MASTER

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TECHNICAL PROGRESS REPORT
SOLAR HEATING AND HOT WATER SYSTEM
FOR
THE CENTRAL ADMINISTRATIVE OFFICE FACILITY

ET-77-A-03-1508

LINCOLN HOUSING AUTHORITY
57TH AND R STREETS
LINCOLN, NEBRASKA

AB03-77CS31508

NOVEMBER, 1978

THE CLARK ENERSEN PARTNERS

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TABLE OF CONTENTS

ACCEPTANCE TEST PLAN
AS BUILT DRAWING
MONITORING SYSTEM
OPERATION AND MAINTENANCE MANUAL
PICTURES OF FINAL INSTALLATION
SYSTEM PERFORMANCE DATA
KEY WORK ABSTRACT
MAJOR MAINTENANCE PROBLEMS AND RECOMMENDATIONS

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221B

ACCEPTANCE TEST PLAN

ACCEPTANCE TEST PLAN

After the construction of the system is complete the system will be tested, adjusted, and balanced to provide the specified capacities.

All piping will first be pressure tested at 60 psi with compressed air. Any leaks will be eliminated and the test repeated until the system is demonstrated to hold air pressure without pressure drop, except that due to temperature changes, for at least 12 hours.

Each piping system will then be filled with water, air vented, and the system again pressure tested at 60 psi. Any leaks found will be repaired and the test repeated until the system is proven leak free.

The collector piping system will then be filled with 50% ethylene glycol solution and the system will be pressure tested at system design pressure. Any leakage will be repaired until the system is leak free with the glycol solution.

All valve, vents, and specialties will be checked and adjusted to operate without binding or leaking.

New operating parts will be installed where ordinary adjustments fail to remedy faulty operation.

Pumps will be started and flow will be adjusted to specified capacity by adjusting the pump discharge balancing valves, to provide the pressure drop across the pump corresponding to the specified conditions on the pump curve. Pump motor amperage readings will be taken and compared to the pump curve.

Temperature readings will be recorded for each thermometer location at 15 minute intervals over a period of at least 6 hours, including readings both before and after solar noon.

- A. The inlet and outlet to each collector bank
- B. The inlet and outlet of each heat exchanger
- C. The inlet and outlet to each storage tank
- D. The storage tank water temperatures

Collector bank balancing valves will be adjusted to equalize temperature rise across all banks - then pump capacity will be rechecked and adjusted if necessary, to rated flow.

The outside air temperature and insolation data for the test period will be obtained from the weather bureau and used to calculate performance of the system.

If the system does not meet specified capacities, necessary adjustments or modifications shall be made and test repeated until the system does meet specified capacities.

The Acceptance Test was run on March 27, 1978.

The test started at 10:00 A.M. The collection system had not started at that time, and temperatures were taken at the space heating heat exchanger, the domestic hotwater heat exchanger, the space heating storage tank and the outside air. The collection system started at 10:30 A.M. The pump discharge and suction pressures were read; temperatures were read at the space heating heat exchanger, the hotwater heat exchanger, the space heating and domestic hotwater storage tanks and the outside air. These readings were repeated periodically until about 1:30 P.M. when the pump pressures were again read.

Readings on the inlet and outlet temperatures of each row of collectors were taken starting at 1:37 P.M. These readings were repeated until 1:51 P.M. Shortly after 2:00 P.M., the heat exchanger storage and outside air temperatures were again read.

Since the collector outlet temperatures had varied considerably, the balancing valves on the outlets from each row of collectors were adjusted starting at 2:08 P.M. to balance the flows so that the outlet temperatures were more nearly equal.

The final series of readings starting at 2:15 indicated that the balancing brought the outlet temperatures to within 2° of one another.

The collector temperatures were read by means of a thermometer inserted between the insulation and the outside of the pipe. The temperature reading in this manner is actually the outside surface temperature of the pipe, which accounts for the fact that the temperatures taken at the collectors are lower than the temperatures at the heat exchanger which were taken with immersion thermometers.

Using the 119 GPM circulating rate for the glycol pump and the 5° temperature drop in the glycol passing through the heat exchanger, (160° to 155° at 2:03 P.M.) the system was collecting energy at the rate of $119 \times 1 \times 8.33 \times 60 = 297,381$ BTU/HR at 2:00 P.M. Using the temperature rise of 20° from 134° to 154° for the 5,760 gallons of water in the space heating storage tank from 10:30 A.M. to 2:00 P.M., the system collected $5,760 \times 20^{\circ} \times 8.33 = 959,616$ BTU's during this period of time.

The system was judged to be collecting and storing heat at a rate comparable to that designed for considering the limited temperature and flow reading equipment available for the test. Since the IBM monitoring equipment was scheduled to be installed later and since the heating season was almost over, it was decided to defer any further testing until the IBM equipment was installed.

(The readings taken during this test are tabulated on the next three pages.)

LINCOLN HOUSING SOLAR SYSTEM TEST

DATE: March 27, 1978

[illegible]

LINCOLN HOLDING SOLAR SYSTEM TEST

DATE: March 27, 1978

[illegible]

AS BUILT DRAWING

MONITORING SYSTEM

17 August 1978

MIN. SENSOR SET SUMMARY
FOR
LINCOLN HOUSING AUTHORITY

		<u>NUMBER</u>	<u>TYPE, COMMENTS</u>
I.	TEMPERATURE		
	Pipes	<u>18</u>	Probe type, immersion wells used in liquid systems
	Tanks	<u>3</u>	
	Ducts	<u>1</u>	
	Ext. Air	<u>1</u>	
	Int. Air	<u>1</u>	
	Surface	<u>2</u>	
II.	FLOWRATE		
	1. Liquid	<u>7</u>	Inline, Ramapo (impact type) or equal
	2. Gas (air)	<u> </u>	Inline, Annubar (pitot type) or equal
III.	POWER	<u>8</u>	Wattmeter in series with load
IV.	INSOLATION		
	1. Total	<u>1</u>	Eppley (thermopile type) or or equal
	2. Diffuse	<u> </u>	Eppley (thermopile type) or equal
V.	WIND SPEED	<u> </u>	Vane/prop type, roof mast mount
	WIND DIRECTION	<u> </u>	Vane/prop type, roof mast mount
VI.	RELATIVE HUMIDITY		
	1. Internal	<u>1</u>	Probe, Weathermeasure or equivalent
	2. External	<u> </u>	Probe, Weathermeasure or equivalent
	TOTAL SENSORS	<u>41</u>	
	TOTAL CHANNELS	<u>41</u>	

Date 4-5-78Site LINCOLN HOUSING WIRE LIST - 7933787sheet 6 of 8

FROM SENSOR				TO JUNCTION BOX			
SENSOR REF. MEAS. SENSOR	SENSOR	SENSOR W/ BOX	SENSOR W/ BOX	TERMINAL	INTERNAL JUMPER		
NUMBER NUMBER	CONNECTION	WIRE COLOR	STRIP NO.	FROM	TO	CHANNEL	LEVEL
<u>I001</u>	<u>I001</u>	1	Black	<u>TB16-12</u>		<u>42</u>	Lo
		2	Red	<u>TB16-11</u>		<u>42</u>	Hi
			Shield	<u>TB16-13</u>			Shield
<u>EP100</u>	<u>EP100</u>	1	Black	<u>TB14-7</u>		<u>35</u>	Lo
		2	Red	<u>TB14-6</u>		<u>35</u>	Hi
			Shield	<u>TB14-8</u>			Shield
<u>EP104</u>	<u>EP104</u>	1	Black	<u>TB14-12</u>		<u>36</u>	Lo
		2	Red	<u>TB14-11</u>		<u>36</u>	Hi
			Shield	<u>TB14-13</u>			Shield
<u>EP105</u>	<u>EP105</u>	1	Black	<u>TB15-2</u>		<u>37</u>	Lo
		2	Red	<u>TB15-1</u>		<u>37</u>	Hi
			Shield	<u>TB15-3</u>			Shield
<u>EP200</u>	<u>EP200</u>	1	Black	<u>TB15-7</u>		<u>38</u>	Lo
		2	Red	<u>TB15-6</u>		<u>38</u>	Hi
			Shield	<u>TB15-8</u>			Shield
<u>EP300</u>	<u>EP300</u>	1	Black	<u>TB15-12</u>		<u>39</u>	Lo
		2	Red	<u>TB15-11</u>		<u>39</u>	Hi
			Shield	<u>TB15-13</u>			Shield
<u>EP400</u>	<u>EP400</u>	1	Black	<u>TB16-2</u>		<u>40</u>	Lo
		2	Red	<u>TB16-1</u>		<u>40</u>	Hi
			Shield	<u>TB16-3</u>			Shield
<u>EP401</u>	<u>EP401</u>	1	Black	<u>TB16-7</u>		<u>41</u>	Lo
		2	Red	<u>TB16-6</u>		<u>41</u>	Hi
			Shield	<u>TB16-8</u>			Shield
<u>EP402</u>	<u>EP402</u>	1	Black	<u>TB18-2</u>		<u>46</u>	Lo
		2	Red	<u>TB18-1</u>		<u>46</u>	Hi
			Shield	<u>TB18-3</u>			Shield

SOLAR SPACE HEATING SYSTEM DIAGRAM

SCALE

LINCOLN HOUSING AUTHORITY
CENTRAL ADMINISTRATIVE OFFICE
LINCOLN, NEBRASKA

SOLAR WATER HEATING SYSTEM DIAGRAM
 NO. _____ SCALE _____

Measurement									Pipe Type	Pipe Size (Inches)	Tube Size (Inches)	Instal- lation Method	Ref. Fig. No.	Thermowell Part No.	Probe Part No.
No.	Designation	Number		Justi- fication	Name	S/N	Range (°F)								
		J-Box	SDAS				Min.	Max.							
1	T001				Average outside ambient temp		-20	120					B29	IS4	S53P40Z36
2	T100				DHW collector inlet temp		30	230	CU	3/4		Solder Tee	B4	F203U4	S53P30Z36
3	T150				DHW collector outlet temp		30	230	CU	3/4		Solder Tee	B4	F203U4	S53P30Z36
4	T101				DHW collector HX inlet temp		30	230	CU	3/4		Solder Tee	B4	F203U4	S53P30Z36
5	T151				DHW collector HX outlet temp		30	230	CU	3/4		Solder Tee	B4	F203U4	S53P30Z36
6	T102				DHW collector absorber plate temp		30	450				Bond	B30		S7301
7	T103				Collector inlet temp		30	230	CU	2-1/2		Solder Tee	B4	F203U15	S53P40Z36
8	T153				Collector outlet temp		30	330	CU	2-1/2		Solder Tee	B4	F203U15	S53P40Z36
9	T104				HX inlet temp (collector side)		30	230	CU	2-1/2		Solder Tee	B4	F203U15	S53P40Z36
10	T154				HX outlet temp (collector side)		30	230	CU	2-1/2		Solder Tee	B4	F203U15	S53P40Z36
11	T105				Collector absorber plate temp		30	450				Bond	B30		S7301
12	T200				Storage tank inlet temp from HX		30	160	CU	3		Solder Tee	B4	F203U15	S53P40Z36
13	T250				Storage tank outlet temp to HX		30	160	CU	3		Solder Tee	B4	F203U15	S53P40Z36
14	T201				Storage tank temp, top		30	160				Tank Probe		F203U440	S53P470
15	T202				Storage tank temp, middle		30	160				Tank Probe		F203U440	S53P470
16	T203				Storage tank temp, bottom		30	160				Tank Probe		F203U440	S53P470
17	T300				Make up water supply temp		-20	120	CU	3/4		Solder Tee	B4	F203U4	S53P30Z36
18	T350				DHW solar storage tank outlet temp		30	160	CU	3/4		Solder Tee	B4	F203U4	S53P30Z36

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OPERATION & MAINTENANCE MANUAL

-INDEX-

LINCOLN HOUSING AUTHORITY SOLAR HEATING SYSTEM

Page 1	Start up Procedure
2	Shut Down Procedure Solar Domestic Water Heating System Seasonal Changeover Procedure
3 & 4	Valve List

SHOP DRAWINGS

Valves
Actuators
Test and Balance Reports
Flexible Connectors
Thermometers
Insulation Materials
Ethylene Glycol
Pumps
Solar Collectors
Heat Exchanger
Solar Water Heater
Differential Thermostats
Relairtrol
Unit Heater
Storage Tank

LINCOLN HOUSING AUTHORITY SOLAR HEATING SYSTEM

START UP AND SHUT DOWN PROCEDURE

START UP PROCEDURE

- 1- Make sure power to pumps (P3 & P5) is turned on in the main electrical panel. North wall of Mechanical room--switch #25 (this switch must remain on at all times).
- 2- Be sure P3 & P5 pumps engage when power is turned on. If pumps fail to come on, push reset buttons on motor starters on south wall of Mechanical room.
- 3- Both pumps will be running when the temperature in the solar collectors is 20 degrees F. greater than the temperature in the storage tank.
- 4- Pressure on storage tank should range from 10 to 25 pounds when in operation.
 - A- If the pressure exceeds 30 pounds on the storage tank, the relief valve on the storage tank should be opened to let the pressure down to 20 pounds.
 - B- If the pressure on the glycol system (pump P3) is below 2 pounds when pump is off, system must have glycol added. Pressure should normally range from 8 to 16 pounds when pump is not operating.
- (1) PROCEDURE FOR ADDING GLYCOL (filling system):
 - Must have a drill pump
 - 5 feet of hose
 - 5 gallon bucket
- (2) Glycol must be added to top of collector--west end--row 4 (counting from the North). Note: This should only be done in early morning hours before the sun has been out for more than one (1) hour or on a cloudy day.
- (3) Add glycol until drill pump will no longer pump into system.
- (4) Be sure to add only pure glycol.
- (5) After pure glycol has been added: go to Mechanical room and add sufficient amount of make up water by opening valves #16 & #17 until pressure gauge reads 14 pounds (at valves #16 & 17).
- 5- Valve #'s ___ and ___ are valves to building heating system. These are to remain on at all times, and bypass valve # ___ is to remain off at all times, except when storage tank in need of maintenance or service.
- 6- In the summertime when building heating system is not in operation, Unit Heater on roof is designed with an Aquastat on return line to come on when return temperature exceeds 120 degrees F. and remove the heat from the collectors

SHUT DOWN PROCEDURE

- 1- To be done only when system needs major maintenance.
- 2- Switch #25 on North wall of Mechanical room for pumps P3 & P5 should be turned off.
- 3- If glycol system needs draining for maintenance or if glycol system is to drained complete. Open drain valve #14 directly below Heat Exchanger, and drain to level maintenance requires.
 - A- When refilling system after maintenance, refer to Start Up Procedure, page 1, #4-3 (1) thru (5).
 - B- Note: This should be done if at all possible in the early morning hours before the sun has been out for more than one (1) hour or on a cloudy day.

SOLAR DOMESTIC WATER HEATING SYSTEM

- 1- Solar domestic hot water heating system is a supplemented by a gas water heater and will remain in operation at all times.
- 2- C.P. 1 (circulating pump) for glycol system just has an electrical outlet directly above water heater. This outlet is to remain in at all times.
 - A- Pump is designed to come on when the temperature in the collectors exceeds temperature in the water heater storage tank by 20 degrees F.
 - B- Pump will keep circulating until temperature in the storage tank equals the temperature in the glycol system.
- 3- Glycol system is drained by drain valve at bottom of water heater storage tank #24.
 - A- System is filled by same procedure as discribed for Solar Heating system in Start Up Procedure, page 1, #4-3 (1) thru (5).
To Be Used Only When Required For Maintenance.
- 4- It is important that valve #21 Supply and #22 Return remain open at all times (located directly above Solar Water Heater)
- 5- Valves #18 and #19 are to remain open at all times. Valve #20 should remain closed at all times.

