Ⅰ. KYPIPE2를 이용한 관망해석 및 설계

1. 관망해석의 기본 이론
2. 입력자료의 준비 및 코딩
3. 결과의 분석
4. 예제 실습
5. APPENDIX

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1. 관망해석의 기본 이론

1.1 Pipe system Geometry

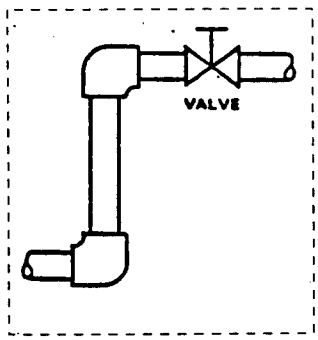


Figure 1 Pipe section

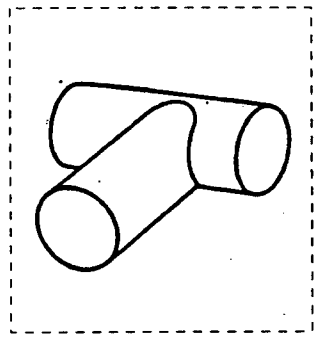
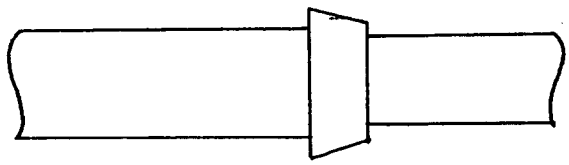


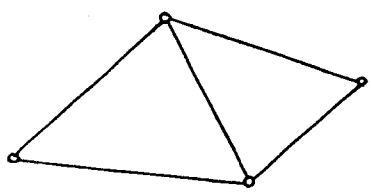
Figure 2 Junction node

관경이 변하는 곳도 Junction Node로 본다.



◦ Fixed grade node - 시스템내의 node중 압력수두와 표고가 기지(known)의 값인 node. 저수지나 storage tank와의 연결부 또는 일정한 압력하에 작용하고 있는 source 또는 discharge point. 한 시스템에는 한 개 이상의 FGN이 존재함.

◦ Primary loop - 폐합회로



◦ Number of pipe sections

$p = j + \ell + f - 1$

j=number of junction nodes

ℓ =number of primary loops

f=number of FGNs

데이터를 작성하기 전에 미리 pipe, junction node 그리고 fixed grade node에 번호와 부호를 붙여야만 한다. 그리고 위 방정식($p = j + \ell + f - 1$)이 성립하는지 확인하여야 한다.

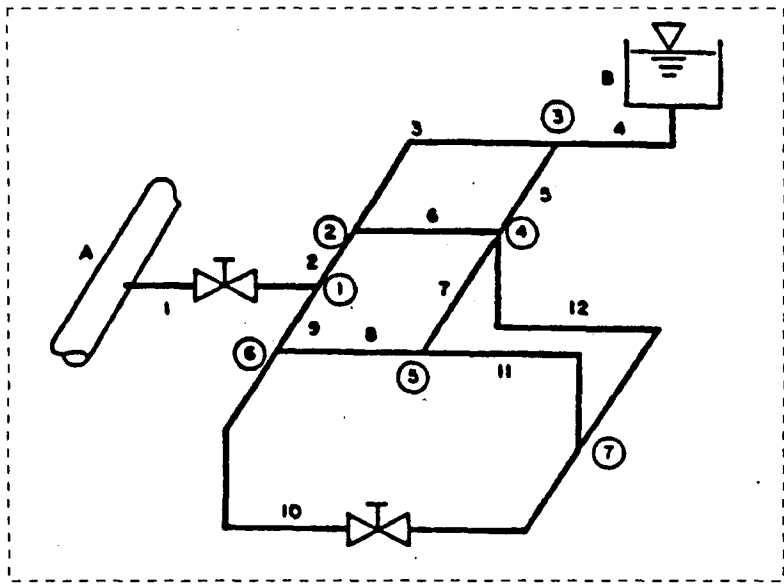


Figure 3 Geometric Relation Demonstration

p=12, j=7, ℓ =4 and f=2 (12=7+4+2-1)

1.2 Pipe System Components

1.2.1 Pipe Sections

각 관의 전체길이(Total length), 내부직경(inside dismeter), 관의 조도(Roughness)

Hazen-Williams equation

$$h_{LP} = \frac{10.675 L Q^{1.852}}{C^{1.852} D^{4.87}}$$

L(m), Q(CMS), D(m)

C : Hazen-Willams roughness facter

Darcy-Weisbach equation

$$h_{LP} = f \frac{L}{D} \frac{V^2}{2g}$$

1.2.2 Pumps

(1) Constant Power Pumps

유체가 펌프를 통과함으로써 얻게 되는 압력수두의 증가분을 일정한 유효동력(HP 또는 KW)으로 나타냄. 펌프의 특정 운영상태를 알 수 없는 경우의 기본설계나 해석에 유용하다.

Useful power $P = \gamma Q E_P$ ┌ $9.8QE_P$(KW)
├ $13.33QE_P$(HP)
└ $1000QE_P$(kg · m/sec)

(2) Head-Flow Data (3data points)

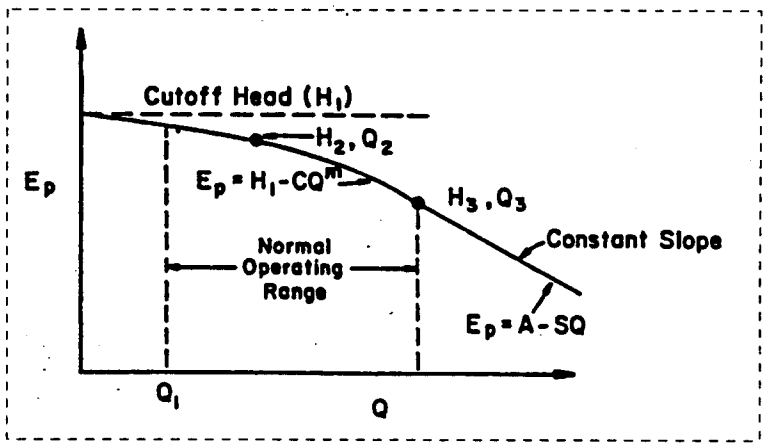


Figure 4 Pump Head Characteristic curve(펌프특성곡선)

KYPIPE가 C와 m을 결정한다.

위 공식 ($E_P = H_1 - CQ^m$)은 pump가 (H_1,0)~(H_3,Q_3)의 범위에서 운영될 때 잘 적용된다.

만약 계산도중 이 영역을 벗어나게 되면 KYPIPE는 다음과 같은 조치를 취하게 된다.

- 역류(flow reversal)가 발생하면 펌프앞에 check valve가 있는 것으로 가정한다.
- Q_3보다 큰 유량으로 펌프의 작동이 필요하다면 일단은 경고메세지를 주며, $Q=Q_3$ 지점에서의 slope로 직선을 그어 (E_P=A-SQ) A와 S를 결정해준다.

(3) Head-Flow Data (Multiple Data Points)

펌프특성곡선이 smooth하지 않다면 더 많은 data point가 필요하게 된다. 이 경우 KYPIPE는 현 운영유량(Q')에서 가까운 세점을 이용하여 2차 함수식을 세운다.

$$E_P = A + BQ + CQ^2$$

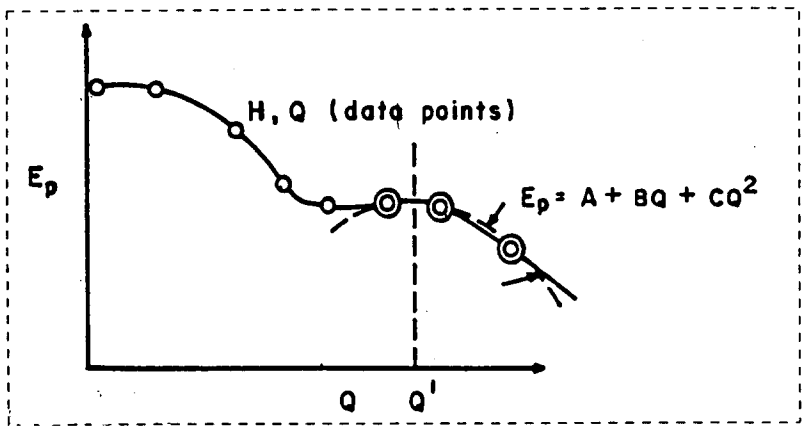


Figure 5 Head-Flow Data (Multiple Data Points)

(4) Variable Speed Pumps

$$n = \frac{N}{N_R} = \frac{\textit{actual pump speed}}{\textit{speed for which the data is applicable}}$$

$$E_P = H_1 - \frac{cn^2}{n^m} Q^m$$

variable speed pump를 사용함으로써 일정수두 또는 일정유량을 유지하는 상태로 펌프운영이 가능함.

펌프기능을 일정수두 유지로 봄 : FGN의 일정수두로 해석.

일정유량 유지로 봄 : junction node에 유입유량이 있는 것으로 해석.

1.2.3 Minor Loss Components

Valves, junctions, bends, meters 등에 의한 미소손실.

관마찰 손실에 비교해서 고려할 필요를 결정한다.

$$h_{LM} = \sum M \frac{V^2}{2g}$$

대개의 경우 M의 값은 상수로 처리하면 된다. 그러나 어떤 component에 대해서는 흐름의 상태에 따라 다른 M값을 주어야 할 경우도 있을 수 있다. 이 경우에는 펌프특성곡선의 data point에 head gain 대신 head loss로 하여 curve fitting해 주는 방법을 쓸 수 있다.

1.2.4 Check Valves

흐름을 특정한 방향으로만 가능케 하며 만약 역류가 발생시는 밸브가 닫히면서 흐름이 멈추게 된다. KYPIPE 계산상 converge에 더 많은 trials를 요하는 수가 있으므로 되도록 사용을 자제하는 것이 좋으며 KYPIPE 해석시에는 펌프에 역류가 안되는 것으로 가정되므로 사용할 필요가 없다. 밸브의 위치와 흐름방향을 input한다.

1.2.5 Regulating Valves

입력 - 밸브형태(valve type), 위치(location), 연결 관(connecting controlled pipe),
밸브 setting(normal-trottled, abnormal-wide open or closed)

① Pressure Regulating Valves(PRVs)

상류쪽보다는 낮은 압력으로 하류쪽의 압력을 일정하게 해준다.

② Pressure Sustaining Valves(PSVs)

상류쪽을 일정압력으로 유지시켜 준다.

③ Flow Control Valves(FCV)

하류쪽의 유량을 조절해준다.

1.2.6 Variable Pessure Supply

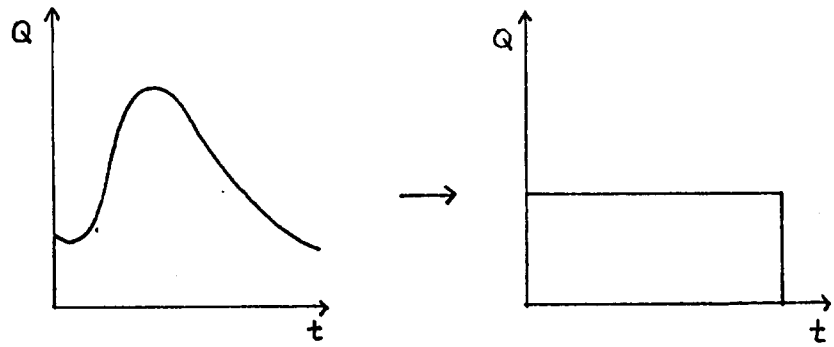
Supply point에서의 수압도 제공유량에 따라 변할 수도 있다. transmission main이 그 예.

만약 field test를 통해서 pressure-flow variation을 안다면 pseudo pump curve를 이용할 수 있을 것이다.

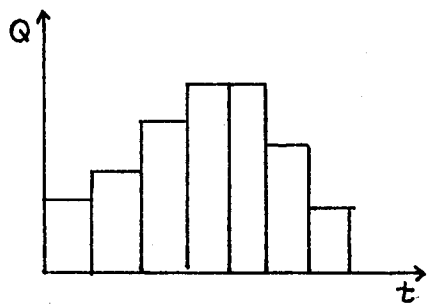
Flow Rate (gpm)	Pressure		Head	
	kg/㎠	psi	m	ft
0	4.92	70	49.2	161.5
1800	4.36	62	43.6	143.0
2500	3.73	53	37.3	122.3

※ EPS (Extended Priod Simulation)

Loading condition - a pattern of nodal damand

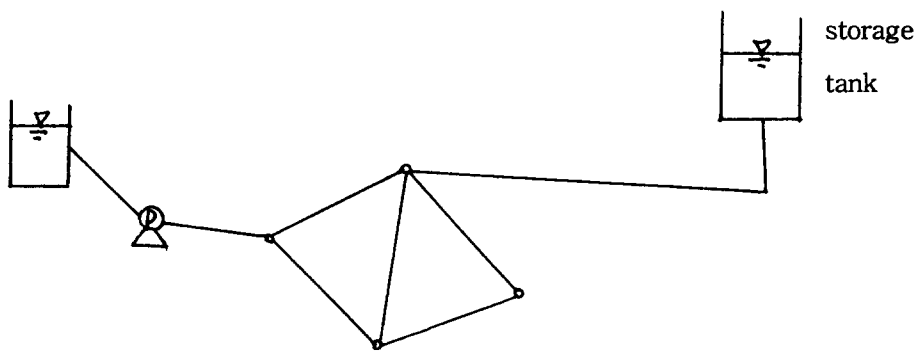


로 가정하기에는 무리



: multiple loading conditions

6 loadings in the case



* Single period analysis → tank level is fixed

* EPS → tank level changes from one period to the next.

1.2.7 Variable Level Storage tank(EPS)

입력 - 대표직경 (representative tank diameter)

최고수위 (maximum surface elevation)

최저수위 (minimum surface elevation)

EPS에서는 storage tank를 연결하는 pipeline에 check valve를 설치할 수 없다.

1.2.8 Flow Meter (EPS)

For EPS, flow meters can be designated for any pipe. these meters produce a tabulation of the total volume of flow passing through that pipe during the EPS.

1.3 Node & Loop Equations

1.3.1 Introduction

engineer ↔ doctor

length(given)

roughness(given)

flow(solve) — hydraulic

head (loss) (solve)

diameter → economic

branched system vs. looped system

(→system 내에 head가 고정된 곳은 한 곳뿐이고 loop가 없는 시스템)

* network flow 문제의 해석은 비선형 연립방정식의 해를 구하는 것이다.

1단계 : 미지수의 갯수와 같은 수의 방정식을 세운다.

The Flow(Q) Equations

The Node(H) Equations

The Loop(△Q) Equations

2단계 : 수치해석 절차를 거쳐서 연립방정식의 해를 구한다.

1.3.2 The Flow(Q) Equations

각 관을 통해 흐르는 유량을 미지수로 하고 관의 갯수와 같은 수의 방정식을 세우는 방법이다. 각 폐합회로마다 한개씩의 에너지방정식과 각 절점(node)에서 마다의 연속방정식을 세우면 이때 유량(Q)이 미지수이기 때문에 flow(Q) equations라 한다.

* 연속방정식(Node Equation)

$Q_{in} - Q_{out} = \underline{Q_e}$ (j equations)----------①

(→external inflow or demand)

* 에너지방정식(Loop Equation)

$\Sigma h_L = 0$; $= \underline{\Sigma E_P}$ (ℓ equations)----------②

(→pumping head, 펌프가 없으면 0)

$\underline{\triangle E} = \Sigma h_L - \Sigma E_P$ (f-1 equations)----------③

(→difference in HGL between two FGNs.)

②식은 ③식의 한 경우로 볼 수 있다.

따라서 ②식을 무시하고 ③식의 갯수를 (ℓ +f-1)로 볼 수 있다. 따라서 ①식과 ③식은 총 p개의 비선형 연립방정식을 형성한다. 물론 미지수는 p개의 Q이다.

$$h_P = h_{LP} + h_{LM} = K_P Q^n + K_M Q^2$$

$$K_P = \frac{10.675L}{C^{1.852}D^{4.87}} \quad \text{or} \quad \frac{8fL}{\pi^2 g D^5}$$

n=1.852, n=2

$$K_M = M\frac{1}{2gA^2} = 0.08265\frac{M}{D^4}$$

Pumping head $E_P = H_1 - CQ^m$: 펌프특성곡선

만약 input에 펌프동력(Pu)를 주게 되면 $\frac{P_u}{\gamma Q} \rightarrow E_P$ 와 같이 변환시킬 수 있다.

식③을 다시 쓰면

$$\triangle E = \Sigma(K_P Q^n + K_M Q^2) - \Sigma(H_1 - CQ^m) \text{----------④}$$

①식과 ④식은 p개의 비선형 연립방정식을 이룬다.

1.3.3 The Node(H) Equations

head loss $h_{Lij} = H_i - H_j = K_{ij} | Q_{ij} |^n sign Q_{ij}$

$$\therefore Q_{ij} = sign(H_i - H_j)\left(\frac{|H_i - H_j|}{K_{ij}}\right)^{1/n}$$

연속방정식(절점방정식) at node i

$$\sum_{k=1}^{m_i} Q_{ki} = Q_{ei}$$

Q_{ki} = flow into node i from node k

Q_{ei} = external demand at node i

m_i = number of pipes connected to node i

에너지방정식과 연속방정식을 결합

$$\sum_{k=1}^{mi} sign(H_k - H_i)\left(\frac{|H_K - H_i|}{K_{ki}}\right)^{1/n} = Q_{ei} \text{ (j equation)}$$

┌ j개의 미지수(H)
└ j개의 방정식 ↔ compared to p(=j+ ℓ +f-1)

1.3.4 The Loop(△Q) Equations

node equations와는 반대로 첫번째 해에 대해 연속방정식이 성립되도록 에너지방정식을 구성하는 방법. 이후로는 계속 연속방정식이 만족될 수 있도록 유량을 조절해 주게 되는데 이를 각 폐합회로의 각 관에서의 유량에 보정유량을 더해줌으로써 가능하다.

1.4 Numerical Solution Techniques

1.4.1 The Linear Theory Method

비선형 연립방정식을 선형화하여 해를 구한 후 이 해를 원래의 비선형 연립방정식에 대입하여 convergence를 확인하는 방법으로 비선형성이 그리 심하지 않은 flow equations에 주로 적용한다.

Q - Equations

- continuity equations → linear
- energy equations → nonlinear

$$h_L = kQ^h = kQ^{n-1}Q$$

※ KYPIPE에서는 약간 변형시켜서 simultaneous path(SP) method라고 함. 어떤 한 pipe section에서의 grade 차는 $f(Q) = k_P Q^n + k_n Q^2 - (H_1 - CQ^m)$

Q에 대한 approximate value를 Q_i라 한다면

$$f(Q_i) = H_i = k_P Q_i^n + k_n Q_i^2 - (H_1 - CQ_i^m)$$

Q=Q_i에서의 gradient

$$f'(Q_i) = G_i = \frac{\partial f}{\partial Q}\Big|_{Q=Q_i} = nk_p Q_i^{n-1} + 2k_n Q_i + mCQ_i^{m-1}$$

연립방정식내의 비선형에너지들을 각 관에서의 개략치 Q_i를 통해서 선형화되는데 이는 다음과 같은 approximation을 이용한다.

$$f(Q) = f(Q_i) + \frac{\partial f}{\partial Q}\Big|_{Q=Q_i}(Q - Q_i) = H_i + G_i(Q - Q_i) \text{ (taylor series)}$$

윗 식을 에너지방정식에 적용하면

$$\sum G_i Q = \sum (G_i Q_i - H_i) + \sum f(Q)$$

윗 식 (ℓ +f-1)개와 j개의 연속(절점)방정식이 p개의 선형 연립방정식을 이루어 p개의 미지수(각 관에서의 유량)에 대하여 해를 구하게 된다. 일단 임의의 유량에 대하여 선형 연립방정식을 세우고 해를 구한다. 이렇게 구해진 각 관에서의 유량set는 선형 연립방정식을 세우는데 Q_i로 쓰이고 두번째 해가 구해진다. 이 과정은 새로 계산되는 Q가 이전의 Q와 별차이를 보이지 않을 때까지 계속된다.

$$\varepsilon = \frac{|Q_i - Q|}{Q}$$ Q_i : 이전 것 Q : 이번 것

(relative accuracy) → default value = 0.005

보통 4-8 trials are required.⇒ KYPIPE, KYPIPE2, KYPIPE 2+, CYBERNET

1.4.2 The Newton-Raphson Method

각 방정식의 1차 미분항을 이용하여 해에 접근하는 방법으로 미지수와 방정식의 수는 줄었으나 모든 방정식이 비선형인 node equations에 주로 적용된다.

