SAN-1537-1

PROGRAM OPPORTUNITY NOTICE DSE-76-2
NATIONAL SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

UNITED STATES DEPARTMENT OF ENERGY
SECRETARY OF CONSERVATION AND SOLAR APPLICATIONS

BILLINGS SHIPPING CORPORATION

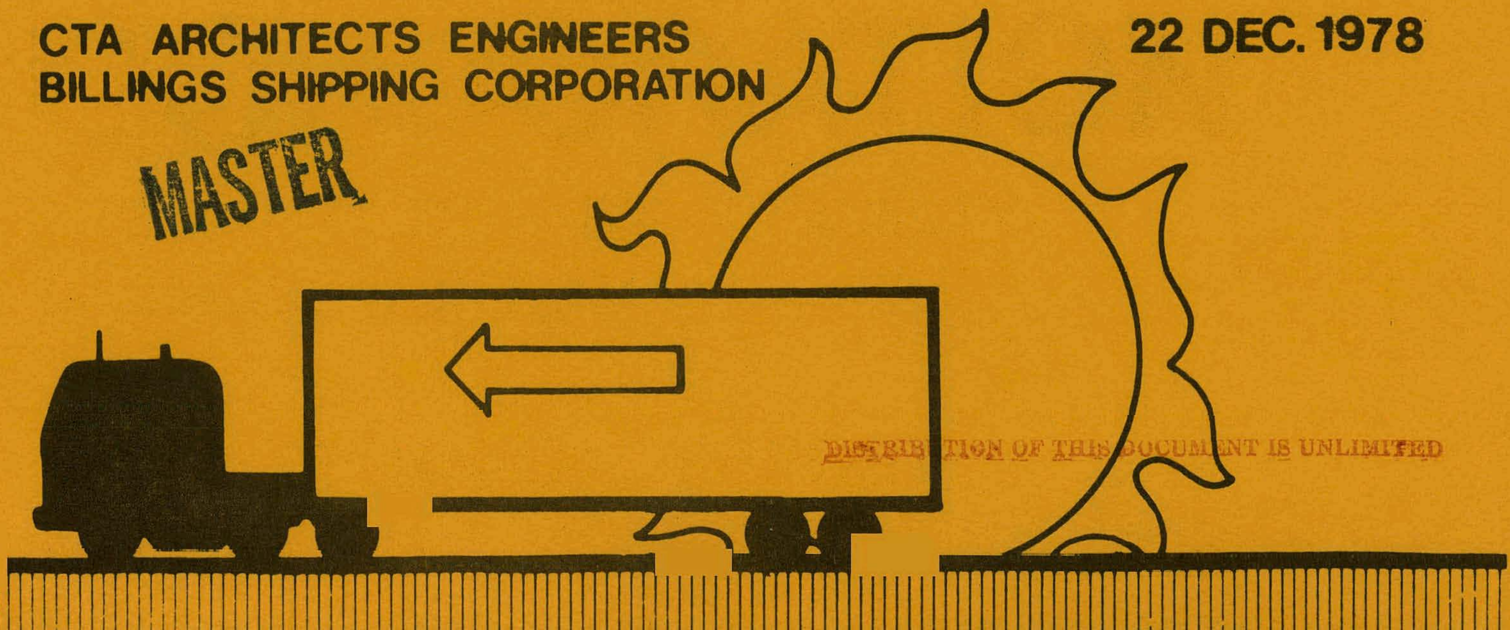
FREIGHT DISTRIBUTION FACILITY
BILLINGS, MONTANA

FINAL TECHNICAL REPORT

CTA ARCHITECTS ENGINEERS
BILLINGS SHIPPING CORPORATION

22 DEC. 1978

MASTER



DISCLAIMER

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Section 1 - Acceptance Test Plan

SYSTEM START-UP

All components used in the solar system are standard manufactured products which have been tested prior to shipment. Thus, no particular component tests need be performed except to check each collector for shipping damage. However, when these standard components are assembled on site into a unique solar system, that system must be checked for proper assembly and operation.

The initial start-up fill and operation of the solar system is primarily to check for leaks, pump operation, and flow balancing. It is important to initially flush the system of residues that may have been left in the system during installation. It is essential that the following be accomplished during this initial fill.

- Flush the collector system piping with a mixture of trisodium phosphate and water with a filter in the pumping loop.
- Check the system hydrostatically for possible leaks and/or malfunctions in system operation. The system should maintain 40 psi for 24 hours with no appreciable drop.
- When draining the flushing solution, measure the amount of fluid in the system so that the correct mixture of glycol anti-freeze can be added.

The following precautions should be observed.

- Do not attempt to fill the collectors in direct or even partial sunlight. Cover collectors completely before attempting to fill, or fill at night or early morning.

- Do not operate pumps dry. The mechanical seals in the pumps generally have a carbon face and these seals will burn out very quickly when operated without fluid.

- Do not over-pressurize the system on initial fill.

- Clean strainer screen after flushing prior to fill with glycol/ water solution.

SYSTEM FILL PROCEDURE

Fill the collector loop with a 50/50 solution of water and Dowtherm SR1 ethylene glycol. The filling procedure is rather simple. One needs something in the neighborhood of a 55 gallon drum and a centrifugal pump with a sufficient head to pump up to the collectors. A positive displacement pump could also be used. Pick the lowest point in the system within the collector loop. Open all air bleeds in the system and fill slowly. It is imperative not to fill the system too rapidly. Close air bleeds as they begin to leak. Some precautions should be taken to prevent the glycol mixture from spilling onto the building roof or collector array.

System Pressurization

Once the system is full and purged of air, it may be pressurized. This can be accomplished in either of two ways. One is to use city line pressure on the fill connection that is in the expansion tank supply line. This will put additional fluid into the system and cause an increase in pressure in the air trapped above the fluid in the expansion tank. The second technique is to put air in the top of the expansion tank to pressurize the system. As the collector system pump is operated, the air that is trapped in small places will tend to be separated by the air separator and travel into the expansion tank. This will cause a decrease in the fluid level within the expansion tank. It is important to watch this fluid level to see that it does not get too low as fluid in the expansion tank is imperative. If the level gets low, then more fluid must be added to the system to maintain the same system charge pressure, some air must be allowed to escape from the top of the tank.

Draining

Make sure all pumps are manually shut off in control box. System may be drained at the lowest point in the fluid loops if air bleeds and appropriate check valves are opened. Check valves with externally operated gates should be specifically used for draining purposes. Plumbing runs should be made so that water traps do not occur as not only will they be impossible to drain but they may also collect sediment and eventually restrict fluid flow. Excessive draining and refilling of the collector loop is not recommended as remaining wetted surfaces in the collector tubes will boil away leaving residue (scaling). This will tend to reduce collector heat transfer capability and eventually restrict fluid flow.

The storage and heating system loop should also be cleaned prior to charging. An initial flush of the storage tank with a hose is imperative to remove residue. The storage tank should be filled, checked for leaks, and inhibitors added to the storage water. Once the inhibitors are in the storage tank loop, then pump operation should be sufficient to purge all the air out of the system. Care should be taken to not operate storage and heating pumps simultaneously in manual modes and to be certain of valve position prior to turning pump switches to on in the control box.

Balancing valves should be adjusted to provide specified flow rates in the appropriate branches of the system.

Clean dirty glass surfaces using a soft clean cloth, mild soap or detergent and clean rinse water. Do not allow alkalies to remain on glass surface.

The ethylene glycol/water mixture should be checked once a year for proper freeze protection and inhibitor level.

Observe the system operation in each operating mode, collector to load, storage to load, and collector to storage. Ascertain that each mode functions as desired.

The above acceptance test procedure was followed in filling and starting the system. Approximately 90 gallons of antifreeze was used to protect the collector loop system from freezing. The system pressure with pumps off was set at 12 psi in the collector loop, in the heat exchanger loop and in the auxiliary boiler loop.

The temperature control system was calibrated and tested by Jerry Doran, an installation technician with Johnson Service Co. in Great Falls, Montana. All modes of operation were functioning as described in Section 3.

Section 2 - Operation and Maintenance

1. Oil all circulating pumps every four months with SAE #20 non-detergent oil.

2. Test antifreeze at the beginning of the heating season. 50% solution will protect to -32°F.

3. Test water in heat exchanger and auxiliary heating system piping loops and add corrosion inhibitor as recommended by treatment company.

4. Check all collectors for leaks at hose connections, damaged glass cover plates and other visible problems which might affect performance.

5. Wash cover glass at the beginning of the heating season.

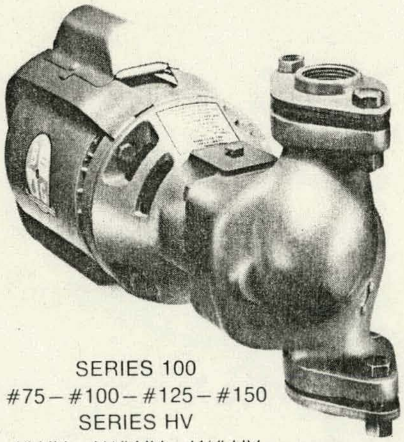
6. Check pressure in each water system and add water if necessary to raise pressure to 12 psi. Do not leave hose connected to collector loop piping.