FOR SEASONAL CHANGEOVER PROCEDURE--REFER TO REGULAR HEATING AND COOLING CHANGEOVER FOR EXSISTING SYSTEM.

OPERATING MODE SCHEDULE - SPACE HEATING

<u>MODE</u>	<u>DESCRIPTION</u>	<u>PUMPS</u>				<u>BACKUP BOILER</u>	<u>HEAT VENT UNIT</u>	<u>Valves*</u>		
		<u>P-1</u>	<u>P-2</u>	<u>P-3</u>	<u>P-5</u>			<u>V-1</u>	<u>V-2</u>	<u>V-3</u>
1	Space Heating Demand Adequate Insolation Adequate Storage of Energy	On	On	On	On	Off	Off	S	C	O
2	Space Heating Demand Inadequate Insolation Inadequate Storage	On	On	Off	Off	On	Off	B	C	O
3	No Space Heating Demand Adequate Insolation Adequate Storage of Energy	Off	Off	On	On	Off	On	S	O	C

- * S - Open to Storage
- B - Open to Boiler
- C - Closed
- O - Open

SOLAR SPACE HEATING SYSTEM DIAGRAM

LINCOLN HOUSING AUTHORITY
CENTRAL ADMINISTRATIVE OFFICE
LINCOLN, NEBRASKA

OPERATING MODE SCHEDULE - WATER HEATING

<u>MODE</u>	<u>DESCRIPTION</u>	<u>PUMP P-4</u>	<u>BACKUP GAS WATER HEATER</u>
1	Water Heating Demand Adequate Insolation Adequate Storage of Energy	On	Off
2	Water Heating Demand Inadequate Insolation Inadequate Storage of Energy	Off	On

SOLAR WATER HEATING SYSTEM DIAGRAM

NO

SCALE

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LINCOLN, NEBR.

LINCOLN HOUSING AUTHORITY

SOLAR HEAT SYSTEM VALVE LIST

<u>Valve No.</u>	<u>Function</u>	<u>Location</u>	<u>Size</u>
1 - - -	Storage tank return - - - - -	Bottom South end of storage tank	3"
2 - - -	Storage tank supply - - - - -	Top North end of storage tank	3"
3 - - -	To boiler supply - - - - -	Top South end of storage tank	2"
4 - - -	From boiler return - - - - -	Bottom North end of storage tank	2"
5 - - -	Heat exchanger supply - - - - -	Heat Exchanger	3"
6 - - -	Heat exchanger return - - - - -	Heat Exchanger	3"
7 - - -	Ethylene Glycol return - - - - -	Heat Exchanger	2 1/2"
8 - - -	Ethylene Glycol supply - - - - -	Heat Exchanger	2 1/2"
9 - - -	Storage tank pump return - - - - -	South end of storage tank	2"
10 - - -	Storage tank pump return - - - - -	South end of storage tank	2"
11 - - -	Ethylene Glycol pump supply - - - - -	North of Heat Exchanger	2"
12 - - -	Ethylene Glycol pump supply - - - - -	North of Heat Exchanger	2"
13 - - -	Heat exchanger tubular drain - - - - -	Heat Exchanger	1/2"
14 - - -	Heat exchanger glycol drain - - - - -	Heat Exchanger	3/4"
15 - - -	Storage tank drain - - - - -	Bottom center of storage tank	2 1/2"
16 - - -	Ethylene Glycol make up water - - - - -	Top of storage tank	3/4"
17 - - -	Ethylene Glycol make up water - - - - -	Top of storage tank	3/4"
18 - - -	Cold water supply to Solar Water Heater - - - - -	Water Heater	3/4"
19 - - -	Hot water supply to Solar Water Heater - - - - -	Water Heater	3/4"
20 - - -	Solar Water Heater bypass - - - - -	Water Heater	3/4"
21 - - -	Solar Water Heater glycol supply - - - - -	Water Heater	1/2"
22 - - -	Solar Water Heater glycol return - - - - -	Water Heater	1/2"
23 - - -	Solar Water Heater Expansion tank supply - - - - -	Water Heater	1/2"
24 - - -	Solar Water Heater glycol drain - - - - -	Water Heater	1/2"
25 - - -	Rolairtrol drain - - - - -	Rolairtrol	1/2"
26 - - -	Ethylene Glycol Expansion tank drain - - - - -	Expansion tank in Southeast corner	1/2"

VALVE LIST FOR ETHYLENE GLYCOL ON ROOF

27 - - -	Row #1 supply - - - - -	Bottom west end Row #1	1 1/2"
28 - - -	Row #1 return - - - - -	Top east end Row #1	1 1/2"
29 - - -	Row #2 supply - - - - -	Bottom west end Row #2	1 1/2"
30 - - -	Row #2 return - - - - -	Top east end Row #2	1 1/2"
31 - - -	Row #3 supply - - - - -	Bottom west end Row #3	1 1/2"
32 - - -	Row #3 return - - - - -	Top east end Row #3	1 1/2"
33 - - -	Row #4 supply - - - - -	Bottom west end Row #4	1 1/2"

-continued-

LINCOLN HOUSING AUTHORITY

VALVE LIST FOR STEWART GYCOL ON ROOF

-continued-

<u>Valve</u> <u>No.</u>	<u>Function</u>	<u>Location</u>	<u>Size</u>
34 - - -	Row #4 return - - - - -	Top east end Row #4	1 1/2"
35 - - -	Row #5 supply - - - - -	Bottom west end Row #5	1 1/2"
36 - - -	Row #5 return - - - - -	Top east end Row #5	1 1/2"
37 - - -	Row #6 supply - - - - -	Bottom west end Row #6	1 1/2"
38 - - -	Row #6 return - - - - -	Top east end Row #6	1 1/2"
39 - - -	Unit Heater supply - - - -	Row #3 west end	2"
40 - - -	Unit Heater supply - - - -	Row #3 west end	2"
41 - - -	Unit Heater supply - - - -	Row #3 west end	2"
42 - - -	Unit Heater bypass - - - -	Row #3 west end	2"
43 - - -	Water Heater supply - - - -	Row #2 west end	1 1/2"
44 - - -	Water Heater supply - - - -	Row #2 west end	1 1/2"
45 - - -	Water Heater return - - - -	Row #2 west end	1 1/2"
46 - - -	Water Heater return - - - -	Row #2 west end	1 1/2"

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ELECTRIC

CLARK ENERSEN

VALVE SIZE	ACTUATOR NO.	TORQUE FT. LBS.	A	B	C	D	E	SPEED /90°
1/4 & 3/8	EVA 25	20.8	SEE VALVE	SEE VALVE	8.05	2.48	7.05	5.5 SEC.
1/2	EVA 25	20.8			8.05	2.48	7.05	5.5 SEC.
3/4	EVA 25	20.8			8.34	2.48	7.05	5.5 SEC.
1	EVA 25	20.8			8.34	2.48	7.05	5.5 SEC.
1-1/4	EVA 25	20.8			9.41	2.48	7.05	5.5 SEC.
1-1/2	EVA 25	20.8			9.60	2.48	7.05	5.5 SEC.
2	EVA 25	20.8			9.82	2.48	7.05	5.5 SEC.
2-1/2 & 3	EVA 40	33.3			10.82	2.48	7.05	8.5 SEC.

DATA

- 115 VOLT A.C. 60/50 HZ 1 PHASE
- OPERATION: UNIDIRECTIONAL
- CONDUIT ENTRY: 1/2"
- AMPS DRAW: EVA 25, 2.8 AMPS
EVA 40, 3.1 AMPS

- BUILT IN OVERLOAD PROTECTION WITH AUTOMATIC RESET
- FAST MANUAL OVERRIDE WITHOUT DISENGAGING A CLUTCH
- PERMANENT LUBRICATED GEAR TRAIN
- OPERATING TEMPERATURES TO 150 DEGREES F.
- TERMINAL STRIP IS PREWIRED FOR SIMPLE INSTALLATION

FEATURES

- BRAKE FOR POSITIVE STOPS
- 15% DUTY CYCLE

PNEUMATIC/HYDRAULIC

	VALVE SIZE	ACTUATOR NO.	TORQUE* FT. LBS.	A	B	C	D	E
STANDARD	1/4 & 3/8	BVA 2	20	SEE VALVE	SEE VALVE	6.00	2.00	7.75
	1/2	BVA 2	20			6.00	2.00	7.75
	3/4	BVA 2	20			6.32	2.00	7.75
	1	BVA 2	20			6.32	2.00	7.75
	1-1/4	BVA 2	20			7.25	2.00	7.75
	1-1/2	BVA 2	20			7.44	2.00	7.75
	2	BVA 2	20			7.66	2.00	7.75
	2-1/2 & 3	BVA 3	73			9.56	2.88	10.48
FAIL-SAFE	1/4 & 3/8	BVA 2S	6.2			6.00	2.00	9.75
	1/2	BVA 2S	6.2			6.00	2.00	9.75
	3/4	BVA 2S	6.2			6.32	2.00	9.75
	1	BVA 2S	6.2			6.32	2.00	9.75
	1-1/4	BVA 3S	20.8			8.06	2.88	15.38
	1-1/2	BVA 3S	20.8			8.25	2.88	15.38
	2	BVA 3S	20.8			8.94	2.88	15.38
	2-1/2 & 3	BVA 3S	20.8			9.56	2.88	15.38

*Torque rating is based on 80 p.s.i. air pressure

FEATURES

- ACTUATORS SIZED FOR 80 TO 125 P.S.I. AIR
- MANUAL OVERRIDE AND POSITION INDICATOR
- ADJUSTABLE STOPS FOR PRECISION POSITIONING

- 1/4 NPT SUPPLY CONNECTIONS
- FAIL-SAFE ACTUATORS ARE NORMALLY MOUNTED FAIL TO CLOSE, BUT CAN BE MOUNTED FAIL TO OPEN
- FILTERED AND LUBRICATED AIR IS RECOMMENDED TO EXTEND PISTON LIFE

OPTIONS

- OTHER A. C. AND D. C. VOLTAGES
- RELAYS FOR TWO WIRE CONTROL
- NEMA 7 EXPLOSION PROOF ENCLOSURES

- AUXILIARY SWITCHES AND CAMS
- REVERSIBLE MOTORS

OPTIONS

- NEMA 1 AND 7 SOLENOIDS, DOUBLE ACTING ACTUATORS REQUIRE TWO

- MOUNTED NEMA 4 SWITCHES

THE SOLDER END *Apollo*®

EXTERNALLY REPLACEABLE STEM

- OPTIONS -

- CHROMIUM PLATED BALL—EXTREMELY HARD WEAR SURFACE REDUCES FRICTION, SEAT WEAR AND THE EROSIVE EFFECTS OF THE MEDIA
- HIGH PERFORMANCE REINFORCED TEFLON® SEATS AND STEM SEALS ARE STANDARD
- 316 STAINLESS STEEL BALL
- BALANCING STOPS
- ROUGH CHROME PLATING
- STEEL TEE HANDLES
- STATIC GROUNDING DEVICES
- LOCKED RETAINER

The "APOLLO" solder end ball valve is designed to be soft soldered into lines without disassembly. This allows a tested valve to be installed without disturbing the seats and seals in any way.

BRONZE — SOLDER ENDS

NUMBER	SIZE	A	B	C	D	E	F	Cv**
70-202	3/8	3/8	1-9/32	2-9/16	1-3/4	3-7/8	.503/.505	5.3
70-203	1/2	1/2	1-7/16	2-7/8	1-13/16	3-7/8	.628/.630	9.8
70-204	3/4	11/16	1-15/16	3-7/8	2-1/8	4-7/8	.878/.880	18
70-205	1	7/8	2-1/4	4-1/2	2-1/4	4-7/8	1.129/1.131	32
70-206	1-1/4	1	2-5/16	4-5/8	2-5/8	5-1/2	1.378/1.381	40
70-207	1-1/2	1-1/4	2-5/8	5-1/4	2-7/8	5-1/2	1.629/1.632	75
70-208	2	1-1/2	3-3/16	6-3/8	3-1/16	5-1/2	2.129/2.132	98

**The Cv factor is the gallons of water per minute that the valve will pass with 1 p.s.i. pressure drop.
SEE BACK COVER FOR ORDERING INFORMATION

FIELD INSTALLATION INSTRUCTIONS MODEL MA-8 UNIDIRECTIONAL

WARNING: Unit should always be handled with care when cover is removed and wired to electric power source.

INSTALLATION:

1. Operate valve manually before installing actuator.
2. When actuator is supplied separately from valve, actuator will be shipped in valve (open) position and care should be taken to maintain proper alignment between the actuator and valve shafts. If actuator shaft must be adjusted to align with valve, this should be done electrically, if possible.
3. Mount actuator to valve and operate manually (see manual instructions) to determine if there is any undue resistance.
4. Remove the four hex head bolts (B) located about the flange of the unit.
5. Lift off control cover (A).
6. Wire per diagram or if actuator is of special design; see special wiring diagram attached. Wiring diagram is drawn with valve in open position. 18 gage stranded wire or better, should be used in field hook-up.
7. Run unit from one extreme to the other several times.
8. Make final cam adjustment (if required) as follows:

STANDARD UNIDIRECTIONAL WIRING DIAGRAM

To adjust open position for undertravel:

- (a) Operate unit electrically to a position which allows easy access to the cam clamping screw of cam "D".
- (b) Loosen clamping screw to give the cam a finger tight grip on shaft.
- (c) Rotate cam slightly in a clockwise direction.
- (d) Run unit into corrected open and check new position. (If unit is still undertravelling, repeat steps (a), (c) and (d) again, taking care not to overadjust.)
- (e) Repeat step (a).
- (f) Tighten clamping screw (Care must be taken not to put undue pressure against cam which might move it out of correct position.)

To adjust open position for overtravel:

- (a) Operate unit electrically to a position which allows easy access to the cam clamping screw of cam "D".
- (b) Loosen clamping screw to give cam a finger tight grip on shaft.
- (c) Rotate cam slightly in a counter-clockwise direction.
- (d) Run unit into corrected position (open) and check new position. (If unit is still over-travelling, repeat steps (a), (c), and (d) again, taking care not to over-adjust).
- (e) Repeat step (a).
- (f) Tighten clamping screw. (Care must be taken not to put undue pressure against cam which might move it out of correct position.)

To adjust close position for undertravel:

- (a) Operate unit electrically to a position which allows easy access to the cam clamping screw of cam "E".
- (b) Loosen clamping screw to give the cam a finger tight grip on shaft.
- (c) Rotate cam slightly in a clockwise direction.
- (d) Run unit into corrected close and check new position. (If unit is still under-travelling, repeat steps (a), (c) and (d) again, taking care not to overadjust.)
- (e) Repeat step (a).
- (f) Tighten clamping screw (care must be taken not to put undue pressure against cam which might move it out of correct position.)

To adjust close position for over-travel:

- (a) Operate unit electrically to a position which allows easy access to the cam clamping screw of cam "E".
- (b) Loosen clamping screw to give cam a finger tight grip on shaft.
- (c) Rotate cam slightly in a counter-clockwise direction.
- (d) Run unit into corrected position and check new position.
- (e) Repeat step (a).
- (f) Tighten clamping screw. (Care should be taken not to put undue pressure against cam which might move it out of correct position.)

In the event that the above procedure does not give the necessary travel control, the micro adjustment cam has to be repositioned as follows:

To adjust open position:

- (a) Loosen pivot and micro adjustment screws on switch "D".
- (b) In the event of actuator under-travel, rotate micro adjustment cam to swing switch outward from cam post.
- (c) In the event of actuator over-travel, swing switch into cam post.
- (d) Tighten pivot and micro adjustment screws on switch "D".

To adjust close position:

- (a) Loosen pivot and micro adjustment screws on switch "E".
 - (b) In the event of actuator under-travel, rotate micro adjustment cam to swing switch outward from cam post.
 - (c) In the event of actuator over-travel, swing switch into cam post.
 - (d) Tighten pivot and micro adjustment screws on switch "E".
9. Replace control cover (A) and tighten all flange bolts (B).
10. Unit is now ready for automatic operation.