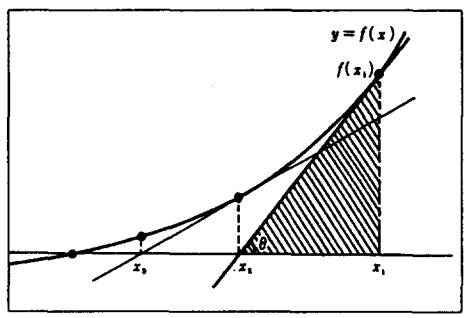
ex)WADISO

F(x)=0 의 해를 구한다 ⇔ F를 0으로 만드는 x를 구한다.

$$\frac{dF}{dx} = F'(x) = \frac{F(x+\triangle x) - F(x)}{\triangle x}$$

Given an initial estimate of x

구하는 해는 F가 0이 되도록하는 x+△x이다.



$$\therefore \triangle x = -\frac{F(x)}{F'(x)}$$

Figure 6 Newton-Raphson Method

$x_{new} = x_{old} + \triangle x$로 하여 $F(x_{new})$가 아직 0에 충분히 가깝지 않으면 위의 과정을 반복한다.

for each node(1 through k)

$$F(H_i) = \sum_{j=1}^{m_i} [sign(H_j - H_i)](\frac{|H_j - H_i|}{K_{ji}})^{1/n} - Q_{ei} = 0$$

연립방정식중의 어떤 F의 i번째 iteration에서의 값을 F(i)라 한다면 i번째와 (i+1)번째 iteration에서의 값의 차이는 $dF = F(i+1) - F(i)$

total derivative로 approximation을 하면

$$dF = \frac{\partial F}{\partial H_1} \triangle H_1 + \frac{\partial F}{\partial H_2} \triangle H_2 + \cdots + \frac{\partial F}{\partial H_k} \triangle H_k$$

여기서 △H는 i번째와 (i+1)번째 iteration에서의 H의 차. 따라서 F(i+1)=0으로 하는 △H를 구하면 된다. 즉

$$F(i+1) - F(i) = \frac{\partial F}{\partial H_1} \triangle H_1 + \frac{\partial F}{\partial H_2} \triangle H_2 + \cdots + \frac{\partial F}{\partial H_k} \triangle H_k$$

위와 같은 식 k개와 k개의 미지수(H)를 해석한다.

<계산과정>

1) 초기 H를 선정한다.
2) 각각의 H에 관한 F의 편미분항을 구한다.
3) 연립방정식의 해 H를 구한다.
4) 모든 F값이 0에 충분히 가까울 때까지 위 과정을 반복한다.
5) 최종 H가 구해졌으면 각 관에서의 Q를 구한다.

1.4.3 The Hardy-Cross Method

다른 두 방법에서 처럼 행렬식(matrix)의 해를 구하는 것이 아니고 한번에 식 하나씩을 반복해 계산하는 방법으로 Newton-Raphson방법을 식 하나씩에 적용하는 특별한 예로 볼 수 있다. 주로 loop equations에 주로 적용한다.

2. 입력자료의 준비 및 코딩

The pipe system data required to analyze a specific piping system is read from an Input Data File which you must create. The data consists of the Original Data which describes the physical characteristics of the pipe system and the initial conditions which apply to the first analysis. To this data you can add 'Change Data' which defines one or more changes in the physical characteristics or operating conditions for additional analyses during a single computer run. As many sets of changes as desired (up to dimensional limit) can be incorporated into the data file. For extended period simulation (EPS), additional EPS Data is required and the changes are defined for specified times throughout the simulation period.

An Input Data File can be created by several means, e.g. word-processing or text editors, provided the data are arranged according to these instructions. For your convenience, however, a special purpose data input-editing program(PIPEDATA), accessed from the KYPIPE Menu is provided. This program uses data screens accessed from a control menu and features cursor controlled full screen data entry and editing.

To get started type KY2 (or GO) and the following KYPIPE Menu appears:

```
****** KYPIPE (Short Course) MENU *******

Name of the Current File is:  c:\ky2\data\EX4

 (1) KYPIPE      - (Network Analysis)
 (2) PIPEDATA    - (Data Entry - Editing)
 (3) PIPEVIEW    - (Screen Graphic Displays)
 (4) PIPEPLOT    - (CAD Graphics)
 (5) RPP         - (Enhance Results Presentation)
 (6)  PLOTXY     - (Produce Graphic Plots)
 (7)  PROFILE    - (Produce Profile Plots)
 (8) KYHYD       - (Fire Hydrant Rating)
 (9) KYFSI       - (Flow Source Identification - Age)

 (C) CHANGE      - (Change Current File Name)
 (V) VIEW        - (View Results on Screen)
 (P) PRINT       - (Print Results Using Printer)
 (S) SHOWGRAF    - (Show Graphic Displays Previously Generated)
 (H) HELP        - (Review KYPIPE Help Information)
 (D) DELFILE     - (Delete Current OUT and RES  Files)
 (X) EXIT        - (Exit to DOS)

         Enter Choice      (1-9, C,V,P,S,H,D or X)
```

PIPEDATA is the data entry-editing program for KYPIPE. This program allows easy access to the various data items for creating and editing Input Data Files. Type 2 to access PIPEDATA and the following PIPEDATA Control Menu appears.

```
                PIPEDATA  -  MAIN MENU
-------------------------------------------------------------------------------

        Current Data File - EX4.DAT


  Load a Data File
  Edit KYPIPE Input Data
  Edit Geometric Data
  Check the Current Data File for Errors
  Save KYPIPE Data File
  Save KYPIPE Data File with GEO file
  Save As...
  Quit


Arrow keys move cursor, ENTER selects an item
```

To edit input data position the cursor above 'Edit KYPIPE Input Data' and type ENTER. Then the KYPIPE DATA MENU screen appears.

```
              KYPIPE DATA MENU
-------------------------------------------------------------------------------

Filename [EX4.DAT]                          Simulation Type: EPS

 1) SYSTEM DATA
 2) CONSTRAINT DATA
 3) LABEL
 4) RV DATA
 5) PIPELINE DATA
 7) JUNCTION DATA
 8) OUTPUT OPTION DATA
 9) PIPES FOR LIMITED OUTPUT
10) JUNCTION NODES FOR LIMITED OUTPUT
11) EPS DATA
12) TANK DATA
13) FLOW METER DATA
14) PRESSURE SWITCH DATA
15) CHANGES


Arrow keys move cursor, ENTER selects an item, R) returns to previous menu
```

2.1 Data (Extended Period Simulation)

The schematic for this system is shown in figure 7. It represents a pump fed municipal water distribution system with three elevated storage tanks and two supply pumps. One pump has two service levels which are represented by two pumps in parallel, with only one operating at any one time. Altogether there are 28 pipes in the system, with 16 junction nodes, six fixed grade nodes and seven primary loops. English units are employed with flowrate expressed in MGD(million gallons/day). Data for the pipe and node characteristics are summarized in TABLE 1

2.1.1 Simulation Period - Demand Pattern

For the particular case being illustrated, an extended period simulation covering a period of 24 hours with calculations every two hours is required. The steady demand on the system is varied using a global demand factor shown below which is applied to all except two nodes(12 and 16) where the demands are assumed to remain constant. These nodes are assigned a demand type two. No changes are defined for the global damand factor for the type two damands(GDF2) so this term defaults to 1.0. This will result in the damands at nodes 12 and 16 remaing fixed for the entire simulation period.

Time	Global Demand Factor
0	1.00 (average demand)
2	1.30
4	1.54
6	1.58 (peak demand)
8	1.55
10	1.46
12	1.20
14	0.85
16	0.65
18	0.55 (slack demand)
20	0.57
22	0.75
24	1.00 (average demand)

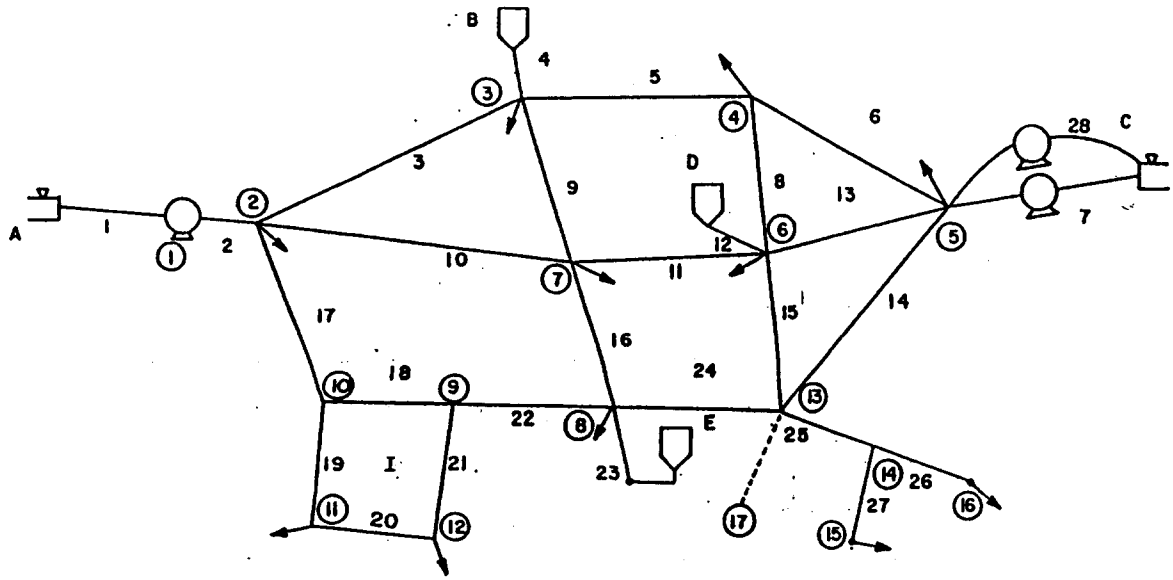


Figure 7 Example 4 - Twenty Eight Pipe System - EPS

TABLE 1 Pipe Distribution System Characteristics

Junction Number	Demend(MGD)	Elevation(ft)	Connecting Pipes	Title
1	0.00	90	1 2	
2	1.00	110	2 3 10 17	Main St.
3	1.00	95	3 4 5 9	
4	3.00	105	5 6 8	
5	1.00	100	6 7 13 14 28	
6	3.50	103	8 11 12 13 15	Bank Tower
7	3.00	97	9 10 11 16	
8	1.50	103	16 22 23 24	Fire Dept.
9	0.00	107	18 21 22	
10	0.00	112	17 18 19	
11	0.50	115	19 20	Lakeview Rd
12	0.50	112	20 21	
13	0.00	110	14 15 24 25	
14	0.00	120	25 26 27	
15	0.25	135	27	East Mall
16	0.25	130	26	Central Hos

TABLE 1 Pipe Distribution System Characteristics(Continue)

Pipe Number	Node# 1	Node# 2	Length(ft)	Diameter(in)	Roughness Coefficient	Minor Loss Coefficient	Fixed Grade(ft)
1	0	1	2000	20	98	0	100
2	1	2	800	18	98	0	
3	2	3	5000	16	97	0	
4	3	0	700	10	94	0	270
5	3	4	3700	12	96	0	
6	5	4	3900	15	97	0	
7	0	5	2100	16	97	0	120
8	6	4	2500	10	94	0	
9	3	7	3100	10	94	0	
10	2	7	5500	15	97	0	
11	6	7	3700	12	96	0	
12	0	6	900	8	93	0	270
13	5	6	2900	12	96	0	
14	5	13	4500	15	97	0	
15	6	13	2500	10	94	0	
16	7	8	2700	10	94	0	
17	2	10	3100	12	96	0	
18	10	90	1900	12	96	0	
19	10	11	1600	8	93	0	
20	11	12	1500	6	91	0	
21	9	12	1650	8	93	0	
22	8	9	2900	8	93	0	
23	0	8	1900	12	96	7	270
24	13	8	3100	12	96	0	
25	13	14	1600	8	93	0	
26	14	16	1750	6	91	0	
27	14	15	1500	6	91	0	
28	0	5	2100	16	97	0	120

2.1.2 Pump Data

The pump head(ft) - flow(MGD) data for the three pumps is as follows:

Pipe	H_C	H_2	Q_2	H_3	Q_3
1	270	240	8	195	10
7	250	225	8	195	10
28	300	275	8	240	12

2.1.3 Variable Level Storage Tanks

The elevated storage tanks have a constant diameter of 60 feet and the level ranges from an elevation of 240 to 270 feet. They are assuumed to be initially full following a period of slack demand and their levels will be monitored. The data required to describe the tanks is as follows:

Pipe No.	Max. El.	Min. El.	Diam.	Capacity	Ext.Flow
4	270	240	60	634,500	0
12	270	240	60	634,500	0
23	270	240	60	634,500	0

The initial tank levels are set at 270ft. (full) in the original data as the HGL values for the FGN's specified for pipes 4, 12 and 23. The capacities (in gallons) are based on a 30ft. high × 60ft. diameter tank.

In order to illustrate the procedure for handling a variable area tank, the tank connecting line 23 is coded as a variable area tank with four intermediate depth-capacity ratios defined as shown.

D/D_M	V/V_M
0.2	0.2
0.4	0.4
0.6	0.6
0.8	0.8

The linear relationship indicates that the tank has a constant cross-sectional area. This same procedure will handle tanks of any shape.

2.1.4 Pressure Switches

The high service pump in line 28 is incorporated into the analysis and is controlled by a pressure switch at the network low pressure node (junction node 15 - elevation = 135 ft). This pump is turned on if the hydraulic grade line (HGL) at junction node 15 falls below 197ft (pressure head = 62ft) and remains in service until the HGL exceeds 226ft (pressure head = 91ft). Initially with all tanks full the low service pump is operating.

Two pressure switches are required to control the operation of the high and low service pumps. The first switch controlling the low service pump is a type 2 because the pipe (pump) will be open (on) if the HGL at node 15 is above the switching grade. This pump is initially on and the first switching grade is set at 197ft. The second switch controlling the high service pump is a type 1 because the pump will be off when the HGL at node 15 is above the switching grade. This pump is initially off (pipe 28 closed in original data) and the first switching grade is set at 197ft. The required data is summarized below.

Pipe No.	Node No.	Switch Type	1st Switching grade(ft)	2nd Switching grade(ft)
7	15	2	197	226
28	15	1	197	226

Note the initial open-closed status of line 7 is open and line 28 is closed (low service pump on) and this situation will reverse if the HGL at node 15 drops below 197ft

2.1.5 Other Data Features

The data is entered as usual accessing the PIPEDATA data screens. Since this is a time (EPS) simulation the simulation key is toggled to EPS. Flow units are toggled to give MGD.

Initially the file may be set up to output only a Data Summary and hence option *1* is selected. The option to limit the output is illustrated in this example by limiting tabulated output to results for pipes 10 and 20 and to node 11, 15 and 16 for junction nodes. This is done with the following data:

number of pipes for output : 2
pipe numbers : 10, 20
number of junctions for output : 3
node number : 11, 15, 16

2.2 System Data

Type 1 to access System Data on the screen of KYPIPE DATA MENU and the following System Data Menu appears:

```
                              1 SYSTEM DATA
--------------------------------------------------------------------------------
                Simulation Type: EPS *
Number of Pressure Constraints:  0 *
                     Flow Units: MGD *
                Number of Pipes:  28
      Number of Junction Nodes: ( 16 ) **
                   Number of RVs:  0
   Analysis or Data Check Only: Analysis *
    Supress Input Data Summary: No *
        Geometric Verification: No *
      Maximum Number of Trials:  20
              Relative Accuracy:  .005
               Specific Gravity:  1
Kinematic Viscosity (DW or HW): Hazen-Williams *
          Print Junction Labels: Yes *
                  Pipe Numbering: Non-Consecutive *

Arrow keys move cursor, ENTER toggles * items or selects a default value
R) returns to previous menu
** Number of Junction Nodes is set automatically
```

Move the cursor up or down to select the desired data screen.

1st line - simulation type key : regular simulation or EPS.

2nd line - number of pressure constraints specified

3rd line - flow units identification key : CFS, GMP, MGD, L/S, CMS

4th line - number of pipe.

5th line - number of junction nodes.

6th line - number of regulating valves.

7th line - data check : to check and print an input data summary but not carry out the analysis. Default is to carry out the analysis.

8th line - suppress input data summary : to suppress the input data summary. Default is to print the summary.

9th line - geometry verification option : to check the consistency of pipe and junction connections in the junction data with pipe and junction connections in the pipeline data. Default is not to perform geometric verification.

10th line - maximun number of trials allowed : If this is omitted a default value of 40 is used.

11th line - relative accuracy : If this is omitted a default value of 0.005 is used.

12th line - specific gravity of the liquid : If this is omitted water the default value of 1.0 is assumed.

13th line - kinematic viscosity of the liquid, ft^2/s : this input keys the use of Darcy-Weisbach head loss equation. Defaults to the used of the Hazen-Williams head loss equation if not input.

14th line - to print junction titles in tabulated output. Default is not to print junction titles.

15th line - the use of non consecutive pipe numbering : If this is used the pipe numbers must be input with the PIPELINE DATA. If this option is not used, the pipes are automaticlly numbered consecutive ascending order.

A return to the Control Menu is accomplished by typing R.

2.3 Constraint Data

Parameter type key : 1 - Pump Speed

2 - Pump Power

3 - HGL setting for FGN

4 - HGL setting (regulating valve)

5 - Valve setting (loss coefficient)

6 - Diameter

7 - Roughness*

8 - Demand*

Enter with a negative (-) sign to key a global facter for roughness(-7) or demand(-8). Constraint numbers for pipes or nodes are not required but can be used to override this option.

Subsequent data for pipes and junctions is required to identify the specific pipes and junctions which are associated with each constraint. This data refers to the above data using the constraint number which is the order in which this data is entered.

2.4 Pipeline Data

To access the PIPELINE DATA, position the cursor above '5) PIPELINE DATA' and enter. The data screen below will appear.

```
Status*  Node1  Node2 Length   Diam.   Rough.  M Loss Pump*  Grade    CD  Number
-------------------------------------------------------------------------------
Open     0      1     2000     20      98      0      [-1]   100      0   1
HC 270     H2 240      Q2 8        H3 195      Q3 10        ID 0  AD 0 N 0
Open     1      2     800      18      98      0      0      -----    0   2
Open     2      3     5000     16      97      0      0      -----    0   3
Open     3      0     700      10      94      0      0      270      0   4
Open     3      4     3700     12      96      0      0      -----    0   5
Open     5      4     3900     15      97      0      0      -----    0   6
Open     0      5     2100     16      97      0      [-1]   120      0   7
HC 250     H2 225      Q2 8        H3 195      Q3 10        ID 0  AD 0 N 0
Open     6      4     2500     10      94      0      0      -----    0   8
Open     3      7     3100     10      94      0      0      -----    0   9
Open     2      7     5500     15      97      0      0      -----    0   10
Open     7      6     3700     12      96      0      0      -----    0   11
Open     0      6     900      8       93      0      0      270      1   12
Open     5      6     2900     12      96      0      0      -----    0   13

Arrow keys move cursor, R) return to previous menu, D) erases a line
Pipe Numbers do not have to be in order but they can not be duplicated.
T) toggels * items, ENTER accepts current values, CD - Constraint Data
Enter zero to set Diameters and Roughnesses to default values.
```

Data items appearing on this screen are accessed by positioning the cursor on the first digit of the data item. You can move the cursor with the four arrow keys. A new or edited value for that data item may then be typed in and entered by depressing the Enter key. Do not use the space bar to move to the next item. You should review the information presented at the bottom of each data screen.

2.5 Junction Data

One data line is required for each junction node selected for data input. Only data for junction nodes with an external demand must be provided. Others are optional. Results for HGL may be output for all junction nodes, but pressures and pressure heads will be output only for junction nodes with elevations input. The order that the junction data is input is arbitrary but input in ascending numerical order is recommended.

```
Dmnd.  Elev.     Num.  Dtype  Constraint Data
-------------------------------------------------------------------------------
 0      90        1      1    0
 1      110       2      1    0
 1      95        3      1    0
 3      105       4      1    0
 1      100       5      1    0
 3.5    103       6      1    0
 3      97        7      1    0
 1.5    103       8      1    0
 0      107       9      1    0
 0      112       10     1    0
 .5     115       11     1    0
 .5     112       12     2    0
 0      110       13     1    0
 0      120       14     1    0
 .25    135       15     1    0
 .25    130       16     2    0

Arrow keys move cursor, D) Delete/Undelete, R) return to previous menu
You have elected not to have geometric verification. To change this select item
1 on the MAIN EDIT MENU then return to this menu and enter connecting pipe data.
```

2.6 EPS Data

To access the EPS DATA position the cursor above '11) EPS DATA' and enter. The data screen below will appear.

```
                                11  EPS DATA
-------------------------------------------------------------------------------
                          Total Time for EPS:  24
                          Normal Time Period:  2
                             Number of Tanks:  3
                Number of Pipes with Flow Meters:  6
                     Number of Pressure Switches:  2


Arrow keys move cursor, R) returns to previous menu
```

Total Time for EPS : hrs

Normal Time Period : hrs

Number of Pressure Switches : pipes with open-closed status controlled by the HGL at specified junction node.

2.7 Tank Data

Conec. Pipe - Pipe number connecting tank.

Max Elev. - maximun surface elevation, ft or m.

Min Elev. - minimum surface elevation, fk or m.

Tank Diam/Vol - tank diameter, ft (m) or tank capacity if variable area tank is specified, ft^3 (m^3) or gallons (liters).

Ext. Flow - inflow from external source to tank at initiation of EPS
- in flow units specified for problem (+ into tank, - out of tank).

Add. Data - tank type key:blank (default) - constant diameter n
- number of data points to define variable area tank
(requires additional data as specified below).