7. Verify operation of relief valves by lifting handle to release a small amount of water.

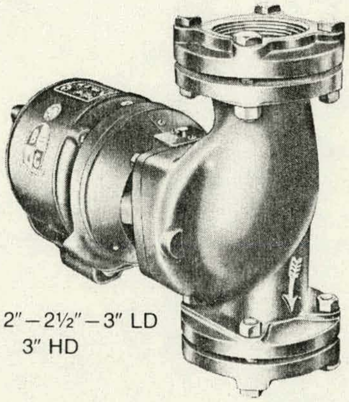
INSTRUCTION MANUAL

S17630

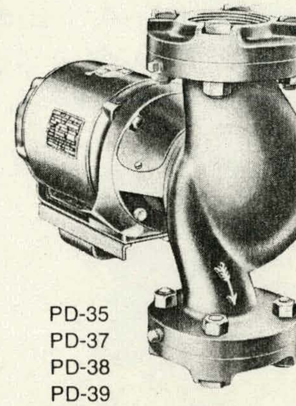
REPLACES SD-1239-CA REVISION 4



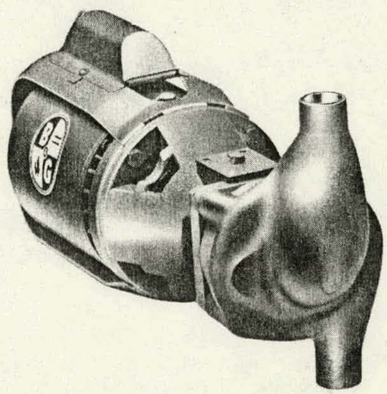
SERIES 100
#75 – #100 – #125 – #150
SERIES HV
1″ HV – 1¼″ HV – 1½″ HV
1½″
1″ PR



2″ – 2½″ – 3″ LD
3″ HD



PD-35
PD-37
PD-38
PD-39
PD-40



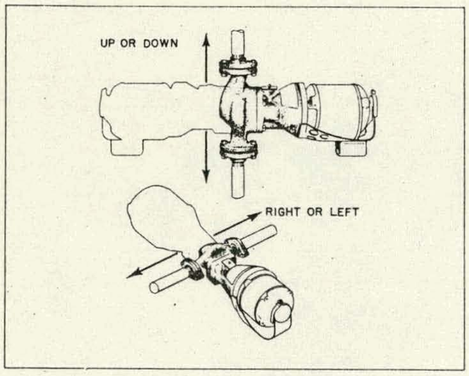
SC-75 BOOSTER PUMP

BOOSTER CIRCULATING PUMPS

INSTALLATION, OPERATION AND SERVICE INSTRUCTIONS

BELL & GOSSETT ITT
FLUID HANDLING DIVISION

GENERAL INSTALLATION and OPERATING INSTRUCTIONS



All B&G Boosters and PD Boosters are horizontally mounted-in-the-line circulating pumps. They are designed to operate in either a horizontal or vertical line, circulate to the right or left, either up or down. To change direction of flow, remove the four body bolts and revolve body 90° or 180° in either direction! On horizontal lines, when possible, install body so volute hump is on the bottom.

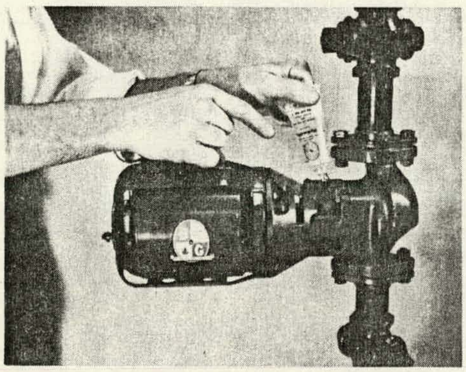
The standard cast iron body Booster is designed for circulating hot or cold water through an open or closed piping system. When fresh water is to be circulated, as on a recirculating line from hot water faucets, all-bronze construction is recommended.

Special attention should be given when installing Booster pump where piping is not able to provide the necessary support. Supporting the Booster pump from above may be necessary to avoid excessive pipe strain.

All Boosters are constructed for continuous operation. Unless otherwise ordered Boosters are equipped with 115 volt, 60 cycle, 1 phase motors and have built-in thermal overload protection.

Never operate a Booster without water. NEVER OPERATE the Booster without first oiling all three oil cups. Recommended lubrication instructions are as follows.

LUBRICATION INSTRUCTIONS



All new B&G Boosters and PD's are supplied with a tube of Hydro-Flo oil for the initial lubrication. Although each Booster is oiled and operated at the factory, IT MUST BE OILED AGAIN BEFORE OPERATED. Oil the three oil cups (2 on the motor, 1 on the pump) as instructed on the oil tube.

Thereafter periodic lubrication periods should be as follows:

A— **Use #20 non-detergent motor oil.**

B— **Lubricate all three oil cups on pumps as directed on lubrication instructions affixed to the pump. Normal heating service will necessitate reoiling every three months. Twelve drops in each motor cup and approximately ½ ounce in the bearing bracket will provide optimum performance for average usage of the 100 series booster, proportionately more for the larger boosters per instructions.**

C— **Although oil overflow holes are available, do not over-oil the pump and motor.**

As with any mechanical device, proper lubrication is the most important single factor in obtaining long life and troublefree operation. A regular schedule of oiling is always a good policy.

NATIONWIDE B&G SERVICE

As an owner of a Bell & Gossett Booster you can expect, and are entitled to, a lifetime of *troublefree and silent operation.* However, while Hydro-Flo products are less apt to need service than other similar mechanical devices, if service is ever required, B&G Service and Parts are readily available.

Sixty-two Bell & Gossett Sales Offices are located throughout the country. In addition, nearly 3330 B&G Parts Wholesalers have been established in major cities to give thousands of heating contractors an immediate supply of genuine Hydro-Flo parts.

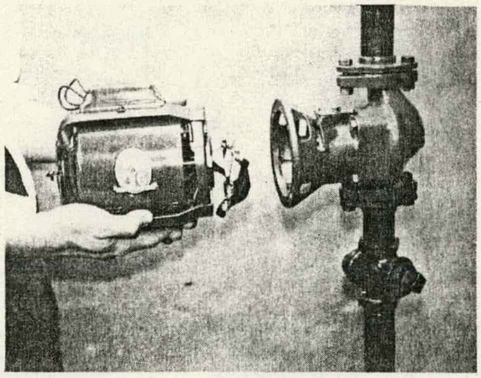
For service on any B&G product, consult your local telephone book or classified directory for the name of the B&G Representative, service station or contractor nearest you.

HOW TO SERVICE YOUR BOOSTER

An exclusive feature of the B&G Booster is the availability of complete bearing bracket assemblies or component parts for fast economical repairs. B&G Boosters and PD's are highly engineered products designed to give you the maximum in quiet operation, dependable performance and long life.

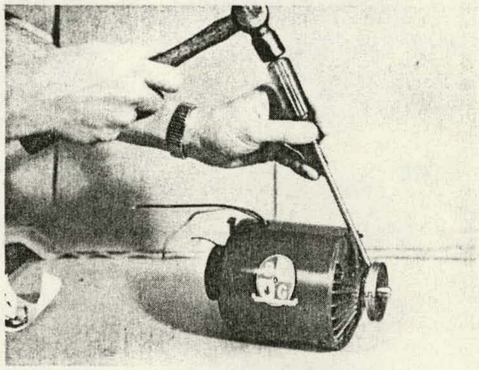
A new bearing bracket assembly or the replacement of component parts provide a quick answer to virtually any service problem encountered. A new replacement bearing bracket assembly receives the same guarantee as a new pump.

Coupler replacement and new motor mountings are the only other repairs that might be necessary. (Over-oiling can cause deterioration of the motor mountings and in turn cause excessive coupler wear from misalignment.)



USE GENUINE BELL & GOSSETT REPLACEMENT PARTS ONLY—DO NOT ACCEPT SUBSTITUTES

How to replace the coupler assembly



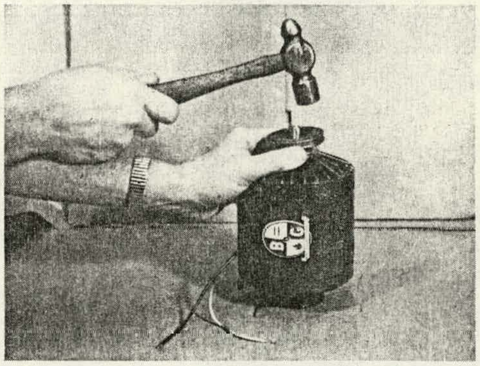
A—Turn off current to motor.

B—Remove protective cover from bearing assembly.

C—Loosen coupler half from pump shaft by turning Allen set screw counterclockwise.

D—Remove four cap screws that connect motor bracket to pump bracket, holding motor in one hand. If coupler sticks on pump shaft, insert screwdriver between rear bearing and coupler half, exerting pressure outward. (Figure 1.)

E—Do not attempt to replace individual coupler springs. If coupler arms are worn or springs are broken, always replace entire coupler assembly.



How to replace the ring motor mountings

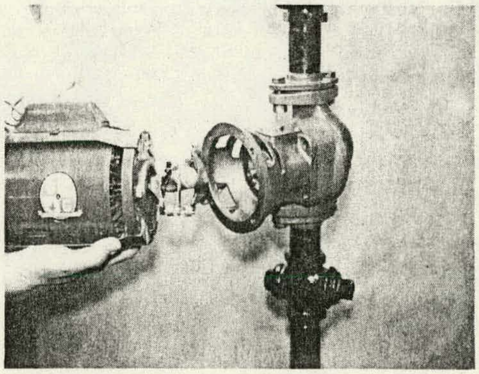
A—To change ring motor mountings remove coupler from motor shaft.