FEATURES:

Maintenance: Gear train is permanently lubricated at the factory for the average life of the actuator. No further attention is required.

Thermal Overload: An integral thermal overload protector guards the motor against overheating. It opens the circuit to the motor when the temperature reaches 180° F., and automatically closes when the temperature drops to a safe level. This feature is not included in explosion-proof models.

TO MANUALLY OPERATE:

Manual operation is accomplished by use of an open end wrench on the hex stock coupling adapter. Direction of rotation and or position can be checked by indicator located on output shaft.

MATERIALS:

HOSE BRONZE

BRAID BRONZE

NIPPLE CARBON STEEL

ITEM	SIZE	OVERALL LENGTH	NOM. MAX. O. D.	PRESSURES		TEMP.	MOTION	
				OPER.	TEST		LATERAL*	OTHER
1	2"	15"	2.93	280	420	70°F		

*TO EITHER SIDE OF CENTER LINE

CUSTOMER WESTERN SUPPLY CO.

PROJECT _____

ENGINEER _____

ARCHITECT _____

P. O. No. 77-5976

Flexonics Division
Universal Oil Products Company
300 East Devon Avenue • Bartlett, Illinois 60103
uop

DESCRIPTION:

METAL HOSE ASSEMBLY, BRAIDED WITH
NPT MALE NIPPLES EACH END

Drawn By
D.L. BARTOSIK 12-2-77

Date

32-100

Industrial Types (Cont.)

CATALOG NUMBERS

DIAL SIZE	STEM LENGTH	90° BACK ANGLE FORM	STRAIGHT FORM	90° LEFT SIDE ANGLE FORM	90° RIGHT SIDE ANGLE FORM
3"	2½"	3A02	3S02	3L02	3R02
	4"	3A04	3S04	3L04	3R04
	6"	3A06	3S06	3L06	3R06
	9"	3A09	3S09	3L08	3R09
	12"	3A12	3S12	3L12	3R12
	15"	3A15	3S15	3L15	3R15
	18"	3A18	3S18	3L18	3R18
	24"	3A24	3S24	3L24	3R24

STANDARD RANGES

-40 to 120°F in 2° divs.*	-50 to 50°C in 1° divs.*
25 to 125°F in 1° divs.*	-70 to 70°C in 2° divs.
-70 to 150°F in 2° divs.	-10 to 110°C in 1° divs.
0 to 150°F in 2° divs.*	0 to 150°C in 2° divs.
0 to 200°F in 2° divs.	0 to 200°C in 2° divs.
20 to 240°F in 2° divs.	0 to 300°C in 5° divs.*
50 to 300°F in 2° divs.	100 to 400°C in 5° divs.*
50 to 400°F in 5° divs.	50 to 500°C in 5° divs.**
50 to 500°F in 5° divs.*	
150 to 750°F in 10° divs.*	
200 to 1000°F in 10° divs.**	

*Not recommended with 2½" stem (on straight, left side or right side angle forms only).

**Not recommended for continuous use above 800°F or equivalent C. For service above 800°F, use Weksler filled-system dial thermometers or industrial liquid-in-glass thermometers.

WHEN ORDERING: Give (1) Type No. (2) Range (3) Variations from standard, if any.

WELLS AND FLANGE FOR INDUSTRIAL BI-METAL THERMOMETERS

WELLS WITHOUT LAGGING EXTENSION

¾" NPT				1" NPT			
CATA-LOG NO.	A	U	Q	CATA-LOG NO.	A	U	Q
S3-4	4	2½	—	S4-4	4	2½	—
S3-6	6	4½	¾	S4-6	6	4½	¾
S3-9	9	7½	¾	S4-9	9	7½	¾
S3-2	12	10½	¾	S4-2	12	10½	¾
S3-5	15	13½	¾	S4-5	15	13½	¾
S3-8	18	16½	¾	S4-8	18	16½	¾
S3-X	24	22½	¾	S4-X	24	22½	¾

WELLS WITH LAGGING EXTENSION

¾" NPT					1" NPT				
CATA-LOG NO.	A	U	T	Q	CATA-LOG NO.	A	U	T	Q
L3-6	6	2½	2	—	L4-6	6	2½	2	—
L3-9	9	4½	3	¾	L4-9	9	4½	3	¾
L3-2	12	7½	3	¾	L4-2	12	7½	3	¾
L3-5	15	10½	3	¾	L4-5	15	10½	3	¾
L3-8	18	13½	3	¾	L4-8	18	13½	3	¾
L3-X	24	19½	3	¾	L4-X	24	19½	3	¾

Catalog numbers require insertion of third digit to denote well material.

B=Brass* G=Type 304 Stainless Steel
S=Carbon Steel

J=Type 316 Stainless Steel M=Monel

*Brass wells are not recommended for installations involving high pressures and/or temperatures over 400°F.

½" NPT FLANGE

Satin finish chrome plated brass. For use in air ducts, dryers, ovens, etc. Cat. No. 2F2

Cat. 225 — pg 6

CLARK &
ENERSEN
HAMERSKY
SCHLAEBITZ
BURROUGHS
& THOMSEN

**ARCHITECTS
ENGINEERS
PLANNERS
LINCOLN, NEBR.**

SHOP DRAWING REVIEW

ARCHITECT'S REVIEW		RESPONSE REQUIRED OF CONTRACTOR	
No Exceptions Taken ☒	Rejected ☐	Confirm ☐	
Note Markings ☐	Comments Attached ☐	Resubmit ☐	

Architect's review is for general conformance with the design concept and contract documents. Markings or comments shall not be construed as relieving the Contractor from compliance with the project plans and specifications, nor departures therefrom. The Contractor remains responsible for details and accuracy for confirming and correlating all quantities and dimensions, for selecting fabrication processes, for techniques of assembly, for performing his work in a safe manner, and coordinating with all trades relating to this submittal.

CLARK & ENERSEN, HAMERSKY, SCHLAEBITZ, BURROUGHS & THOMSEN

By CLT Date 1/12/78

CERTAIN-TEED 500° SNAP*ON FIBER GLASS PIPE INSULATION

PRODUCT DATA

**Certain-teed 500° snap*on
fiber glass
pipe insulation**

WITH FACTORY APPLIED ALL SERVICE JACKET (ASJ)

CERTAINTEED
CSG GROUP

Description

Certain-teed 500° Snap*On Pipe Insulation is composed of extremely fine diameter glass fibers bonded together with a phenolic resin and molded in one piece sections. Made with a single seam, Certain-teed Snap*On spreads open to receive the pipe and snaps quickly in place. It has all the desirable features of glass. The glass fiber will not burn, is not affected by moisture, will not corrode metals, will not rot or mildew and is permanent. The insulation will permit expansion and contraction of the pipe without cracking and it will not shrink.

Certain-teed 500° Snap*On Pipe Insulation with factory applied ALL SERVICE JACKET is specifically designed for dual temperature piping. The product may be used on lines operating from -20F to 500F.

Uses

Domestic Hot Water
Heating Hot Water
High Temperature
Hot Water
Chilled Water
Dual Temperature

Steam and Condensate
Fuel Oil Piping
Tempered Water
Booster Heater Water
Refrigerated Lines
Concealed and Exposed

Benefits

- Quick and clean application
- Flame resistant
- High thermal efficiency
- Vapor barrier not broken as need for staples is eliminated
- Meets the fire and safety requirements of building codes and government guide specifications

Specification Compliances

Certain-teed 500° Snap*On Pipe Insulation with factory applied ALL SERVICE JACKET meets the following specifications:

HH-B-100B, Types I and II, (Jacket)

HH-I-558B, Form D, Type III, Class 12 (to 450F)
Class 13 (to 500F)

MIL-I-22344B

ASTM C547-67

U.L. Listing

Certain-teed 500° Snap*On with factory applied ALL SERVICE JACKET is listed by Underwriters' Laboratories as having a composite (pipe covering and jacket) flame hazard classification not to exceed the following:

Flame Spread 25 Fuel Contributed 50
Smoke Developed 50

Jacket Properties

- Laminated aluminum foil, glass reinforcing and white kraft paper
- Perm rating of 0.02 perms (HH-B-100B, Type I)
- Puncture resistance: 50 (Beach puncture)
- Tensile strength: 35 lbs./in.

850° Snap*On

Certain-teed also manufactures a Snap*On Pipe Insulation for service temperatures up to 850°F. Description of this extremely efficient fiber glass insulation for these temperatures is covered in data sheet #30-31-49U.

Thermal Efficiency

Recommendations For Installing Certain-teed 500° Snap*On With Self Sealing ASJ Jacket

1. Make certain ASJ Jacket is clean.
2. Make all cuts and fabrications before removing release paper.
3. Make sure to rub hard to assure a positive seal.
4. Do not install when air temperature is lower than 35 F or over 120 F.
5. Do not leave adhesive strip exposed to the air. Adhere self sealing lap immediately after removing paper backing.

PRODUCT DATA

snap* form
fitting systems

ONE-PIECE PVC INSULATED FITTING JACKETS

CERTAINTEED
CSG GROUP

Snap*Form—An Important New Way to Insulate Fittings Quickly, Professionally and Economically

Why Use Insulated Fittings?

The current energy shortages and the escalating costs of energy have made full insulation of pipes and fittings an economic necessity rather than an option.

Snap*FORM, a new development by Certain-teed, offers building owners and insulation contractors insulated fitting jackets that install quickly and economically, without the time-consuming, multi-step operation formerly associated with this task.

Snap*FORM is factory formed. The fitting can be wrapped and the jacket snapped in place in seconds... with professional looking results. There is no need for special skills or prolonged training.

And Snap*FORM not only looks good, it meets specifications for thermal efficiency every time, automatically, no guesswork, no chance of failure.

You can use Snap*FORM indoors or outdoors. Use on hot or cold lines. There are a wide range of sizes and styles to fit your needs (see charts on following pages).

Best of all, Snap*FORM costs no more than ordinary insulated fitting systems. Because of the fast, simple installation method, Snap*FORM can offer you substantial savings in first costs plus measurable savings in energy costs and maintenance after installation.

See the pages that follow for complete information on Snap*FORM.

What Is Snap*Form?

Snap*FORM is Certain-teed's name for a new and improved fitting insulation system comprised of a molded, one-piece PVC fitting jacket and Certain-teed fiber glass insulation insert. This PVC fitting jacket provides an attractive, tough, exterior surface for the fitting. It is held in place by stainless steel metal fasteners.

Certain-teed Products Corporation, a recognized leader in PVC technology, has developed jackets of one-piece design for 90° elbows (short and long radius), 45° elbows, valves and tees. Snap*FORM jackets have been designed by Certain-teed to readily conform to the fittings for quick, easy installation on standard iron pipe and copper water tube sizes.

Important Reasons for Owners and Contractors to Insist on Snap*Form

Snap*FORM eliminates many of the problems associated with other types of fittings requiring multi-step installation. Snap*FORM fitting jackets are factory formed to the contour of the pipe fitting which eliminates costly on-the-job fabrication and finishing. One man can do the job without special tools or lengthy training. Snap*FORM fitting jackets are designed for good looks and long life, and are perfect for easy maintenance using ordinary procedures... especially important where sanitation is a factor, such as in the food and pharmaceutical industries. Snap*FORM systems are your best value because:

● Low Initial Cost

Snap*FORM costs no more than comparable fitting systems... installs quickly and easily without extra tools to carry.

● Good Looking Appearance

Snap*FORM makes up into a good looking professional installation. Off-white color is excellent for most applications. May be painted with alkyl base enamel if desired.

● Non-Toxic, Odorless, Tasteless

Snap*FORM may be used safely in the food or chemical processing industries. It is mold and bacteria resistant and will not contaminate food.

● Corrosion Resistant

Snap*FORM is excellent for use where corrosion due to industrial fumes, humidity conditions, salt water, galvanic or electrolytic action are encountered. Gives years of low-maintenance, trouble-free service under these conditions.

● Superior Vapor Barrier

Snap*FORM provides a vapor barrier as good as or superior to that on adjacent piping. Prevents condensation problems at fittings.

● No Washdown Problems

Snap*FORM withstands water and most chemical and low-solvency washdowns. These properties make Snap*FORM fitting jackets easy to maintain over the years.

● High Impact Resistance

Snap*FORM resists denting and chipping prevalent with other insulation systems, gives years of trouble-free service.

● Easily Available in Most Sizes

Snap*FORM fitting jackets are stocked for immediate delivery in most standard sizes.

● Supplied With Pre-Cut Insulation

Snap*FORM fitting jackets are supplied complete with Certain-teed fiber glass insulation, cut to size (up to size #19).

Proven in Use

PVC, the material used to make Snap*FORM fitting jackets, has been used successfully in many building materials applications for over two decades. Snap*FORM takes full advantage of the properties of PVC to afford an attractive, low maintenance, long-life fitting system that is easy to install.

Where to Use Snap*Form

1. Use Snap*FORM when the surface temperature of the piping jacket is less than 150F.
2. Use Snap*FORM where service temperatures in the pipe are in the range of -120F to 550F when used with Certain-teed Snap*ON Pipe Insulation.

Snap*Form Fitting Systems

1. 90° Elbows (available in long and short radius)

2. Tees

3. Valves

4. 45° Elbows

Product Specifications Snap*Form Insulated Fittings

PVC Jacket

1. Composition: Meets L-P-535D Composition A, Type 11, Grade GU
2. Moisture absorption: 0.5% by weight, maximum.
3. Weatherability: 3000 hours weatherometer test, no product degradation
4. Corrosion resistance: Does not cause or contribute to corrosion of steel, copper or aluminum.
5. Odor resistance: Odorless. Does not absorb odors.
6. Mold and bacteria resistance: Does not support growth of mold or bacteria. Does not provide sustenance for insects, rodents or vermin.
7. Upper temperature limit: 150F is maximum rated temperature of jacket
8. Chemical resistance: Resistant to most inorganic

- acids and bases. Organic solvents may cause deterioration. Resistant to normal cleaning agents
9. Impact strength, IZOD: 5.0 foot pounds/inch of notch, ASTM D 256
10. Flammability: Self-extinguishing ASTM D 568*
11. Paintability: Alkyd base enamel

*Not to be used for rating purposes

Certain-teed Fibrous Glass Inserts

Federal and Military Specifications:

HH-1-558B	Insulation blankets flexible	Form B Type 1 Class 7 Class 8	Flexible blankets below ambient to 1000F
MIL-1-2023C	Thermal insulation for	Type 1 Class 3	Therma

RUBATEX FS

**FLEXIBLE CLOSED CELL
TUBING AND SHEET
INSULATIONS**

• INSULATION TAPE
• ANTI VIBRATION PADS
• ADHESIVES

T-277
SUPERSEDES T-276

RUBATEX
RUBATEX
RUBATEX
RUBATEX

RUBATEX FS

TUBING INSULATION

R-180-FS TUBING INSULATION

is a lightweight, flexible closed cell material designed for insulating liquid cooling and heating lines. The closed cell structure of R-180-FS forms a barrier to prevent condensation/frost formation and heat gain on cold lines; also to control heat loss on liquid heating lines in airconditioning, refrigeration, plumbing and heating systems when installed in recommended thicknesses.

APPLICATION:

RUBATEX R-180-FS TUBING INSULATION is easily applied to either preassembled lines or on existing lines.

Where practical it is easier and time saving to apply the insulation prior to assembling the line. Just slip the full length of Rubatex Tubing over the end of the pipe. The ID is powdered to allow easy slippage even around most bends in the pipes. Brush a light, even coat of Rubatex 373 (or 372) adhesive on both ends to be sealed. Allow the adhesive to set until dry to the touch but tacky under slight pressure, then butt the joints together firmly.