2.8 Pressure Swith Data

Pipe Number - reference pipe number.
(pipe with open-closed status controlled by this switch)

Junction Num. - reference junction node number.
(HGL at this node is compared to switching grade)

Switch Type - switch type:
one (1) will close reference pipe if HGL at reference node exceeds switching grade, two (2) will open reference pipe if HGL at reference node exceeds switching grade, three (3) will close reference pipe if reference HGL is between switching grades and four (4) will open reference pipe if reference HGL is between switching grades.

1st Switch Grd - grade (HGL) for which first switch will occur, (ft or m).
This switching grade is the one utilized at the initiation of the EPS (time=0).

2nd Switch Grd - grade (HGL) for which second switch will occur, (ft or m).
If this data is omitted the same value used for first switching grade will be employed.

2.9 Change Data

Changes handled with PIPEDATA as follows. The CHANGES data screen (15) is first accessed. The number of changes defined will appear as shown on Figure 8. Changes can be defined, inserted (I) or deleted (D) on this screen. The cursor is then positioned adjacent to the change number to access the data associated with a particular change which produces Figure 9. With the exception of the stared items the data displayed can be entered on this screen. The first two entries require you to input the number of each of these items you wish to change. After this number is entered position the cursor beside the number and depress Enter and you will access a data screen for the additional data required. In the same manner, positioning the cursor on the left of the starred(*) data change items accesses the data entry screen for each type of these data changes as depicted on Figure 10 for Other Pipe Parameter Changes. As much data as desired can be entered for each of these. The total number of the various types of data changes then automatically appears on Figure 9 and is altered only by adding or deleting data on the starred data changes.

Note that changes for the HGL of pipes connected to FGN's are handled using a separate data screen.

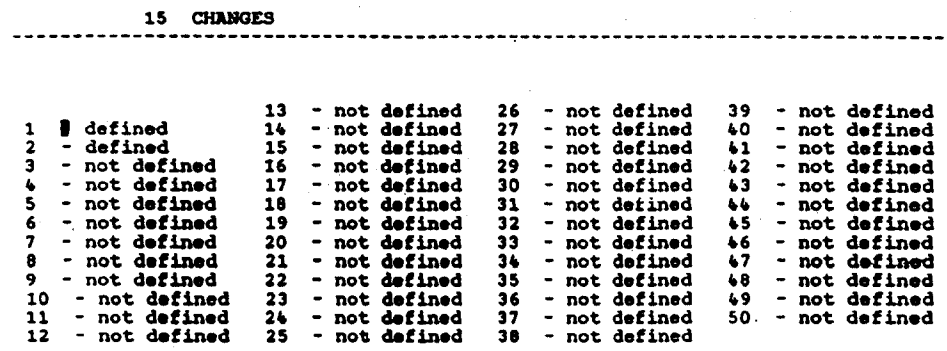


Figure 8 Change screen

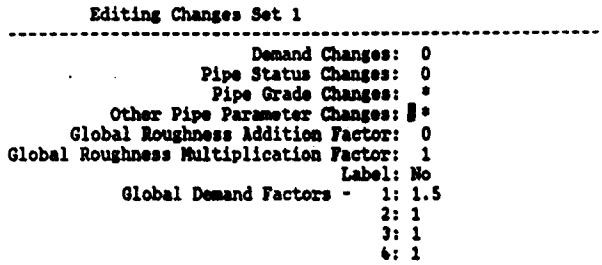


Figure 9 Editing Change Set screen

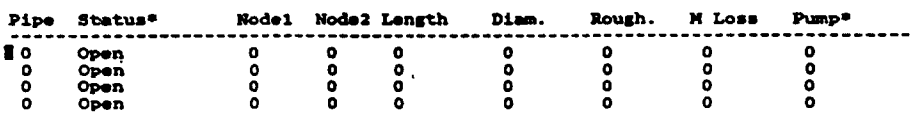


Figure 10 Other Pipe Parameter Changes screen

Depress R to return to the previous menu. You can depress R until the Main Edit appears.

3. 결과의 분석

The discussion so far have concentrated on creating and editing data files for networks and on performing both steady state and extended period time simulations of the hydraulic behavior of complex pipe systems. This can lead to the generation of a large volume of tabulated data. For many applications assimilation and presentation of this data is considerably improved by displaying selected parts of it in graphical or re-arranged tabular format.

The section of the Manual describes in detail how the presentation of enhanced results can be achieved using the PIPEVIEW, RPP, PLOTXY and PROFILE programs accessed from the KYPIPE menu. To help illustrate these features reference will be made to Example No.4.

3.1 Creation of Geometric Data Files

Before using PIPEDATA to create a Geometric Data File for a specific system a scaled schematic of the network from which coordinates can be measured must be prepared. Any convenient x-y coordinate system can be used. For large metropolitan water supply system, for example, the coordinates may be the distances in miles or kilometers east and north from a convenient reference point. For a building fire sprinkler system, inches or centimeter distances from a working drawing might be used.

If available, a digitizer should be employed to determine the coordinates.

Also labels should be assigned to FGN's, pumps and pressure regulators. The following guidelines apply:

Tanks (FGN) - single letter

Reservoirs (FGN) - double letter (do not use R for the first letter)

Pressure Regulators - double letter starting with R

Pump - P followed by a single or double digit number

Note all FGN should be assigned either a single or double letter label.

The coordinates tabulated for Example 4 follow:

Junction Node No.	x coordinate	y coordinate
1	1.45	3.75
2	2.1	3.65
3	4.4	4.7
4	6.45	4.75
5	8.2	3.75
6	6.55	3.35
7	4.85	3.3
8	5.25	1.9
9	3.8	2.0
10	2.7	2.0
11	2.6	0.9
12	3.65	0.75
13	6.7	1.9
14	7.6	1.55
15	7.4	0.7
16	8.45	2.2

FGN in Line No.	ID Label	Coordinates		Elevation of Pipe Connection
		x	y	
1	AA	0.3	3.85	90
4	B	4.3	5.2	95
7	CC	10.0	4.0	100
12	D	6.05	3.6	103
23	E	5.75	1.35	103
28	CC	10.0	4.0	100

Pump No.	In Line No.	Coordinates		Elevation of Pipe Connection
		x	y	
P1	1	1.45	3.75	90
P2	7	9.05	3.7	100
P3	28	9.05	4.3	100

Having now collected all the additional data required to create the Geometric Data File you now ready to access PIPEDATA and enter this data. First load the data file EX4.DAT. Then select the operation, 'Edit Geometric Data', from the PIPEDATA Main Menu. The Geometric Data Menu below will appear:

```
                GEOMETRIC DATA MENU
--------------------------------------------------------------------------------

Filename [EX4.DAT]

  Junction Node Data
  Fixed Grade Node Data
  RV Data
  Pump Data
  Junction Titles
  Pipe and Fixed Grade Node Titles      (label Fixed Grade Nodes first)
  Pump Titles                           (label Pumps first)
  Incorporate a Node Data File          (label FGN's and Pumps first)


Arrow keys move cursor, ENTER selects an item, R) return to MAIN MENU
```

Select the first four items (skip PRV and or Pump Data if your network does not contain these elements). Provide the data missing on each of the data screens. To clarify this procedure these screens are shown on the next page after the additional data is provided.

After the data is entered return to the main PIPEDATA menu and select Save KYPIPE Data File with GEO file. A Geometric Data File with a .GEO extension will be automatically generated. This file may now be used with PIPEVIEW (PIPEPLOT), RPP and PROFILE as described in the next section.

3.2 PIPEVIEW - Schematic Layouts of Pipe Systems

The purpose of this program is to graphically display pipe network configurations and the results of the hydraulic analysis can be displayed in several ways.

System pressure, flow velocities and losses per 1000 units of pipe length (feet or meters) can be displayed on a schematic of the network. This is accomplished by emphasizing values above or below a selected value as dotted lines on the schematic. If, for example, all pressures below 50 psig are emphasized, all pipes (or parts thereof) in the network where pressure below 50 psig occur wll be shown as dotted lines, and the rest will appear as solid lines. Individual pipes can be emphsized as well as all pipes of given sizes or roughness. In addition, contour lines for pressure, elevations and hydraulic grades can be produced.

Another principal feature of the program is that the entire pipe network or any portion of it can be displayed on the screen, together with the appropriate contour lines and emphasized.

3.2.1 Setting Up the Plot - The Plot Status Menu

Using Example 4 again, the program features are now illustrated. Note that before using the graphical display features, the DOS utility, GRAPHICS.COM, should be loaded from the DOS of your computer.

With the Main Screen Menu displayed, enter 3, for PIPEVIEW, and press Enter. If the Current File is defined you will automatically load the .GEO file and directly access the PIPEVIEW Plot Status Menu as described below. If no Current File is defined you will have to go through a set up routine. In this case the following information and prompt will apper. Proceed as follows in response to the screen prompts.

**** PIPEVIEW Version 4.00 ****
Plotted results of pipe network hydraulic analysis results
Copyright by W.D.Wood, D.J.Wood, and W.Gilbert, Lexington, Ky. 1991
Updated - 8/30/91 (1000 pipes - 1000 Nodes)

Portions Copyrighted by Microsoft Corporation 1984-1990

>>>>>>>>>> No Current File is defined

```
For user responces use upper case letters - DEPRESS CAPS LOCK

   If you want printed copies of the plot using the graphics printer
then you must load GRAPHICS from the DOS disk before requesting a screen
dump of the graphic display (depress Prt Sc). If you have not loaded
GRAPHICS exit now to DOS and do so.
Geometric data file = ?
```

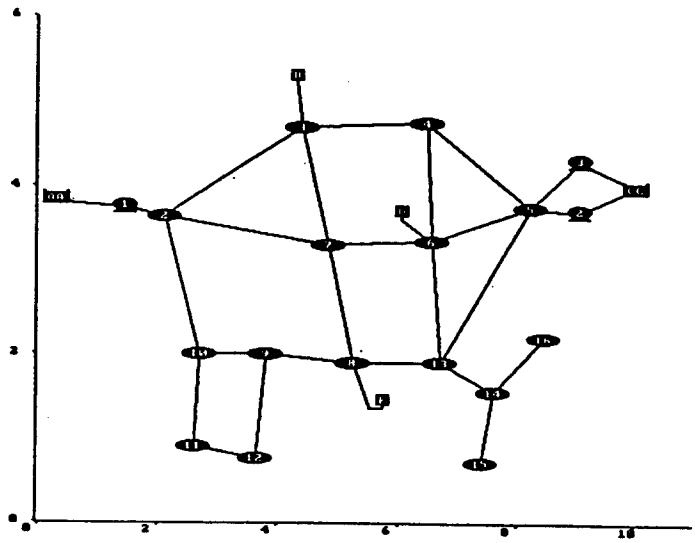
Note that upper case letters should be used for all responses to prompts. Having entered (or defaulted to) the Geometric Data File name and pressed Enter the following Plot Status Menu (PSM) will appear on the screen.

```
          Geometric Data File Name - EX4.GEO

A - Current Area ( 0, 0 ) - ( 11, 6 )
B - Division:  1hor.  By  1ver.
C - Plot Section: ( 1, 1 )

D - Large Symbols
E - Print Coordinates on Axes
F - No Dots on Plot Borders
G - Plot Title: None
H - Hi-Res VGA 16-color (154K)

I - No Contour Data has been Generated
J - Number of Contours presently Defined: 0
K - No Contours to be Plotted
L - Unlabeled Contours

M - No Results File has been Loaded
N - No Emphasis (Velocity, Pressure, HL/1000)
O - No Flow Direction Arrows

  Type A-O to change parameters, Q to quit
  Type P to plot (S-Stop  C-Capture Plot  B-Convert to CGA (Black & White)
```

The PSM offers you a variety of operations which are implemented by typing the letter noted on the left. Certain operations will require additional input to responses which will appear on the PROMPT line noted. The PSM groups operations with similar objectives.

Operations A-C control the selection of the region of the network to be displayed. Operations D-H control the appearance and characteristics of the plot (title, symbols, coordinates, screen type, color, screen, etc.). Operation I-L are associated with contour plotting. Operation M-O define the specific results set and parameters to be displayed.

Read through the PSM, then type P and you will be rewarded by the graphical representation of the network shown below.



3.2.1 Plot section and Appearance

The intial plot is quite a good, full screen, view, which fits the network into the screen display. This may cause some scaling distortion of the network which we can eliminate. Consider the following:

(a) can we compress or expand the plot a bit (change the scales)?

(b) do we need the axes plotted?

(c) can we add a title?

Type S, to get back to the plot Status Menu (PSM).

At the top of the PSM, the minimum x, y and maximum x, y values defining the coordinate limits on the display are shown as being 0, 0 and 11, 6 respectively.

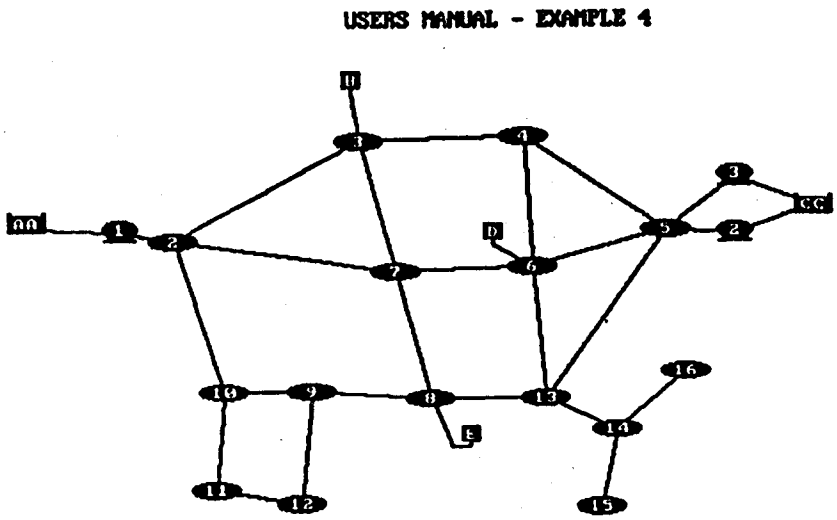
Press A, and at the bottom of the screen (on the prompt line) you will see a request for new values of Xlo, Xhi, Ylo, Yhi. Try entering 0,12 - 2,8 and press Return. The top line will now read A - Current Area (0,2)-(12,8).

Now press E. The menu will disappear and then re-appear with line 5 reading "E-No coordinates noted on plots".

Finally, press G, and at the bottom of the screen (on the prompt line) a prompt will appear requsting a title for the plot. Enter, for example, USERS MANUAL - EXAMPLE 4, press Enter which will again cause the revised PSM to be reprinted on the screen.

Pressing P will display the network again, as shown below.

The plot is now compressed vertically on the screen and more closely represents the scaled schematic. Also the plot has no coordinate axes, and includes a title. The plot can be copied to the printer by converting it to Black-White (depress B) and keying in pritSc.



Now consider the other display options available on the PSM. So far, A, E and G have been demonstrated. Consider D, selection and size of the symbols used.

The symbols for nodes and pumps have so far been large ones containing the relevant identification number or letter. Press D and you will be asked if you wish to retain specific large symbols. Answer, for example, Y(es) and in response to the prompts enter B, D, and E. Now only the tanks will be labeled. If at this point you had said you wanted no large symbols, only small ones without any identification numbers or letters will appear on the schematic plot. This will remove much of the screen clutter and allow better presentation of contours,, etc. Press P to produce and review the plot and S to return to the plot Status Menu.

The diagram above is of the entire system. You can, however, view an enlarge form, by sections by using Options B and C. Option B enables you to sub-divide the complete diagram into sections as shown below - note the numbering.

1, 2	2, 2
1, 1	2, 1

1, 2	2, 2	2, 3
1, 1	2, 1	3, 1

Numbering Scheme for Sections

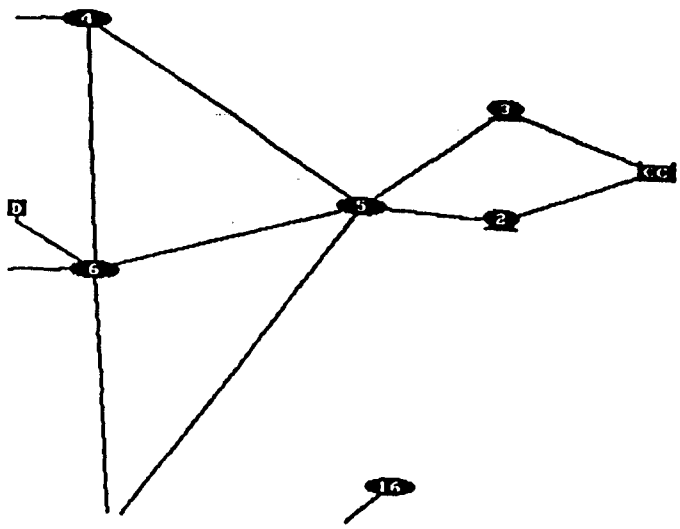
Suppose, for now, we just wish to divide the network into quarters. Press B. and in response to the prompt, enter 2 horizontal divisions, 2 vertical (as shown below) and press Enter.

Now press C, whereupon you are asked - Do you want to plot all sections? If you answer Y(es) you will be led through all the enlargements, but suppose you are interested only in the upper right hand quadrant of the diagram. Key in N(o) and the next prompt is - Plot which section (x, y)? Enter 2, 2 (as shown below) and press Enter which takes you back to the PSM.

Prompt for B:
Input horizontal (X) and vertical (Y) divisions? 2,2

Prompt for C:
Do you want to plot all sections? (type N)
Plot which section (X,Y)? 2,2

Finally, press P again to view the plot you have set up.



Large scale network plots of good resolution may be produced by plotting the network in sections as demonstrated and printing all the sections. These may then be attached to produce a single schematic of the entire network.

Type S to return to the PSM. To get back to being able to view the entire system press B and Enter to activate the default of one section. This automatically resets Option C and you will display the entire network as a single section.

An alternative strategy to zoom in on a specific feature, e.g. details of interconnections associated with a pumping station, is to use Option A to define the x-y coordinates of a 'box' containing the section of interest.

3.2.2 Network Data Emphasis

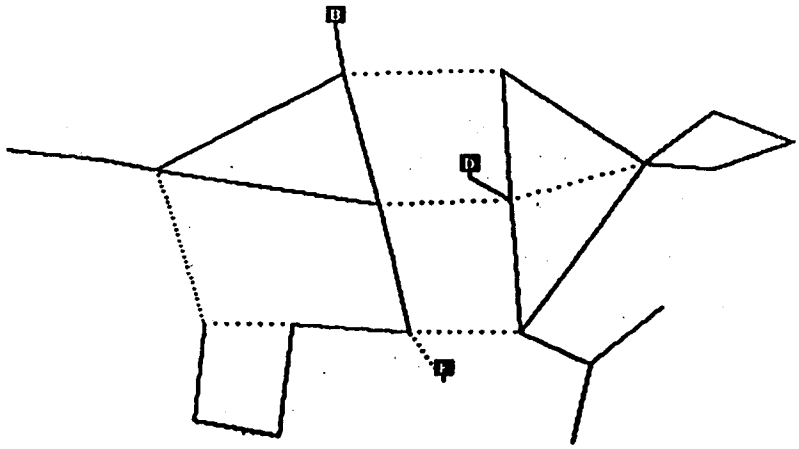
Now press N, which is the Emphasis Option, and a new menu will appear, as shown below.

```
1 - No Emphasis
2 - Emphasize High Pressures
3 - Emphasize Low Pressures
4 - Emphasize High Velocities
5 - Emphasize Low Velocities
6 - Emphasize High Head Loss
7 - Emphasize Low Head Loss
8 - Emphasize Diameters
9 - Emphasize Roughness
10 - Emphasize Certain Pipes

Select Option (1- 10 ) ? 8
Minimum Emphasis Value? 11.9
Maximum Emphasis Value? 12.1
```

The menu indicates the network parameters that can be emphasized, however, at present on Results Data File has been loaded, only the Geometric Data File. therefore only the Options 8, 9 and 10 are usable.

Assume we wish to emphasize all of 12 in. diameter pipes. Select Option 8. It is now necessary to bracket the required 12 in. size by a Minimum Emphasis Value (say 11.9 in.) and a Maximum Emphasis Value (say 12.1 in.).

Enter these values as shown below. This also depicts the use of selected node labeling as previously discussed, and only the tank labels are displayed on the plot.



3.2.3 Plots Depicting Hydraulic Analysis Results

A number of additional graphical displays can be created which depict various results for a specific hydraulic analysis. These displays are very useful for evaluating network performance and utilize the information stored in a Results Data File.

PIPEVIEW can highlight individual pipes with high or low velocities, pressures, or head losses and can provide contour lines of pressure heads, hydraulic grades and elevation. To do this requires loading a Results File created by KYPIPE. For Example 4 you created EX4.RES which will be used in the following demonstration.

To load this file into memory, type M (from the PSM) and in response to the request for the Results File Name default to the file name offered or directly input the appropriate file name (EX4.RES). Also at this time you must indicate whether you wish to display pressure in psi (KPa) or pressure hesd (feet or meters). Select perssure Enter.