B—Loosen rear clamp on motor using screwdriver to pry off clamp. Motor can then be lifted out of bracket.

C—Place screwdriver between front mounting and end-bell of motor and strike firmly with a hammer on handle of screwdriver, forcing inner ring of motor mounting off the boss of end-bell. (Figure 2.)

D—To reinstall, hold mounting firmly against boss of end-bell and tap inner ring lightly until mounting has started. Continue to tap around the inner ring (compression ring) until mounting is flush with end of boss. (Figure 3.) Repeat procedure with rear mount; however, *do not* rest motor on end of shaft when applying this unit.

E—Replace motor in bracket with oil well spouts up and tighten clamp. (Figure 4.)



GUARANTEE AND LIABILITY

ITT Fluid Handling Division, International Telephone & Telegraph Corporation, warrants that all BELL & GOSSETT products furnished by it for a period of one year after date of shipment from its factory to be free from defects in material and workmanship, subject only to the following:

1. Manufacturer's liability under this warranty (and under any other warranty express or implied, statutory or otherwise) is limited to repair or, at Manufacturer's option, replacement of all parts which are shown to have been defective when shipped, and then only if Manufacturer is notified of such defects within such warranty period and such defective parts are promptly delivered to its factory at 8200 N. Austin Avenue, Morton Grove, Illinois, transportation charges prepaid. Manufacturer's liability hereunder shall not be enforceable until such equipment has been fully paid for. Except to the extent expressly assumed herein, Manufacturer's liability for incidental and consequential damages is hereby excluded to the full extent permitted by applicable law. Manufacturer's liability as stated herein cannot be altered or enlarged except by a writing signed by an officer of Manufacturer.

2. Replacement parts will be invoiced in the regular way with invoices subject to adjustment after the parts claimed defective are examined at our factory. ITT Fluid Handling Division reserves the right to make such changes in details of design, construction or product arrangement as shall, in its judgment, constitute an improvement over former practice.

RETURNED GOODS: Written permission must be obtained before returning any material for any reason. Material returned for credit will be subject to factory inspection. In-warranty product, in original cartons, of current design will be subject to a 15% rehandling charge less freight originally allowed. All material must be shipped with transportation charges prepaid.

Products which are obsolete or made to special order are not returnable.

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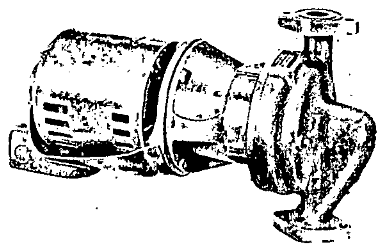
INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

BELL & GOSSETT

INSTRUCTION SHEET

S16946
REVISION 3



PD BOOSTERS & SERIES "60" IN-LINE CENTRIFUGAL PUMPS

INSTALLATION & OPERATION INSTRUCTIONS

LOCATION

If the pump is not installed on a closed system it should be placed as near as possible to the source of supply, and located to permit installation with the fewest possible number of bends or elbows in the suction pipe.

ALIGNMENT

The compact construction of this pump makes it very unlikely that any misalignment of parts will occur, but a check should be made before putting the pump in service by turning the shaft by hand to determine that there is no binding.

Misalignment of the Series 60 and PD-38 and PD-40 Model Pumps must not exceed two (2°) degrees in any direction.

PIPING

It is important that air be kept out of the system. On an open system always place the end of the suction pipe at least 3 feet below the surface of the water in the suction well to prevent air from being drawn into the pump. Avoid air pockets in the suction line and make sure that each section of the suction pipe is absolutely air tight.

Install a square head valve and a check valve in the discharge pipe close to the pump. The check valve should be between the square head valve and the pump discharge nozzle. The square head valve can be used to control the capacity of the pump or to shut off the discharge line while repairs are being made. The function of the check is to protect the pump casing from breakage that might occur due to the action of water hammer.

A 10-32NF eye bolt has been included with the pump package, use of which is optional, to enable supporting the bearing bracket from above the pump when the piping is not able to provide the necessary support.

Do not provide additional support to the pump by means of a cradle under the motor. To do so may create a strain on the motor bracket and cause shaft misalignment.

PRIMING

DO NOT RUN PUMP DRY. Before starting, these pumps must be filled with water. After the pump has been filled, turn the shaft a few times by hand to allow all air to escape and if necessary add more water. The square head valve in the discharge should be kept closed until the pump is running at full speed and then gradually opened.

LUBRICATION INSTRUCTIONS

All new Bell & Gossett PD Boosters and Series "60" in-line centrifugal pumps are test run at the factory, but must be lubricated before being placed in operation.

Lubricate as follows:

1. Pump Bearings—Fill the bearing frame per oiling instruction tag with SAE #20 oil until oil flows from the overflow hole on the side of the bearing bracket. PD-38 and PD-40 model pumps and 1½" and 2" Series 60 are to be lubricated until oil level is up to the side hole. Relubricate as necessary to maintain this level.
2. Sleeve Bearing Motor—Lubricate thru the two motor oil cups per motor lubrication tag once every four months. Use ten to fifteen drops in each oil cup.
3. Ball Bearing Motor—Relubricate every six months to two years depending on operating conditions with a good soda-soap or lithium base grease.

HOW TO SERVICE YOUR PD BOOSTER & SERIES "60" IN-LINE CENTRIFUGAL PUMP

An exclusive feature of the B & G PD Booster & Series "60" pumps is the availability of complete bearing bracket assemblies as replacements.

In those cases where it may be necessary only to replace the seal assembly the following instructions apply:

1. Close valves on both sides of pump (If no valves have been installed, it may be necessary to drain the system).
2. Detach bearing-frame assembly from pump volute by removing eight cap-screws from center body-flange.
3. Remove impeller from pump-shaft (First turning impeller-nut counter clockwise).
4. Lift off seal-spring — then place screwdriver point under top compression ring of seal and pry off. Seal can then be removed by pulling upward.
5. Be sure that the shaft is thoroughly cleaned then lubricate with a thin film of oil or water and push the replacement seal on as far as possible by hand. Next, using a screwdriver press down firmly all around the outer edge of the top compression ring until the seal is tight against the face of the remite insert. If end play is present push the seal on tighter.
6. Replace impeller on shaft making certain that impeller-nut is firmly tightened. The pump and bracket can then be reassembled into pump volute and placed in service.

HOW TO REPLACE THE COUPLER ASSEMBLY

A — Turn off current to motor.

B — Remove bearing bracket cover.

C — Loosen coupler half from pump shaft by turning Allen set screw counter-clockwise.

D — Remove four cap screws that connect motor bracket to pump bracket and slide motor away from bracket. If coupler sticks on pump, insert screwdriver between rear bearing and coupler half, exerting pressure outward. Loosen set screw on motor coupling half and remove coupling.

E — Install new coupler, slipping one coupling half on motor shaft first and tighten set screw. Slip other coupling half on pump shaft, tighten set screw and bolt motor bracket to pump bracket. Replace bearing bracket cover.

CAUTION:
Do not attempt to replace individual coupler springs. If coupler arms are worn or springs are broken, always replace entire coupler assembly.

BELL & GOSSETT ITT
FLUID HANDLING DIVISION

OPERATING THE PUMP

1. Be sure to operate the pump in the proper direction. All B & G centrifugal pumps run clockwise when looking at the pump from the motor end. All pumps are provided with arrows showing direction of rotation.
2. Keep pump and motor bearings lubricated.
3. Do not disassemble pump unless absolutely necessary as impeller has been accurately adjusted and tested before leaving factory.
4. Pump shaft should always turn freely by hand.
5. Ask for information or help if trouble is experienced that cannot be rectified since this pump is guaranteed to operate as recommended.
6. If pumps are to be idle for a very long period of time the interior of the volute should be cleaned and oiled. This prevents parts from rusting together and assures a longer period of satisfactory operation.
7. The motor should be protected against overload and under-voltage. Control devices for this purpose can be obtained at a very low cost. They are inexpensive insurance.

GUARANTEE AND LIABILITY

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1. Manufacturer's liability under this warranty (and under any, other warranty express or implied, statutory or otherwise) is limited to repair or at Manufacturer's option, replacement of all parts which are shown to have been defective when shipped, and then only if Manufacturer is notified of such defects within such warranty period and such defective parts are promptly delivered to its factory at 8200 N. Austin Avenue, Morton Grove, Illinois, transportation charges prepaid. Manufacturer's liability hereunder shall not be enforceable until such equipment has been fully paid for. Except to the extent expressly assumed herein; Manufacturer's liability for incidental and consequential damages is hereby excluded to the full extent permitted by applicable law. Manufacturer's liability as stated herein cannot be altered or enlarged except by a writing signed by an officer of Manufacturer.
2. Replacement parts will be invoiced in the regular way with invoices subject to adjustment after the parts claimed defective are examined at our factory. ITT Fluid Handling Division reserves the right to make such changes in details of design, construction or product arrangement as shall, in its judgment, constitute an improvement over former practice.