To insulate existing lines, slit Rubatex Tubing lengthwise with a sharp knife or razor blade and snap it on the lines. Seal longitudinal slit surfaces and butt joints with Rubatex 373 (or 372) adhesive.

To assure a complete seal and avoid loss of insulation efficiency the seams and butt joints must be fully covered with adhesive, and the surface nearest the pipe should be pressed together first and evenly before joining the entire surface. Tape should never be used on seams and joints in lieu of adhesive. Tape is less effective than adhesive and may allow passage of moisture and air.

The tubing insulation should not be stretched to force longer lengths. This reduces the wall thickness and insulating properties, and can cause failure of butt-joint adhesive bonds.

Rubatex R-180-FS can be used to insulate lines buried underground but any backfill will depress the wall thickness. If backfill contains large, dense aggregate that may damage or depress the insulation, a 3 to 5 inch prior layer of sand on the exterior is recommended.

RUBATEX

INSULATION PRODUCTS

INSULATING FITTINGS

Rubatex R-180-FS Tubing Insulation is easy to cut and fabricate for tees, elbows, crosses, or almost any sweat or threaded fitting on existing or preassembled lines.

Use of a well sharpened knife is satisfactory for cutting the insulation, but a knife with tooth-blade combination (bread knife), or a hacksaw blade ground to a knife edge for a smoother, more accurate cut is preferable. For best results full back and forth cuts are used, depressing the insulation as little as possible to avoid irregular cuts.

The most commonly used fittings—tees, elbows and crosses—require only 45° and 90° cuts. A miter box will offer more accurate cuts but careful free-hand cuts are usually faster and more convenient on job site installations.

Insulation for sweat and threaded fittings should be the same wall thickness as for all adjacent line insulation.

INSULATING SWEAT FITTINGS

On preassembled lines push back the insulation on the pipes a sufficient distance from fittings to prevent burning of insulation. Apply clamps to pipes—not on insulation—to hold insulation in place while soldering fittings. Remove clamps as soon as fittings and pipes are cool.

Fabricate insulation for fitting and join sections with Rubatex 373 (or 372) adhesive. After adhesive is dry, slit insulation and snap over fitting. Follow same procedure for pre-assembled or existing lines. Slits and joints should be carefully bonded with adhesive after lines have been tested.

INSULATING THREADED FITTINGS

Cut line insulation long enough to press against threaded fitting. Inside diameter of fitting insulation should be approximately the same as outside diameter of line insulation to cover overlap surface snugly. Allow a minimum of 1" overlap on line insulation. Follow same fabricating and bonding procedures as for insulating sweat fittings and apply adhesive on overlap surfaces between fitting insulation and line insulation.

SHEET INSULATION

R-1800-FS SHEET INSULATION

is made from the same material as Rubatex R-180-FS tubing insulation and the closed cell structure offers the same efficient thermal properties to control condensation and loss of heat and cold when applied in recommended thicknesses. The extreme flexibility and ease of application makes the R-1800-FS sheet particularly adaptable to insulating large pipes, chillers, tanks and ducts.

APPLICATION:

RUBATEX R-1800-FS SHEET INSULATION is available in 36"x48" standard sheet size, 1/8" to 1 1/2" max. thicknesses. The flexibility and ease of application adapts it ideally to insulating air ducts, large pipe and tanks—even where the shapes are irregular.

Rubatex R-1800-FS is supplied with skin one side and should always be applied with the skin side out. The material may be cut with a regular but well sharpened knife. Cuts must be accurate to assure full contact with mating sheets when bonded together.

For proper adhesion, the surfaces to which Rubatex R-1800-FS is to be applied must be thoroughly clean and dry. Primed and painted surfaces should be adhesive tested beforehand to be sure that insulation will not lift off after application.

Brush (or roll) a thin, even coat of Rubatex 373 (or 372) adhesive on the cellular surface of the sheet and on the surface to be insulated. Allow the adhesive films to become dry

Place the sheet tightly against the mating sheet or sheets. Be sure it is in the desired position before the adhesive surfaces make initial contact since the adhesive forms an instant bond and repositioning after contact is difficult.

Allow the sheet to remain in a relaxed state and apply pressure inward to the surface until the entire adhesive area is contacted. Stretching of the sheet should be avoided to prevent weakening of the adhesive bond and stress-opening of

CHARACTERISTICS

TEMPERATURE RANGE

Rubatex R-180-FS Tubing and R-1800-FS Sheets insulate and prevent condensation when used as recommended at operating temperatures down to -40°F (-40°C) and insulate against heat loss up to 220°F (104°C). At temperatures below zero the materials will have a tendency to become firmer, but this does not affect the thermal efficiency and water vapor permeability.

THERMAL EFFICIENCY

Low K factor. 0.28 at 75°F (24°C).

MOISTURE RESISTANCE

The closed cell structure seals out moisture and eliminates the need for a vapor barrier in most applications. Under continuous conditions of high humidity (such as tropical areas) a vapor barrier is recommended.

TIMESAIVING

The light weight and extreme flexibility of Rubatex tubing and sheet insulations make applications fast and easy. Both are clean to handle, they fabricate easily and conform to sharp

bends and curvatures. The I.D. of R-180-FS is powdered for ease of application. All joints can be sealed with Rubatex 373 (or 372) adhesive.

NEAT APPEARANCE

Smooth outer surface offers neat finished appearance even at joints. No decorative or protective coatings are needed for most indoor installations. For outdoor installations, a top quality white exterior latex or vinyl base paint is recommended for weather protection on Rubatex Tubing and Sheet Insulation.

RECOMMENDED THICKNESSES

To prevent condensation when used on indoor installations within the temperature ranges and under the design conditions indicated.

Design Conditions	Pipe Size	WALL THICKNESS		
		Line Temperatures		
		50°F (10°C)	32°F (0°C)	0°F (-18°C)
*Average	3/8" ID thru 2" IPS	3/8"	1/2"	1"
*Average	Over 2" IPS thru 5" IPS	1/2"	3/4"	1"
**Severe	3/8" ID thru 5" IPS	3/4"	1"	1 1/2"

Design Conditions	THICKNESSES		
	Cold Surface Temperatures		
	50°F (10°C)	32°F (0°C)	0°F (-18°C)
*Average	3/8"	5/8"	1 1/8"
**Severe	7/8"	1 1/4"	2"

*MAXIMUM SEVERITY 85°F (29°C) and 70% RH - Most Areas Continental North America.

**MAXIMUM SEVERITY 90°F (32°C) and 80% RH - Poorly ventilated enclosed areas and/or areas with severe moisture conditions not exceeding the above. Under continuous conditions of high humidity the use of a vapor barrier is recommended.

SPECIFICATION COMPLIANCE

ASTM C-534 Type I (Tubing), Type II (Sheets)
ASTM D-1056 SCE-41
MIL-C-3133 Grade SCE-41
MIL-C-3133B (MIL-STD 670A) Grade SCE-3
HH-I-573 (GSA-FSS)
UL94-5V Flammability Classification (Approval No. E55475)
UL94-HF1 Flammability Classification (Approval No. E55475)
MIL-P-15280-E Amend. 1 Form T (Tubing) and Form S (Sheets)
MIL-P-15280-G Amend. 1 Form T (Tubing) and Form S (Sheets)

Rubatex Tubing and Sheet materials meet many State and Local Municipality Specifications for building codes. For specific approvals contact Bedford, VA office.

MARKED

Identified by Trade Mark, I.D. and Wall Thickness.

FIVE WALL THICKNESSES AVAILABLE:

Standard Inside Diameters	Wall Thicknesses
3/8" to 2 1/8"	3/16" & 1/4"
3/8" to 4 1/8"	3/8"
3/8" to 5 1/2"	1/2" & 3/4"

6 FOOT LENGTHS standard. Random lengths (50 ft. min.) available on special quotation.

AVERAGE PHYSICAL PROPERTIES

R-180-FS TUBING INSULATION

R-1800-FS SHEET INSULATION

		TEST METHOD
DENSITY, P.C.F.	4.5 - 8.5	ASTM D-1667
COMPRESSION DEFLECTION, P.S.I.	2 - 6	ASTM D-1056
WATER ABSORPTION		
% by Volume	1.0 Max.	ASTM D-1056-59T
% by Weight	10.0 Max.	ASTM D-1056-68
WATER VAPOR PERMEABILITY		
Perm - In. Max.	.20	ASTM C-355
K FACTOR (Btu - in/hr. ft. 2°F)		
@ 75°F - Mean Temperature	.28	ASTM C-177
@ 50°F - Mean Temperature	.27	
OZONE RESISTANCE		
(70 hrs. 100°F 100pphm)	Passes	ASTM D-1149
CHEMICAL RESISTANCE		
(Room Temperature) to:		
Water	Good	
Oil (Occasional Contact)	Good	
Gasoline (Occasional Contact)	Good	
MILDEW RESISTANCE	No Fungal Growth After 90 Days Incubation	MIL-F-13927A Method B

FLAME SPREAD 25
SMOKE DENSITY 100 MAX.
FUEL CONTRIBUTED FACTOR 30

Rubatex R-180-FS (Tubing Insulation) and R-1800-FS (Sheet Insulation) have been specially compounded to meet the indicated flame spread and smoke density ratings in 1/2" thickness according to ASTM E-84 test method entitled "Surface Burning Characteristics of Building Materials." This test is a measure of a material's surface flammability and smoke evolution while burning.

CAUTION: THESE RATINGS ALONE DO NOT DEFINE THE HAZARDS PRESENTED BY THE MATERIALS UNDER ACTUAL FIRE CONDITIONS.

ERIKSEN
HAMERSKY
SCHLAESITZ
BURROUGHS
& THOMSEN

ARCHITECTS
ENGINEERS
PLANNERS
LINCOLN, NEBR.

ARCHITECT'S REVIEW

No Exceptions Taken ☒ Remarks ☐
Note Markings ☐ Comments ☐

Architect's review is for general performance with the design concept and contract documents. Markings and comments shall not be construed as relieving the Contractor from a million-dollar project. The Contractor shall be responsible for confirming and correlating all quantities and for confirming and correlating all assembly, erection, and construction details in all manner, and coordinating with all trades relating to the project.

CLARK & ENERSEN, HAMERSKY, SCHLAESITZ, BURROUGHS & THOMSEN

By CU

Date 1/12/78

POLAR PERMANENT ANTI-FREEZE & COOLANT PROTECTION CHART

Quarts of POLAR PERMANENT ANTI-FREEZE required for protection to temperatures (°F.) shown.		2	3	4	5	6	7	8	9	10	11
10	16	4	-12	-24	-32						
11	18	8	-6	-21	-27						
12	19	10	0	-18	-24	-32					
13	21	13	3	-9	-18	-27					
14		16	6	-3	-12	-21	-32				
15		18	8	0	-12	-21	-32				
16		17	10	2	-6	-18	-27	-32			
17		18	12	5	-3	-14	-22	-32			
18		19	14	7	0	-10	-21	-30	-32		
19		20	15	9	2	-7	-18	-27	-32		
20			16	10	4	-5	-12	-22	-34	-40	
21			17	12	6	0	-6	-17	-28	-41	
22			18	13	8	2	-4	-14	-23	-34	
23			19	14	9	4	-2	-10	-19	-29	
24			19	15	10	5	0	-8	-15	-24	
25			20	16	12	7	1	-6	-12	-20	
26			21	17	13	8	3	-4	-9	-16	

Add an extra quart of ANTI-FREEZE if car is equipped with hot water heater.

WARNING: HARMFUL OR FATAL IF SWALLOWED. DO NOT DRINK ANTI-FREEZE OR SOLUTION. IF SWALLOWED, INDUCE VOMITING IMMEDIATELY AND CALL A PHYSICIAN. Ruben Chemical Corp. 2500 N. 1st St. is open or unlabeled containers. KEEP OUT OF THE REACH OF CHILDREN.

Page _____ of _____ pages

TO

DATE NOVEMBER 17, 1977

PROJECT LINCOLN HOUSING AUTHORITY
LINCOLN, NEBRASKA

138 CHAMBERLAIN SOLAR COLLECTORS, 7' x 3' 2 LITE, BLACK PAINT, MODEL NO.
712201. PER PLANS AND SPECIFICATIONS AS PREPARED BY CLARK ENERSEN
PARTNERS.

CLARK &
ENERSEN
HAMERSKY
SCHLAEBITZ
BURROUGHS
& THOMSENARCHITECTS
ENGINEERS
PLANNERS
LINCOLN, NEBR.

SHOP DRAWING REVIEW

ARCHITECT'S REVIEW		RESPONSE REQUIRED OF CONTRACTOR
No Exceptions Taken ☒	Rejected ☐	Confirm ☐
Note Markings ☐	Comments Attached ☐	Resubmit ☐

Architect's review is for general conformance with the design concept and contract documents. Markings or comments shall not be construed as relieving the Contractor from compliance with the project plans and specifications, nor departures therefrom. The Contractor remains responsible for details and accuracy, for confirming and correlating all quantities and dimensions, for selecting fabrication processes, for techniques of assembly, for performing his work in a safe manner, and coordinating with all trades relating to this submittal.

CLARK & ENERSEN, HAMERSKY, SCHLAEBITZ, BURROUGHS & THOMSEN

By: ELT Date: 11/10/77

TECHNICAL DATA
ON THE
CHAMBERLAIN MANUFACTURING CORPORATION
FLAT PLATE SOLAR COLLECTOR

January 1977

INTRODUCTION:

The Chamberlain solar collector is a cost-effective unit resulting from an extensive engineering effort having been directed toward the development of a product for nationwide distribution. Three key features of the design rationale were: (1) the collector design should use as much current Company technology as possible; (2) within established constraints, the most cost-effective components were selected; (3) chosen components had to be building code acceptable.

Chamberlain entered the solar collector field with the belief that its insulating window and door production experience and steel forming expertise would be of value in collector production. Designed to take advantage of the Corporation's existing technology, no long technological development was necessary in the manufacturing design phase, resulting in an early entry into the marketplace. Wherever Company expertise could not be called upon, proven off-the-shelf items were used as much as possible.

Cost-effectiveness, as measured by heat gain per square foot of collector per dollar invested, was an important criterion in evaluating alternate designs. Within predetermined constraints (e.g., the cover will be of glass), collector components were varied, and the resulting change in collector performance was compared with the change in collector cost. Sixty (60) collector designs, utilizing various coatings and cover configurations, were analyzed for their cost effectiveness. The study and other considerations were used to arrive at the four collector models described in this document.

Building code considerations were important in selecting the insulation material and the glass type. Four model building codes, the HUD Minimum Property Standards, and seven local building codes were used in determining the necessary requirements.

COLLECTOR DESIGN:

Designed under a Company-sponsored program initiated in 1974, the four collector models underwent final prototype evaluation before being marketed. The prototype collectors have been in operation since autumn 1975; similar collectors have been undergoing performance testing at Chamberlain since spring 1975.

Key features of the collector are described below and illustrated by Figure 1 on the following page.

- Absorber Plate - Two 20 gauge mild steel sheets seam welded together around the perimeter and stitch welded on 1-3/4 inch centers over the entire plate. The assembly is then pressure expanded to form a flow passage between the plates resulting in a very durable, low cost absorber with excellent heat transfer characteristics due to the 90% wetted area.