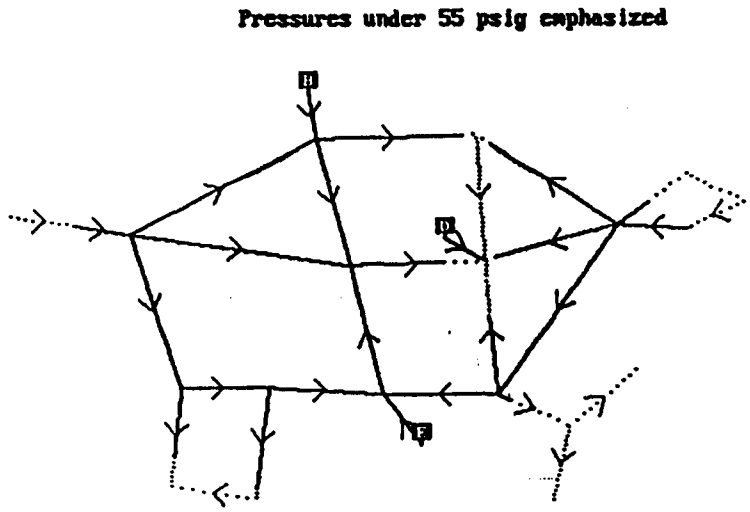
```
Results Data File (ENTER to default to EX4.RES) = ?
This is a time simulation
What time do you wish to use ? 6
   Pressure (Default) or Pressure Head (ENTER 1) Displayed ?
```

PIPEVIEW realized that this is an EPS, states that this is so and asks - What time do you wish to use? This example uses 6 hours (which is at peak demand conditions), i.e. key in 6, press Enter to get to the PSM.

3.2.4 Results Emphasis

Now consider the Emphasis feature again (N). Suppose we wish to highlight pressure heads below 55 psi, key in N, select Option 3, then enter 55 as the Minimum Emphasis value. Change the Plot Title (Key G) to read "Pressure under 55 psig emphasized" and re-display the layout by pressing P to get the following result. Depress S to return to the PSM.

Show flow directions by depressing O and depress P to get the following display.



3.2.5 Contour Plots

Finally, consider plotting contour lines. It is first necessary to generate contour data so key in I and respond to the prompts which appear.

As low pressures have already been emphasized, continue this theme and generate contour data to plot pressure contour lines in the range 55-75 psi.

One prompt refers to the size of the data array which is generated for the contour plotting. The "Large", "Medium" and "Small" array sizes are 90×90, 60×60 and 30×30.

These relate to the resolution of the contour plots and particularly affect contour plots produced in several sections.

System represented by one section	- Small array
Systems represented by 4 sections	- Medium array
Systems represented by more than 4	- Large array

These are only intended as a rough guide and for the present example the small array was chosen - but you are encouraged to try the others for comparison, but note that the large arrays take additional time to generate the contour data.

Enter S for Small, and then P, in response to the contour type prompt, for pressure.

When defining pressure contours the question "Include pump supply contours?" appears. The recommended response to this prompt is N(o). Since the objective is normally to produce contour plots of the pressurized regions. For systems fed by pumps the answer Y(es) will show undue influence of the low pressure in the suction line to the contours which are then forced through the pump. You are encouraged to try both options for comparison - but for now, since the example system is fed by pumps, say N(o). Only networks with pumps in lines supplied by a FGN will be affected by this selection.

Generation of the contour data then proceeds.

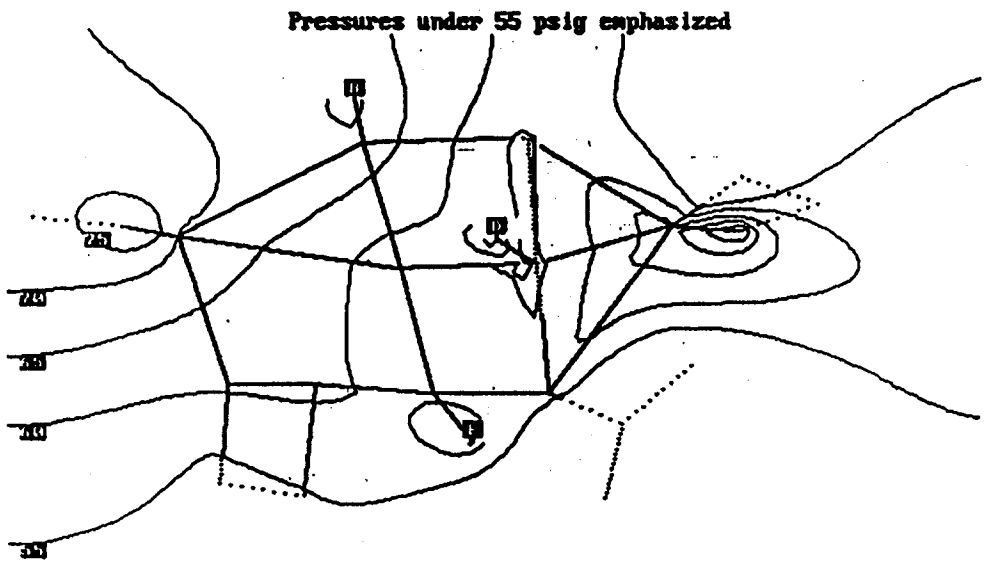
Now key in J to be prompted for the number of contours required. The pressure range of interest is 55-75 psi in 5 psi steps, so enter 5. Then enter Y(es) for "Do you want evenly spaced contours?" and 55 and 75 for the first and last contours. This step is shown below.

```
How many contours do you want to plot ? 5
Do you want evenly spaced contours?
Input first and last contours ? 55,75
```

Now key K for the contours to be plotted and L to be labelled. The PSM will look as shown below.

```
    Geometric Data File Name - EX4.GEO
    Results Data File Name - EX4.RES  Time:  6                    Cntr    Value
A - Current Area ( 0, 0 ) - ( 11, 6 )                               1       55
B - Division:  1 hor. BY 1 ver.                                     2       60
C - Plot Section: ( 1 , 1 )                                         3       65
D - Large Symbols                                                   4       70
E - Print Coordinates on Axes                                       5       75
F - No Dots on Plot Borders
G - Plot Tilte: None
H - Hi-Res VGA 16-color (154K)
I - Contour Data has been Generated: Pressure (Small)
J - Number of Contours Presently Defined: 5
K - Plot Pressure Contours
L - Label Contours
M - Results Data File Loaded
N - No Emphasis (Velocity, Pressure, HL/1000)
O - No Flow Direction Arrows
    Type A-O to change parameters, Q to quit
    Type P to plot [S-Stop  C-Capture Plot  B-Convert to CGA (Black & White)]
```

Keying in P results in the contour plot shown below. Note that the 55 psi contour lines pass through the pipelines at the edges of those lines emphasized as being below 55 psi head.



Note that K is an on-off switch for plotting contours. Also contours can not be plotted unless the values to be shown are first defined using operation J. The defined contour values will appear in the upper right hand corner of the PSM when contours are to be plotted as shown in the above PSM.

3.3 RPP - Results Enhancement Program

Like PIPEVIEW, this program utilizes the Geometric Data File and Results File to enable you to produce tables and graphical displays of results of interest. Although PIPEVIEW and RPP utilize the same data files these two programs are quite independent of each other.

RPP is primarily intended to enhance the presentation of EPS results. Therefore, the features of RPP will be illustrated by taking you through a tutorial on how to use the program, using Example NO.4 as before.

From the Main Screen Menu, key in 5, press Enter. If no Current File is defined you will be required to respond to prompts and provide file names for a Geometric Data File, a Results File and a file for storing the enhanced results produced by RPP. If the Current File is defined these files will be automatically accessed and the file names along with pertinent information concerning the network geometry and results will be displayed as shown below.

```
**** RPP PROGRAM - Execution proceeding using the following files:
        Geometric Data File = EX4.GEO
        Results Data File = EX4.RES
        File of Tabulated Results for this run - EX4.ENH

SUMMARY OF GEOMETRIC DATA FOR FILE - EX4.GEO
        NUMBER OF JUNCTION NODES = 16
        NUMBER OF GRADE LABELS :
                AA      B       CC      D
                E       CC
        NUMBER OF PUMPS = 3
        PUMP LABELS :
                        P1      P2      P3
        NUMBER OF PIPE SECTIONS = 28
```

```
TYPE OF SIMULATION = TIME (EPS)
NUMBER OF RESULTS SETS IN DATA FILE = 23

Depress Enter to go to RPP Menu?
```

You can now press Enter to access the RPP menu and view the various options for the presentation of selected results.

```
**************************************************************************
    SELECT ONE OF THE FOLLOWING OPERATIONS
    A - SELECT ITEMS FOR X-Y (time) PLOTS
    B - GENERATE TABLES OF NET FLOWS AND HGL FOR FGN'S
    C - GENERATE TABLES OF PRESSURE OR HGL VALUES
    D - GENERATE TABLES OF PUMP OPERATION WITH COSTS
          (additional data may be required for this operation)
    E - PRODUCE GRAPHICS PLOTS (PLOTXY)
    F - END OPERATIONS
**************************************************************************
  ENTER OPERATION (Type upper case letter)
```

These operations will now be demonstrated. Since operation A requires an additional step, the others will be demonstrated first. Note that upper case letters are required to access these operations.

3.3.1 Operation B - Generate Tables of Net Flows and HGL's for FGN's

To generate Tables of Net Flows and Hydraulic Grades for reservoirs and tanks, key in B from the RPP menu for selection instructions and summary of the available data. The three FGN's which represent the variable level tanks are selected for tabulation and display - ie, B, D and E are chosen here.

Note you can enter descriptive text labels for the items selected as illustrated below.

```
        B. GENERATE TABLES FOR FGN's
   Generate tables of inflows (or outflows) and
HGL levels at fixed grade nodes. A single table
can contain a maximum of four (4) items selected
from the following list of FGN labels.
NUMBER OF FIXED GRADE NODES = 6
FIXED GRADE LABELS:
              AA      B       CC      D
              E       CC
ENTER NUMBER OF ITEMS FOR TABLE ? 3
   LABEL = ? B
         ENTER EXPANDED LABEL - LIMIT 16 SPACES (Enter to Drfault) ? HILLS TANK
   LABEL = ? D
         ENTER EXPANDED LABEL - LIMIT 16 SPACES (Enter to Drfault) ? MALL TANK
   LABEL = ? E
         ENTER EXPANDED LABEL - LIMIT 16 SPACES (Enter to Drfault) ? TOWN TANK
```

The resulting table is shown below.

********** TABLE OF FGN INFLOWS (OUTFLOWS) AND GRADES **********

	LOCATIONS FOR FIXED GRADE NODES					
	HILLS TANK		MALL TANK		TOWN TANK	
TIME	HGL	FLOW	HGL	FLOW	HGL	FLOW
0.00	270.00	0.00	270.00	0.00	270.00	0.00
2.00	270.00	0.36	270.00	0.95	270.00	1.32
4.00	268.67	1.59	266.26	1.44	264.78	2.07
6.00	262.42	1.66	260.58	1.51	256.62	2.08
8.00	255.87	1.42	254.63	1.62	248.44	1.82
10.00	250.27	1.34	249.04	1.39	241.28	1.69
10.38	249.27	1.32	247.99	1.39	240.00	1.67
10.38	249.26	1.98	247.99	1.73	240.00	0.00
10.38	249.26	1.23	247.99	1.33	240.00	0.00
12.00	245.35	-1.13	243.76	0.17	240.00	-0.51
12.00	245.35	-0.60	243.76	0.63	240.00	0.00
14.00	247.71	-1.85	241.28	-0.88	240.00	-1.35
16.00	254.99	-2.50	244.75	-1.35	245.33	-3.00
18.00	264.84	-2.64	250.06	-1.54	253.20	-2.21
18.99	270.00	-2.51	253.06	-1.53	257.52	-2.15
18.99	270.00	0.00	253.06	-1.86	257.52	-2.66
20.00	270.00	0.00	256.76	-1.78	262.81	-2.48
21.47	270.00	0.00	261.92	-1.73	270.00	-2.32
21.47	270.00	0.00	261.92	-2.07	270.00	0.00
22.00	270.00	0.00	264.08	-1.61	270.00	0.00
23.86	270.00	0.00	270.00	-1.61	270.00	0.00
23.86	270.00	0.00	270.00	0.00	270.00	0.00
24.00	270.00	0.00	270.00	0.00	270.00	0.00

3.3.2 Operation C - Generate Tables of Pressure and HGL

For Tables of Pressure (or Pressure Head) and Hydraulic Grades at junction nodes, key in Option C from the RPP menu which will provide instructions for selecting junction nodes for the table.

In response to the query select pressure for pressure tabulation (enter 1). Suppose Junction Nodes 2, 6 and 15 are of interest, and they may also be known as Pump No.1, Business Area and PS Reference Node respectively. Enter this information as shown below.

```
   Generate tables of hydraulic grade lines (HGL)
and pressures at junction nodes. A single table
can contain a maximum of four (4) items selected
from the following list of system junction nodes.

NUMBER OF JUNCTION NODES IN DATA SET = 16
   JUNCTION NODE LABELS :
      1     2     3     4
      5     6     7     8
      9     10    11    12
      13    14    15    16

ENTER NUMBER OF ITENS FOR TABLE ? 3
Do You Want Pressure (default) or pressure head (enter 1)?
JUNCTION NODE NUMBER = ? 2
     ENTER EXPANEDE LABEL - LIMIT 16 SPACES (OR RETURN) ? Pump No. 1
JUNCTION NODE NUMBER = ? 6
     ENTER EXPANEDE LABEL - LIMIT 16 SPACES (OR RETURN) ? Business Area
JUNCTION NODE NUMBER = ? 15
     ENTER EXPANEDE LABEL - LIMIT 16 SPACES (OR RETURN) ? PS Ref. Node
```

The following table will be displayed and can be printed.

Note the two outputs for hours 6 and 12 when the pump service level was switched and the additional intermediate simulations when various tanks emptied or filled.

********** TABLE OF HYDRAULIC GRADE LINES AND PRESSURES **********

LOCATIONS FOR JUNCTION NODES

	Pump No. 1		Business Area		PS Ref. Node	
TIME	HGL	PRESSURE	HGL	PRESSURE	HGL	PRESSURE
0.00	311.52	87.33	281.60	77.39	272.78	59.70
3.00	290.06	78.03	255.85	66.23	242.60	46.54
4.00	276.98	72.36	235.61	57.46	218.17	36.04
6.00	270.38	69.50	227.27	53.85	208.99	32.06
8.00	267.68	68.33	224.87	52.81	206.85	31.13
10.00	263.71	66.61	220.33	50.84	202.17	29.11
10.38	262.99	66.29	219.50	50.48	201.32	28.74
10.38	252.95	61.94	204.86	44.14	183.13	20.86
10.38	262.55	66.11	221.60	51.39	204.51	30.12
12.00	276.61	72.20	243.19	60.75	235.52	43.56
12.00	273.15	70.70	237.18	58.14	225.43	39.19
14.00	287.87	77.07	253.56	65.24	248.27	49.08
16.00	302.96	83.61	271.82	73.15	267.97	57.62
18.00	313.18	88.04	284.60	78.69	281.19	63.35
18.99	315.33	88.97	287.21	79.82	283.78	64.47
18.99	331.84	96.13	302.18	86.31	296.96	70.18
20.00	331.54	96.00	302.09	86.27	296.91	70.16
21.67	333.15	96.70	304.65	87.38	299.63	71.34
21.67	346.00	102.27	321.70	94.77	322.24	81.14
22.00	331.36	95.92	301.79	86.14	300.12	71.55
23.86	332.09	96.24	303.34	86.81	301.25	72.04
23.86	341.60	100.36	323.06	95.34	316.08	78.47
24.00	311.52	87.33	281.60	77.39	272.78	59.70

3.3.3 Operation D - Pump Operating Data and Costs

You can generate a table summarizing the pump operation for the EPS including the cost of operation. After keying in D from the RPP menu the following information and selection choice is displayed and in the present case no pumps were omitted from this summary.

D. TABLE FOR PUMP OPERATION

Generate a table of pump operating results. Pump efficiency data can be input for designated pumps or the default value of 0.75 may be used. Enter the cost of electricity (cents/KWH) or the default value of 5 cents/KWH can be used. For time simulations a variable cost schedule may be specified.

NUMBER OF PUMPS = 3

PUMP LABELS :

1 - P1 2 - P2 3 - P3

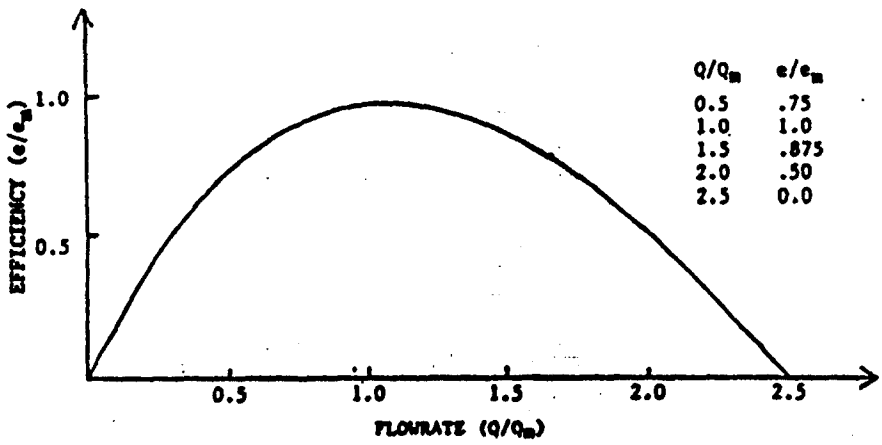
DO YOU WANT TO OMIT ANY PUMPS FROM THE SUMMARY (Y or N(Default))?

Two additional variables require consideration, the efficiency of the pumps and the cost of electricity.

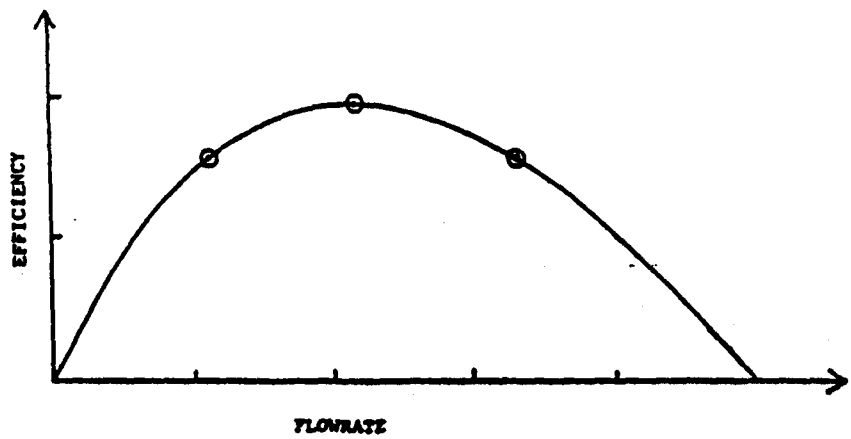
Pump Efficiency Data - Other than using a default efficiency of 0.75 for all pumps there are four options, of which the last three will be demonstrated as there are three pumps. For Pump No.1 a constant efficiency of 0.82 (82%) is assumed. For Pump No.2 a typical efficiency-flow curve is utilized with the maximum efficiency of .85 at a flowrate of 8 MGD. For Pump No.3 three points of available efficiency-flow data are provided and an efficiency-flow curve is calculated and used to determine efficiency. The set-up to provide these efficiency calculations is shown below:

```
DO YOU WANT TO ENTER EFFICIENCY DATA (Y or N(Default))? Y
   You must define efficiency for each pump using one of the following OPTIONS:
     A - USE DEFAULT VALUE FOR EFFICIENCY.
     B - USE A SPECIFIED VALUE FOR EFFICIENCY (not the DEFAULT)
     C - USE THE DEFAULT EFFICIENCY CURVE (must input max. eff. - flow)
     D - ENTER EFFICIENCY DATA - three efficiency - flow points
PUNP LABEL = P1
  EFFICIENCY OPTION = ? B
  INPUT CONSTANT VALUE FOR EFFICIENCY = ? .82
PUNP LABEL = P2
  EFFICIENCY OPTION = ? C
  INPUT CONSTANT VALUE FOR EFFICIENCY = ? .85
  INPUT CORRESPONDING FLOWRATE = ? 8
PUNP LABEL = P3
  EFFICIENCY OPTION = ? D
  INPUT THREE POINTS OF PUMP EFFICIENCY DATA :
       FIRST (LOWEST) FLOWRATE = ? 4
         CORRESPONDING EFFICIENCY = ? .72
       SECOND (INTERMEDIATE) FLOWRATE = ? 6
         CORRESPONDING EFFICIENCY = ? .84
       THIRD (HIGHEST) FLOWRATE = ? 12
         CORRESPONDING EFFICIENCY = ? .68
```

Efficiency Option C, for which you enter the maximum efficiency and its corresponding flow rate causes the program to adopt a typical efficiency-flow curve as shown below.



This is a default curve for cases where the actual efficiency-flow data is not available. Should it be available, three pairs of efficiency-flow data are provided and a curve is fit to this data as shown below. Option D implements this process as demonstrated.