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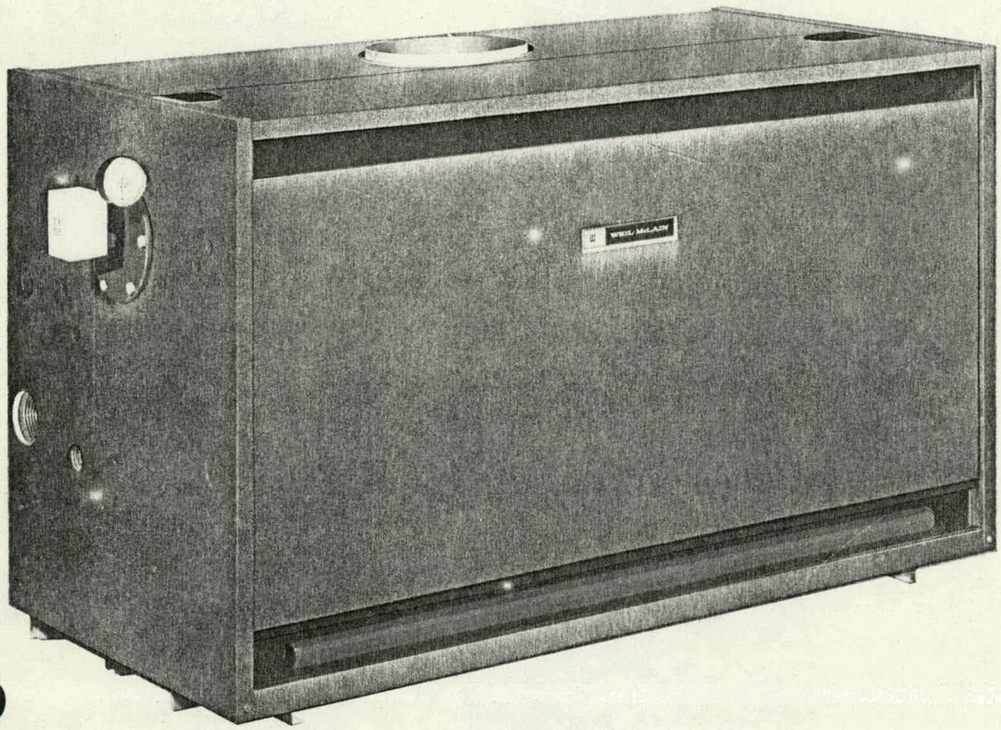
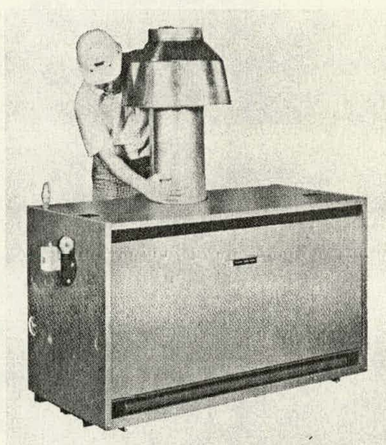
INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

WEIL-McLAIN

TYPE EGH

COMMERCIAL GAS BOILER





NET LOAD RANGE

HOT WATER:
243,500 to
382,600 BTU/Hr.

STEAM:
875 to
1,375 sq. ft.

Design Certified by
American Gas Association

Net ratings are approved by
The Hydronics Institute

Built in accordance
with the requirements
of the ASME Boiler and
Pressure Vessel Code

A. I. A. 30-C-1

AMERICA'S MOST COMPLETE LINE OF CAST IRON BOILERS
RESIDENTIAL...COMMERCIAL...INDUSTRIAL...INSTITUTIONAL

TYPE **EGH**

COMMERCIAL GAS BOILER

WEIL-McLAIN
HYDRONIC DIVISION
MICHIGAN CITY INDIANA

The Weil-McLain Type EGH is a medium-capacity cast iron boiler for heating apartments, large residences, commercial and institutional buildings. It is available in five sizes for hot water or steam with net I-B-R ratings from 243,500 to 382,600 BTU/Hr.; 875 to 1,375 square feet steam.

The EGH incorporates design and construction features for ease of installation, space conservation, easy servicing and cleaning, fuel efficiency and long, trouble-free life. Outstanding features include compact design, insulated steel jacket, tankless heaters for water and steam, aluminized steel burners and, of course, Weil-McLain cast iron construction.

STANDARD EQUIPMENT

Assembled Section Block
Insulated Jacket
Vertical (Top Outlet) Draft Hood
Aluminized Steel Burners
Combination Gas Control Valve (includes main gas valve, pressure regulator, three-position gas cock, pilot filter, and pilot adjustment), for 24 volt
100% Shutoff
Thermocouple
Non-Linting Pilot Burner
Heater Cover Plates (for boilers without tankless heater)
Safety Control Wire
Electrical Junction Box
40 VA Transformer (except self-generating system)

For Water Boilers

Built-In Air Eliminator
ASME Safety Relief Valve
Combination Pressure-Temperature Gauge
High-Limit Control

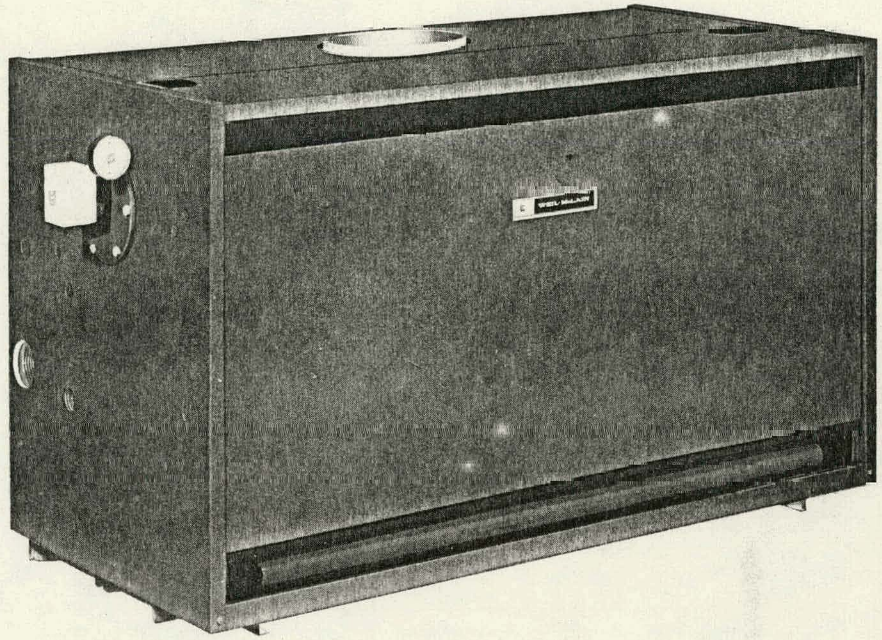
For Steam Boilers

ASME Safety Valve
Steam Pressure Gauge
High-Limit Pressure Control
Gauge Cocks
Gauge Glass
Low-Water Cutoff
With Tankless Heater(s):
Operating Control

ADDITIONAL EQUIPMENT

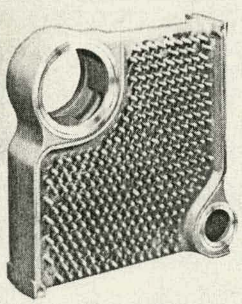
Tankless Heaters — for water or steam
Storage Heater
Self-Generating Control System with 100% Shutoff
Thermostat
Low-Water Cutoff and Feeder Combination

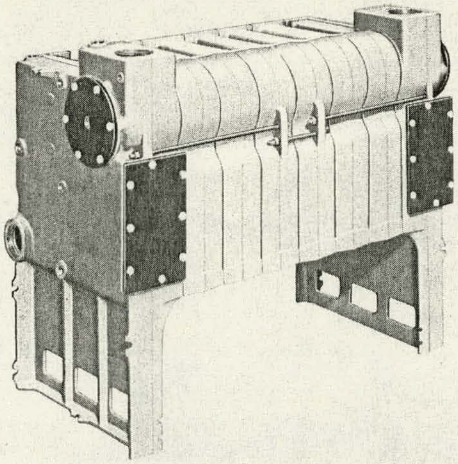
DESIGN FEATURES



1. **Cast iron sections** for corrosion resistance and extra-long life.
2. **A.G.A. design certified for natural and propane gas** . . . develops full capacity as rated by A.G.A. and I-B-R.
3. **Compact design** saves boiler room space, simplifies handling and installation. The EGH is only 33¾" high; 27⅝" deep.
4. **Tankless heaters** for water or steam available as additional equipment.
5. **Aluminized steel burners** feature quiet ignition and extinction . . . no air adjustment necessary.
6. **Steel jacket** finished in attractive blue hammerloid . . . completely insulated with one-inch fiberglass . . . clear of the floor to prevent rust.
7. **Built-in air eliminator** in water boilers saves the cost of a separate device.
8. **Vertical (top outlet) draft hood** reduces floor space.
9. **Factory-assembled sections** and factory-assembled burners and burner drawer reduce installation time.
10. **Designed for easy servicing and cleaning** with vertical flueways, top cleaning, and accessible burners.

CAST IRON CONSTRUCTION...FACTORY-ASSEMBLED SECTIONS





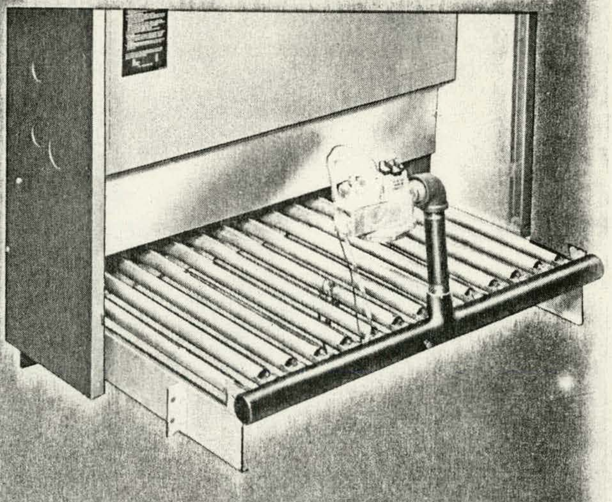
EGH Boiler sections are made of dura-'le cast iron for extra-long life. The ections are not face-ground, but retain he tough original skin which is extremely resistant to the corrosive effects of combustion by-products and ondensation.