FIGURE 1. EXPLODED VIEW OF SOLAR COLLECTOR

- Black Chrome Selective Coating - Solar absorptivity = 0.94, infrared emissivity = 0.12, or
- Selective Black Paint Absorber Surface - Solar absorptivity = 0.90, infrared emissivity = 0.60.
- Two Lite 1/8-Inch Thick Low Iron Tempered Glass Cover in Extruded Aluminum Frame - outer cover tempered glass, inner cover tempered glass. Total solar energy transmission of each lite is 90% ($.90 \times .90 = .81$ = total transmissivity), or
- One Lite 1/8-Inch Thick Low Iron Tempered Glass Cover in Extruded Aluminum Frame - total solar energy transmission of 90%.
- Roll-Formed, 18-Gauge Galvanized Steel Frame - roll-formed steel can be shaped at low cost at high production rates and in a large variety of shapes. Galvanizing reduces corrosion problems.
- 1,000°F Rated Face-Temperature Fiberglass - The fiberglass insulation is formed from a 5-inch thick blanket compressed to a nominal 3-inch thickness. The insulation has an effective thermal resistance factor of approximately $R = 10$. The material has a very low binder content, which eliminates outgassing problems sometimes encountered in fiberglass insulations. The side insulation thickness was sized to result in the greatest overall collector efficiency. The insulation is building code approved.
- Desiccant - a passive drying system regenerated by the heat of the absorber plate. The desiccant used is silica gel. The desiccant system reduces moisture condensation in the collector.
- Inlet/Outlet Steel Tubes - angled from the absorber plate to the collector frame. All expansion/contraction of the absorber is taken up in the flexing of the tube internally to the collector. The tubes terminate flush to the box in a 1/2-inch NPT female connection.
- Heat Transfer Fluid - a water/glycol or corrosion-inhibited water is recommended.

TRANSPARENT COVER:

Materials and Selection Rationale. The transparent cover material is composed of one or two lites of 1/8-inch tempered glass with low iron content. Tempered glass was selected for its ability to withstand wind and snow loads, induced thermal stresses, and its resistance to degradation with temperature and time. Low iron glass was chosen because of its high transmissivity and cost-effectiveness.

Optical Properties. Tests conducted over a seven-month sample period showed that the total solar energy transmissivity of the glass is $90\% \pm 0.5\%$. The transmission losses are 8% reflection and 2% absorption. The glass emissivity is 0.88; infrared reflectance is 4% and IR absorptance is 0.96.

Physical Properties. The thermal and physical properties of the glass are those common to standard tempered glass. The coefficient of thermal expansion is about 5×10^{-6} in./in./°F; the modulus of elasticity is 10,000,000 psi. The tensile strength is 30,000 psi. Tests on a 3 ft by 7 ft sheet of glass show it will withstand loads up to 50 psf. The glass meets standards set forth by FHA, AAMA, and the Safety Glazing Code.

ABSORBER PLATE COATING:

Two absorptive coatings are offered on the collector models described in this document.

Material and Selection Rationale. Six of the most promising absorber coatings were tested, and the two most resistant to thermal degradation and offering the highest cost-effectiveness were selected. The black paint was superior at low average plate temperature, and the black chrome was superior at high average plate temperature.

Black Chrome. The coating consists of black chrome over dull nickel. The solar absorptivity is a minimum of 0.94, and the infrared emissivity is 0.12 maximum. The coating maintains its optical properties to 750°F. Black chrome is not subject to photo degradation, and nickel-chromium coatings offer excellent corrosion protection.

Black Paint. The optical properties of the paint vary with thickness. The optimum thickness is 0.9-1.0 mil, which yields a mildly selective surface with an absorptivity of 0.90 and an infrared emissivity of 0.60. This paint can withstand temperatures up to 400°F, where it begins to soften but does not run.

ABSORBER PLATE:

Materials and Selection Rationale. The absorber plate is made of mild carbon steel seam welded and pressure expanded. This results in a wetted surface of over 90%. The selection of steel was based on its superior corrosion properties, as compared to aluminum, and its cost advantage over copper. In addition, Chamberlain's years of fabricating steel products makes the eventual inclusion of the manufacturing of steel absorber plates a natural expansion of the Corporation's product line.

Fabrication Procedures/Processes. The 81.25-inch by 34.30-inch plates are produced as follows: Two sheets 20-gauge (.0359-inch thick) carbon steel material are placed flat against each other, with one of the sheets having

inlet/outlet tube "stubs" brazed in place. A continuous seam weld is made around the perimeter of the plates, closing the system. Beginning a short distance (approximately three inches) from either end of the smaller span, intermittent seam welds approximately 0.5-inch long are applied to within about three inches of the other end, which results in a "quilted" pattern, or "stitch" weld. The dimensions are approximate, because each end has a slight taper to the stitch weld for drainage purposes. Following completion of the lengthwise stitch welding at 1-23/32 center-to-center spacing, hydraulic pressure is applied to expand the metal, forming the flow passages with nominal 0.090-inch inside height on each passage.

Physical Properties and Dimensions. The absorber plate is 81.25 by 34.30 by 0.17 inch. Fluid pressures up to 75 psi can be sustained without deformation or degradation of the absorber plate. A manifold at each end of the plate ensures proper flow distribution in the flow passages.

Thermal Properties. The absorber plate design results in over 90% wetted area. This results in excellent heat transfer characteristics with a heat removal factor F_R of about 0.97 and a collector efficiency factor F' of about 0.99.

Manifold Design. The manifold design allows for even flow distribution. Tests in Chamberlain's solar laboratory have shown that the temperature distribution across the collector at any longitudinal position is essentially constant. The manifold is designed to allow the collector to be drained completely at typical installation angles.

Inlet/Outlet Tube Design. The inlet/outlet tubes exit the absorber plate in the center bottom of each end and exit the collector housing at the sides of the lower and upper ends. The tubes are made of 0.375-inch O.D. by 0.035-inch wall, low carbon steel, dead soft annealed. They terminate flush to the collector housing in a 1/2-inch NPT female fitting. This arrangement allows the thermal expansion/contraction of the absorber plate to be absorbed in the flexing of the tubing internal to the collector box.

INSULATION:

Materials and Selection Rationale. The insulation used for back and edge thermal protection is a low binder content insulation rated for 1,000°F face temperatures. A 5-inch thick blanket is compressed to the 3-inch dimensioned cavity behind the absorber plate. The edge insulation is formed from a 1-inch thick blanket compressed to 0.5 inch. Transportation tests have proven that insulation movement, or "packing," does not occur. The overall R factor on the backside is approximately 10.

Density. Nominal density is 1.05 lb./ft.³

OUTER BASE ENCLOSURE:

Materials and Selection Rationale. The basic collector box is fabricated from galvanized 18-gauge (.052 inch) cold-rolled steel. The selection was based on the excellent corrosion resistance of galvanized steel and on Chamberlain's ability to economically roll-form sheet steel.

The cover framework is extruded 6063 aluminum, painted black with Duracron series paint. Selection was based on the applicability of the framework to Chamberlain's insulating door manufacturing expertise and the excellent corrosion resistance of painted aluminum.

Thermal Properties. The only significant thermal property of the collector housings is the coefficient of thermal expansion of the aluminum cover (12×10^{-6} in./in./°F). The aluminum frame is partially isolated thermally by the rubber gasket between the steel frame and the aluminum cover frame. The rest of the box is isolated by the insulation.

OTHER COMPONENTS AND MATERIALS:

A number of other materials are used in the collector. The glazing channel seal is made of EPDM (Ethylene, Propylene, Diene Monomer) rubber. EPDM has excellent resistance to degradation due to ozone weathering and elevated temperatures (continuous exposure up to nearly 300°F).

The weather seal between the cover assembly and the main collector housing is EPDM foam with a pressure sensitive adhesive. It is a closed cell sponge material. The material retains its elasticity and resiliency over the temperature range -100 to +250°F. The material provides a protection against electrolysis due to the presence of dissimilar metals and thermal shielding, in addition to the weather-sealing characteristics.

The absorber plate is held in place by screws to the support brackets. The slot/shoulder bolt design maintains the vertical integrity of the system while allowing longitudinal movement for expansion and/or contraction.

The corners of the box are caulked to make them weatherproof. Any one of a number of sealants may be used.

Silica gel desiccant is used to reduce the humidity in the collector and thus the amount of condensate formed. The desiccant used is 8-mesh silica gel which can be regenerated almost indefinitely (c. 10,000 cycles) by the heat given off of the absorber plate in operation.

COMPOSITE COLLECTOR:

Basic Fluid, Commercial Identification and Selection Rationale. The fluids to be used in the collector are either a glycol base and water or corrosion inhibited water. These fluids were selected because of their availability,

their excellent heat transfer properties, their lack of corrosiveness on steel, and in the case of water/glycol, the resistance to freezing. Since freezing weather occurs in most of the country, water/glycol will be used most often.

Additives, Commercial Identification and Material Selection Rationale. No specific antifreeze or inhibitors are recommended as this choice is based on the overall system requirements. Typical inhibitors are Na_2CrO_4 or $\text{Na}_2\text{Cr}_2\text{O}_7$. Chromate inhibitors should not be considered for use with water/antifreeze mixtures.

Quantities. The amount of antifreeze in the fluid depends upon the amount of freezing protection required. Inhibitor concentrations should be 500-700 ppm. Data on these products are available from the manufacturers.

pH. The pH should remain near neutral (6.5 to 8.5).

Mineral Content. Water should be relatively free from impurities.

Durability/Compatibility. Antifreeze solutions used in automotive applications have a lifetime of 2-3 years. The expected lifetime of the solution in the collector is in excess of this, but maintenance of the fluid will be necessary. The water/glycol solution is fully compatible with the components to which it is exposed.

COLLECTOR PERFORMANCE DATA:

The accompanying daily collection curves are analytical predictions of the thermal properties under the following conditions.

1. Collector Location = 40° north latitude; Collector Tilt = 40° facing due south.
2. Constant Ambient Temperature 90°F (summer), 20°F (winter); Constant Wind Velocity = 10 mph.
3. Insolation data was generated using NBSIR 74-635 Methods of Testing for Rating Solar Collectors Based on Thermal Performance for July 21 (summer) and January 21 (winter).
4. Collection period is one day.
5. Flow rate is 1.0 gal/hr/ft^2 . Collector fluid is 50/50 water/glycol.
6. Inlet temperature - 140°F (winter), 200°F (summer).

The data given on the curves shown by Figures 2 and 3 on the following two pages have been substantiated by test data gathered from instantaneous efficiency tests conducted on prototype collectors.

COLLECTOR LOCATION: 40° North Latitude	FLOW RATE: 14.7 lb _m /hr./ft. ²
COLLECTOR ORIENTATION: 40° Tilt, Facing Due South	INLET TEMPERATURE:
	140°F Winter (January 21)
CONSTANT AMBIENT TEMPERATURE:	200°F Summer (July 21)
20°F Winter (January 21)	90% OF HORIZONTAL RADIATION IS
90°F Summer (July 21)	DIRECT; 10% OF HORIZONTAL
FLUID: 50/50 Water/Antifreeze	RADIATION IS DIFFUSE

FIGURE 2. PREDICTED DAILY ENERGY COLLECTION USING BLACK PAINT ABSORBER COATING

COLLECTOR LOCATION: 40° North Latitude	FLOW RATE: 14.7 lb _m /hr./ft. ²
COLLECTOR ORIENTATION: 40° Tilt, Facing Due South	INLET TEMPERATURE:
	140°F Winter (January 21)
CONSTANT AMBIENT TEMPERATURE:	200°F Summer (July 21)
20°F Winter (January 21)	90% OF HORIZONTAL RADIATION IS
90°F Summer (July 21)	DIRECT; 10% OF HORIZONTAL
FLUID: 50/50 Water/Antifreeze	RADIATION IS DIFFUSE

FIGURE 3. PREDICTED DAILY ENERGY COLLECTION USING BLACK CHROME ABSORBER COATING

NOTE: All experimental performance data on the Chamberlain prototype collectors were obtained using the NBS recommended practices and techniques provided in NBSIR 74-635. This test procedure does not provide for transient testing. Chamberlain does not presently have the capability for providing experimental daily efficiencies.

The instantaneous efficiency versus temperature curves (Figures 4 and 5) have been normalized to account for the varying insolation rates and ambient temperatures. The curves thus represent efficiency versus (average fluid temperature - ambient temperature)/insolation. This form is useful in describing collector parameters for systems analysis computer programs such as TRNSYS; it is also the form recommended by NBS. Collector efficiency is defined as the ratio of energy collected to the energy falling on the gross collector area.

Curves represented by a least-squares, linear fit were generated with the following input data.

Insolation = 200 BTU/ft²-hr. All direct insolation, normal to collector surface

Ambient Temperatures = 20°F, 90°F

Inlet Temperatures = 100, 120, 140, 160, 180, 200°F

Wind Speed = 7 mph

The curves shown by Figures 4 and 5 have been substantiated by test data gathered from prototype collectors.

The pressure drop through the collector has been determined experimentally and is represented by the curve in Figure 6. The test was conducted with water at 70°F. Water at 70°F has an absolute viscosity corresponding to that of a 50/50 water/glycol mixture at 170°F.

COLLECTOR ARRAY CHARACTERISTICS:

Weights of Collectors. The collector with two glass lites weighs 190 pounds dry (9 pounds/square foot); the one glass collector weighs 160 pounds (7.6 pounds/square foot). Liquid capacity is approximately 0.6 gallon.

Method of Support. The collector is supported on each of the four corners and attached by means of 5/16-18NC bolts (two at each corner).

Provision for Uplift of Covers and Collectors. The entire cover assembly can be removed from the collector by removing the retaining screws. The cover can be removed without removing the collector from the array or disturbing adjacent collectors. Lifting the collector should be accomplished by lifting from all four corners with an appropriate spreader, but the collector may be lifted by hand without incurring damage.

ONE COVER BLACK PAINT

TWO COVER BLACK PAINT

INSOLATION: 200 BTU/hr.-ft.² All Direct,
Normal to Collector
AMBIENT TEMPERATURES: 20°F, 90°F
WIND SPEED: 7 mph

INLET TEMPERATURES: 100, 120, 140, 160,
180, 200°F
COLLECTOR FLUID: 50/50 Water/Antifreeze
FLOW RATE: 14.7 lb_m/hr./ft.²

FIGURE 4. INSTANTANEOUS EFFICIENCY

INSOLATION: 200 BTU/hr.-ft.² All Direct,
Normal to Collector
AMBIENT TEMPERATURES: 20°F, 90°F
WIND SPEED: 7 mph

INLET TEMPERATURES: 100, 120, 140, 160,
180, 200°F
COLLECTOR FLUID: 50/50 Water/Antifreeze
FLOW RATE: 14.7 lb_m/hr./ft.²

FIGURE 5. INSTANTANEOUS EFFICIENCY

FIGURE 6

Collector Ganging Configurations. Collectors may be positioned in arrays in any manner as long as provisions are made to ensure that pressure drop requirements are within acceptable limits, that there is equal flow to all collectors, and that no localized boiling occurs. Most large installations will require analysis of the flow distribution.

Thermal Expansion with a Ganged Collector. All expansion occurs within the collector box; therefore, the only expansion which must be considered in the ganged collector is that of the connecting piping.

Differential Expansion Between Roof and Collector. The collector box is thermally isolated from the absorber and will not experience sufficient thermal expansion to cause differential expansion problems.

Maintenance of Weather-Tight Seal. Experience with the collectors has demonstrated that no leakage occurs. This is a result of Chamberlain's years of experience in manufacturing insulating doors and windows. The various parts of the collector housing are weatherproofed with a standard architectural sealant.

TO CONVERT

<u>FROM</u>	<u>TO</u>	<u>MULTIPLY BY</u>
BTU/hr.-ft. ²	W/m °C	0.144
°F	°C	$C = (°F - 32) \frac{5}{9}$
°F-ft. ² -hr./BTU	°C m ² /W	0.176
Gallon	L	3.785
Gallon/Minute	Liter/S	6.309×10^{-2}
Inch	cm	2.54
In./in./°F	cm/cm/°C	1.800
Lb./inch ²	kN/m ²	6.895
Lb _m /hr.-ft. ²	kg/S m ²	1.356×10^{-3}
mil	cm	2.54×10^{-3}
mph	m/s	0.447

MODEL NO.	COVERS	COATING	"A" DIMENSION	WEIGHT (DRY), (LBS.)
711101	1	Black Chrome	4-3/8	160
711301	2	Black Chrome	5-1/16	190
712101	1	Black Paint	4-3/8	160
712301	2	Black Paint	5-1/16	190

Chamberlain

Solar Collector Panels

Designed and built by
Chamberlain Manufacturing Corporation:
experts in specialized metal fabrication with
years of experience and proven capability.

