DOE/ET/27256--T27

DE82 015103

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MODIFICATIONS FOR
GEOTHERMAL-HEATING SYSTEM FOR
KINGSWOOD APARTMENTS,
Klamath Falls, Oregon

April 1982

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KINGSWOOD APARTMENTS

Klamath Falls, Oregon

The following is the result of a request for technical assistance.

INTRODUCTION

The Kingswood Apartments, located on Eberlein Street in Klamath Falls, are currently heated by a geothermal well producing 118°F water. Geothermal water from the well is piped directly through fan coil units in each of the 117 apartments and disposed of in the storm sewer system. Since the installation of the system in 1975, a large number of corrosion failures of the finned tube coils have occurred with increasing frequency. This corrosion is probably the result of small concentrations of Hydrogen Sulfide (H_2S) dissolved in the geothermal water. This constituent is not compatible with the copper of which the finned coils are made.

This report explores the possibility of modifying the existing, open type piping system to a closed loop/heat exchanger design to minimize the current corrosion problems.

EXISTING HEATING SYSTEM

As mentioned above, the present system is basically a once through open type arrangement. The production well pump circulates geothermal water through buried, uninsulated PVC distribution lines. Due to scaling and sediment buildup, discharge pressure has been raised from the original design of 35 psi to 60 psi in order to supply the necessary

flow to buildings in the Phase II section. Water enters each building through a pressure control valve and is then distributed to the individual terminal units through copper piping. One unit in each building is supplied with a three way bypass valve. This valve maintains a minimum flow rate through the system to ensure adequate supply water temperatures. The balance of the units in each building are controlled by two way water valves. Cooled geothermal water is disposed of to the storm sewer through copper piping (in buildings) and buried uninsulated PVC lines (outside buildings).

The basic terminal unit used in all units is a ducted fan coil arrangement supplying 600 cfm to the space. Actual finned coils are 3 row, 8 tube, 13 fins/inch, with 2.0 square feet of surface area.

PROPOSED MODIFICATIONS

In order to reduce the present corrosion problem, a closed loop system which isolates the copper areas of the existing system from the geothermal water is required. Figure 1 shows the location of this new piping. Actual piping lengths and routing would be determined by the location of the existing underground disposal piping. These should be verified with the original plumbing contractor if possible. New piping could be run, for the most part, under currently unpaved areas to reduce costs. Cost estimates were based upon uninsulated PVC (160 psi, SDR 126) material.

FIGURE 1A
Kingswood Apartments Site Plan

FIGURE 1B
Kingswood Apartments Site Plan

These new return lines would be connected to a new plate heat exchanger and circulating pump to be located at the present well head. Figure 2 shows the general flow scheme for the system. The heat exchanger would form the separation between the "clean" water loop and the geothermal water. Based on a 5° approach, the supply water could be heated to 113°F . This is less than the current 118°F supply temperature. However, an analysis of the existing coil characteristics in conjunction with calculated peak heating loads indicates the lower temperature will be sufficient to meet heating requirements. Details of these calculations are shown in the appendix.

Total heat exchanger duty is 2,400,000 Btu/hr based upon a 100% coincident peak at 0°F outside and 68°F inside with a flow rate of 240 gpm. Based on a 20° Δt , 240 gpm of 118°F geothermal water would be required. This flow would be regulated by a temperature control valve maintaining a constant supply water temperature. Cooled geothermal water would be discharged to the storm sewer. Water flow to the sewer would occur at the same rate as under the current system.

Since the geothermal water will be passed only through a heat exchanger, a relatively small discharge pressure is required compared to the current 60 psi. As a result, a 7.5 hp motor will suffice in place of the existing 15 hp. Replacement of this motor would result (for the proposed system) in an electrical savings of about \$1,480 per year. On the clean water side of the heat exchanger a new cir-

FIGURE 2
FLOW DIAGRAM - KINGSWOOD OPTS.

KR-4-13-82

culating pump is necessary. In order to supply the required flow at a 60 psi discharge pressure, a 20 hp unit would result. However, a different approach could reduce the electrical consumption (for pumping) at approximately the same capital cost. A 15 hp circulating pump would be installed at the heat exchanger site. This unit would supply the design flow rate at 35 psi. An additional booster pump for the Phase II buildings would be installed between buildings 1 and 2 as shown in Figure 1. This pump would supply the necessary head to move water through these additional buildings. This approach eliminates the need to supply all water at 60 psi as in the current system, thus reducing the horsepower requirement. Compared to the single 20 hp pump this approach would result in an electrical savings of about \$660 per year.

Capital costs for the modification are shown in Table 1. In addition, costs for increased electrical usage and maintenance are shown. The increased electrical use is due to the net increase in pumping horsepower for the closed loop system. Maintenance costs would only increase in the first few years of the project. This is the result of continued coil failures which will occur in addition to the requirement of the new equipment. However, the modifications will result in significantly reduced corrosion rates thus eliminating the need for coil replacement and reconditioning.