The vertical flue passages are studded ith tips which cause the hot gases to swirl about, scrubbing the entire surface of each section for maximum heat 'ransfer and increased efficiency.

The EGH Boiler is shipped with the ections factory assembled in one block. If desired, the installer can separate the boiler into two blocks to simplify 'andling since short draw rods are used etween the two intermediate sections n the middle of the assembly.

A special high-temperature mastic sealant is used between sections to assure a gastight assembly and consistently high efficiency. The flexible sealant allows for expansion and contraction, is impervious to heat and moisture, and will last the life of the sections. A flexible elastomer sealing ring in each port opening assures a watertight seal. Individual sections as well as the assembled section block are hydrostatically tested before shipping.

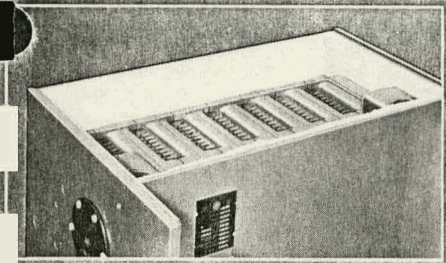
BURNERS AND BURNER ASSEMBLY



The EGH Boiler is design certified for natural and propane gas. One-piece, high-temperature, aluminized steel burners feature high efficiency, excellent flame characteristics, and quiet ignition and extinction. Burners provide fixed primary air . . . no air adjustment required for approved gases.

To simplify handling and reduce installation time, the burners and manifold are assembled in a burner drawer which slides easily into the boiler.

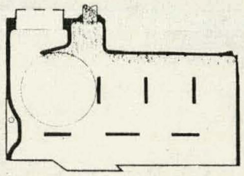
EASY CLEANING AND SERVICING



All heating surfaces in the EGH Boiler can be easily cleaned to maintain continued high operating efficiency. Removing the top jacket panel and the collector hood exposes all flueways for straight-through cleaning.

The jacket door and burner access panel are easily removed for access to the burners. The front and back steel base panels are lined with high-temperature insulating material; end sections rest on the floor.

BUILT-IN AIR ELIMINATOR



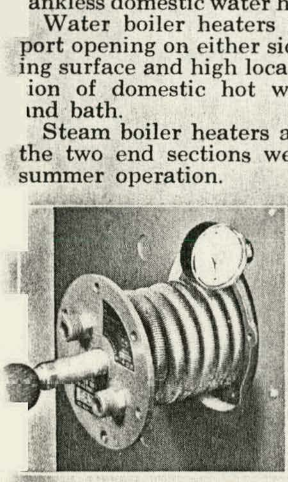
Type EGH water boilers have a cast-in air eliminator . . . no need for a separate air eliminating device. As shown in the illustration, rising air bubbles are diverted to the expansion tank through a ¾-inch tapping located next to the supply outlet.

ESS WATER HEATERS—OPTIONAL

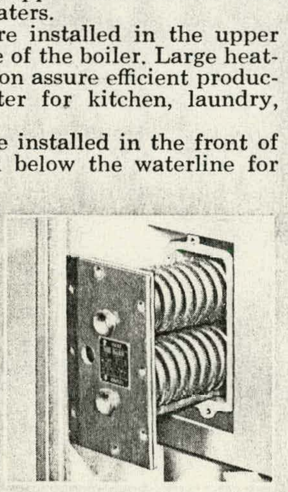
EGH Boilers may be equipped with one or two ankless domestic water heaters.

Water boiler heaters are installed in the upper port opening on either side of the boiler. Large heating surface and high location assure efficient producion of domestic hot water for kitchen, laundry, nd bath.

Steam boiler heaters are installed in the front of the two end sections well below the waterline for summer operation.



WATER HEATER



STEAM HEATER

TANKLESS WATER HEATER CAPACITIES

Boiler Number	Heater Number	Intermittent Draw GPM* 100° F. Av. Temp. Rise	Continuous Draw GPM** 100° F. Av. Temp. Rise	Inlet and Outlet Tappings	Temp. Control Tapping
WATER					
EGH-85	E-626	4.00	2.80	½″	¾″
EGH-95	E-632	4.25	3.20	½″	¾″
EGH-105	E-632	4.50	3.60	½″	¾″
EGH-115	E-632	4.50	4.00	½″	¾″
EGH-125	E-632	4.50	4.40	½″	¾″
STEAM					
EGH-85	35-S-29	3.25	2.80	¾″	¾″
EGH-95	35-S-29	3.50	3.20	¾″	¾″
EGH-105	35-S-29	3.50	3.60	¾″	¾″
EGH-115	35-S-29	3.75	4.00	¾″	¾″
EGH-125	35-S-29	3.75	4.40	¾″	¾″

Weil-McLain ratings based on 60 PSIG domestic water pressure at heater.
*Gallons of water per minute heated from 40° to 140° F. with 200° F. boiler water temperature.
**Continuous draw — no recovery period
NOTE: For two heaters, multiply heater ratings by 2.

STORAGE HEATER

Water Boiler Size	Storage Heater Number	180° Boiler Water Heater Capacity Gals. 40°-140° Rise	212° Boiler Water Heater Capacity Gals. 40°-140° Rise
EGH-85 through EGH-125	62-2-E	50 in 3 hours	70 in 3 hours
RECOMMENDED STORAGE TANK		50-90 Gallons	75-125 Gallons

ATINGS

ɔiler ɲber*	A.G.A. Input MBH+	A.G.A. Gross Output MBH+	Net I-B-R Ratings** Sq. Ft. Steam	Net I-B-R Ratings** Steam MBH+	Net I-B-R Ratings** Water MBH+	Net Sq. Ft. Water ▲	Boiler H.P.	Supply Tappings No. & Size	Return Tappings No. & Size	Dimensions — Inches B	Dimensions — Inches D	Dimensions — Inches W	Gas Connection Size† Natural	Gas Connection Size† Propane	Draft Hood Outlets No. & Size	Chimney and Breeching Size***	Approx. Shipping Weight Lbs.
EGH-85	350	280	875	210.1	243.5	1,620	8.4	2 — 3″	2 — 2½″	29³⁄₃₂	9	38¼	¾″	¾″	1 — 9″	9″	825
H-95	400	320	1000	240.1	278.3	1,855	9.6	2 — 3″	2 — 2½″	29³⁄₃₂	9	42½	¾″	¾″	1 — 9″	9″	915
H-105	450	360	1125	270.1	313.0	2,085	10.8	2 — 3″	2 — 2½″	30³⁄₃₂	10	46¾	1″	1″	1 — 10″	10″	1005
ꞁGH-115	500	400	1250	300.1	347.8	2,320	11.9	2 — 3″	2 — 2½″	30³⁄₃₂	10	51	1″	1″	1 — 10″	10″	1095
EGH-125	550	440	1375	350.1	382.6	2,550	13.1	2 — 3″	2 — 2½″	30³⁄₃₂	10	55¼	1″	1″	1 — 10″	10″	1185

ıen ordering, add to boiler number "S" for Steam; "W" for Water. Add .WT" for water boiler with one tankless heater; "-2WT" for water boiler :h two tankless heaters. Add "-1ST" for steam boiler with one tankless heater; "-2ST" for steam boiler with two tankless heaters. Add "WHS" for water boiler with storage heater.

ᐩᐩBH refers to thousands of BTU per hour.

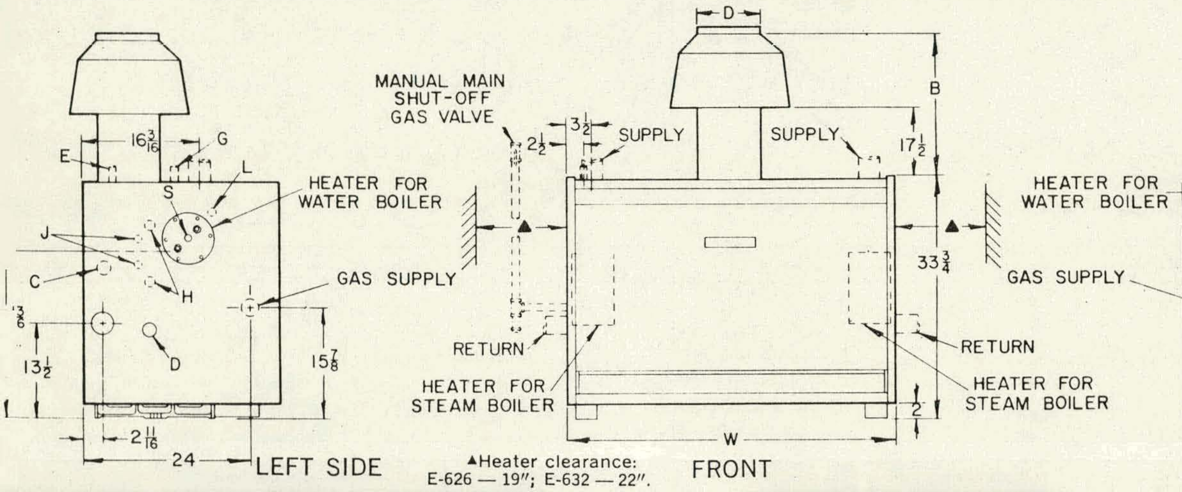
t I-B-R ratings are based on net installed radiation of sufficient quantity the requirements of the building and nothing need be added for normal ɔing and pick-up. Steam ratings are based on a piping and pick-up allowance of 1.333; water ratings on an allowance of 1.15. An additional allowance should be made for unusual piping and pick-up loads. Consult Customer Services Department. Ratings shown are for elevations up to 2,000 feet. For elevations above 2,000 feet, ratings should be reduced at the rate of 4 percent for each 1,000 feet above sea level.