Each panel comes factory assembled.

Durability is built-in, with every component
engineered for years of performance.

Panels are designed for easy modular
installation and low cost on the spot
maintenance.

The more you know about Chamberlain
Solar Collector Panels, the more
you'll know why they're called
The Panel of Experts.

Chamberlain Expertise

Chamberlain Manufacturing Corporation's broad production experience has resulted in a well deserved reputation as one of America's foremost experts in specialized metal fabrication.

Here are some examples of Chamberlain's expertise:

1. Major manufacturer of storm doors and windows.
2. Fabricator of a wide variety of roll formed steel and aluminum products for the construction industry.
3. World's largest manufacturer of garage door openers.
4. Major producer of self propelled aerial work platforms for the airline and construction industries.
5. Builder of huge refinery and storage vessels for the petro-chemical industry.
6. Important manufacturer of metal-wire refrigerator and freezer shelving.
7. Extensive capability and fully staffed facilities in research and development.
8. Large contractor for the Department of Defense in metal forming, machining, and research.

Chamberlain manufacturing facilities span the country

Manufacturing Expertise

For years, Chamberlain Manufacturing Divisions across the country have designed, produced, and assembled a wide variety of quality products involving highest sophistication in steel weldments, metal extrusions, electroplating, roll forming, stamping, glazing, forging and metal forming.

Chamberlain has broad practical experience in each of these areas.

This means Chamberlain already has both the existing manufacturing facilities and the experienced personnel necessary to build superior, reliable solar collector panels—in quantity.

Fully staffed and instrumented laboratory

Design Expertise

The design of the Chamberlain Solar Collector Panel has been a team effort.

The Research and Development Engineers designed a computer program and utilized it to optimize solar panel performance.

Chamberlain engineers contributed their broad experience in all aspects of collector design for a *completely* engineered unit.

Testing Expertise

Chamberlain's facilities provide the capability for testing all aspects of the solar collector's design:

- Solar Panel performance, in accordance with National Bureau of Standards specifications
- Corrosion
- Insulation
- Physical properties of fenestration
- Properties of absorber plate coatings
- Stagnation conditions
- Life expectancy of components

The Selection of Experts

Chamberlain has been selected as an active participant in U. S. Government sponsored and funded programs for solar development and commercialization, and as a major supplier to America's largest private label retailers.

This is a direct result of Chamberlain's superior reputation for:

- Research and Development
- Design
- Reliable Performance
- Manufacturing
- Quality Control

Features and Specifications:

Model	Absorber Coating	Glazing	Length	Width	Depth
711101	Blk Chrome	Single	84 $\frac{1}{4}$	36 $\frac{1}{4}$	4 $\frac{3}{8}$
711201	Blk Chrome	Double	84 $\frac{1}{4}$	36 $\frac{1}{4}$	5 $\frac{1}{16}$
712101	Blk Paint	Single	84 $\frac{1}{4}$	36 $\frac{1}{4}$	4 $\frac{3}{8}$
712201	Blk Paint	Double	84 $\frac{1}{4}$	36 $\frac{1}{4}$	5 $\frac{1}{16}$

Cover Assembly:

- Rigid extruded aluminum frame
- Marine glazing
- Stable, long life, weather resistant glass
- Low iron glass—high transmissivity
- Minimum restriction for insolation entry
- Tempered glass provides resistance to breakage
- Serviceable in the field

Cover Gasket:

- Provides seal between cover and box
- Thermally isolates absorber cavity from metal parts exposed to atmosphere
- Resilient, long life material

Steel Absorber Plate:

- Maximum wetted surface
- Minimum flow resistance
- Rugged steel construction
- Pressure tested
- Selection of coatings available

High Temperature Insulating Strip:

- Insulates absorber plate from frame

Absorber Support:

- Rigid support bracket welded to side of box

Mounting:

- Two $\frac{3}{16}$ " weld nuts each corner
- Rigid
- Easy to adapt to any support
- No projections—will not become damaged in shipment

Piping Connection:

- $\frac{1}{2}$ " Female iron pipe thread
- Flush mounted avoids shipping damage
- Uses standard pipe fittings
- Thermally insulated from box
- Ruggedly attached to box—allows for heavy handed plumbers
- Isolates absorber plate from external piping movement

Desiccant:

- Controls moisture in absorber cavity
- Minimizes condensation on glass
- Regenerated by absorber plate heat

Insulation:

- High temperature Fiberglass insulation
- Maximum insulation with minimum volume

Above from left: Roll forming collector box/Glazing the cover/Extruding cover frame
Below from left: Assembling Solar Collector Panels/Corporate headquarters, Elmhurst, Illinois

Chamberlain Experience

Over the years, the biggest customers in the world have come to depend on Chamberlain.

From pressure vessels for the petro-chemical industry, to Defense Department ordnance, to mass-produced storm doors...Chamberlain has a reputation for dependability, durability, and quality.

And over the years, we've learned that the best way to build a better reputation is to build better products. That's why Chamberlain has pioneered in metal fabrication technology.

That's why Chamberlain will lead the way in the mass production of solar collectors.

And that's why, in the new and rapidly developing field of solar energy, you'll be able to depend on Chamberlain. Today...and for years to come.

For the latest information on Chamberlain Solar Collector Panels write: Marketing Manager, Solar Products; Chamberlain Manufacturing Corporation, 845 Larch Avenue, Elmhurst, Illinois 60126.

Chamberlain Solar Collector Panels...The Panel of Experts

Chamberlain

Chamberlain Manufacturing Corporation
845 Larch Avenue, Elmhurst, Illinois 60126

C-131.4
REVISION 5

12" Series Type "WU" Heat Exchangers "U" Tube Design

Gen-Mech		B & G REPRESENTATIVE <u>Verne Simmonds Company</u>	
JOB <u>% Lincoln Housing Authority</u>			
UNIT TAG NO. _____	ORDER NO. _____	DATE _____	
ENGINEER _____	SUBMITTED BY <u>Cliff Dean</u>	DATE <u>3/2/78</u>	
CONTRACTOR _____	APPROVED BY _____	DATE _____	

B&G "WU" Heat Exchangers are of the shell and tube type. The tube bundle is of "U" bend construction with tube ends expanded into a stationary tube sheet. This construction permits ample expansion or contraction for wide temperature variations. A fluid entering the tubes is heated or cooled by a fluid being circulated through a baffled shell. The unit is designed primarily for pumped circulation through the shell.

This form is signed by a qualified inspector, holding a National Board Commission, and who is employed by an authorized inspection agency, certifying that construction conforms to the latest A.S.M.E. code for pressure vessels. The A.S.M.E. "U" symbol is stamped on each vessel.

MODEL NO. WU-125-46

HEATING SURFACE (SQ. FT.) 98

APPROVALS

		<div style="border: 1px solid black; padding: 5px; display: inline-block;"> OPERATING DATA <div style="display: flex; justify-content: space-between; font-size: small;"> EVERSEN HAMERSKY SHELL SIDE </div> <div style="display: flex; justify-content: space-between; font-size: small;"> SCHLAEBITZ BURROUGHS & THOMSEN </div> </div>
1. Fluid Circulated		ARCHITECTS
2. Total Flow* (*Expressed in GPM, GPH, or lbs./hr.)		ENGINEERS
3. Temperature In/Out		PLANNERS
4. Transfer BTU/hr.		LINCOLN, NEBR.
5. Pressure Drop (Maximum)		
6. Fouling Factor or Percentage of Additional Surface		
Note: Following applies only for fluids other than water.		
7. Specific Gravity		
8. Specific Heat		
9. Latent Heat		
10. Viscosity**		
11. Thermal Conductivity		

SHOP DRAWING REVIEW	
ARCHITECT'S REVIEW	RESPONSE REQUIRED OF CONTRACTOR
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> No Exceptions Taken ☒ </div> <div style="width: 45%;"> Rejected ☐ </div> </div>	Confirm ☐
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> Note Markings ☐ </div> <div style="width: 45%;"> Comments Attached ☐ </div> </div>	
<p style="font-size: small;">Architect's review is for general conformance with contract documents. Markings or comments shall not be construed as relieving the Contractor of responsibility for details and accuracy, or for conformance with the design concept and contract documents. The Contractor remains responsible for details and accuracy, or for conformance with the design concept and contract documents. The Contractor remains responsible for details and accuracy, or for conformance with the design concept and contract documents. The Contractor remains responsible for details and accuracy, or for conformance with the design concept and contract documents.</p>	

BURROUGHS & THOMSEN

3/24/78

BELL & GOSSETT **ITT**
FLUID HANDLING DIVISION

12" Series TYPE "WU" HEAT EXCHANGERS ("U" Tube Design)

2 PASS HEAD

4 PASS HEAD

6 PASS HEAD

Flange connections for field piping drilled and faced per 150# ANSI standards.

Room for removal of tube bundle, equal to or greater than "A", should be provided.

Cast iron or bolted steel legs can be supplied when specified.

Optional Cast Iron

150 PSI DESIGN PRESSURE HEADS (Flanged Connections)

2 PASS HEAD (Flanged Connections)

DIMENSIONS

Complete sales number consists of example: WU126-26

UNIT NUMBER			DIMENSIONS IN INCHES															HEATING SURFACE (SQ. FT.)			APPROX. SHIPPING WT. (LBS.)
			2 PASS		4 PASS				6 PASS			2, 4 AND 6 PASS						2 Pass	4 Pass	6 Pass	
2 PASS	4 PASS	6 PASS	J	K	H	L	M	N	P	R	S	A	B	C	D	E	FLG F	2 Pass	4 Pass	6 Pass	
WU124-26	WU124-46	WU124-66	4 NPT	7 3/4	4 NPT	2 3/8	5 3/8	5 3/8	4 1/2	3 NPT	5 13/16	56 1/2	16 3/8	37 3/4	10 3/4	12 3/4	5	83	78	68	456
WU125-26	WU125-46	WU125-66	4 NPT	7 3/4	4 NPT	2 3/8	5 3/8	5 3/8	4 1/2	3 NPT	5 13/16	68 1/2	16 3/8	49 3/4	10 3/4	12 3/4	5	104	98	85	525
WU126-26	WU126-46	WU126-66	4 NPT	7 3/4	4 NPT	2 3/8	5 3/8	5 3/8	4 1/2	3 NPT	5 13/16	80 1/2	16 3/8	61 1/4	10 3/4	12 3/4	5	126	119	103	594
WU127-26	WU127-46	WU127-66	4 NPT	7 3/4	4 NPT	2 3/8	5 3/8	5 3/8	4 1/2	3 NPT	5 13/16	92 1/2	16 3/8	73 3/4	10 3/4	12 3/4	5	148	139	121	663
WU128-26	WU128-46	WU128-66	4 NPT	7 3/4	4 NPT	2 3/8	5 3/8	5 3/8	4 1/2	3 NPT	5 13/16	104 1/2	16 3/8	85 3/4	10 3/4	12 3/4	5	169	160	139	732
WU129-26	WU129-46	WU129-66	4 NPT	7 3/4	4 NPT	2 3/8	5 3/8	5 3/8	4 1/2	3 NPT	5 13/16	116 1/2	16 3/8	97 3/4	10 3/4	12 3/4	5	191	180	156	801

MATERIALS

PART	STANDARD CAST IRON UNIT	BRASS UNIT
	2, 4 & 6 Pass	2 & 4 Pass
Shell	Steel	Steel
Head	Cast Iron	Cast Brass
Tubes 3/4" O.D.	Copper	Copper
Tube Sheet	Steel	Rolled Naval Brass
Baffles	Steel	Steel
Nuts & Bolts	Steel	Steel

DESIGN PRESSURES—A.S.M.E. CONSTRUCTION CAST IRON & BRASS UNITS

DESIGN PRESSURES*				DESIGN TEMPERATURES* TUBE & SHELL SIDE	
TUBE SIDE		SHELL SIDE			
DESIGN	TEST	DESIGN	TEST	CAST IRON	BRASS
6 Pass					
150 psi	300 psi	150 psi	300 psi	375 F	—
2 & 4 Pass					
125 psi	250 psi	150 psi	300 psi	375 F	300 F
2 Pass Head (Flanged Connections) Cast Iron only					
150 psi	300 psi	150 psi	300 psi	375 F	—

*For design pressures and temperatures higher than shown, consult B & G Representative for specifications and dimensions.

Caution:

A properly sized relief valve must be installed on the heated water side to protect heat exchangers from possible damage due to volumetric expansion.

THE J. L. HOUSTON CO.

Sales Office and Manufacturing Plant

Phone 816-778-3393

MANUFACTURERS OF QUALITY STEEL PRODUCTS

CUSTOMER Low Rent Housing, Lincoln, Ne

CUSTOMER ORDER # 10791

OUR ORDER # 26239

SHIP TO: Low Rent Housing, Lincoln, Ne

DATE SUBMITTED 1-8-78

Hopkins, Missouri 64461

Section at Manhole

Section of Fitting

CAPACITY 5760 GALLONS

SHELL LENGTH 20'

SHELL O.D. 84" Nominal HEAD O.D. 84" Nominal

MATERIAL:

SHELL 5/16" HEAD 5/16"

FITTINGS IN ACCORDANCE WITH DRAWING ABOVE AND ATTACHED SHEET

MANHOLE IN ACCORDANCE WITH DRAWING ABOVE AND ATTACHED SHEET

UNDERWRITER'S LABEL IS NOT REQUIRED

APPROXIMATE TOTAL WEIGHT 7,700 POUNDS

PAINT : RED OXIDE PRIMER , Use 1 Coats

10791

HEAD DETAIL, PAGE 2

RAN 1/8/78

SINGLE & MULTI-OPENING PIPE PORTAL SYSTEM (1 THRU 5 OPENINGS)

P.O. No. 010

CUSTOMER Gen-Mech Contractors
5620 South 49th

Lincoln, Nebr. 68516

PROJECT Lincoln Housing Authority
Solar Building

LOCATION Lincoln, Nebr.

ARCHITECT Clark, Enersen Partner

STANDARD CONSTRUCTION

- ABS PLASTIC COVER
- EPDM RUBBER NIPPLE
- STAINLESS STEEL CLAMPS
- 18 GA. GALVANIZED STEEL
- 1-1/2" 3LB. FIBERGLASS INSULATION
- WOOD NAILER

PIPE PORTAL		CURB OPENINGS		PIPE PORTAL		
				CURB QTY.	STYLE QTY.	
<p>N62 CAP FOR USE WITH 2" to 6" PIPE</p> <p>N28 CAP FOR USE WITH 3/8" to 2" PIPE</p> <p>CURB COVER</p>	1 OPENING O.D.=12X12			N62		
				N28		
	2 OPENINGS O.D.=12 X 28 1/2			N62		
				N28		
	3 OPENINGS O.D.=12 X 45 1/4			N62		
				N28		
DESCRIPTION				1	N62	2
N62-FOR ONE 2" THRU 6" PIPE 13-1/2"x13-1/2" I.D. REINFORCED ABS PLASTIC COVER... SINGLE NIPPLED EPDM RUBBER CAP... ONE LGE. ADJ. STAINLESS STEEL CLAMP		4 OPENINGS O.D.=12 X 62			N28	1
N28-FOR TWO 3/8" THRU 1" & TWO 1" THRU 2" PIPE...13-1/2" x13-1/2" I.D. REINFORCED ABS PLASTIC COVER... FOUR NIPPLED EPDM RUBBER CAP... TWO PAIR ADJ. STAINLESS STEEL CLAMPS		5 OPENINGS O.D.=12 X 78 3/4			N62	
					N28	

CURB STYLES

TOTAL CURBS (FROM ABOVE)	CURB STYLE	*OVERALL HEIGHT	"R" DIM.	TOTAL PIPE PORTALS (FROM ABOVE)	REMARKS
	RC-2A			N62	
				N28	
	RC-3A			N62	
				N28	
1	RC-4A	11 1/2		N62	
				N28	

ROOF PRODUCTS & SYSTEMS CORP.
ADDISON, ILLINOIS

REPRESENTED BY:

SUPER HI-MILER® FLEET QUALITY RADIATOR AND BYPASS HOSE

- Saves Downtime Costs
- Delivers Up to 500,000 Miles of Service

Now, up to 500,000 miles of heavy-duty fleet service with *Super Hi-Miler Radiator Hose*.

