	842.S	HW	20.500	1.000	H/CL	55.5758	V	8.4
1185	1186	842.S	837.S	HW	11.400	1.000	H/CL	18.7491	V	4.7
1186	1187	837.S	836.S	HW	4.600	1.000	H/CL	3.4912	V	1.9
12	13	935.S	924.S	HW	531.554	6.000	H/CL	3.7423	V	6.0
1208	1209	770.S	747.S	HW	26.400	1.000	H/CL	88.7798	V	10.8
1209	1210	747.S	739.S	HW	14.700	1.000	H/CL	30.0199	V	6.0
121	122	996.S	993.S	HW	490.938	10.000	H/CL	0.2684	V	2.0
1210	1211	739.S	738.S	HW	5.900	1.000	H/CL	5.5364	V	2.4
122	123	993.S	943.S	HW	489.737	6.000	H/CL	3.2155	V	5.6
123	124	943.S	933.S	HW	489.324	6.000	H/CL	3.2104	V	5.6
124	125	933.S	858.S	HW	489.051	4.000	H/CL	23.1070	V	12.5
1240	1241	980.S	979.S	HW	6.112	1.000	H/CL	5.9101	V	2.5
1241	1242	979.S	977.S	HW	6.104	1.000	H/CL	5.8960	V	2.5
1242	1243	977.S	977.S	HW	0.0	1.000	H/CL	0.0	V	0.0
125	1184	858.S	856.S	HW	31.899	2.000	H/CL	4.3088	V	3.3
125	608	858.S	856.S	HW	31.899	2.000	H/CL	4.3088	V	3.3
125	126	858.S	764.S	HW	425.114	3.000	H/CL	72.3704	V	19.3
126	1322	764.S	757.S	HW	68.400	2.000	H/CL	17.6945	V	7.0
126	127	764.S	718.S	HW	288.199	3.000	H/CL	35.2327	V	13.1
126	746	764.S	757.S	HW	68.400	2.000	H/CL	17.6945	V	7.0
1264	1265	961.S	961.S	HW	7.515	1.000	H/CL	8.6651	V	3.1
1265	1266	961.S	959.S	HW	7.505	1.000	H/CL	8.6445	V	3.1
1266	1267	959.S	959.S	HW	-0.054	1.000	H/CL	-0.0009	V	-0.0
127	458	719.S	712.S	HW	64.800	2.000	H/CL	16.0087	V	6.6
127	1034	719.S	711.S	HW	68.400	2.000	H/CL	17.6945	V	7.0
127	128	718.S	683.S	HW	86.600	2.000	H/CL	27.3896	V	8.8
1272	1273	721.S	718.S	HW	56.999	2.000	H/CL	12.6239	V	5.8
1273	1274	718.S	716.S	HW	34.202	2.000	H/CL	4.9025	V	3.5
1274	1275	716.S	706.S	HW	17.100	1.000	H/CL	39.7226	V	7.0
1275	1276	706.S	705.S	HW	5.700	1.000	H/CL	5.1936	V	2.3
128	129	683.S	681.S	HW	31.901	2.000	H/CL	4.3094	V	3.3
128	896	683.S	681.S	HW	31.901	2.000	H/CL	4.3094	V	3.3
129	130	681.S	667.S	HW	20.500	1.000	H/CL	55.5758	V	8.4
13	14	924.S	836.S	HW	531.213	4.000	H/CL	26.9310	V	13.6
130	131	667.S	662.S	HW	11.400	1.000	H/CL	18.7472	V	4.7
131	132	662.S	661.S	HW	4.600	1.000	H/CL	3.4921	V	1.9
1322	1323	757.S	755.S	HW	45.598	2.000	H/CL	8.3505	V	4.7
1323	1324	755.S	754.S	HW	27.401	2.000	H/CL	3.2518	V	2.8
1324	1325	754.S	747.S	HW	13.700	1.000	H/CL	26.3484	V	5.6
1325	1326	747.S	746.S	HW	4.600	1.000	H/CL	3.4912	V	1.9

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      XXXXX  XX      XX  X      XX  XXXXXXXX  XX  XX      XXXXXX
      XX  XX      XX  XX      XX  XX      XX  XX      XX  XX
      XX      XX  XX      XXX  XX      XX      XX  XX      XX  XX
      XX      XXXX      XXXX  XX      XX      XX  XXXXXXXX
      XXXXX      XX      XX  XX  XX      XX      XXXXXXXX
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      XX  XX      XX      XX  XXX      XX      XX  XX
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      XX      XX      XX
      XXXXXXXXXXXXXXXXXXXXX

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SYNTHA III IS A PROPRIETARY PROGRAM OF THE SYNTHA CORPORATION, 41 WEST PUTNUM AVENUE, GREENWICH CONNECTICUT 06830.

COMPONENT INPUT DATA.