TABLE 1

Capital Costs:

Circulating Pump 15 hp	\$ 3,900
Heat Exchanger	14,000
Controls	800
Piping	500
Underground Piping	19,400
Well Heat Enclosure	2,500
Secondary Pump 15 hp	1,200
New Well Pump Motor	<u>700</u>
Subtotal	\$43,000
10% Contingency & Engr.	<u>4,300</u>
TOTAL	\$47,300

Operating Costs:

Increased Electrical Use	\$ 1,405 per year
Insurance @ 1/2%	
.005 X \$47,300	236
Maintenance	
.005 X 19,400 X (473/430) = 106.7	
.02 X 23,100 X (473/430) = <u>762.3</u>	
	369

APPENDIX

KINGSWOOD SPT.

D UNIT HEAT LOSS:

WALLS - 558 · .09 · 68
GLASS - 98 · .63 · 68
FLOOR - 584 · .052 · 68
CEILING - 584 · .052 · 68
INFIL - 77.8 · 1.08 · 68

= 3414

= 4198

= 2065

= 2065

= 5718

17460 BTU/HK

'Δ' UNIT HEAT LOSS

WALLS - 311 · .09 · 68
GLASS - 65 · .63 · 68
FLOOR - 616 · .052 ·
CEILING - 616 · .052 ·
INFIL - 82 · 1.08 ·

= 1903

= 2785

= 2178

= 2178

= 6032

15075 BTU/HK

'B' UNIT HEAT LOSS

SAME AS 'D' UNIT

= 17460 BTU/HK

'C' UNIT HEAT LOSS

WALLS - 540 · .09 · 68
GLASS - 100 · .63
FLOOR - 792 · .052
CEILING - 792 · .052
INFIL - 106 · 1.08

= 3305

= 4284

= 2800

= 2800

= 7785

20975 BTU/HK

TOTAL LOAD

86 'Δ' UNITS @ 15075

= 1296450

6 'B' UNITS @ 17460

= 104760

12 'D' UNITS @ 17460

= 209520

1 'C' UNIT @ 20975

= 20975

1631705

ADD LAUNDRY & OFFICE @

26.5 BTU/HK · FT²

960 · 26.5

= 25440

1657145

KINGWOOD SPTS

PIPING ADDITION -

FROM PARKING LOT PHASE II TO CORNER VALVE #3

72 gpm 3" @ 1.41' / 100'

$$L = 80 + 285 = 365 \cdot 1.2 \div 100 = 4.38$$

$$4.38 \cdot 1.41 = 6.2'$$

VALVE #3 TO VALVE #6

96 gpm 3" @ 2.19' / 100'

$$L = 125' \cdot 1.2 \div 100 = 1.5$$

$$1.5 \cdot 2.19 = 3.28'$$

VALVE #6 TO VALVE #7

120 gpm - 3" @ 3.38' / 100'

$$L = 200 \cdot 1.2 \div 100 = 2.4$$

$$2.4 \cdot 3.38 = 8.1'$$

VALVE #7 TO VALVES #8 AND 9 JUNCTION

156 gpm - 4" @ 1.20' / 100'

$$L = 380 \cdot 1.2 \div 100 = 4.56$$

$$4.56 \cdot 1.2 = 5.5'$$

VALVES #8 AND #9 TO HT-X HOUSE

172 gpm - 4" @ 1.72' / 100'

$$L = 230 \cdot 1.2 \div 100 = 2.76$$

$$2.76 \cdot 1.72 = 4.75'$$

TOTAL ADDITIONAL HEAD DUE TO PIPING

$$6.2 + 3.28 + 8.1 + 5.5 + 4.75 = 27.8'$$

EXISTING SUPPLY PRESSURE - 60 psi - 139'

HEAT EXCHANGER LOSS - ASSUME 6 psi - 13.8'

TOTAL ADDITIONAL PUMP HEAD - 180.6

FLOW REQUIREMENT - 240 gpm

HOUSEPOWER (HYDRAULIC) -

$$240 \cdot 8.3 \cdot 181 \div 33000 = 10.9 \text{ IP}$$

FROM WELL AND GOSSETT

PUMP MOUNTED 2 1/2" Δ 7" IMPELLER 280 gpm @

180' HD 70% EFF. →

$$10.9 \div .70 = 15.57 \text{ IP} - 20 \text{ IP DRIVER.}$$

(30 NPSH_R)

@ 35 psi (ORIGINAL DESIGN)

$$35 \div .433 = 80.8'$$

$$\text{TOTAL} = 80 + 13.8 + 27.8 = 122.4$$

$$122.4 \cdot 9.3 \cdot 240 \div 33000 = 7.39 \text{ IP}$$

FROM RELL AND GOSSETT

2 1/2" Δ w/ 63' INFEED / 15 IP DRIVE
(20' NDESK)