You name the fleet service, and we'll show you how to get hundreds more hours out of your radiator and bypass hose . . . and that saves on expensive downtime and maintenance costs.

Super Hi-Miler hose is made with a unique thermo-set compound of synthetic materials that won't crack or harden, even in extreme cold. It has a low compression set for a lasting leak-free fit. And it resists heat, ozone and aging—to far outlast ordinary rubber hose.

Super Hi-Miler hose withstands temperatures up to 450° F, so that there's no splitting—even in turbo-charger service. And in cold climates, when ordi-

nary hose would split, Super Hi-Miler hose remains flexible below -65° F, even when the engine isn't running.

Where is Super Hi-Miler hose recommended? For any equipment that is expected to operate for long periods under heavy load demand. This includes: Trucks, buses, off-the-road equipment and taxi cabs. It's an ideal solution for operators who have experienced costly downtime and loss of coolant from failure of regular hose.

Reduce *your* downtime on fleet equipment—with Super Hi-Miler radiator and bypass hose.

• BYPASS HOSE

• STRAIGHT
RADIATOR
HOSE

• MOLDED RADIATOR HOSE

For Silicone Hose

or other
soft-surface
materials

Developed by Breeze over a decade ago, Aero-Seal Liner Clamps protect soft-surface hose materials from extrusion and/or shear through the band slots. In addition to the other Aero-Seal features, a key advance of the

Breeze design is integral construction — the liner being an extension of the band itself, providing for higher sealing pressure with lower applied torque on the screw.

Aero-Seal Liner Clamps are made in a size range from 06 to 104. Breeze heavy-duty Hi-Torque Clamps are also available in Liner Clamp form. (see page 7)

Aero-Seal Liners are available in four types, each identified by a number in which the first two digits show the type, remaining digits the size. Available as stock item:

Stock Number 9200 — 300 Series stainless steel band, saddle, and housing with a carbon steel 5/16" HEX screw, case hardened, cadmium plated. (Aero-Seal series 100 clamp with liner).

Stock Number 9100 — 300 Series stainless steel band, saddle, and housing with a carbon steel COLLARED screw, case hardened, cadmium plated. (Aero-Seal series 100 clamp with liner).

Stock Number 9300 — 100% stainless steel. 300 Series stainless steel band, saddle, and housing with a 410 stainless COLLARED screw, bright hardened and passivated. (Aero-Seal series 200 clamp with liner).

Stock Number 9400 — 100% stainless steel. 300 Series stainless steel band, saddle, and housing with a 410 stainless steel 5/16" HEX screw, bright hardened and passivated. (Aero-Seal series 200 clamp with liner).

SIZE TABLE — LINER CLAMPS

Stock Numbers				Effective Range						
Plated Coll. Screw**	Plated Hex Screw	Stainless Coll. Screw**	Stainless Hex Screw**	Min.		Max.		Wt. per 100 Clamps		Clamps per Carton*
				In.	mm.	In.	mm.	Lbs.	Kgs.	
9106	9206	9306	9406	9/16	14	13/16	21	6.2	2.8	200
9108	9208	9308	9408	11/16	17	15/16	24	6.3	2.9	200
9110	9210	9310	9410	13/16	21	1-1/16	27	6.3	2.9	500
9112	9212	9312	9412	15/16	24	1-1/4	32	6.5	3.0	500
9116	9216	9316	9416	13/16	21	1-1/2	38	7.6	3.4	500
9120	9220	9320	9420	13/16	21	1-3/4	44	8.1	3.7	500
9124	9224	9324	9424	1-1/16	27	2	51	8.6	3.9	500
9128	9228	9328	9428	1-5/16	33	2-1/4	57	8.6	3.9	500
9132	9232	9332	9432	1-9/16	40	2-1/2	64	9.3	4.2	500
9136	9236	9336	9436	1-13/16	46	2-3/4	70	9.5	4.3	500
9140	9240	9340	9440	2-1/16	52	3	76	10.0	4.5	200
9144	9244	9344	9444	2-5/16	59	3-1/4	83	10.4	4.7	200
9148	9248	9348	9448	2-9/16	65	3-1/2	89	11.0	5.0	200
9152	9252	9352	9452	2-13/16	71	3-3/4	95	11.7	5.3	200
9156	9256	9356	9456	3-1/16	78	4	102	11.9	5.4	200
9160	9260	9360	9460	3-5/16	84	4-1/4	108	12.6	5.7	200
9164	9264	9364	9464	3-9/16	91	4-1/2	114	13.1	5.9	200
9172	9272	9372	9472	4-1/8	105	5	127	14.0	6.4	100
9180	9280	9380	9480	4-5/8	110	5-1/2	140	14.5	6.6	100
9188	9288	9388	9488	5-1/8	130	6	152	15.0	6.8	100
9196	9296	9396	9496	5-5/8	143	6-1/2	165	15.5	7.0	100
91104	92104	93104	94104	6-1/8	156	7	178	16.0	7.3	100

*Inner-packed 10 clamps per box.

**Available on special order only.

AERO-SEAL (.564 BAND WIDTH)

AERO-SEAL JET® Series QS 500M -- S and QS 600M -- S

Aero-Seal Jet Clamps have been superceded as stock items by series QS 100M -- S and QS 200M -- S collared screw clamps, which are identical in all specifications except for screw and housing configurations that constitute the Jet mechanism.

Aero-Seal Jets are available in sizes 10 or larger on special order for those preferring the quick-connect feature. Effective ranges, weights, packaging and other specifications are identical to those in the Aero-Seal size table on page 4. Be sure to specify Series 500 for carbon screw or Series 600 for all stainless.

Breeze Corporation Inc.
700 Liberty

PICTURES OF FINISHED INSTALLATION

PHOTOGRAPHS OF COMPLETED SYSTEM

1. Front of building during open house showing solar collectors on roof.
2. Closeup of solar collectors.
3. Heat exchanger with backup gas boiler in background.
4. Space heating system storage tank.
5. Domestic hot water system storage tank and backup gas heater.

SYSTEM PERFORMANCE DATA

APPENDIX B

System and Subsystem Performance/Technical Data INSERTS FOR VOLUME II

NOTE: All units for physical and thermal properties must be expressed in English Units. (eg. density in LBS/FT³ and thermal conductivity in BTU/HR.FT°F).

System and Subsystem Performance/Technical Data*

A. Climatological Data:

For the proposed project site provide the following information:

1. Latitude 41
2. Heating degree days
Yearly 5864
January 1237
3. Annual Cooling Hours 750
4. Peak daily insolation 2040.6 BTU/ft²
5. Yearly sunshine 64 %

B. Collector:

Commercial/Brand Name Chamberlain

1. Type of Collector

- a. Flat Plate X
- b. Tubular
 - i) Acceptance Angle
 - ii) Concentration
 - iii) Interception Area
 - iv) Mirror Reflector Characteristics
- c. Concentrator
 - i) Focusing
 - ii) Non-Focusing
 - iii) Tracking; Mode
 - iv) Non-Tracking
 - v) Concentration Ratio
 - vi) Reflector Reflection

* All data requested in this Appendix must be supplied or a statement given as to why it was omitted. Data requested are specified for single system or subsystem. If more than one, specify and supply data for each.

System and Subsystem Performance/Technical Data—Continued

2. Transparent Cover

a. Materials

1. Type 1/8" tempered, double strength glass

2. Composition Low iron content

b. Commercial Identification Fourco Glass Co., "Cleartemp"

c. Solar Spectrum Transmissivity 90 %

d. Solar Spectrum Reflectivity 8 %

e. Infrared Transmissivity 0 %

f. Infrared Reflectivity 4 %
Infrared Absorptance 96

g. Number of Covers Two %

h. Combustibility Non-combustible

i. Edge Treatment Fired, rounded edges

j. Physical Properties**

1. Density 157 lb/ft³

2. Linear Coefficient of Expansion $5 \times 10^{-6} \frac{\text{in}}{\text{in}^\circ \text{F.}}$

3. Thermal Conductivity $.54 \frac{\text{BTU}}{\text{ft/hr}^\circ \text{F.}}$

4. Specific Heat $.199 \frac{\text{BTU}}{\text{lb}^\circ \text{F.}}$

5. Tensile Strength 30,000 PSI

6. Compressive Strength _____

7. Weight 34 lbs.

3. Absorber Plate

a. Absorptive Coating

1. Materials

a. Type Black paint

** Properties of conventional materials that are available in standard references such as Mark's Engineering Handbook need not be restated here provided the material is adequately specified so that its properties can be determined from such references. Properties of materials not commonly available in standard references should be submitted with system data to the extent known.

System and Subsystem Performance/Technical Data—Continued

b. Alloy _____

c. Commercial Identification Caldwell C-1077

2. Solar Spectrum Absorptivity 90 %

3. Infrared Emissivity 60 %

b. Base Plate

1. Materials

a. Type Cold Rolled Steel

b. Alloy Low carbon

c. Commercial Identification _____

2. Thermal Properties

a. Thermal Conductivity 26 $\frac{\text{BTU}}{\text{ft/hr}^\circ \text{F.}}$

b. Specific Heat .12 $\frac{\text{BTU}}{\text{lb}^\circ \text{F.}}$

3. Physical Properties

a. Linear Coefficient of expansion $6 \times 10^{-6} \frac{\text{in}}{\text{in}^\circ \text{F.}}$

b. Density 490 lb/ft³

c. Tensile Strength 50,000 lb/in²

d. Compressive Strength 50,000 lb/in²

4. Bonding Materials

a. Type (Brazed, Soldered, etc.) Resistance Welded

b. Composition N/A

c. Commercial Identification N/A

4. Insulation

a. Materials

1. Type Low binder content fiberglass

2. Composition Fiberglass, 1.25% binder

3. Commercial Identification Owens-Corning AWX-HT

System and Subsystem Performance/Technical Data—Continued

b. Outgassing Characteristics

1. Outgassing Temperature > 500° F.
2. Gas given off Unkown
3. Any Condensation No

c. Physical Properties

1. Linear Coefficient of expansion N/A
2. Density 1.05 lb/ft³
3. Thermal Conductivity .33 $\frac{\text{BTU/in}}{^\circ\text{F/hr/ft}^2}$ @ 150° F.
4. Specific Heat .5 $\frac{\text{BTU}}{\text{lbm}^\circ\text{F.}}$
5. Coefficient of Cubical expansion N/A
6. Dimensions 38" x 86" x 5" compressed to 36" x 84" x 3"

5. Outer Base Enclosure

a. Materials

1. Type Galvanized Steel
2. Composition Low Carbon
3. Commercial Identification G 60 MIN
4. Combustibility Non-combustible

b. Physical Properties (As Applicable)

1. Linear Coefficient of expansion $6 \times 10^{-6} \frac{\text{in}}{\text{in}} ^\circ\text{F.}$
2. Density 490 lb/ft³
3. Thermal Conductivity $26 \frac{\text{BTU}}{\text{ft/hr/}^\circ\text{F.}}$
4. Specific Heat $.12 \frac{\text{BTU}}{\text{lb}^\circ\text{F.}}$
5. Coefficient of Cubical expansion N/A
6. Dimensions 36" x 84" x 3-1/2"

c. Thermal Conductivity

System and Subsystem Performance/Technical Data—Continued

6. Composite Collector

a. Cooling/Transport Fluid

1. Fluid

a. Commercial Identification Water

b. Type _____

2. Additives

a. Commercial Identification Union Carbide Prestone II

b. Type Ethylene Glycol

3. Quantities of fluid in collector _____

a. Fluid _____ 50 %

b. Additive _____ 50 %

4. pH 6.5 to 8.5

5. Ion Content Unknown

6. Mineral Content Unknown

7. Durability (Service Life) 24 - 36 mos.

8. Properties

a. Thermal Conductivity .256 - .240 BTU/HR/Sq.Ft./DEG. F./FT.

b. Specific Heat .82 - .88 BTU/LB/DEG F.

c. Density 8.97 - 8.63 LB/GAL.

d. Viscosity 2.7 - .7 Centipoise

e. Coefficient of Cubical expansion ----

9. Other pertinent qualities _____

- b. Performance Data—Provide test or Performance Analysis Data along with information detailing the conditions under which the data were generated. Active systems require that test results be submitted rating the solar collector in accordance with the NBS "Method of Testing for Rating Solar Collectors Based on Thermal Performance," Document NBSIR 74-365,* or through other procedures which will provide similar performance information, as determined by ERDA.

* Request for copies of this document should be addressed to Energy Research & Development Administration (ERDA), Technical Information Center, P.O. Box 62, Oak Ridge, Tennessee 37830.

System and Subsystem Performance/Technical Data—Continued

Passive systems require that sufficient calculations or test results to determine how effective the concepts will be in providing the necessary functions. As a minimum, the following should be provided.

1. Test method used NBSIR74-635 and computer analysis*
2. Energy Collection Rate (BTU/Hr-ft²) Versus time for selected winter conditions and (if applicable) for selected summer conditions over a collection day. The following should be provided:
 - a. Collector Orientation
 1. Azimuth _____ Degrees
 2. Elevation _____ Degrees
 - b. Ambient Conditions
 1. Temperature _____ °F
 2. Wind Velocity _____ MPH
 3. Wind Direction _____ Degree
 - c. Insolation
 - d. Collection Period (Time of Day) _____ to _____
 1. Provide Graph of Inlet Temperatures

2. Provide Graph of Outlet Temperatures

*Chamberlain Mfg. Corp.'s solar laboratory compiles with NBSIR 74-635 for instantaneous efficiency. All-day efficiencies are not within the present capabilities. All-day efficiencies are confirmed by comparing analytical results for instantaneous and all-day efficiencies.

System and Subsystem Performance/Technical Data—Continued

3. Provide a graph of Collector efficiency (n) versus the parameter $\frac{T_i - T_a}{I}$.

$$\text{where } n = \frac{MC_p (T_o - T_i)}{A_c I}$$

T_o = Collector transport media outlet temperature ($^{\circ}\text{F}$)

* T_i = Collector transport media inlet temperature ($^{\circ}\text{F}$)

T_a = Ambient Temp. ($^{\circ}\text{F}$)

** I = Solar Insolation on the Collector plane (BTU/HR - FT^2)

M = Transport media mass flowrate (lb/hr)

C_p = Specific heat of transport media
(BTU/LB $^{\circ}\text{F}$)

A_c = Area of Collector (ft^2)

*Average Collector Temp. may be used $\frac{T_i + T_o}{2}$

**For concentrating collectors this value should be only the beam or direct component for the solar radiation.

4. Maximum expected temperature under no flow conditions 4000 $^{\circ}\text{F}$.
5. Discuss provisions for protecting collector under no flow conditions.
6. Collector Array Characteristics
- Total Area 2898 ft^2
 - Solar Window Area 19.35 ft^2
 - Weights of Collector and Framing 10 lbs/ft^2

System and Subsystem Performance/Technical Data--Continued

C. Storage

1. Type (Tank, Rock Bed, etc.) Tank
2. Materials
 - a. Type Steel
 - b. Finishes _____
 - c. Commercial Identification J.L. Houston Company; Hopkins, Missouri
3. Physical Dimensions:
 - a. Height 84" diameter
 - b. Width _____
 - c. Length 20 feet
4. Thermal Properties*
 - a. Thermal Conductivity _____
 - b. Coefficient of Thermal expansion _____
5. Operating Temperature Range _____ to 250 °F
6. Operating Pressure Range* _____ to 15 PSI
7. Burst Pressure* Designed for Working Pressure of 30 PSI

D. Cooling Subsystem

1. Type No Solar Cooling
2. Commercial Unit
 - a. Type _____
 - b. Size _____ TONS
 - c. Identification _____
3. Materials
 - a. Types _____
 - b. Commercial Identification _____

* Properties of conventional materials that are available in standard references such as Mark's Engineering Handbook need not be restated here provided the material is adequately specified so that its properties can be determined from such references. Properties of materials not commonly available in standard references should be submitted with system data to the extent known.