▲Based on average water temperature of 170° F. in radiators.

†Sizes shown are gas connection sizes. Gas piping from meter to boiler to be sized according to local utility requirements.

***In special cases where surrounding conditions permit, chimney height may be reduced by 10 ft.

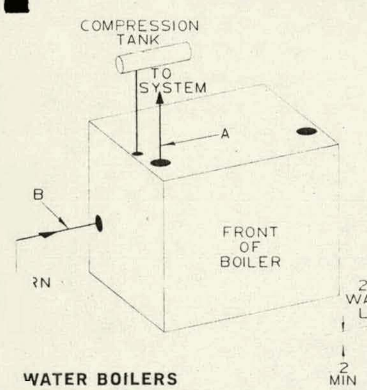
Note: Water boilers tested for 50 P.S.I. working pressure; also available upon special request at 80 P.S.I. working pressure.



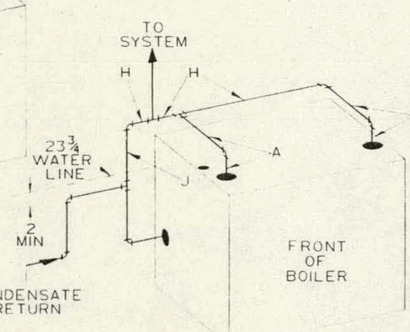
▲Heater clearance: E-626 — 19″; E-632 — 22″.

RECOMMENDED PIPING CONNECTIONS

Note: Supply and return sizes for water boilers refer to minimum size of pipe connected to boiler for 20° or higher temperature drop between supply and return.



WATER BOILERS



STEAM BOILERS

WATER BOILER SIZE	PIPE SIZE A (Supply)	PIPE SIZE B (Return)
EGH-85 & EGH-95	2″	2″
EGH-105 thru EGH-125	2½″	2½″

STEAM BOILER SIZE	RISER PIPE SIZE A	RISER PIPE SIZE B	HEADER* H	EQUALIZER J
EGH-85 & EGH-95	2″	2″	3″	1½″
EGH-105	2½″	2½″	3″	1½″
EGH-115 & EGH-125	2½″	2½″	4″	1½″

*24 minimum from waterline to header

CONTROL TAPPINGS

LOCATION	SIZE	STEAM	WATER
C	¾″	Probe Type Low Water Cutoff	Plugged
D	¾″	Drain	Drain
E	¾″	Safety Valve	Safety Relief Valve
G	¾″	Plugged	Piping to Compression Tank or Auto Air Vent
H	½″	Gauge Glass and/or Low Water Cutoff	Low Water Cutoff
J*	⅜″	Try Cock Tappings	—
L	¼″	Plugged	Combination Pressure-Temperature Gauge
P	1″	Low Water Cutoff, Pressure Limit Control and Pressure Gauge; or Low Water Cutoff and Feeder Combination; or Low Water Cutoff and Pump Control	Low Water Cutoff; or Low Water Cutoff and Feeder Combination; or Low Water Cutoff and Pump Control
S	1½″ (Steam)	Skim Tapping	—
S	¾″ (Water)	—	Limit Control

*Available only on special request.

NOTE: Limit Control and Supply Piping must be on the same end of the boiler.

NOTE: When an internal type water heater is installed, use the tapping in the heater for an additional operating control.

WEIL-McLAIN COMPANY INC • MICHIGAN CITY, INDIANA

HYDRONIC DIVISION

Form No. C-526 R1 (376)

Litho in U.S.A.

MAINTENANCE

VII - MAINTENANCE

1 - If the glass cover becomes dirty, clean the glass using a soft clean cloth, mild soap or detergent and clean rinse water. Alkalies can stain the glass if allowed to remain in contact too long.

NOTE - The collector surface temperature can burn. Handle solar collector with caution.

2 - Use rubber gloves when handling solar collector to avoid finger prints on glass.

3 - To replace the glass, remove the collector as shown in Figure 19 and dismantle according to Figure 20. To re-assemble frame, insert the glass sheets and new gaskets into side pieces making sure the glass is centered and the ends are even. Next insert the glass into the end pieces and secure with existing screws. Use sealer compound on corner joints.

4 - To replace an absorber plate refer to following sequence and Figure 21.

a - Drain collector.

b - Remove collector frame.

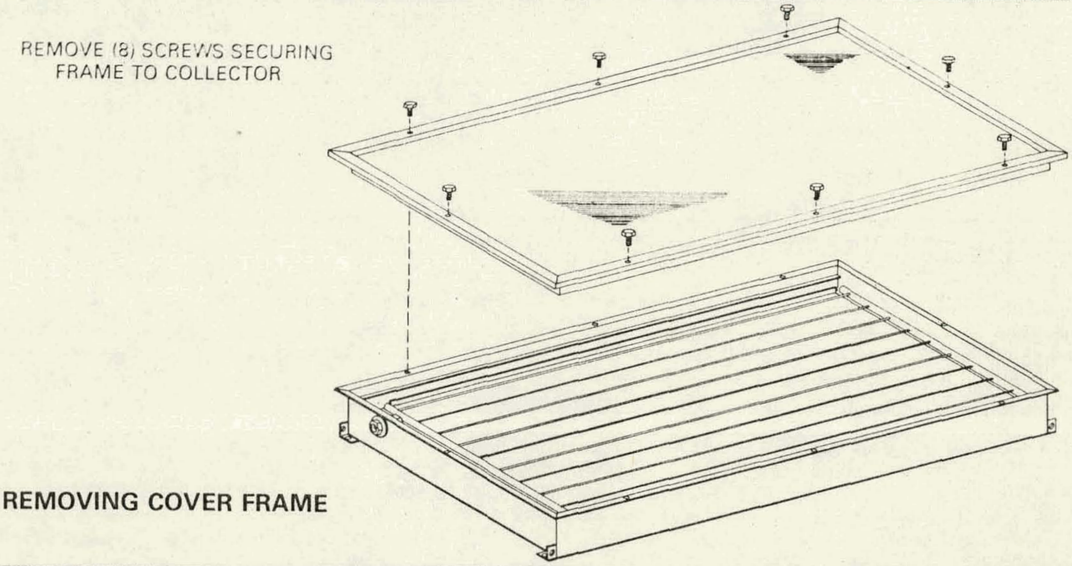
c - Remove plate seal and gasket on each end of collector.

d - Disconnect flare fitting on each end of collector.

e - Remove 6 screws securing absorber and left plate from cabinet. Avoid touching coating on plate.

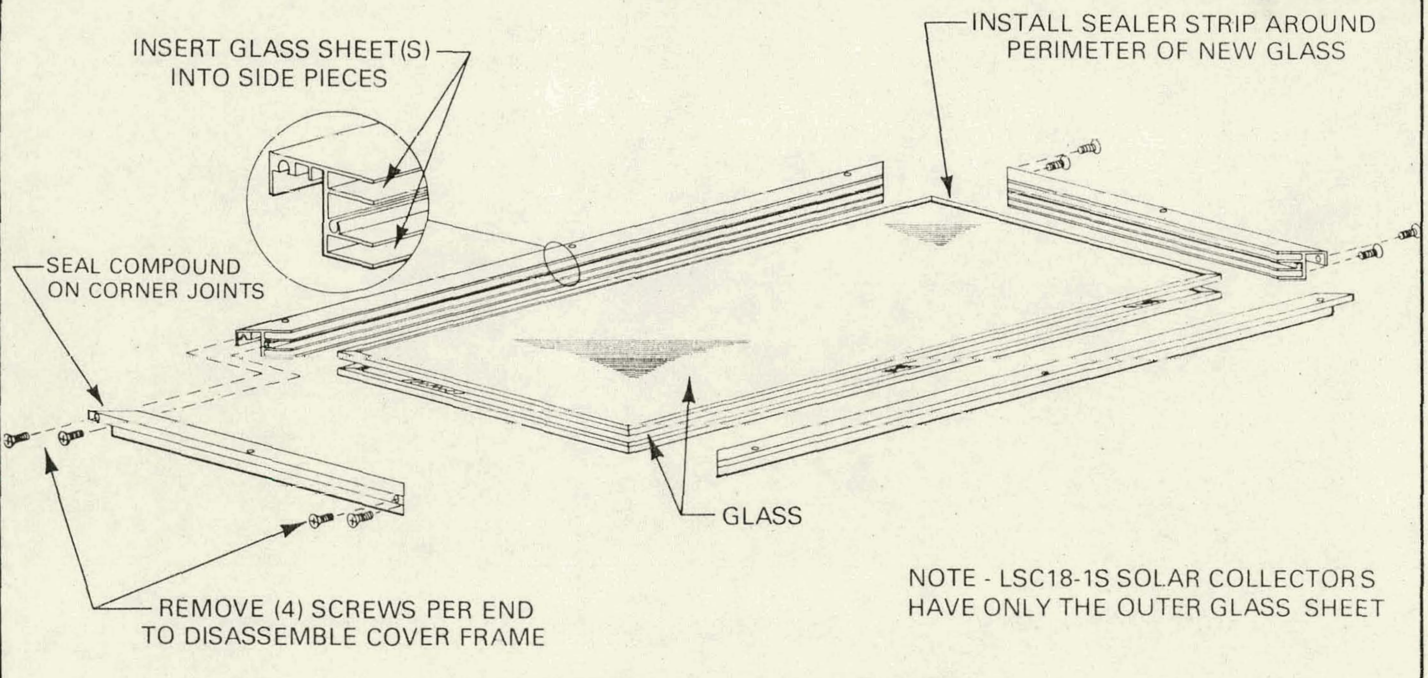
f - When re-assemblying absorber plate, tighten screws between 10 lbs and 15 lbs torque.