COIL PERFORMANCE @ 113° EWT 320V, 13 FPI 5 TONAE

ED	68		
LD	100	98	99
EIV	113		
LIV	93		
CFIA	600		
FD	2		
FEEL	4		
COLE	1		
EL	4000		
ROW	3		
FPI	13.97	11.67	12.73

@ 113°F SUPPLY UNITS WILL PROVIDE 99°F SUPPLY ΔK

@ 600 CFM CAPACITY =

$$600 \cdot 1.08 (68 - 99) = 20,085 \text{ BTU/HK}$$

CAPACITY MEETS DESIGN REQUIREMENTS

PIPING TEMPERATURE LOSS:

DESIGNE 2" P.V.C., 3', @ 113°F, THY. NET SOIL, 5°F

01	9.068	
02	3.5	93.9 BTU/HK·FT ²
03	3.5	1120' FROM SUPPLY TO WADQ. 2-1
04	3.5	
05	3.0	1120 · 93.9 = 105168 BTU/HK
06	1.5	@ PEAK CONDITIONS
07	9	FLOW AVG. = $(16 + 240) \div 2 = 128 \text{ gpm}$
08	9	
13	9	105168 ÷ 500 ÷ 128 = 1.64°F
10	9	
11	113	→ 113 - 1.64 = 111.4°F SUPPLY WATER
12	5	FROM ABOVE 14°F APPROXIM TEMP.

$$111.4 - 14 = 97.4°F$$

$$600 \cdot 1.08 \cdot (97.4 - 68) = 19051 \text{ BTU/HK}$$

PEAK LOSS TYPE "D" UNIT - 17460 BTU/HK

MEETS REQUIREMENT.

WELL PUMP REQUIREMENT:

BASED ON 60' PUMP HEAD DEPTH

$$\begin{array}{rcl} \text{H-TX LOSS} - \text{ASSUME } 6 \text{ PSI} & - & 13.9' \\ \text{STATIC} & & \underline{60'} \\ & & 73.9 \text{ SAY } 75' \end{array}$$

$$240 \cdot 8.33 \cdot 75 \div 33000 = \underline{4.53 \text{ IP}}$$

$$\text{PUMP EFF. @ } 65\% - 6.47 \text{ IP} - \underline{7.5 \text{ IP}}$$

CHANGE WELL PUMP DRIVER TO 7.5 IP

* PRESENT FLOW RATE 15 IP DRIVER ASSUME 65%
 $60 \text{ PSI} \div .433 = 139' + 60' = 199'$

$$(15 \cdot 33000 \cdot .65) \div 199 \cdot 8.33 = \underline{194 \text{ gpm}}$$

$$\text{@ } 70\% = 208 \text{ gpm}$$

EXISTING WELL PUMP ELECTRICAL CONSUMPTION -
 $85000 \text{ kWh/YR} \cdot .035 = 2975 \text{ \$/YR}$

NEW WELL PUMP @ $7\frac{1}{2}$ IP

$$.5 \cdot 85000 \cdot .035 = 1489 \text{ \$/YR}$$

FOR CIRC PUMP @ 60 PSI DISCH. HD.
FROM ABOVE

15.57 IP - 20 IP DRIVER

$$15.57 \cdot .746 \cdot 8760 \cdot .035 = 3561 \text{ \$/YR}$$

$$\text{TOTAL} = 5050 \text{ \$/YR}$$

FOR CIRC PUMP @ 35 PSI AND SECONDARY PUMP.

FROM ABOVE

11.36 IP - 15 IP DRIVER

$$11.36 \cdot .746 \cdot 8760 \cdot .035 = 2600 \text{ \$/YR}$$

BOOSTER PUMP 72 gpm @ 20 PSI

$$72 \cdot 8.33 \cdot 20 \div .433 \div 33000 \cdot .65 = 1.286 \text{ IP}$$

$$1.286 \cdot .746 \cdot 8760 \cdot .035 = 294 \text{ \$/YR}$$

$$\text{TOTAL} = 4383 \text{ \$/YR}$$

$$\text{SAVINGS} = \underline{666 \text{ \$/YR}}$$

PIPING COSTS - KINGWOOD 160 psi 126

4"

MAT'L - 1.11
 T&B - 8.00
 INST - 3.00
 FITTINGS - .28 (C25%)
 12.39

FOR REPAVED DND 5% LF

3"

MAT'L - .725
 T&B - 8.00
 INST - 3.20
 FITTINGS - .34 (C33%)
 12.16

11

2 1/2"

MAT'L - .56
 T&B - 8.00
 INST - 3.00
 FITTINGS - .28 (C50%)
 11.84

11

$$2 1/2" \quad 700 \cdot 11.84 = 8290$$

$$3" \quad 680 \cdot 12.16 = 8270$$

$$4" \quad 230 \cdot 12.39 = \underline{2850}$$

19410