System and Subsystem Performance/Technical Data—Continued

4. Fluids

- a. Types _____
- b. Composition _____

5. Coefficient of performance (COP) data versus pertinent operating conditions (ambient temperature etc.) along with a definition of the COP used.

6. Total Cooling Capacity

Total cooling capacity of the solar system shall be no less than _____ BTU/HR (if it is a heating and cooling system). Sensible capacity shall be no less than _____ BTU/HR at _____ CFM of entering evaporator air at _____ °F dry bulb and _____ °F wet bulb. For other systems such as desiccant cycling cooling, the terms evaporator and condenser are not applicable. These systems shall deliver the above cooling capacity at inlet air flow of _____ CFM at °F dry bulb and _____ °F wet bulb.

E. Heating Subsystem

Perimeter finned tube heaters with cabinet unit heaters at entrances

1. Type _____ and heating coil in air handling unit for warm-up cycle.
2. Commercial Unit
 - a. Type See attached equipment schedule.
 - b. Size _____
 - c. Commercial Identification _____
3. Coefficient of Performance (COP, if applicable, data versus pertinent operating conditions (ambient temperature etc.) Not applicable
4. Total Heating Capacity

The total heating capacity of the solar system shall be no less than 441,931 BTU/HR at _____ CFM of air flow entering at _____ °F dry bulb and _____ % relative humidity. Exposed heated panel (baseboard or ceiling) temperatures shall not exceed 130 °F.

F. Hot Water Subsystem

1. Type Two solar collectors, preheat tank with heat exchangers, and back-up gas heater

System and Subsystem Performance/Technical Data--Continued

2. Commercial Unit

- a. Type Glass lined tank with heat exchanger
 - b. Size 82 Gallon
 - c. Commercial Identification American Heliothermal Corporation
3. Hot Water (Back Up System) : _____ gallons of potable (of useable) hot water shall be delivered at no less than _____ gal/min at temperature no less than _____ °F. Recovery time shall be no greater than _____ hours. 20 Gal. Storage and 25 Gal./Hr. Recovery at 100° Rise
4. Code and Safety Standard Certified Under _____

G. Transport Between Subsystems

1. Provide Sketch/Block diagram of Proposed Solar System giving dimensions and subsystems/components location and identification. See Attached Drawings.
2. Piping Details
 - a. Diameter _____
 - b. Length of Run _____
 - c. Materials _____
3. Piping Insulation
 - a. Type _____
 - b. Thickness _____
 - c. Performance _____
4. Transport Media for each element
 - a. Type _____
 - b. Flow Rate _____ GPM (Liquid) _____ CFM (Air)
 - c. Specify Pressure drop between components. _____
5. Provide Flow diagram for Proposed Solar Energy System.

H. System

1. Operating Requirements

- a. The maximum electrical energy required to drive the solar portion of the system at its rated

System and Subsystem Performance/Technical Data—Continued

capacity shall be no greater than 5 K.W. Water requirements for cooling condensers and/or air humidification shall be no greater than --- gal/hr.

b. Subsystems/Components requiring electrical energy:

1. Pumps 2 kw, Function Collector Pumps
2. Fans kw, Function
3. Controls 1 kw, Function Temperature Controls
4. Other kw, Function

2. Design Load Data:

ANNUAL SUMMARY TABLE

Month	Heating (BTU) x 10 ⁶	Hot Water (BTU) x 10 ⁶	Cooling BTU
January	123.7	.63	
February	101.6	.57	
March	83.4	.63	
April	40.2	.61	
May	17.1	.63	
June	3.0	.61	
July	0	.63	
August	.6	.63	
September	7.5	.61	
October	30.1	.63	
November	72.6	.61	
December	106.6	.63	
Yearly Total	586.4	7.42	
Peak (BTU/HR)	441,931	8,750	

System and Subsystem Performance/Technical Data-Continued

3. Provide the following summary of system performance data:

Month	Solar Energy Collected (BTU) $\times 10^6$	Electrical Energy Req'd for Component ($\times 10^6$)	Auxiliary Energy (BTU) $\times 10^6$	System Heat Loss (BTU) ($\times 10^6$)	Equivalent Energy Req'd for Conventional System (BTU) ($\times 10^6$)
January	39.17	1.08	85.16	1.96	124.33
February	38.46	1.08	63.71	1.54	102.17
March	43.23	1.08	40.8	1.29	84.03
April	40.81	.92		.81	40.81
May	17.73	.60		.35	17.73
June	3.61	.19		.07	3.61
July	.63	.19		.01	.63
August	1.23	.19		.01	1.23
September	8.11	.19		.16	8.11
October	30.73	.92		.92	30.73
November	38.76	1.08	34.45	1.55	73.21
December	37.85	1.08	69.38	1.89	107.23
TOTALS	300.32	8.60	293.50	10.56	576.09

4. Provide estimate of yearly energy savings in terms of BTU's and/or Dollars along with the rationale for the estimate. Solar energy collected 300×10^6 , elec. energy 9×10^6 , System Heat Loss $11 \times 10^6 = 280 \times 10^6$ BTU/Yr. Energy Savings.

5. Any subsystems or system energy conversion inefficiencies which have not been specified in the previous subsystem section should be provided now. For example, if an oil fired heater is used for an auxiliary energy source state its:

1. Commercial identification Gas-Fired Hot Water Boiler, Kawanee M-65
2. Size/Rating (BTU) 650 MBH output
3. Efficiency 80%
4. Electrical Power Requirements 1/3 H.P.

6. Provide summary of insolation data used for section H Analysis.

System and Subsystem Performance/Technical Data—Continued

7. Design Life and Maintenance

a. Describe Periodic Maintenance provisions and requirements.

b. Specify design life of all components (if available).

1. Heating	20	yrs.
2. Cooling	20	yrs.
3. Auxiliary Energy	20	yrs.
4. Storage	20	yrs.
5. Potable	20	yrs.
6. Collector	20	yrs.
7. Energy Transport	20	yrs.
8. Controls	20	yrs.
9. Hot Water	20	yrs.
10. Pumps	20	yrs.
11. Fans	15	yrs.
12. Other	20	yrs.

c. Provide Warranty period and extent of coverage of the proposed Solar Energy System and subsystems. A warranty will be provided for the entire solar energy system for a period of one year after acceptance of the system by the building Owner.

KEY WORK ABSTRACT

Lincoln Housing Authority Office Building Solar System
Lincoln, Nebraska

KEY WORK ABSTRACT

Application--heating and hot water
System Type--active hydronic
Collector Type--flat plate liquid
Collector Manufacturer--Chamberlain Manufacturing Corporation
Collector Area--2,898 square feet
Storage Capacity--5,760-gallon steel tank
Building Load-- 586.4×10^6 BTU/yr.
BTU's Produced-- 300×10^6 BTU/yr.
Building Owner--Lincoln Housing Authority
Architect-Engineer--The Clark Enersen Partners
Contractor--Gen-Mech Contractors

INTRODUCTION

The building is a two-story masonry building. The lower floor is mostly below grade. The upper floor is used as office space for the Lincoln Housing Authority. The mechanical equipment room and a garage are located on the lower floor with the remainder of the lower floor space reserved for later development as future office space. The solar system is predicted to supply 50% of the annual space heating requirement and 90% of the annual hot water requirement.

DESIGN PHILOSOPHY

The basic design philosophy was to reduce energy requirements as much as possible within the program requirements and then to add the solar system to provide an additional reduction in energy use. The ratio of window area to wall area is very small and windows are double pane glass. Walls are of masonry which provides heat storage and the building is very well insulated. The solar system is a roof-mounted liquid flat plate collector system. Collectors are mounted in rows on the flat roof of the building, since ground space was not available and the building configuration had been determined before the decision to add the solar system was made.

The space heating and hot water systems are separate and completely independent of one another.

Space Heating System

The solar space heating system consists of a roof-mounted array of flat plate collectors, a water storage tank located in the lower level equipment room, a piping system with a pump to transfer heat from the collectors to a heat exchanger in the storage tank, a piping system with pumps to circulate heated water from the tank to the building heating equipment, an auxiliary gas-fired heating boiler, and controls.

Collectors Since the roof of the building is almost flat, with enough slope for drainage, the collectors are arranged in six east-west rows facing due south, tilted 56° above the horizontal. This angle is equal to the latitude of the building, 41° , plus 15° . The rows are spaced so that rows of collectors do not shade each other at noon, on the winter solst December 21, when the sun is at its lowest point, 26° above the horizon. The collectors are supported above the roof on a rack constructed of steel angles with legs of steel pipe welded to the angles. The steel pipe legs are supported on roof curbs bolted to the roof joists and flashed.

Collectors are mounted so that each collector can be removed without disturbing the adjacent collectors.

Piping System The collectors are connected with a reverse return piping system to provide an equal length flow path for each collector to equalize flows through all collectors. A branch supply main and a branch return main are mounted on each rack. Collector connections are silicone rubber hoses with stainless steel clamps. Piping on the racks is sloped up 1" in 50' in the direction of flow. An air vent and relief valve are provided at the high point of the collector outlet main on each rack.

The mains are routed down through a pipe chase to the lower level equipment room. A pipe-mounted circulating pump circulates heated water from the collectors through a heat exchanger in the storage tank and back to the collectors. An air separator and an expansion tank are provided. The water circulated through the collectors is mixed with ethylene glycol in a 50% solution. Piping is copper and all mains above the roof are insulated with armaflex foamed plastic pipe insulation. Piping below the roof level has fiberglass pipe insulation.

Storage Tank The storage tank is a steel pressure tank located in the lower level equipment room. A heat exchanger with a separate pump transfers heat from the ethylene glycol solution to the water in the tank. A temperature and pressure relief valve is provided on the tank. The tank is supported on concrete piers. The tank has an armaflex foamed plastic insulation. Dielectric fittings are provided in the connections between the copper piping and the steel tank.

Auxiliary Backup System An auxiliary gas-fired, hot water boiler is provided for backup to the solar heating system. It is connected to the solar storage tank and the building heating system through an automatic three-way valve. The boiler is sized for 100% of the building's heating requirements.

Solar Domestic Water Heating System

The solar domestic water heating system consists of two roof-mounted flat plate collectors, a water storage tank located in the lower level equipment room, a piping system with pump to transfer heat from the collectors to a heat exchanger on the storage tank, a gas-fired auxiliary water heater, and controls.

Collector The collectors for the solar domestic water heating system are mounted on the same racks as the solar space heating system collectors.

Piping The solar domestic water heating piping system is entirely separate from the solar space heating system piping. Reverse return piping connections are provided with silicone rubber hoses, relief valve, and an air vent as for the space heating system collectors. Piping is routed down through a pipe chase to the storage tank in the lower level equipment room. A pipe-mounted pump circulates an ethylene glycol solution from the collectors through a heat exchanger on the storage tank, and back to the collectors. An air separator and an expansion tank is provided. Piping is copper with insulation as described for the space heating system.

Storage Tank The storage tank is a glass-lined steel tank with a double wall wrap-around heat exchanger, fiberglass insulation and a metal jacket. A temperature and pressure relief valve is provided on the tank.

Auxiliary Water Heater An auxiliary gas-fired water heater with a glass-lined storage tank and a gas burner is provided to boost the solar heater water when necessary.

OPERATION OF THE SYSTEM

The system was put into operation on about the first of April 1978. The space heating system operated satisfactorily for the short time remaining of the heating season. The domestic water heating system has been in continuous operation with no problems since it was started up, except for a short shut-down in September 1978 to install instrumentation for the monitoring system. No information on performance is available since the monitoring system was not yet in operation at the time this was written.

PROBLEMS ENCOUNTERED AND SOLUTIONS

At the first contractor's review held in December 1977, several people reported difficulties in using stainless steel clamps with silicone hose. Because of this we used plastic hose clamps recommended by the silicone hose manufacturer. These were not satisfactory and many hose leaks resulted. The clamps were replaced with heavy duty stainless steel clamps which solved the problem.

The contractor had great difficulty getting all the air out of the collectors when he tried to fill the system from the top. When he filled it from the bottom up, it worked very much better.

SUCCESSFUL COMPONENTS OR PROCESSES

Great effort was taken in the design process to keep the system as simple as possible. Layout of equipment and its spacial relationships were arranged to make the function and operation of each item as obvious as possible. The controls were kept as simple as possible to make it easier for the contractors and the building owner's operator to understand them. The system was very carefully explained in detail to the contractor before construction was started and the owner's operator was on the job during construction.

These efforts at simplification and clarifying the operation of the system helped keep the cost much lower than the average of the demonstration projects, and the system has operated almost completely troublefree since it was started.

COSTS

The project was bid twice. The first set of bids was too high. The design was carefully reviewed with the bidders and with ERDA representatives. As a result of these reviews many design revisions were made and the project was rebid successfully.

Main cost reductions were:

- Simplified collector supports.

- Locating piping mains on the support racks above the roof rather than below the roof.

- Using a steel tank designed for 30 psi rather than 150 psi for the heating system storage tank and deleting the cement lining for the tank.

- Eliminating the individual shutoff valves for each collector.

The construction cost as bid by the successful contractor was \$92,450. Four change orders were written during construction which brought the total construction cost to \$95,997.95 or \$33.13 per square foot of collector area.

LESSONS LEARNED

The cost of the collectors themselves is not as large a proportion of the total cost as we had anticipated. The cost of the piping system and collector supports were much higher than we anticipated.

The use of larger collectors with internal manifolds should be considered since it would reduce the amount of field piping and reduce the number of connections.

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Simplification of collector supports using as much of the roof structure itself as possible would also reduce costs.

Heat venting during the summer has not been a major problem. We had originally planned to drain down the space heating system during the summer, but did not do so. The collectors are less efficient in the summer due to the high sun angle on the collectors which are at winter optimum tilt, and because of the higher storage tank temperature. Heat gain into the building from the storage tank has not been a problem since the tank is in an uncooled equipment room. It appears that the cost of operating the pumps during summer operation may be justified by avoiding the possible problems of stagnation.

We provided a completely separate system for domestic hot water in this application, but the cost of this separate system was probably unnecessary.

MAJOR MAINTENANCE PROBLEMS
AND RECOMMENDATIONS

Major Maintenance Problems and Recommendations

The major maintenance problems to date have been leaks in the hoses for the collector connections and faulty controls.

Silicon hose was used for the final connections between the piping system and the collectors to provide for expansion and to provide a dielectric break between the copper piping and the steel collectors. The contractor had great difficulty keeping the hoses from leaking when he first installed them. By changing the hose clamps to the heavy duty stainless steel, worm gear type and flaring the ends of the pipe connections, he was finally able to get a leak-free installation. On several occasions since the installation was completed, one or more of the hoses has been accidentally bumped causing leakage. A soft copper connector with a dielectric coupling would have been better.

The controllers used are manufactured by companies specializing in solar system controls. These were used since the normal HVAC temperature control companies did not have such controls at the time the system was designed. Parts and service have been very hard to get on these controls. Since the normal HVAC temperature control companies now have solar controls, their controls should be used to take advantage of local parts stocking and service.