Power Cost Data - You may select the option to use a default value of 5 cents/kwh. If not you must provide power cost data. Note the power costs can be interpreted in any currency with cents and dollars corresponding to pence and pounds or phenigs and marks, for example. In the case of an EPS the costs can vary with time - and a sample response to the screen prompts is shown below.

```
IF YOU DO NOT ENTER POWER COST DATA THE DEFAULT OF 5 CENTS/KWH WILL APPLY
DO YOU WANT TO ENTER POWER COST DATA (Y or N(Default))? Y
NEW DEFAULT VALUE FOR POWER COST (RETURN FOR NO CHANGE) = ?
RESULTS FILE IS FOR AN EPS - DO YOU WANT TO ENTER DATA
FOR A VARIABLE RATE SCHEDULE (Y or N) ? Y
ENTER VALUES FOR TIME AND CORRESPONDING COSTS IN CENTS/KWH
  START AT TIME = 0
  INITIAL POWER COST = ? 8
  TIME (ENTER -1 TO END INPUT) = ? 12
  NEW POWER COST = ? 6
  TIME (ENTER -1 TO END INPUT) = ? -1
```

The above response for power costs sets a cost of 8 cents/kwh for the first 12 hours of the simulation and 6 cents/kwh for the last 12 hours.

Having entered these data the output shown on the following page is obtained - both on the screen and on the printer. The output shown does cover the entire 24 hour period with some of intermediate times skipped.

3.3.4 Operation A - Select Items for X-Y (time) Plots

To select items for X-Y Plots, key in A from the RPP menu and the following information will appear.

```
                A. SELECT ITEMS FOR X-Y (time) Plots
Generate a file to be used with the XYPLOT program to produce plots
of various results.  If the RESULTS FILE is for an EPS the plots
will be time plots.  If not the plots will represent variation in
designated parameters for the cases included in the RESULTS FILE
A maximum of nine items can be selected from the following list
    1.  Pressures or HGL variations for Junction Nodes
    2.  Variations in HGL levels for Fixed Grade Nodes
    3.  Variations in pump heads for Pumps
    4.  Total Demands and Demand Factors (also table)
SELECT OUTPUT FOR PLOT FILE (MAXIMUM OF 9 ITEMS)
```

You will then be automatically prompted for selections for each of these 4 categories. You can make selections or depress Enter to go to the next category. Note the limit of nine selections for a single Plot File.

********** PUMP OPERATION RESULTS **********

TIME = 0 HRS - POWER COSTS = 8 cents/KWH

PUMP LABEL	FLOW RATE	PUMP HEAD	USEFUL POWER	EFFIC-IENCY	REQ. KWH	COST PER HR	TOTAL COSTS
P1	8.01	239.95	337.06	0.82	306.64	24.53	0.00
P2	7.50	230.13	302.83	0.85	266.83	21.35	0.00
P3	0.00	0.00	0.00	0.32	0.00	0.00	0.00

TOTAL COST PER HOUR = $ 45.87 - TOTAL COSTS TO THIS POINT = $ 0

TIME = 2 HRS - POWER COSTS = 8 cents/KWH

PUMP LABEL	FLOW RATE	PUMP HEAD	USEFUL POWER	EFFIC-IENCY	REQ. KWH	COST PER HR	TOTAL COSTS
P1	8.86	224.38	348.96	0.82	317.47	25.40	50.80
P2	8.46	219.64	325.88	0.85	286.47	22.92	45.84
P3	0.00	0.00	0.00	0.32	0.00	0.00	0.00

TOTAL COST PER HOUR = $ 48.31 - TOTAL COSTS TO THIS POINT = $ 96.63

TIME = 4 HRS - POWER COSTS = 8 cents/KWH

PUMP LABEL	FLOW RATE	PUMP HEAD	USEFUL POWER	EFFIC-IENCY	REQ. KWH	COST PER HR	TOTAL COSTS
P1	9.30	214.48	349.91	0.82	318.34	25.47	101.73
P2	9.08	210.98	336.06	0.84	297.65	23.81	93.46
P3	0.00	0.00	0.00	0.32	0.00	0.00	0.00

TOTAL COST PER HOUR = $ 49.27 - TOTAL COSTS TO THIS POINT = $ 195.18

TIME = 6 HRS - POWER COSTS = 8 cents/KWH

PUMP LABEL	FLOW RATE	PUMP HEAD	USEFUL POWER	EFFIC-IENCY	REQ. KWH	COST PER HR	TOTAL COSTS
P1	9.50	209.39	348.97	0.82	317.48	25.40	152.53
P2	9.32	207.24	338.76	0.84	301.39	24.11	141.68
P3	0.00	0.00	0.00	0.32	0.00	0.00	0.00

TOTAL COST PER HOUR = $ 49.5 - TOTAL COSTS TO THIS POINT = $ 294.2

TIME = 8 HRS - POWER COSTS = 8 cents/KWH

PUMP LABEL	FLOW RATE	PUMP HEAD	USEFUL POWER	EFFIC-IENCY	REQ. KWH	COST PER HR	TOTAL COSTS
P1	9.58	207.30	348.36	0.82	316.92	25.35	203.23
P2	9.38	206.12	339.42	0.84	302.42	24.19	190.07
P3	0.00	0.00	0.00	0.32	0.00	0.00	0.00

TOTAL COST PER HOUR = $ 49.54 - TOTAL COSTS TO THIS POINT = $ 393.3

TIME = 10 HRS - POWER COSTS = 8 cents/KWH

PUMP LABEL	FLOW RATE	PUMP HEAD	USEFUL POWER	EFFIC-IENCY	REQ. KWH	COST PER HR	TOTAL COSTS
P1	9.69	204.20	347.19	0.82	315.86	25.27	253.77
P2	9.51	204.03	340.41	0.83	304.17	24.33	238.74
P3	0.00	0.00	0.00	0.32	0.00	0.00	0.00

TOTAL COST PER HOUR = $ 49.6 - TOTAL COSTS TO THIS POINT = $ 492.5

TIME = 20 HRS - POWER COSTS = 6 cents/KWH

PUMP LABEL	FLOW RATE	PUMP HEAD	USEFUL POWER	EFFIC-IENCY	REQ. KWH	COST PER HR	TOTAL COSTS
P1	6.94	253.33	308.32	0.82	280.50	16.83	441.61
P2	6.49	238.09	271.04	0.82	246.69	14.80	377.27
P3	0.00	0.00	0.00	0.32	0.00	0.00	44.68

TOTAL COST PER HOUR = $ 31.63 - TOTAL COSTS TO THIS POINT = $ 863.55

TIME = 21.472 HRS - POWER COSTS = 6 cents/KWH

PUMP LABEL	FLOW RATE	PUMP HEAD	USEFUL POWER	EFFIC-IENCY	REQ. KWH	COST PER HR	TOTAL COSTS
P1	6.83	254.34	304.89	0.82	277.38	16.64	466.10
P2	6.37	238.81	267.13	0.81	244.54	14.67	398.87
P3	0.00	0.00	0.00	0.32	0.00	0.00	44.68

TOTAL COST PER HOUR = $ 31.31 - TOTAL COSTS TO THIS POINT = $ 909.65

TIME = 21.472 HRS - POWER COSTS = 6 cents/KWH

PUMP LABEL	FLOW RATE	PUMP HEAD	USEFUL POWER	EFFIC-IENCY	REQ. KWH	COST PER HR	TOTAL COSTS
P1	5.83	261.82	267.97	0.82	243.79	14.63	466.10
P2	5.40	243.79	230.87	0.76	226.61	13.60	398.87
P3	0.00	0.00	0.00	0.32	0.00	0.00	44.68

TOTAL COST PER HOUR = $ 28.22 - TOTAL COSTS TO THIS POINT = $ 909.65

TIME = 22 HRS - POWER COSTS = 6 cents/KWH

PUMP LABEL	FLOW RATE	PUMP HEAD	USEFUL POWER	EFFIC-IENCY	REQ. KWH	COST PER HR	TOTAL COSTS
P1	6.95	253.22	308.69	0.82	280.83	16.85	475.00
P2	6.48	238.12	270.88	0.82	246.60	14.80	406.68
P3	0.00	0.00	0.00	0.32	0.00	0.00	44.68

TOTAL COST PER HOUR = $ 31.64 - TOTAL COSTS TO THIS POINT = $ 926.36

TIME = 23.865 HRS - POWER COSTS = 6 cents/KWH

PUMP LABEL	FLOW RATE	PUMP HEAD	USEFUL POWER	EFFIC-IENCY	REQ. KWH	COST PER HR	TOTAL COSTS
P1	6.90	253.68	307.11	0.82	279.40	16.76	506.26
P2	6.43	238.49	268.92	0.82	245.52	14.73	434.15
P3	0.00	0.00	0.00	0.32	0.00	0.00	44.68

TOTAL COST PER HOUR = $ 31.49 - TOTAL COSTS TO THIS POINT = $ 985.09

TIME = 23.865 HRS - POWER COSTS = 6 cents/KWH

PUMP LABEL	FLOW RATE	PUMP HEAD	USEFUL POWER	EFFIC-IENCY	REQ. KWH	COST PER HR	TOTAL COSTS
P1	6.21	259.38	282.82	0.82	257.29	15.44	506.26
P2	5.60	242.91	238.81	0.77	230.27	13.82	434.15
P3	0.00	0.00	0.00	0.32	0.00	0.00	44.68

TOTAL COST PER HOUR = $ 29.25 - TOTAL COSTS TO THIS POINT = $ 985.09

TIME = 24 HRS - POWER COSTS = 6 cents/KWH

PUMP LABEL	FLOW RATE	PUMP HEAD	USEFUL POWER	EFFIC-IENCY	REQ. KWH	COST PER HR	TOTAL COSTS
P1	8.01	239.95	337.06	0.82	306.64	18.40	508.75
P2	7.50	230.13	302.83	0.85	266.83	16.01	436.31
P3	0.00	0.00	0.00	0.32	0.00	0.00	44.68

TOTAL COST PER HOUR = $ 34.4 - TOTAL COSTS TO THIS POINT = $ 989.74

Table of Operation and Cost - Example 4

For the present illustration, suppose we wish to create a Plot File to plot pressure at Junction Nodes 6 and 15, the changing water level in Tanks B, D and E and the discharge heads of Pumps P1, P2 and P3.

To achieve this respond to the screen prompts as follows:

```
Depress Enter to skip any of the following types :
NUMBER OF JUNCTION OUTPUTS (HGL OR PRESSURES) = ? 2
   KEY FOR PRESSURES (1(Drfault)), PRESSURE HEADS (2), OR HGL (3) = ?
   JUNCTION NUMBER = ? 6
   JUNCTION NUMBER = ? 15
NUMBER OF TANK LEVELS FOR PLOT FILE = ? 3
   TANK LABEL = ? B
   TANK LABEL = ? D
   TANK LABEL = ? E
NUMBER OF PUMP HAEDS FOR PLOT FILE = ? 3
   PUMP LABEL = ? P1
   PUMP LABEL = ? P2
   PUMP LABEL = ? P3
NAME FOR X-Y PLOT FILE (ENTER to default to EX4.PLT) = ?
```

You will be asked for a name for the X-Y Plot File, for which the default name offered, (EX4.PLT for this demonstration) should normally be accepted.

The Plot File will be stored and a message to this effect, plus a summary of the selections included in the Plot File will appear as follows:

```
AN X-Y PLOT FILE NAMED EX4.PLT HAS BEEN GENERATED AND CONTAINS:
ITEM NUMBER   NODE LABEL
      1              6
      2              15
      3              B
      4              D
      5              E
      6              P1
      7              P2
      8              P3
Depress Enter to Return to Menu?
```

To actually plot out this data in the form of graphs a subsidiary program (PLOTXY) will be used and it is therefore necessary to store the above data in a Plot File to be read by PLOTXY.

This Plot File contains 8 data sets and so the option to include the Total System Demand and Demand Factor was skipped over since this would have exceeded the limit of 9 data sets which can be accommodated by the Plot File.

However, if fewer items were selected the Demand Data could have been included for subsequent graphical display and a table of Total System Demand and Demand Factor would have been printed out and this information stored in a Plot File.

The Demand Factor is defined as the Total System Demand divided by the Average Demand for all the runs recorded in the Results File. When plotted it produces a curve of similar shape to the Total System Demand, but in non-dimensional form.

Now press Enter to go to the RPP Menu and type E (Enter) to access the graphic plotting program. This program can also be accessed directly from the KYPIPE menu (type 6).

3.3.5 Operation E - Produce Graphics Plots (PLOTXY)

A Plot File EX4.PLT was created in the previous section using operation A of the RPP Program. This section indicates how the data stored in that file can be displayed graphically. From the RPP Menu, type E. PLOTXY automatically accesses the Current File with the .PLT extension if such a file is available. If this file is not available or the Current File is undefined then you will have to key in the name of a Plot File which was previously created. Once the Plot File is loaded the following Set-up Menu appears on the screen.

```
PLOTXY Version 4.0  Copyright 1991

A - Plot File: EX4.PLT
B - Screen Type: Hi-Res VGA  16-color (154K)
C - Plot Items: [ 1  2  3  4  5  6  7  8 ]
D - Item Names: Default
E - Plot Title: Plot of EX4.PLT
F - Axis Labels: Default
G - X Axis: 0 to 24
H - Y Axis:-10 to 280
I - Lines: straight lines
Q - Quit
P - Generate Plot - after plot appears type B to convert plot to black & white
                    (for printing), C to capture plot, or S to continue.
```

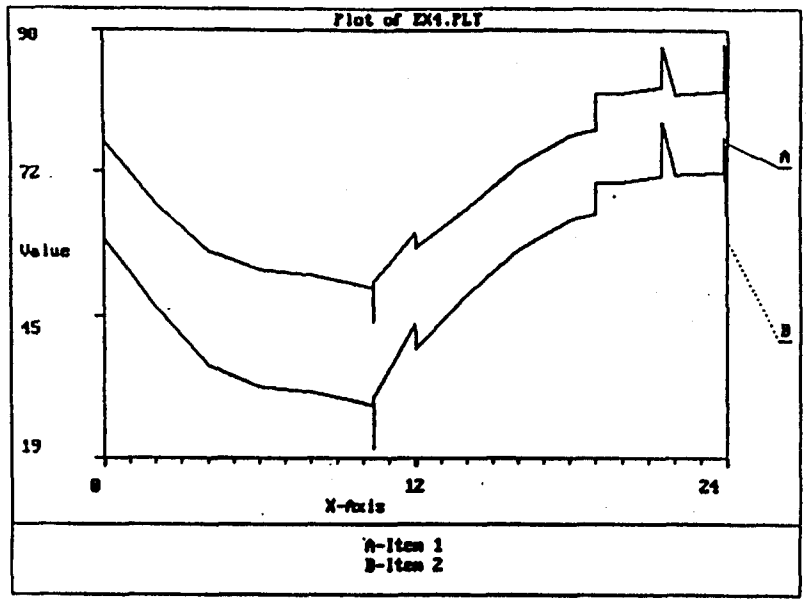
C indicates that there are 8 items in the Plot File which can be utilized to produce plots.

Recall that a table of the items included in the Plot File was provided at the time the Plot File was created. Initially, the pressure heads at Junction Nodes 6 and 15 will be plotted, then two of the pump heads and finally the elevation of the water levels in the three variable elevation water tanks. To make your selection of items type C. You will be reminded that this particular Plot File contains 8 data sets, and be asked how many items and which specific items you wish to plot. The response to set up the desired plot are shown below.

```
There are 8 items in the plot File. How many do you wish to plot? 2
Plot File item number = ? 1
Plot File item number = ? 2
```

After you make your selections from the Plot File you may obtain a quick review of the plot using defaults for all labels and options without going through a fairly extensive set up to define the various labels and options. First obtain the quick plot by typing P.

The following plot is obtained. This shows the numerical range of the X and Y (time) axes and the shape of the plot but is devoid of specific descriptive labels which are required for a formal presentation.

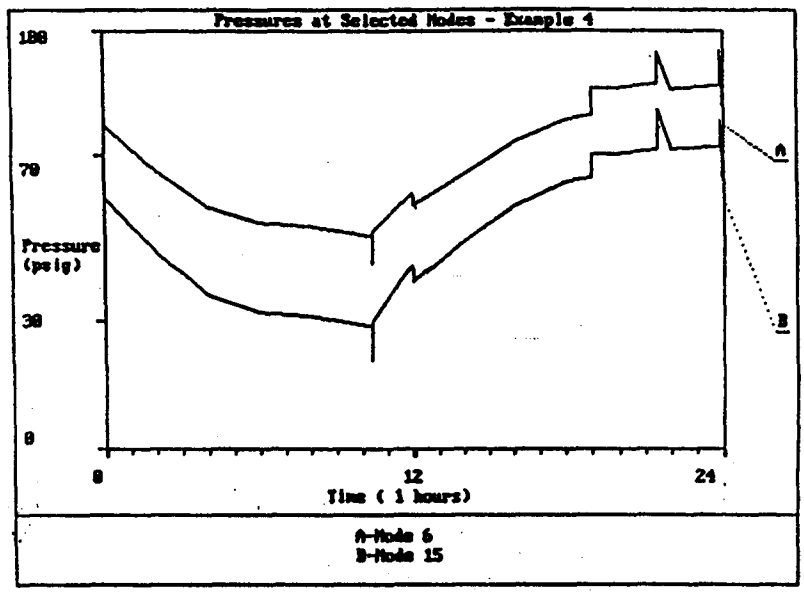


Type S to remove the plot and return to the Set-up Menu. This time select the same two items (1 and 2) but go through the set-up process and respond to the various set up prompts. Generally this involves defining item names for the plot legend (D), a plot title (E), Axis labels (F) and, perhaps, selecting the Y range displayed (H). Suitable responses for this set-up are shown below.

```
      ┌─ You have selected 2 items to plot please input labels for each item.
      │  The maximun label length is 25 characters.
D     │  Input label for item 1 : Node 6
      └─ Input label for item 2 : Node 15

E   ─── Plot Title = ? Pressures at Selected Nodes - Example 4

      ┌─ Automatic Y-Axis scaling (Y/N)
      │  For the input data the Y values range from 20.85617 to 95.35989
F     │  Input the minimum and maximum y values to be represented
      │  Minimum Y value (must be < 20.85617 ) :0
      └─ Maximum Y value (must be > 95.35989) :100

      ┌─ Y-Axis Title (Maximum 8 characters) ? Pressure
      │  Y-Axis Units (Maximum 6 characters) = ? psig
H     │  X-Axis Title = ? Time
      └─ X-Axis Units = ? hours
```

Note that automatic scaling for the Y axis is available but that it is often preferable to introduce your own minimum and maximum values for the Y-axis as demonstrated above. This range will be sub-divided into 3 divisions, with 4 numerical labels attached, as shown. The default for the X axis range (G) is to show all the data included in the Plot File. However, the X range displayed can be selected by depressing G and responding to the prompts.

Depress D to get the plot shown below with the set up demonstrated above.

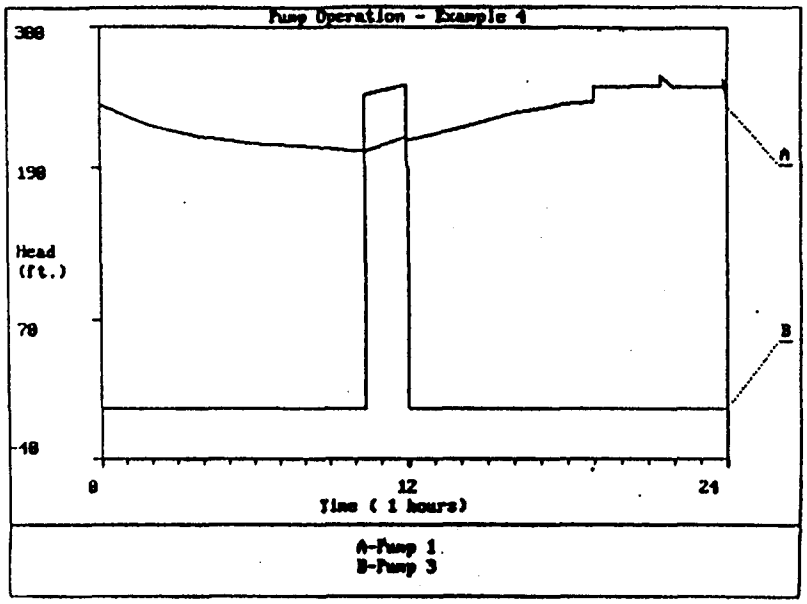


Note the effects of pressure switch and tank action which are depicted on this plot. To obtain a hard copy of this display, press Shift + PrtSc or Print Screen as appropriate for your computer.

To proceed type S and you will return to the Set-up Menu and you can set up other plots using the procedures just illustrated.

The next example is a plot of two items, numbers 6 and 8 which correspond to heads for two of the pumps. Pump No.1 is in service for the whole 24 hours. Pump No.3 cuts in at 10.32 hours and out again at 12 hours to supplement pumping requirments due to the heavy demand on the system. The plot titles and labels were set up using the procedures just demonstrated.

The plot generated is shown below.