COMPONENT NO. KIND	INPUT 1	INPUT 2	INPUT 3	INPUT 4	INPUT 5	INPUT 6	INPUT 7	INPUT 8	INPUT 9
1 1	.10000E+01	.23500E+03	0.	0.	.10000E+01	0.	0.	0.	0.
2 3	0.	0.	0.	0.	0.	0.	0.	0.	0.
3 2	0.	0.	0.	0.	0.	0.	0.	0.	0.
4 3	.40000E+01	0.	.12000E+02	0.	.90000E+02	0.	0.	0.	0.
5 2	0.	0.	0.	0.	0.	0.	0.	0.	0.
6 3	.20000E+01	.30000E+01	0.	0.	-.10000E+01	0.	0.	0.	0.
7 2	0.	0.	0.	0.	0.	0.	0.	0.	0.
8 3	.40000E+01	0.	.11000E+02	0.	.90000E+02	0.	0.	0.	0.
9 3	.20000E+01	.30000E+01	0.	0.	-.10000E+01	0.	0.	0.	0.
10 3	.40000E+01	0.	.57000E+02	0.	.90000E+02	0.	0.	0.	0.
11 3	.20000E+01	.30000E+01	0.	0.	-.10000E+01	0.	0.	0.	0.
12 2	0.	0.	0.	0.	0.	0.	0.	0.	0.
13 3	.40000E+01	0.	.59000E+02	0.	.90000E+02	0.	0.	0.	0.
14 3	.20000E+01	.30000E+01	0.	0.	-.10000E+01	0.	0.	0.	0.
15 3	.40000E+01	0.	.10800E+03	0.	.90000E+02	0.	0.	0.	0.
16 12	.30000E+03	.20000E+01	.20000E+01	0.	.20000E+01	.10000E+01	0.	.40000E+01	.10000E+01

STEAM FLOW STREAM PROPERTIES.

STREAM NO.	FLOW 1000 LB/HR	PRESSURE PSIA	TEMPERATURE DEG. F	QUALITY	ENTHALPY BTU/LB	ENTROPY BTU/LB-F
1	247.0000	235.0000	395.56	1.0000	1200.39	1.5317
2	247.0000	235.0000	395.56	1.0000	1200.39	1.5317
3	247.0000	220.3185	391.16	1.0000	1200.39	1.5382
4	12.0000	220.3185	391.16	1.0000	1200.39	1.5382
5	12.0000	220.3185	390.00	0.0000	364.31	.5542
6	235.0000	220.3185	391.16	1.0000	1200.39	1.5382
7	68.0000	220.3185	391.16	1.0000	1200.39	1.5382
8	68.0000	213.7089	387.66	1.0000	1199.39	1.5400
9	11.0000	213.7089	387.66	1.0000	1199.39	1.5400
10	11.0000	213.7089	387.40	0.0000	361.51	.5509
11	57.0000	213.7089	387.66	1.0000	1199.39	1.5400
12	57.0000	207.2977	384.82	.9995	1198.39	1.5419
13	57.0000	207.2977	384.82	0.0000	358.74	.5476
14	167.0000	220.3185	391.16	1.0000	1200.39	1.5382
15	167.0000	213.7089	387.66	1.0000	1199.39	1.5400
16	59.0000	213.7089	387.66	1.0000	1199.39	1.5400
17	59.0000	213.7089	387.40	0.0000	361.51	.5509
18	108.0000	213.7089	387.66	1.0000	1199.39	1.5400
19	108.0000	207.2977	384.82	.9995	1198.39	1.5419
20	108.0000	207.2977	384.82	0.0000	358.74	.5476

COMPONENT OUTPUT DATA.

COMPONENT NO. KIND	OUTPUT 1	OUTPUT 2	OUTPUT 3	OUTPUT 4	OUTPUT 5	OUTPUT 6	OUTPUT 7	OUTPUT 8	OUTPUT 9
1 1	0.	0.	0.	0.	0.	0.	0.	0.	0.
2 3	-.43983E+01	.62475E+01	.68611E+02	-.11628E+01	0.	0.	0.	0.	0.
3 2	0.	0.	.68611E+02	0.	.19583E+02	.51064E-01	0.	0.	0.
4 3	-.11628E+01	0.	.33333E+01	0.	-.10033E+08	-.90297E+07	0.	.90000E+02	0.
5 2	0.	0.	.65278E+02	0.	.40719E+00	.24559E+01	0.	0.	0.
6 3	-.35049E+01	.30000E+01	.18889E+02	-.25629E+00	-.68000E+05	-.68000E+05	0.	0.	0.
7 2	0.	0.	.18889E+02	0.	.19298E+00	.51818E+01	0.	0.	0.
8 3	-.25629E+00	0.	.30556E+01	0.	-.92166E+07	-.82949E+07	0.	.90000E+02	0.
9 3	-.28374E+01	.30000E+01	.15833E+02	0.	-.57000E+05	-.57000E+05	0.	0.	0.
10 3	0.	0.	.15833E+02	0.	-.47800E+08	-.43074E+08	0.	.90000E+02	0.
11 3	-.35049E+01	.30000E+01	.46389E+02	-.25629E+00	-.16700E+06	-.16700E+06	0.	0.	0.
12 2	0.	0.	.46389E+02	0.	.54630E+00	.18305E+01	0.	0.	0.
13 3	-.25629E+00	0.	.16389E+02	0.	-.49434E+08	-.44491E+08	0.	.90000E+02	0.
14 3	-.28374E+01	.30000E+01	.30000E+02	0.	-.10800E+06	-.10800E+06	0.	0.	0.
15 3	0.	0.	.30000E+02	0.	-.90681E+08	-.81613E+08	0.	.90000E+02	0.
16 12	0.	.62475E+01	.62475E+01	0.	.24700E+03	.24700E+03	.12000E+02	.12000E+02	.62475E+01