5 - The ethylene glycol/water mixture should be checked once a year by your Lennox service organization for proper freeze protection and inhibitor level.



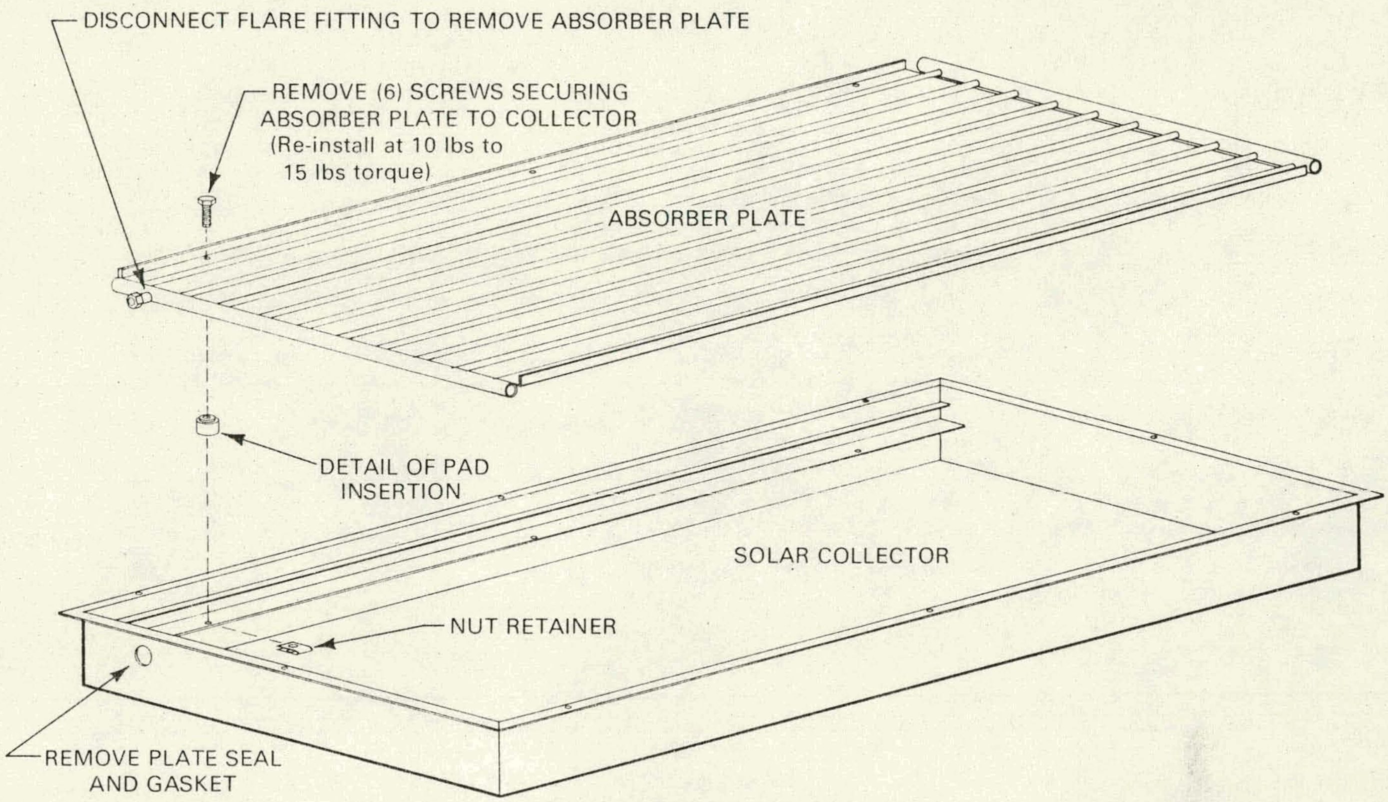
REMOVING COVER FRAME

FIGURE 19



DISASSEMBLING COVER FRAME

FIGURE 20



REMOVING ABSORBER PLATE

FIGURE 21

Section 3 - Operating Mode Table

OPERATING MODES

	Pumps				Valves				Heat Register	
	P-1	P-2	P-3	P-4	V-1	V-2	V-3	V-4	HR-1	HR-2
1. Heating from Collector	ON	ON	OFF	OFF	A or B	M	A	B	OFF	OFF
2. Heating Storage	ON	ON	OFF	OFF	B	A	A	B	OFF	OFF
3. Heating from Storage	OFF	OFF	ON	OFF	B	M	A	B	OFF	OFF
4. Heat Rejection	ON	OFF	OFF	OFF	B	A	A	A	ON	ON
5. Auxiliary Heating	OFF	OFF	OFF	ON	B	B	M	B	OFF	OFF

Description of Operation

Pump P-1 is controlled by temperature sensor T-1 to come on with adequate insulation (on at 130° and off at 100°).

Pump P-2 comes on when P-1 is on and either $T_1 \geq T_2$ or space heat is required (signal from switch on V-2).

Pump P-3 comes on when space heat is required unless P-2 is on or $T_2 \ll 70°$.

Pump P-4 comes on when auxiliary heat is required (signal from switch on V-3).

Valve V-1 is in the "A" position unless P-2 is on and $T_2 \gg T_3$.

Valves V-2 and V-3 operate as shown on the drawing.

Valve V 4 is a 2-way valve that switches to bypass on signal from T-4 (bypass flow at 180°F).

*Temperatures listed are approximate and provision has been made for adjustment.

A = Bypass
B = Thru Flow

System and Subsystem Performance/Technical Data*

A. *Climatalogical Data:*

For the proposed project site provide the following information:

1. Latitude 45° 5'
2. Heating degree days

   Yearly 7049

   January 1296
3. Annual Cooling Hours N/A
4. Peak daily insolation 276 BTU/ft²
5. Yearly sunshine 60 %

B. *Collector:* Commercial/Brand Name Lennox LSC18-1S

1. Type of Collector
   a. Flate Plate Hydronic Flat Plate
   b. Tubular N/A
      i) Acceptance Angle N/A
      ii) Concentration N/A
      iii) Interception Area N/A
      iv) Mirror Reflector Characteristics N/A
   c. Concentrator N/A
      i) Focusing N/A
      ii) Non-Focusing N/A
      iii) Tracking N/A ; Mode
      iv) Non-Tracking N/A
      v) Concentration Ratio N/A
      vi) Reflector Reflection N/A

* 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 low-iron glass

      2. Composition Iron content .07% by weight maximum

   b. Commercial Identification Fourco Clearlite

   c. Solar Spectrum Transmissivity @ 0.4 - 0.7 microns 91.0 min %

   d. Solar Spectrum Reflectivity @ 0.4 - 0.7 microns 5.3 %

   e. Infrared Transmissivity @ 1.05 microns 86.8 min %

   f. Infrared Reflectivity @ 1.05 microns 9.5 %

   g. Number of Covers 1 %

   h. Combustibility Will withstand high temperatures (500°F) without loss of temper.

   i. Edge Treatment Smooth edges (glass is tempered)

   j. Physical Properties**

      1. Density 155.376 lb/Ft^3

      2. Linear Coefficient of Expansion 90.3×10^{-7} in/in $^{\circ}$C (0-300°C)

      3. Thermal Conductivity 1.10 Btu - ft/ft^2 -hr - $^{\circ}$F

      4. Specific Heat 0.273 Btu/lb - $^{\circ}$C

      5. Tensile Strength Not available

      6. Compressive Strength Not available

      7. Weight 1.55 lb/ft^2

3. Absorber Plate

   a. Absorptive Coating

      1. Materials

         a. Type Coating is electroplated (Harshaw process)

** 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 Black chrome over bright nickel

c. Commercial Identification HARSHAW CHROMONYX

2. Solar Spectrum Absorptivity 95.0 %

3. Infrared Emissivity 0.09 %

b. Base Plate

1. Materials

a. Type Copper tube/steel plate

b. Alloy Copper-alloy 194 (tubes),/low carbon steel (plate)

c. Commercial Identification 194 HSM Copper/ASTM A3H, 375 steel

2. Thermal Properties

a. Thermal Conductivity 150 Btu/hr-ft-°F/31 Btu/hr-ft-°F

b. Specific Heat 0.09 Btu/lb-°F/0.11 Btu/lb-°F

3. Physical Properties

a. Linear Coefficient of expansion 9.0×10^{-6} in/°F/Not available

b. Density 548 lb/cu ft/490 lb/cu ft

c. Tensile Strength 50 Kpsi (annealed)/67-70 Kpsi

d. Compressive Strength Not available

4. Bonding Materials

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

b. Composition 95% tin 5% antimony

c. Commerical Identification Johnson Formula E99

4. Insulation

a. Materials

1. Type Semirigid fiberglass board

2. Composition Glass fibers bonded together with phenolic resin

3. Commercial Identification CERTAINTEED 850

System and Subsystem Performance/Technical Data—Continued

b. Outgassing Characteristics

1. Outgassing Temperature 545 °F
2. Gas given off Data not available
3. Any Condensation Data not available

c. Physical Properties

1. Linear Coefficient of expansion Data not available
2. Density Data not available
3. Thermal Conductivity 0-30 Btu - in/hr-ft^2 at 200 °F
4. Specific Heat Btu/lb - °F
5. Coefficient of Cubical expansion Data not available
6. Dimensions 70" x 34" x 3" bottom insulation