3.4 HGL - Profile Plots

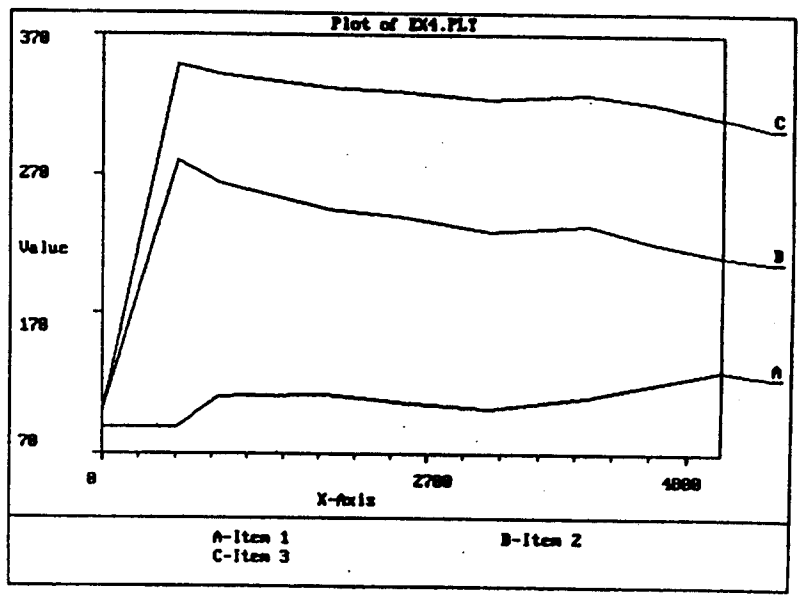
In section 2 a demonstration of the use of the PROFILE - PLOTXY programs to produce HGL profile plots was presented. You can repeat this demonstration using the EX4 data file and some selected times. To do this type 7 and set up the same path as demonstrated previously. Then load the default Results File (EX4.RES) and select two cases (time = 6 (case 4) and time = 23.865 (case 22)). These represent extreme cases where there are peak demands and when the tanks are all completely refilled. Once these cases are selected choose the option to review the plot and type P when the plot Set-up Menu appears. The set up for PROFILE is shown below.

```
PROFILE Set Up - Geometric Data File = EX4.GEO

NODES FOR THIS SYSTEM :
1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16  AA  B  CC  D  E  CC
SELECT NODE LABELS (IN ORDER) FOR PROFILE PLOT :
     NODE LABEL (type ENTER to end input )= ? AA
     NODE LABEL (type ENTER to end input )= ? 1
     NODE LABEL (type ENTER to end input )= ? 2
     NODE LABEL (type ENTER to end input )= ? 10
     NODE LABEL (type ENTER to end input )= ? 9
     NODE LABEL (type ENTER to end input )= ? 8
     NODE LABEL (type ENTER to end input )= ? 13
     NODE LABEL (type ENTER to end input )= ? 14
     NODE LABEL (type ENTER to end input )= ? 16
     NODE LABEL (type ENTER to end input )= ?
>>>>> NODE INPUT COMPLETED -
     Distance data will now be calculated (if coordinate data
     is availabe) or additional input data will be required.
INPUT THE DISTANCE BETWEEN NODE AA AND  1? 610

RESULTS FILE NAME (ENTER to default to EX4.RES) = ?
     CASE 1     TIME = 0
     CASE 2     TIME = 2
     CASE 3     TIME = 4
     CASE 4     TIME = 6
     CASE 5     TIME = 8
     CASE 6     TIME = 10
     CASE 7     TIME = 10.383
     CASE 8     TIME = 10.383
     CASE 9     TIME = 10.383
     CASE 10    TIME = 12
     CASE 11    TIME = 12
     CASE 12    TIME = 14
     CASE 13    TIME = 16
     CASE 14    TIME = 18
     CASE 15    TIME = 18.991
     CASE 16    TIME = 18.991
     CASE 17    TIME = 20
     CASE 18    TIME = 21.472
```

```
     CASE 19     TIME = 21.472
     CASE 20     TIME = 22
     CASE 21     TIME = 23.865
     CASE 22     TIME = 23.865
     CASE 23     TIME = 24
HOW MANY OF THESE CASES DO YOU WANT TO INCLUDE IN THE PROFILE PLOT FILE ? 2
     CASE NO = ? 6
     CASE NO = ? 22
DO WANT TO INCLUDE CASES FROM OTHER RESULTS FILES (Y or N(default)) ?
SELECT NAME FOR PROFILE PLOT FILE (default to EX4.PLT) =?
PLOT PROFILE PLOT (EX4.PLT) CONTAINS THE FOLLOWING:
     ITEM NO.      TITLE
        1          ELEVATIONS
        2          CASE 6
        3          CASE 22
Do you want to review this plot (Y or N(default)) ? Y
```

If you answer the last prompt as affirmative (Y) as shown then you can produce the HGL-profile plot. When the plot set-up menu appears type P to get the display shown below.

Note that Item 1 for these displays is always the pipeline profile for the selected path.



HGL - Profile Plot (no plot setup-Example 4)

4. 예제 프로그램

This is a fifteen pipe, pump-fed system with several storage reservoirs, as shown in the diagram Fig. 11. The pipe lengths, diameters, minor loss coefficients, junction demands and elevations and FGN elevations are noted on the schematic. Among the features that are demonstrated with this example are:

< Regular Simulation>

1) a non-consecutive numbering scheme is used for the pipes (and junctions) i.e. the fifteen pipes are numbered 1-9, 20-24, 40. A schematic denoting the numbering scheme is also shown in Fig 11. SI units are employed.

2) two pipes (22 and 24 in this example) are fed from a common source. There are, in effect, two separate fixed grade node connections required. Thus, the model requires a total of four FGN reservoir connections in this case, not three. This also means that there are just four primary loops (including the parallel pipe loop). Note p=15, j=8, ℓ =4 and f=4 which satisfies Equation (1)

3) the pump is described by three sets of head-flow data points taken from the pump operating curve. The data is shown on Fig. 11.

4) hydraulic components including a check valve (CV), pressure regulating valve (PRV) and a parallel line are featured in this example. The check valve prevents flow reversal in line 4. The PRV limits the pressure head at the upstream end of line 9 (adjacent to node 1) to 43m. by setting the HGL at the upstream end of line 9 to 55m. (elevation=12m).

< EPS Simulation >

5) For EPS Simulation, FGN reservoirs altered storage tanks as below:

Pipe No.	Label	Max. El	Min. El	Diam.	Capacity	Ext. Flow
21	E_b	45	25	15	3,534,300	0
22	E_c	50	30	15	3,534,300	0
24	E_d	50	30	15	3,534,300	0

6) In order to illustrate the procedure for handling a variable area tank, the tank is cod ed as a variable area tank with four intermediate depth-capacity ratios defined as shown.

D/D_M	V/V_M
0.2	0.2
0.4	0.4
0.6	0.6
0.8	0.8

The linear relationship indicates that the tank has a constant cross-sectional area. This same procedure will handle tanks of any shape.

< Geometric Data >

Junction No.	x coord.	y coord.	Pipe No.	x coord.	y coord.
1	4.8	7.4	21	12.6	4.2
2	6.9	7.4	22	7.4	0
3	11.5	7.4	23	0	8
4	11.5	3.5	24	6.5	0
5	11.5	0.5			
6	7.7	3.2			
7	8.5	0.5			
8	3.1	3.6			

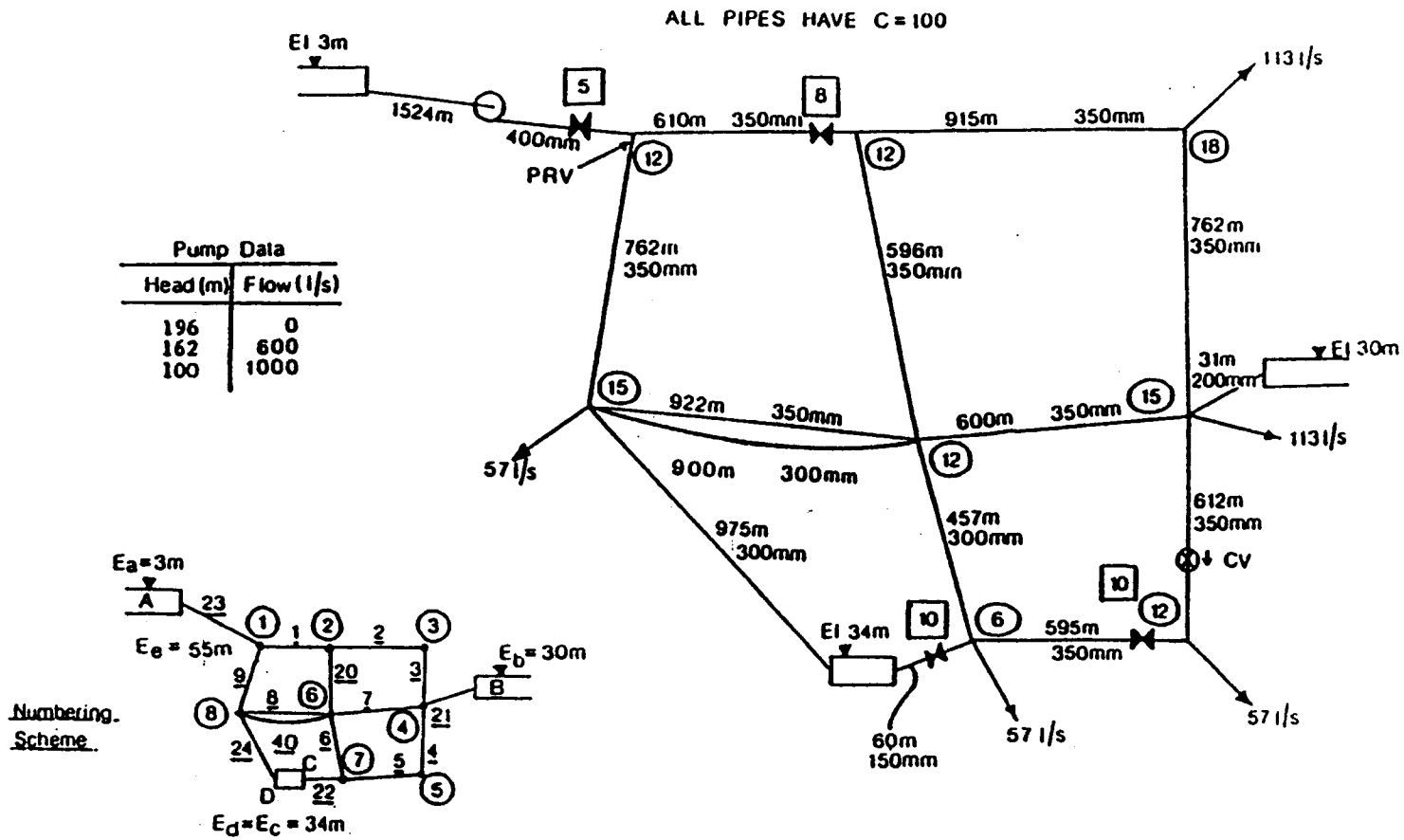


Figure 11 Example - Fifteen Pipe System

<예제 프로그램 결과 (Regular Simulation)>

```
          * * * * * * * * * *  K Y P I P E 2  * * * * * * * * * *
          *  University of Kentucky Hydraulic Analysis Program   *
          * Distribution of Pressure and Flows in Piping Networks *
          *          60 PIPE VERSION - 1.22   (09/14/93)         *
          * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

DATE:  1/ 3/1986
TIME: 15:31:20

INPUT          DATA          FILENAME          ----------          C:\KYPIPE2\DATA\EX2.DAT

TABULATED          OUTPUT          FILENAME          --------          C:\KYPIPE2\DATA\EX2.OUT

POSTPROCESSOR RESULTS FILENAME --- C:\KYPIPE2\DATA\EX2.RES

              ************************************************
               S U M M A R Y   O F   O R I G I N A L   D A T A
              ************************************************

U N I T S   S P E C I F I E D

   FLOWRATE ..... = liters/second
   HEAD (HGL) ..... = meters
   PRESSURE ..... = kpa

R E G U L A T I N G   V A L V E   D A T A

    VALVE     POSITION     CONTROLLED      VALVE
    TYPE      JUNCTION       PIPE         SETTING
                                         (m or l/s)
    ------------------------------------------
    PRV-1         1            9           55.00

P I P E L I N E   D A T A

STATUS CODE:   XX -CLOSED PIPE     FG -FIXED GRADE NODE     PU -PUMP LINE
               CV -CHECK VALVE     RV -REGULATING VALVE
```

PIPE NUMBER	NODE NOS. #1	#2	LENGTH (m)	DIAMETER (cm)	ROUGHNESS COEFF.	MINOR LOSS COEFF.	FGN-HGL (m)
1	1	2	610.0	35.0	100.00	8.00	
2	2	3	915.0	35.0	100.00	.00	
3	3	4	762.0	35.0	100.00	.00	
4-CV	4	5	612.0	35.0	100.00	.00	
5	5	7	595.0	35.0	100.00	10.00	
6	6	7	457.0	30.0	100.00	.00	
7	4	6	600.0	35.0	100.00	.00	
8	6	8	922.0	35.0	100.00	.00	
9-RV	1	8	762.0	35.0	100.00	.00	
20	2	6	596.0	35.0	100.00	.00	
21-FG	4	0	31.0	20.0	100.00	.00	30.00
22-FG	7	0	60.0	15.0	100.00	10.00	34.00
23-FGPU	0	1	1524.0	40.0	100.00	5.00	3.00
24-FG	8	0	975.0	30.0	100.00	.00	34.00
40	6	8	900.0	30.0	140.00	.00	

P U M P D A T A

THERE IS A PUMP IN LINE 23 DESCRIBED BY THE FOLLOWING DATA:

HEAD (m)	FLOWRATE (l/s)
196.00	.00
162.00	600.00
100.00	1000.00

J U N C T I O N N O D E D A T A

JUNCTION NUMBER	JUNCTION TITLE	EXTERNAL DEMAND (l/s)	JUNCTION ELEVATION (m)	CONNECTING PIPES				
1		.00	.00	1	9	23		
2		.00	.00	1	2	20		
3		113.00	18.00	2	3			
4		113.00	15.00	3	4	7	21	
5		57.00	12.00	4	5			
6		.00	.00	6	7	8	20	40
7		57.00	6.00	5	6	22		
8		57.00	15.00	8	9	24	40	

O U T P U T O P T I O N D A T A

OUTPUT SELECTION: ALL RESULTS ARE INCLUDED IN THE TABULATED OUTPUT
MAXIMUM AND MINIMUM PRESSURES = 3
MAXIMUM AND MINIMUM VELOCITIES = 3

S Y S T E M C O N F I G U R A T I O N

NUMBER OF PIPES .....(p) = 15
NUMBER OF JUNCTION NODES .....(j) = 8
NUMBER OF PRIMARY LOOPS .....(l) = 4
NUMBER OF FIXED GRADE NODES .....(f) = 4
NUMBER OF SUPPLY ZONES .....(z) = 1

****
S I M U L A T I O N R E S U L T S
****

THE RESULTS ARE OBTAINED AFTER 6 TRIALS WITH AN ACCURACY = .00167

P I P E L I N E R E S U L T S

STATUS CODE: XX -CLOSED PIPE FG -FIXED GRADE NODE PU -PUMP LINE
CV -CHECK VALVE RV -REGULATING VALVE TK -STORAGE TANK

PIPE NUMBER	NODE NOS. #1	#2	FLOWRATE (l/s)	HEAD LOSS (m)	PUMP HEAD (m)	MINOR LOSS (m)	LINE VELO. (m/s)	HL/ 1000 (m/m)
1	1	2	325.68	26.82	.00	4.67	3.39	43.96
2	2	3	167.74	11.77	.00	.00	1.74	12.87
3	3	4	54.74	1.23	.00	.00	.57	1.62
4-XXCV	4	5						
5	5	7	-57.00	1.04	.00	.18	.59	1.74
6	6	7	100.46	4.82	.00	.00	1.42	10.55
7	4	6	-148.32	6.15	.00	.00	1.54	10.24
8	6	8	-46.69	1.11	.00	.00	.49	1.20
9-RV	1	8	217.21	15.82	.00	.00	2.26	20.76
20	2	6	157.94	6.86	.00	.00	1.64	11.51
21-FG	4	0	90.06	1.92	.00	.00	2.87	62.05
22-FG	7	0	-13.54	.45	.00	.30	.77	7.54
23-FGPU	0	1	542.89	90.08	168.25	4.76	4.32	59.11
24-FG	8	0	69.37	5.18	.00	.00	.98	5.31
40	6	8	-44.15	1.11	.00	.00	.62	1.23

JUNCTION NODE RESULTS

JUNCTION NUMBER	JUNCTION TITLE	EXTERNAL DEMAND (l/s)	HYDRAULIC GRADE (m)	JUNCTION ELEVATION (m)	PRESSURE HEAD (m)	JUNCTION PRESSURE (kpa)
1		.00	76.42			
2		.00	44.93			
3		113.00	33.16	18.00	15.16	148.63
4		113.00	31.92	15.00	16.92	165.96
5		57.00	32.03	12.00	20.03	196.47
6		.00	38.07			
7		57.00	33.25	6.00	27.25	267.22
8		57.00	39.18	15.00	24.18	237.12

MAXIMUM AND MINIMUM VALUES

PRESSURES

JUNCTION NUMBER	MAXIMUM PRESSURES (kpa)	JUNCTION NUMBER	MINIMUM PRESSURES (kpa)
7	267.22	3	148.63
8	237.12	4	165.96
5	196.47	5	196.47

VELOCITIES

PIPE NUMBER	MAXIMUM VELOCITY (m/s)	PIPE NUMBER	MINIMUM VELOCITY (m/s)
23	4.32	8	.49
1	3.39	3	.57
21	2.87	5	.59

REGULATING VALVE REPORT

VALVE TYPE	POSITION NODE	CONTROLLED PIPE	VALVE SETTING (m or l/s)	VALVE STATUS	UPSTREAM GRADE (m)	DOWNSTREAM GRADE (m)	THROUGH FLOW (l/s)
PRV-1	1	9	55.00	THROTTLED	76.42	39.18	217.21

S U M M A R Y O F I N F L O W S A N D O U T F L O W S

(+) INFLOWS INTO THE SYSTEM FROM FIXED GRADE NODES
(-) OUTFLOWS FROM THE SYSTEM INTO FIXED GRADE NODES

PIPE NUMBER	FLOWRATE (l/s)
21	-90.06
22	13.54
23	542.89
24	-69.37

NET SYSTEM INFLOW = 556.43
NET SYSTEM OUTFLOW = -159.43
NET SYSTEM DEMAND = 397.00

**** KYPIPE SIMULATION COMPLETED ****

DATE: 1/ 3/1986
TIME: 15:31:20

<예제 프로그램 결과 (EPS Simulation)>

```
          * * * * * * * * * *  K Y P I P E 2  * * * * * * * * * *
          *  University of Kentucky Hydraulic Analysis Program   *
          * Distribution of Pressure and Flows in Piping Networks *
          *          60 PIPE VERSION - 1.22   (09/14/93)         *
          * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

DATE:  1/ 5/1986
TIME: 14:59:37

INPUT          DATA          FILENAME          ----------          C:\KYPIPE2\DATA\EX2-1.DAT

TABULATED OUTPUT FILENAME -------- C:\KYPIPE2\DATA\EX2-1.OUT

POSTPROCESSOR RESULTS FILENAME --- C:\KYPIPE2\DATA\EX2-1.RES

POSTPROCESSOR RESULTS FILENAME --- C:\KYPIPE2\DATA\EX2-1.RES

U N I T S   S P E C I F I E D

   FLOWRATE ..... = liters/second
   HEAD (HGL) ..... = meters
   PRESSURE ..... = kpa
   METERED FLOW ..... = liters

O U T P U T   O P T I O N   D A T A

OUTPUT SELECTION:  ALL RESULTS ARE INCLUDED IN THE TABULATED OUTPUT

E P S   D A T A

    TOTAL TIME FOR SIMULATION =   24.000
    NORMAL TIME PERIOD        =    2.000

    V A R I A B L E   H E A D   T A N K   D A T A

  TANK    PIPE     MAXIMUM     MINIMUM       TANK        INITIAL     EXTERNAL
 NUMBER  NUMBER   ELEVATION   ELEVATION     CAPACITY     VOLUME       FLOW
   (*)              (m)         (m)          (l)          (l)        (l/s)
-------------------------------------------------------------------------------
    1-1     21       45.00       25.00     3534300.     883575.       .00
    2-1     22       50.00       30.00     3534300.     706860.       .00
    3-2     24       50.00       30.00     3534300.     706860.       .00
```

DEPTH/VOLUME RATIOS FOR TANK # 3

DEPTH	/	VOLUME
.000	/	.000
.200	/	.200
.400	/	.400
.600	/	.600
.800	/	.800
1.000	/	1.000

* TANK TYPE: 1 - CONSTANT DIAMETER 2 - VARIABLE AREA

F L O W M E T E R S U M M A R Y

THE FOLLOWING PIPES CONTAIN FLOW METERS:
23 1 5 22

S Y S T E M C O N F I G U R A T I O N

NUMBER OF PIPES .....(p) = 15
NUMBER OF JUNCTION NODES .....(j) = 8
NUMBER OF PRIMARY LOOPS .....(l) = 4
NUMBER OF FIXED GRADE NODES .....(f) = 4
NUMBER OF SUPPLY ZONES .....(z) = 1

****
S I M U L A T I O N R E S U L T S
****

TIME FROM INITIATION OF EPS = .0000 HOURS

THE RESULTS ARE OBTAINED AFTER 6 TRIALS WITH AN ACCURACY = .00016

P I P E L I N E R E S U L T S

STATUS CODE: XX -CLOSED PIPE FG -FIXED GRADE NODE PU -PUMP LINE
CV -CHECK VALVE RV -REGULATING VALVE TK -STORAGE TANK

PIPE NUMBER	NODE NOS. #1	#2	FLOWRATE (l/s)	HEAD LOSS (m)	PUMP HEAD (m)	MINOR LOSS (m)	LINE VELO. (m/s)	HL/ 1000 (m/m)
1	1	2	325.66	26.81	.00	4.67	3.38	43.95
2	2	3	167.63	11.76	.00	.00	1.74	12.85
3	3	4	54.63	1.23	.00	.00	.57	1.61
4	4	5	-.96	.00	.00	.00	.01	.00
5	5	7	-57.96	1.07	.00	.19	.60	1.80

6	6	7	100.96	4.86	.00	.00	1.43	10.64
7	4	6	-147.97	6.12	.00	.00	1.54	10.20
8	6	8	-46.72	1.11	.00	.00	.49	1.21
9-RV	1	8	217.24	15.83	.00	.00	2.26	20.77
20	2	6	158.03	6.87	.00	.00	1.64	11.52
21-TK	4	0	90.57	1.94	.00	.00	2.88	62.70
22-TK	7	0	-14.00	.48	.00	.32	.79	8.02
23-FGPU	0	1	542.90	90.08	168.25	4.76	4.32	59.11
24-TK	8	0	69.34	5.17	.00	.00	.98	5.31
40	6	8	-44.18	1.11	.00	.00	.63	1.24

J U N C T I O N N O D E R E S U L T S

JUNCTION NUMBER	JUNCTION TITLE	EXTERNAL DEMAND (l/s)	HYDRAULIC GRADE (m)	JUNCTION ELEVATION (m)	PRESSURE HEAD (m)	JUNCTION PRESSURE (kpa)
1		.00	76.41	12.00	64.41	631.68
2		.00	44.93	12.00	32.93	322.92
3		113.00	33.17	18.00	15.17	148.78
4		113.00	31.94	15.00	16.94	166.16
5		57.00	31.94	12.00	19.94	195.59
6		.00	38.06	12.00	26.06	255.59
7		57.00	33.20	6.00	27.20	266.73
8		57.00	39.17	15.00	24.17	237.07

R E G U L A T I N G V A L V E R E P O R T

VALVE TYPE	POSITION NODE	CONTROLLED PIPE	VALVE SETTING (m or l/s)	VALVE STATUS	UPSTREAM GRADE (m)	DOWNSTREAM GRADE (m)	THROUGH FLOW (l/s)
PRV-1	1	9	55.00	THROTTLED	76.41	39.17	217.24

S U M M A R Y O F I N F L O W S A N D O U T F L O W S

(+) INFLOWS INTO THE SYSTEM FROM FIXED GRADE NODES
(-) OUTFLOWS FROM THE SYSTEM INTO FIXED GRADE NODES

PIPE NUMBER	FLOWRATE (l/s)
21	-90.57
22	14.00
23	542.90
24	-69.34

NET SYSTEM INFLOW = 556.90
NET SYSTEM OUTFLOW = -159.90
NET SYSTEM DEMAND = 397.00

T A N K S T A T U S R E P O R T (time = .0000 hours)

TANK NUMBER (*)	PIPE NUMBER	NET FLOW (l/s)	WATER ELEVATION (m)	TANK DEPTH (m)	TANK VOLUME (l)	TANK VOLUME (%)	TANK STATUS	PROJECTED DEPTH (m)
1-1	21	90.57	30.00	5.00	883575.	25.0	FILLING	8.69
2-1	22	-14.00	34.00	4.00	706860.	20.0	DRAINING	3.43
3-2	24	69.34	34.00	4.00	706860.	20.0	FILLING	6.83

* TANK TYPE: 1 - CONSTANT DIAMETER 2 - VARIABLE AREA

F L O W M E T E R R E P O R T (time = .0000 hours)

PIPE NUMBER	NODE NUMBERS #1	#2	METERED FLOW (l)
23	0	1	0.
1	1	2	0.
5	5	7	0.
22	7	0	0.

****
S I M U L A T I O N R E S U L T S
****

TIME FROM INITIATION OF EPS = 8.0000 HOURS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00101

P I P E L I N E R E S U L T S

STATUS CODE: XX -CLOSED PIPE FG -FIXED GRADE NODE PU -PUMP LINE
CV -CHECK VALVE RV -REGULATING VALVE TK -STORAGE TANK

PIPE NUMBER	NODE NOS. #1	#2	FLOWRATE (l/s)	HEAD LOSS (m)	PUMP HEAD (m)	MINOR LOSS (m)	LINE VELO. (m/s)	HL/ 1000 (m/m)
1	1	2	349.07	30.49	.00	5.37	3.63	49.98
2	2	3	171.09	12.21	.00	.00	1.78	13.34
3	3	4	58.09	1.38	.00	.00	.60	1.81
4	4	5	37.95	.50	.00	.00	.39	.82
5	5	7	-19.05	.14	.00	.02	.20	.23
6	6	7	106.56	5.38	.00	.00	1.51	11.76
7	4	6	-133.11	5.03	.00	.00	1.38	8.38
8	6	8	-31.71	.54	.00	.00	.33	.59
9-RV	1	8	162.06	9.20	.00	.00	1.68	12.07
20	2	6	177.97	8.56	.00	.00	1.85	14.36
21-TK	4	0	40.25	.43	.00	.00	1.28	13.96
22-TK	7	0	30.52	2.04	.00	1.52	1.73	33.94
23-FGPU	0	1	511.12	80.56	171.45	4.22	4.07	52.86
24-TK	8	0	43.36	2.17	.00	.00	.61	2.22
40	6	8	-29.99	.54	.00	.00	.42	.60

J U N C T I O N N O D E R E S U L T S

JUNCTION NUMBER	JUNCTION TITLE	EXTERNAL DEMAND (l/s)	HYDRAULIC GRADE (m)	JUNCTION ELEVATION (m)	PRESSURE HEAD (m)	JUNCTION PRESSURE (kpa)
1		.00	89.68	12.00	77.68	761.75
2		.00	53.82	12.00	41.82	410.09
3		113.00	41.61	18.00	23.61	231.50
4		113.00	40.23	15.00	25.23	247.43
5		57.00	39.73	12.00	27.73	271.93
6		.00	45.26	12.00	33.26	326.18
7		57.00	39.89	6.00	33.89	332.30
8		57.00	45.80	15.00	30.80	302.08

R E G U L A T I N G V A L V E R E P O R T

VALVE TYPE	POSITION NODE	CONTROLLED PIPE	VALVE SETTING (m or l/s)	VALVE STATUS	UPSTREAM GRADE (m)	DOWNSTREAM GRADE (m)	THROUGH FLOW (l/s)
PRV-1	1	9	55.00	THROTTLED	89.68	45.80	162.06

S U M M A R Y O F I N F L O W S A N D O U T F L O W S

(+) INFLOWS INTO THE SYSTEM FROM FIXED GRADE NODES
(-) OUTFLOWS FROM THE SYSTEM INTO FIXED GRADE NODES

PIPE NUMBER	FLOWRATE (l/s)
21	-40.25
22	-30.52
23	511.12
24	-43.36

NET SYSTEM INFLOW = 511.12
NET SYSTEM OUTFLOW = -114.12
NET SYSTEM DEMAND = 397.00

T A N K S T A T U S R E P O R T (time = 8.0000 hours)

TANK NUMBER (*)	PIPE NUMBER	NET FLOW (l/s)	WATER ELEVATION (m)	TANK DEPTH (m)	TANK VOLUME (l)	TANK VOLUME (%)	TANK STATUS	PROJECTED DEPTH (m)
1-1	21	40.25	39.80	14.80	2615088.	74.0	FILLING	16.44
2-1	22	30.52	36.33	6.33	1118346.	31.6	FILLING	7.57
3-2	24	43.36	43.63	13.63	2409465.	68.2	FILLING	15.40

* TANK TYPE: 1 - CONSTANT DIAMETER 2 - VARIABLE AREA

F L O W M E T E R R E P O R T (time = 8.0000 hours)

PIPE NUMBER	NODE NUMBERS #1	NODE NUMBERS #2	METERED FLOW (l)
23	0	1	15279200.
1	1	2	9634098.
5	5	7	-987485.
22	7	0	411486.

****
S I M U L A T I O N R E S U L T S
****

TIME FROM INITIATION OF EPS = 12.0000 HOURS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00103

P I P E L I N E R E S U L T S

STATUS CODE: XX -CLOSED PIPE FG -FIXED GRADE NODE PU -PUMP LINE
CV -CHECK VALVE RV -REGULATING VALVE TK -STORAGE TANK

PIPE NUMBER	NODE NOS. #1	#2	FLOWRATE (l/s)	HEAD LOSS (m)	PUMP HEAD (m)	MINOR LOSS (m)	LINE VELO. (m/s)	HL/ 1000 (m/m)
1	1	2	360.27	32.33	.00	5.72	3.74	53.00
2	2	3	173.65	12.55	.00	.00	1.80	13.72
3	3	4	60.65	1.49	.00	.00	.63	1.96
4	4	5	41.59	.59	.00	.00	.43	.97
5	5	7	-15.41	.09	.00	.01	.16	.15
6	6	7	104.54	5.19	.00	.00	1.48	11.35
7	4	6	-128.30	4.70	.00	.00	1.33	7.83
8	6	8	-23.75	.32	.00	.00	.25	.34
9-RV	1	8	136.66	6.71	.00	.00	1.42	8.80
20	2	6	186.62	9.34	.00	.00	1.94	15.67
21-TK	4	0	34.36	.32	.00	.00	1.09	10.42
22-TK	7	0	32.13	2.24	.00	1.69	1.82	37.34
23-FGPU	0	1	496.93	76.47	172.82	3.99	3.95	50.18
24-TK	8	0	33.44	1.34	.00	.00	.47	1.38
40	6	8	-22.46	.32	.00	.00	.32	.35

J U N C T I O N N O D E R E S U L T S

JUNCTION NUMBER	JUNCTION TITLE	EXTERNAL DEMAND (l/s)	HYDRAULIC GRADE (m)	JUNCTION ELEVATION (m)	PRESSURE HEAD (m)	JUNCTION PRESSURE (kpa)
1		.00	95.36	12.00	83.36	817.53
2		.00	57.32	12.00	45.32	444.42
3		113.00	44.77	18.00	26.77	262.49
4		113.00	43.28	15.00	28.28	277.30
5		57.00	42.68	12.00	30.68	300.89
6		.00	47.98	12.00	35.98	352.80
7		57.00	42.79	6.00	36.79	360.76

8	57.00	48.29	15.00	33.29	326.50

R E G U L A T I N G V A L V E R E P O R T

VALVE TYPE	POSITION NODE	CONTROLLED PIPE	VALVE SETTING (m or l/s)	VALVE STATUS	UPSTREAM GRADE (m)	DOWNSTREAM GRADE (m)	THROUGH FLOW (l/s)
PRV-1	1	9	55.00	THROTTLED	95.36	48.29	136.66

S U M M A R Y O F I N F L O W S A N D O U T F L O W S

(+) INFLOWS INTO THE SYSTEM FROM FIXED GRADE NODES
(-) OUTFLOWS FROM THE SYSTEM INTO FIXED GRADE NODES

PIPE NUMBER	FLOWRATE (l/s)
21	-34.36
22	-32.13
23	496.93
24	-33.44

NET SYSTEM INFLOW = 496.93
NET SYSTEM OUTFLOW = -99.93
NET SYSTEM DEMAND = 397.00

T A N K S T A T U S R E P O R T (time = 12.0000 hours)

TANK NUMBER (*)	PIPE NUMBER	NET FLOW (l/s)	WATER ELEVATION (m)	TANK DEPTH (m)	TANK VOLUME (l)	TANK VOLUME (%)	TANK STATUS	PROJECTED DEPTH (m)
1-1	21	34.36	42.95	17.95	3172733.	89.8	FILLING	19.35
2-1	22	32.13	38.86	8.86	1565941.	44.3	FILLING	10.17
3-2	24	33.44	46.95	16.95	2995779.	84.8	FILLING	18.32

* TANK TYPE: 1 - CONSTANT DIAMETER 2 - VARIABLE AREA

F L O W M E T E R R E P O R T (time = 12.0000 hours)

PIPE NUMBER	NODE NUMBERS #1	#2	METERED FLOW (l)
23	0	1	22587560.
1	1	2	14701220.
5	5	7	-1247280.
22	7	0	859081.

****
S I M U L A T I O N R E S U L T S
****

TIME FROM INITIATION OF EPS = 15.0030 HOURS

THE RESULTS ARE OBTAINED AFTER 3 TRIALS WITH AN ACCURACY = .00006

P I P E L I N E R E S U L T S

STATUS CODE: XX -CLOSED PIPE FG -FIXED GRADE NODE PU -PUMP LINE
CV -CHECK VALVE RV -REGULATING VALVE TK -STORAGE TANK

PIPE NUMBER	NODE NOS. #1	#2	FLOWRATE (l/s)	HEAD LOSS (m)	PUMP HEAD (m)	MINOR LOSS (m)	LINE VELO. (m/s)	HL/ 1000 (m/m)
1	1	2	374.73	34.77	.00	6.19	3.89	57.00
2	2	3	174.08	12.61	.00	.00	1.81	13.78
3	3	4	61.08	1.51	.00	.00	.63	1.98
4	4	5	56.39	1.05	.00	.00	.59	1.71
5	5	7	-.61	.00	.00	.00	.01	.00
6	6	7	96.56	4.48	.00	.00	1.37	9.80
7	4	6	-108.31	3.43	.00	.00	1.13	5.72
8	6	8	-2.17	.00	.00	.00	.02	.00
9-RV	1	8	103.54	4.01	.00	.00	1.08	5.26
20	2	6	200.65	10.68	.00	.00	2.09	17.93
21-XXTK	4	0						
22-TK	7	0	38.96	3.20	.00	2.48	2.20	53.36
23-FGPU	0	1	478.27	71.23	174.55	3.69	3.81	46.74
24-TK	8	0	42.31	2.07	.00	.00	.60	2.13
40	6	8	-2.06	.00	.00	.00	.03	.00

J U N C T I O N N O D E R E S U L T S

JUNCTION NUMBER	JUNCTION TITLE	EXTERNAL DEMAND (l/s)	HYDRAULIC GRADE (m)	JUNCTION ELEVATION (m)	PRESSURE HEAD (m)	JUNCTION PRESSURE (kpa)
1		.00	102.63	12.00	90.63	888.76
2		.00	61.67	12.00	49.67	487.09
3		113.00	49.06	18.00	31.06	304.60
4		113.00	47.55	15.00	32.55	319.22
5		57.00	46.51	12.00	34.51	338.38
6		.00	50.98	12.00	38.98	382.31
7		57.00	46.51	6.00	40.51	397.23
8		57.00	50.99	15.00	35.99	352.93

R E G U L A T I N G V A L V E R E P O R T

VALVE TYPE	POSITION NODE	CONTROLLED PIPE	VALVE SETTING (m or l/s)	VALVE STATUS	UPSTREAM GRADE (m)	DOWNSTREAM GRADE (m)	THROUGH FLOW (l/s)
PRV-1	1	9	55.00	THROTTLED	102.63	50.99	103.54

S U M M A R Y O F I N F L O W S A N D O U T F L O W S

(+) INFLOWS INTO THE SYSTEM FROM FIXED GRADE NODES
(-) OUTFLOWS FROM THE SYSTEM INTO FIXED GRADE NODES

PIPE NUMBER	FLOWRATE (l/s)
22	-38.96
23	478.27
24	-42.31

NET SYSTEM INFLOW = 478.27
NET SYSTEM OUTFLOW = -81.27
NET SYSTEM DEMAND = 397.00

T A N K S T A T U S R E P O R T (time = 15.0030 hours)

TANK NUMBER (*)	PIPE NUMBER	NET FLOW (l/s)	WATER ELEVATION (m)	TANK DEPTH (m)	TANK VOLUME (l)	TANK VOLUME (%)	TANK STATUS	PROJECTED DEPTH (m)
1-1	21	.00	45.00	20.00	3534300.	100.0	FULL	20.00
2-1	22	38.96	40.83	10.83	1913161.	54.1	FILLING	11.62
3-2	24	42.31	48.92	18.92	3342709.	94.6	FILLING	19.78

* TANK TYPE: 1 - CONSTANT DIAMETER 2 - VARIABLE AREA

F L O W M E T E R R E P O R T (time = 15.0030 hours)

PIPE NUMBER	NODE NUMBERS #1	NODE NUMBERS #2	METERED FLOW (l)
23	0	1	27935130.
1	1	2	18616000.
5	5	7	-1409052.
22	7	0	1206301.

****
S I M U L A T I O N R E S U L T S
****

TIME FROM INITIATION OF EPS = 18.0000 HOURS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00080

P I P E L I N E R E S U L T S

STATUS CODE: XX -CLOSED PIPE FG -FIXED GRADE NODE PU -PUMP LINE
CV -CHECK VALVE RV -REGULATING VALVE TK -STORAGE TANK

PIPE NUMBER	NODE NOS. #1	NODE NOS. #2	FLOWRATE (l/s)	HEAD LOSS (m)	PUMP HEAD (m)	MINOR LOSS (m)	LINE VELO. (m/s)	HL/ 1000 (m/m)
1	1	2	411.01	41.26	.00	7.44	4.27	67.64
2	2	3	185.82	14.23	.00	.00	1.93	15.55
3	3	4	72.82	2.09	.00	.00	.76	2.74
4	4	5	62.10	1.25	.00	.00	.65	2.04
5	5	7	5.10	.01	.00	.00	.05	.02
6	6	7	95.06	4.35	.00	.00	1.34	9.52

7	4	6	-102.28	3.09	.00	.00	1.06	5.15
8	6	8	14.31	.12	.00	.00	.15	.13
9-RV	1	8	29.15	.38	.00	.00	.30	.50
20	2	6	225.19	13.23	.00	.00	2.34	22.20
21-XXTK	4	0						
22-TK	7	0	43.16	3.87	.00	3.04	2.44	64.50
23-FGPU	0	1	440.16	61.08	177.88	3.13	3.50	40.08
24-XXTK	8	0						
40	6	8	13.54	.12	.00	.00	.19	.14

J U N C T I O N N O D E R E S U L T S

JUNCTION NUMBER	JUNCTION TITLE	EXTERNAL DEMAND (l/s)	HYDRAULIC GRADE (m)	JUNCTION ELEVATION (m)	PRESSURE HEAD (m)	JUNCTION PRESSURE (kpa)
1		.00	116.68	12.00	104.68	1026.52
2		.00	67.97	12.00	55.97	548.89
3		113.00	53.74	18.00	35.74	350.52
4		113.00	51.65	15.00	36.65	359.44
5		57.00	50.40	12.00	38.40	376.61
6		.00	54.74	12.00	42.74	419.15
7		57.00	50.39	6.00	44.39	435.32
8		57.00	54.62	15.00	39.62	388.51

R E G U L A T I N G V A L V E R E P O R T

VALVE TYPE	POSITION NODE	CONTROLLED PIPE	VALVE SETTING (m or l/s)	VALVE STATUS	UPSTREAM GRADE (m)	DOWNSTREAM GRADE (m)	THROUGH FLOW (l/s)
PRV-1	1	9	55.00	THROTTLED	116.68	54.62	29.15

S U M M A R Y O F I N F L O W S A N D O U T F L O W S

(+) INFLOWS INTO THE SYSTEM FROM FIXED GRADE NODES

(-) OUTFLOWS FROM THE SYSTEM INTO FIXED GRADE NODES

PIPE NUMBER	FLOWRATE (l/s)
22	-43.16
23	440.16

NET SYSTEM INFLOW = 440.16

NET SYSTEM OUTFLOW = -43.16

NET SYSTEM DEMAND = 397.00

T A N K S T A T U S R E P O R T (time = 18.0000 hours)

TANK NUMBER (*)	PIPE NUMBER	NET FLOW (l/s)	WATER ELEVATION (m)	TANK DEPTH (m)	TANK VOLUME (l)	TANK VOLUME (%)	TANK STATUS	PROJECTED DEPTH (m)
1-1	21	.00	45.00	20.00	3534300.	100.0	FULL	20.00
2-1	22	43.16	43.48	13.48	2381881.	67.4	FILLING	15.24
3-2	24	.00	50.00	20.00	3534300.	100.0	FULL	20.00

* TANK TYPE: 1 - CONSTANT DIAMETER 2 - VARIABLE AREA

F L O W M E T E R R E P O R T (time = 18.0000 hours)

PIPE NUMBER	NODE NUMBERS #1	NODE NUMBERS #2	METERED FLOW (l)
23	0	1	32878830.
1	1	2	22864950.
5	5	7	-1371225.
22	7	0	1675020.

****
S I M U L A T I O N R E S U L T S
****

TIME FROM INITIATION OF EPS = 24.0000 HOURS

THE RESULTS ARE OBTAINED AFTER 2 TRIALS WITH AN ACCURACY = .00161

P I P E L I N E R E S U L T S

STATUS CODE: XX -CLOSED PIPE FG -FIXED GRADE NODE PU -PUMP LINE
CV -CHECK VALVE RV -REGULATING VALVE TK -STORAGE TANK

PIPE NUMBER	NODE NOS. #1	NODE NOS. #2	FLOWRATE (l/s)	HEAD LOSS (m)	PUMP HEAD (m)	MINOR LOSS (m)	LINE VELO. (m/s)	HL/ 1000 (m/m)
1	1	2	423.59	43.63	.00	7.91	4.40	71.53
2	2	3	188.90	14.67	.00	.00	1.96	16.03
3	3	4	75.90	2.26	.00	.00	.79	2.96
4	4	5	56.95	1.06	.00	.00	.59	1.74
5	5	7	-.05	.00	.00	.00	.00	.00

6	6	7	87.20	3.71	.00	.00	1.23	8.11
7	4	6	-94.05	2.64	.00	.00	.98	4.41
8	6	8	27.46	.42	.00	.00	.29	.45
9-RV	1	8	3.56	.01	.00	.00	.04	.01
20	2	6	234.69	14.28	.00	.00	2.44	23.96
21-XXTK	4	0						
22-TK	7	0	30.16	1.99	.00	1.48	1.71	33.21
23-FGPU	0	1	427.16	57.78	178.95	2.95	3.40	37.91
24-XXTK	8	0						
40	6	8	25.97	.42	.00	.00	.37	.46

J U N C T I O N N O D E R E S U L T S

JUNCTION NUMBER	JUNCTION TITLE	EXTERNAL DEMAND (l/s)	HYDRAULIC GRADE (m)	JUNCTION ELEVATION (m)	PRESSURE HEAD (m)	JUNCTION PRESSURE (kpa)
1		.00	121.23	12.00	109.23	1071.17
2		.00	69.69	12.00	57.69	565.74
3		113.00	55.02	18.00	37.02	363.06
4		113.00	52.76	15.00	37.76	370.34
5		57.00	51.70	12.00	39.70	389.32
6		.00	55.41	12.00	43.41	425.69
7		57.00	51.70	6.00	45.70	448.16
8		57.00	54.99	15.00	39.99	392.19

R E G U L A T I N G V A L V E R E P O R T

VALVE TYPE	POSITION NODE	CONTROLLED PIPE	VALVE SETTING (m or l/s)	VALVE STATUS	UPSTREAM GRADE (m)	DOWNSTREAM GRADE (m)	THROUGH FLOW (l/s)
PRV-1	1	9	55.00	THROTTLED	121.23	54.99	3.56

S U M M A R Y O F I N F L O W S A N D O U T F L O W S

(+) INFLOWS INTO THE SYSTEM FROM FIXED GRADE NODES
(-) OUTFLOWS FROM THE SYSTEM INTO FIXED GRADE NODES

PIPE NUMBER	FLOWRATE (l/s)
22	-30.16
23	427.16

NET SYSTEM INFLOW = 427.16
NET SYSTEM OUTFLOW = -30.16
NET SYSTEM DEMAND = 397.00

T A N K S T A T U S R E P O R T (time = 24.0000 hours)

TANK NUMBER (*)	PIPE NUMBER	NET FLOW (l/s)	WATER ELEVATION (m)	TANK DEPTH (m)	TANK VOLUME (l)	TANK VOLUME (%)	TANK STATUS	PROJECTED DEPTH (m)
1-1	21	.00	45.00	20.00	3534300.	100.0	FULL	20.00
2-1	22	30.16	48.22	18.22	3220173.	91.1	FILLING	19.45
3-2	24	.00	50.00	20.00	3534300.	100.0	FULL	20.00

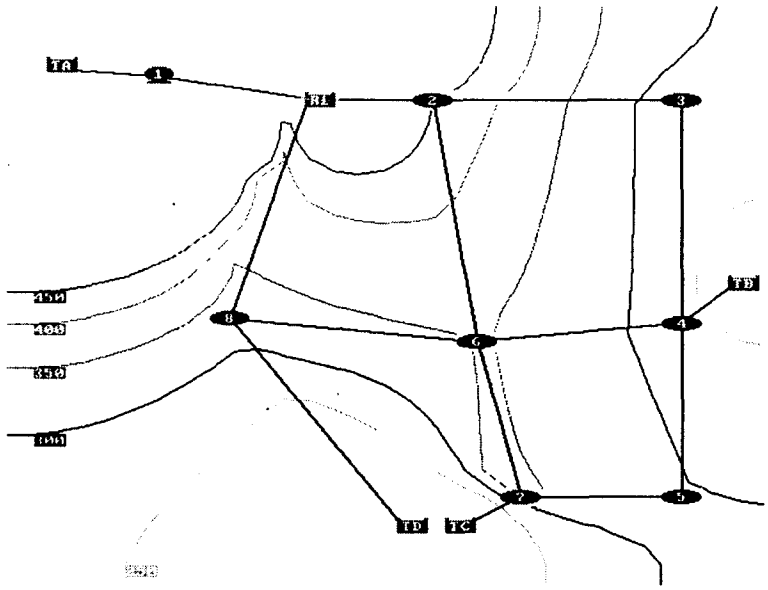
* TANK TYPE: 1 - CONSTANT DIAMETER 2 - VARIABLE AREA

F L O W M E T E R R E P O R T (time = 24.0000 hours)

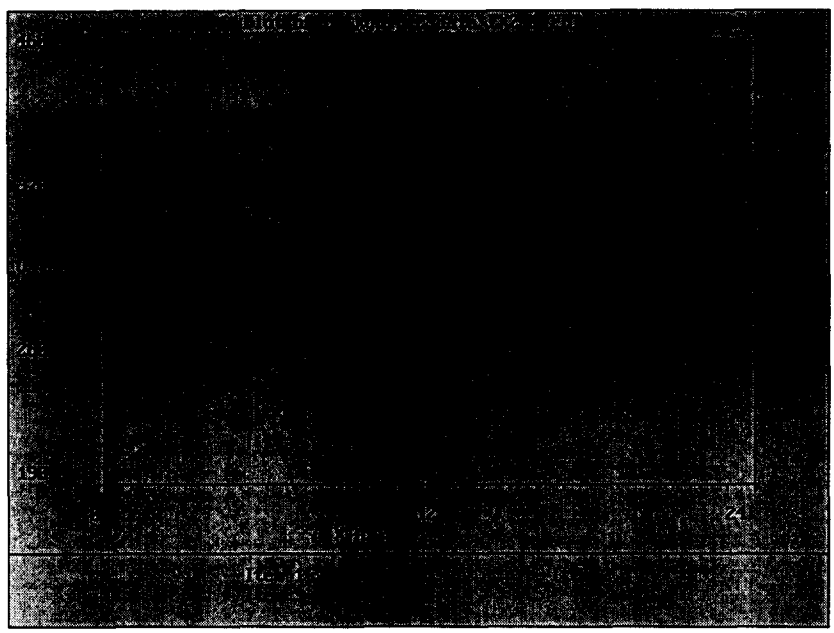
PIPE NUMBER	NODE NUMBERS #1	NODE NUMBERS #2	METERED FLOW (l)
23	0	1	42292320.
1	1	2	31833020.
5	5	7	-1298245.
22	7	0	2513313.

**** KYPIPE SIMULATION COMPLETED ****

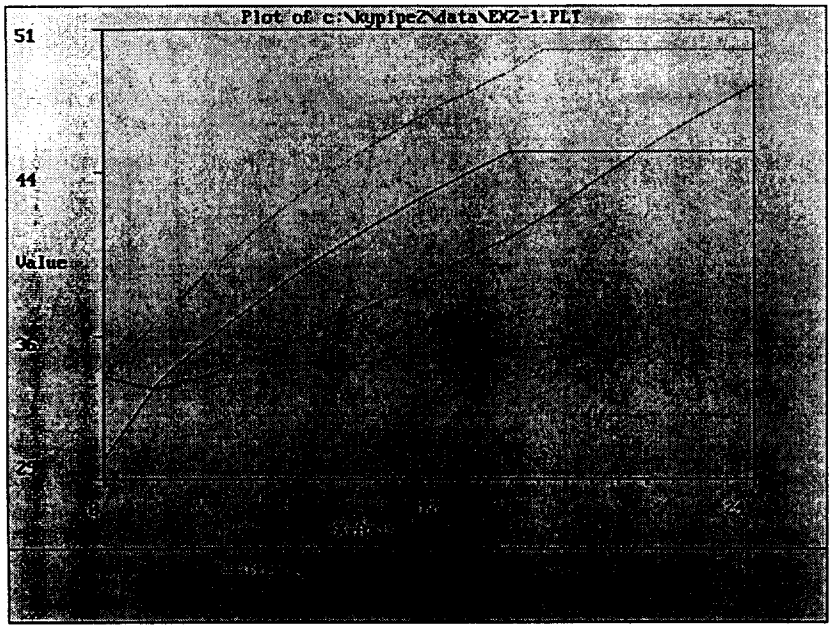
DATE: 1/ 5/1986
TIME: 14:59:37



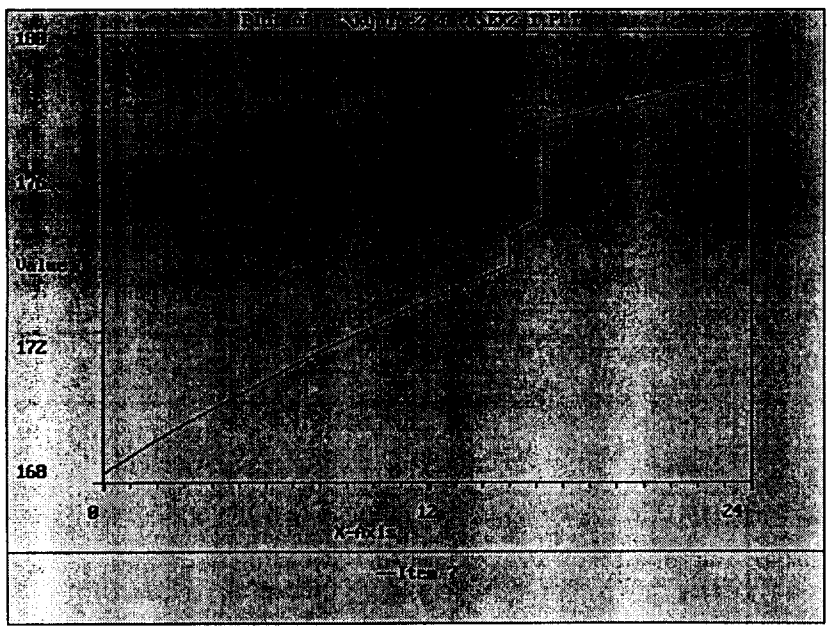
< 12시간의 등압선 분포 >



< Node 5, 7, 8 에서의 압력의 변화 (Item 1 - Node 5
Item 2 - Node 7
Item 3 - Node 8) >



< Pump 의 수위변화 (Item 1 - Tank TB
Item 2 - Tank TC
Item 3 - Tank TD) >



< Pump Head 의 변화 >

APPENDIX I.

VALUES OF C IN HAZEN WILLIAMS EQUATION

TYPE OF PIPE		Condition	C
Cast Iron	New	All Sizes	130
	5 years old	12" and over	120
		8"	119
		4"	118
	10 years old	24" and over	113
		12"	111
		4"	107
	20 years old	24" and over	100
		12"	96
		4"	89
	30 years old	30" and over	90
		16"	87
		4"	75
	40 years old	30" and over	83
		16"	80
		4"	64
	50 years old	40" and over	77
		24"	74
		4"	55
Welded Steel	Values of C the same as for cast-iron pipes, 5 years older		
Riveted Steel	Values of C the same as for cast-iron pipes, 10 years older		
Wood Stave	Average value, regardless of age		120
Concrete or concrete lined	Large sizes, good workmanship, steel forms		140
	Large sizes, good workmanship, woodenl forms		120
	Centrifugally spun		135
Vitrified	In good condition		110
Plastic or Drawn Tubing			150

APPENDIX II

VALUES OF ε FOR THE DARCY WEISBACH EQUATION

MATERIAL	ε (ft)	ε (m)
Riveted steel	0.003-0.03	0.0009-0.009
Concrete	0.001-0.0 1	0.0003-0.003
Cast iron	0.00085	0.00026
Galvanised iron	0.0005	0.00015
Asphalted cast iuon	0.0004	0.00012
Commercial steel or wrought iron	0.00015	0.000045
Drawn tubing and plastic pipe	0.000005	0.0000015

$$h_{LP} = \frac{f\ L\ V^2}{2\ g\ D}$$ (Darcy Weisbach Equation)

$$f = \frac{0.25}{\left\{\log\left(\frac{\varepsilon}{3.7D} + \frac{5.74}{R^{0.9}}\right)\right\}^2}$$ (Jain-fricition factor Equation)

f = friction factor

R = Reynolds number

ε = roughness

APPENDIX Ⅲ

MINOR LOSS COEFFICIENTS FOR COMMON FITTINGS

Fitting	M
Globe valve, fully open	10.0
Angle valve, fully open	5.0
Swing check valve, fully open	2.5
Gate valve, fully open	0.2
Gate valve, three quarters open	1.0
Gate valve, half open	5.6
Gate valve, a quarter open	24.0
Short-radius elbow	0.9
Medium-radius elbow	0.8
Long-radius elbow	0.6
45° elbow	0.4
Close return bend	2.2
Tee, through side outlet	1.8
Tee, straight run	0.3
Coupling	0.3
45° Y, through side outlet	0.8
45° Y, straight run	0.3
Entrance:	
square	0.5
bell mouth	0.1
re-entrant	0.9
Exit	1.0

$$h_{LP} = M\frac{V^2}{2g} \qquad \text{(English or SI units)}$$

APPENDIX Ⅳ

DATA PREPARATION FORM - KYPIPE2

1. SYSTEM DATA

Simulation type key (1 for EPS) ---------- = _____

Number of pressure constraints ---------- = _____

Flow identification key (0-CFS, 1-GPM, 2-MGD, 3-L/S, 4-CMS) ---------- = _____

Number of pipes ---------- = _____

Number of junction nodes ---------- = _____

Number of regulating valves ---------- = _____

*Data check (*1*) ---------- = _____

*Suppress input summary (*2*) ---------- = _____

*Geometric verification (*3*) ---------- = _____

*Maximum number of treals (default-40) (*4*) ---------- = _____

*Relative accuracy (default-40) (*4*) ---------- = _____

*Specific gravity (default-40) (*4*) ---------- = _____

*Kinematic viscosity (default-40) (*4*) ---------- = _____

*Print junction titles (*8*) ---------- = _____

*Non consecutive pipe numbering (*9*) ---------- = _____

* Omit this data to use program defaults

* * * * * *

2. CONSTRAINT DATA

Constraint no.	Parameter type key*	Junction node no.	Specified HGL
1			
2			
3			
4			
5			

Keys: 1-pump speed 3-HGL(FGN) 5-M value 7-Roughness*
2-pump power 4-HGL(RV) 6-Diameter 8-Demand*
*enter with a negative (-) sign for global application

3. LABEL

* * * * * * * *

4. RV DATA(provide data for each RV specified in SYSTEM data)

type key*	Junction no.	pipe no.	Valve Setting

key: * 0 - PRV-1
1 - PRV-2
2 - PSV
3 - FCV-1
4 - FCV-2

5. PIPE DATA(one line for each pipe)

Status Code	Node No. 1	Node No. 2	Length	Diam. *10*	Roughness *10*	Minor Loss	Pump Data *11*	FGN HGL	* CD	Pipe No. *9*

* Constraint Data - Enter constraint number if parameter for this pipe is to be determined

6. PUMP DATA(for pumps described by operating data (*11*))

Pipes no.				
Cutoff head (Hc)				
Q1 (or 0)				
H2				
Q2				
H3				
Q3				
Identifier no. (ID)				
*No.additional data (AD)				
Pump speed (N) (defaults to 1)				

* Enter this number of head-flow data points following the above data (in order of ascending flowrate).

* Additional Pump Data (maximum of 8 points)

head	flow

7. JUNCTION DATA(data mugt be provided if flow demend present-otherwise optional)

Demend**	Elevation	* CD	Junction no.	Demand Type ***	Connecting Pipes -*3*

* Constraint Data-Enter constraint number if demend is to be calculated

** Use flow units previously specified

*** Defaults to 1 (enter only higher demend types)

BLANK LINE (end of junction data)

8. OUT OPTION DATA

Output selection (blank for full, 1 for limited)---------- = _____

Number of junction for max-min pressure summary---------- = _____

Number of pipes for max-min velocity summary---------- = _____

Input next two items for limited output only

Number of pipes for limited output---------- = _____

Number of junction nodes for limited output---------- = _____

Omit items 9 and 10 for full output

9. PIPES FOR LIMITED OUTPUT

Pipes no's	

10. JUNCTIONS FOR LIMITED OUTPUT

Junction no's	

EXTENDED PERIOD SIMULATION DATA

The following data will be required only if the Simulation Type Key (SYSTEM DATA) was entered in as 1.

11. EPS DATA SET UP DATA

Total time for the simulation(hrs)---------- = _____
Time increment(hrs)---------- = _____
Number of tanks with varying surface levels---------- = _____
Number of pressure switches---------- = _____

* * * * * * *

12. TANK DATA

Connecting Pipes no.	Maximum El.	Minimum El.	Tank Dia. or capacity	Inflow (+)/ Outflow (-)	Type Key*

* Key = 0 (blank) for constant diameter tank. Key = number of depth, volume (ratios) points to input for variable area tank. Input pairs of depth ratio, volume ratio directly following this data.

13. FLOW METER DATA

Pipes no.					

14. PRESSURE SWITCH DATA

Pipe no.	node no.	switch type(1,2,3 or 4)	1st switching grade	2nd switching grade

15. CHANGES SPECIFED

** Time for these changes (only for ESP)---------- = _____

a) Number of junction nodes-demand changes---------- = _____

b) Number of open-closed pipe status changes---------- = _____

Global roughness addition factor (default = 0)---------- = _____

Global roughness multiplication factor (default = 1)---------- = _____

GDF1 (default = 1)---------- = _____

GDF2 (default = 1)---------- = _____

GDF3 (default = 1)---------- = _____

GDF4 (default = 1)---------- = _____

** Tine interval for EPS calculations (change only)---------- = _____

c) ** Number of tanks-external inflow changed---------- = _____

*** This data requested (or required) only for EPS

* * * * * * *

LABEL (optional)

_____

_____

_____

* * * * * * * *

Provide the following data for the number of changes specified above :

a) JUNCTION DEMAND CHANGES

Junction no.							
New demand							

* * * * * * * *

b) PIPES OPEN CLOSED STATUS CHANGE

pipe no.								

c) EXTERNAL TANK FLOWS

tank no.					
external flow + in, - out					

PIPE PARAMETER CHANGE DATA

I provide the following data for each pipe with data changes

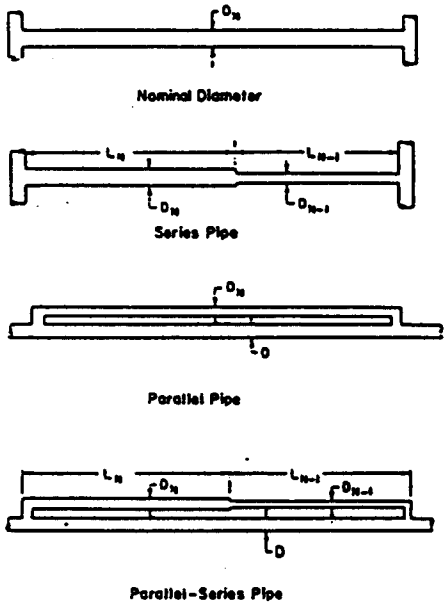
pipe number					
length					
diameter					
roughness					
minor loss					
pump data					

II provide the following for each HGL change for FGN's

pipe no. (must connect FGN)					
new HGL					

APPENDIX V SIZE program

In Section 8 four alternatives were noted for determining pipe diameters utilizing results which do not represent available diameters. These alternatives are listed below and depicted in a schematic. Not all of these alternatives are feasible for some situations.



1. Select the next largest nominal diameter.
2. Determine the length of sections of a series pipe of the next smallest and next largest nominal pipe equivalent to the calculated diameter, Dc.
3. Determine the smallest nominal diameter of a pipe parallel to the original pipe which provides a capacity equal or greater than Dc.
4. Determine lengths of a series pipe installed parallel to the original pipe with a capacity equal to Dc.

A program called SIZE is provided to enable you to evaluate these options for a particular result. This program selects diameters from a table of available diameter for the alternative design. You can add or delete items from this table. You then provide required basic data and the calculations are carried out.

To access SIZE get the DOS prompt and type SIZE. You then respond to screen prompts as shown.

```
***** TABLE OF NOMINAL DIAMETERS *****
   1.00     2.00     3.00     4.00     6.00
   8.00    10.00    12.00    14.00    15.00
  16.00    18.00    21.00    24.00    30.00
  36.00    42.00    48.00    60.00    72.00
  84.00    96.00
DO YOU WANT TO A)DD  OR D)ELETE  A DIAMETER OR  C)ONTINUE?
Enter Data to Carry Out Pipe Diameter Calculations

Original Length = ? 2100
Original Diameter = ? 10
Original C Value = ? 120
Design C Value = ? 130
Calculated Diameter = ? 11.67

********** PIPE SIZE ANALYSIS **********
design calc. diameter  series pipe  parallel pipe (parallel-series)
HW-C  DC    DA    DN    DN-1   LN    LN-1   DC    DN    DN-1   LN    LN-1
 130  11.67 11.32 12.00 10.00  1618   482   7.45  8.00  6.00  2100   284

Do you want to do another case (Y or N) ? N
```