5. Outer Base Enclosure

a. Materials

1. Type Galvalume
2. Composition 55% al; 1.6% Si Zinc
3. Commercial Identification Bethlehem Steel trademark
4. Combustibility Not applicable

b. Physical Properties (As Applicable)

1. Linear Coefficient of expansion 27.25 cm/m x 10^{-6} at 100°C
2. Density 3.75 gm/cu cm
3. Thermal Conductivity .1565 cal/gm - °C
4. Specific Heat 0.16 Btu/lb °F
5. Coefficient of Cubical expansion 2.203 x 10^{-15} at 100 °C
6. Dimensions 71" 1/16 x 32" 1/8

c. Thermal Conductivity .428 cal/°C sec - cm^2 at 100 °C

System and Subsystem Performance/Technical Data—Continued

6. Composite Collector

   a. Cooling/Transport Fluid

      1. Fluid

         a. Commercial Identification Antifreeze

         b. Type 50-50 ethylene glycol/water

      2. Additives

         a. Commercial Identification Dowtherm SR1

         b. Type Ethylene Glycol

      3. Quantities of fluid in collector .3 gal

         a. Fluid .15 gal %

         b. Additive .15 gal %

      4. pH 9.3

      5. Ion Content Not available

      6. Mineral Content None

      7. Durability (Service Life) Does not degrade (inhibitors must be added) mos.

      8. Properties

         a. Thermal Conductivity 0.22 - 0.245 from 60 - 220 ^{o}F

         b. Specific Heat 0.75 - 0.87 Btu/lbm ^{o}F from 0^{o}-220^{o}F

         c. Density 8.6 - 8.98 lbm/gallon from 80^{o}- 200^{o}F

         d. Viscosity 6.0 - 0.7 centipoise from 50-220^{o}F

         e. Coefficient of Cubical expansion 0.0382/^{o}F (for Dowtherm SR1)

      9. Other pertinent qualities freeze protection, low corrosivity

   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.

6, b, 1. Test Method used - NBSIR 74-365

2. Energy Collection Rate (one double-glazed LSC18-1 collector)

ambient temp, °F	inlet temp, °F	outlet temp, °F	insolation Btu/hr-ft^2	collected Btu/hr-ft^2
35.2	69.2	74.5	132.6	56.6
36.0	68.1	76.2	144.4	70.5
37.3	67.8	77.4	160.5	83.9
37.9	67.6	78.4	172.4	95.3
37.9	67.9	73.5	176.9	100.6

a. Collector orientation

1. Azimuth 180 degrees
2. Elevation 40 degrees

b. Ambient conditions

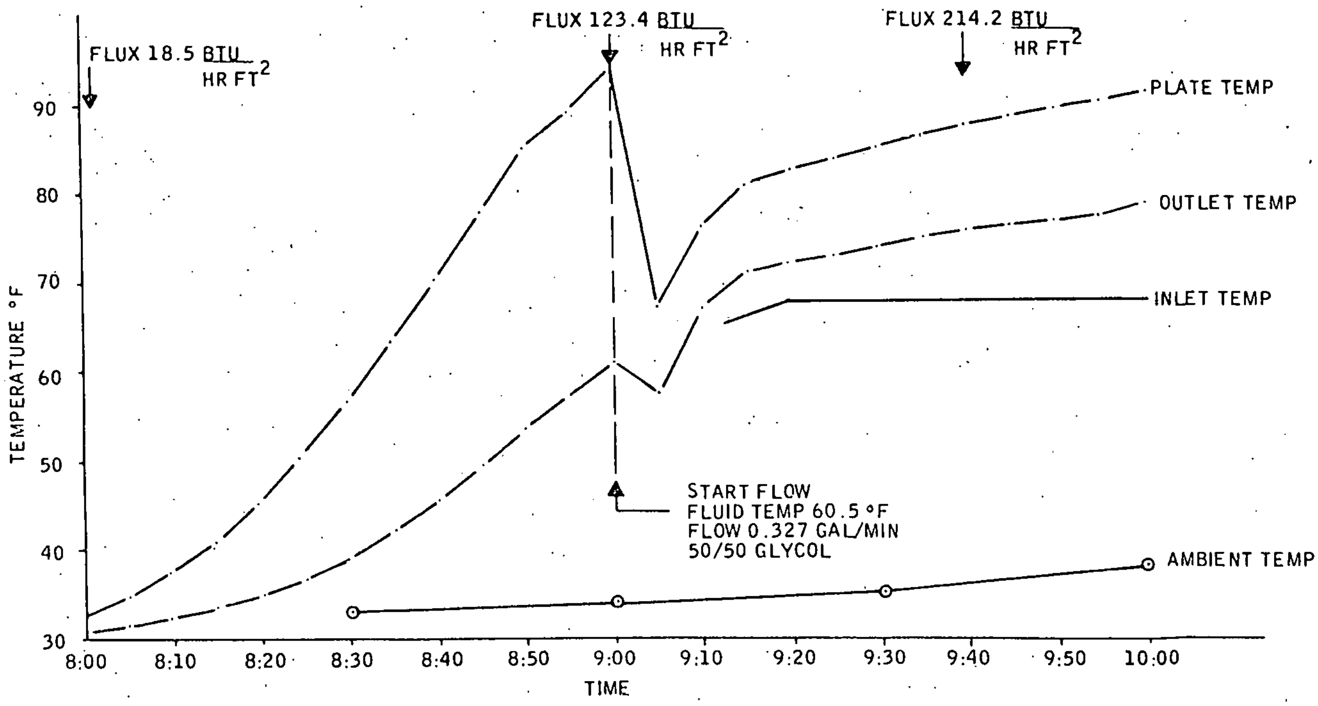
1. Temperature 37°F
2. Wind velocity 9 mph
3. Wind direction 250 degrees

c. Average insolation

d. Collection period (Time of day 9:25 am to 10:00 am)

3. Following are the results of testing performed at Honeywell Inc., in Minneapolis, on a random production sample of the LSC18-1S flat-plate collector. The testing was performed on the Honeywell solar simulator. This solar simulator is of similar construction to that available at the NASA Lewis Research Center. A collector development program, NAS3-17862, was completed for NASA LeRC to establish correlation. Also included in the test report is the result of correlation testing on the LSC18-1 (2 cover) collector,

comparing testing of the solar simulator with that performed on the Honeywell outdoor test facility. The outdoor facility is set up to test to NBSIR-74-635. This facility is participating in the NBS Round Robin test program.



Inlet/Outlet Temperature

Indoor Test Procedure Followed

a) Mount collector on a frame normal to the radiation incoming from the simulator, making sure that no portion of the collector is shadowed.

b) Connect the collector to flow loop, and the thermocouples to readout instruments, then run the fluid through the system.

c) Bleed any trapped air and adjust the fluid flow to approximately 0.35 GPM (11.5 to 13 lbm/hr-ft^2).

d) Adjust the collector inlet temperature with the constant temperature oil bath (20°F, 55°F, 85°F, 120°F above ambient temperature).

e) Turn on the simulator and adjust the flux to approximately 250 $\frac{\text{Btu}}{\text{hr-ft}^2}$.

f) Measure the pressure drop across the collector with a manometer.

g) When steady-state conditions are reached (no change in inlet and outlet temperatures, no change in flux or fluid flow), record the following data for 15 minutes at 1-minute intervals:

- ambient, inlet and outlet temperatures
- Δt* given by a six-junction differential thermopile
- flow rate of transfer fluid
- incident flux (average of 120 flux readings taken in collector flux field)

For each inlet temperature, one data point is obtained. To generate the data necessary to determine the efficiency curve, we repeat steps c, d, e, f, and g.

Outdoor Test Procedure

This procedure is outlined in Section 8 of "NBSIR74-635" (method of testing for rating solar collectors based on thermal performance). This procedure is recommended by the National Bureau of Standards, and we follow it.

*Δt is the difference between the fluid outlet temperature and the fluid inlet temperature.

Nomenclature

T_a(°F)	Ambient temperature
$T_{f,i}$(°F)	Fluid inlet temperature
$T_{f,o}$(°F)	Fluid outlet temperature
$\dot{m}(\frac{lbm}{hr\text{-}ft^2})$	Flow rate of transfer fluid
$Q_{inc}(\frac{Btu}{hr\text{-}ft^2})$	Rate of incident flux on collector aperture
$C_p(\frac{Btu}{lbm\text{-}°F})$	Specific heat of transfer fluid
$(\tau\alpha)_e$	Effective transmission - absorptance product
F_R	Actual useful energy collected/useful energy collected if the entire collector surface were at the temperature of the fluid entering the collector.
$U_L(\frac{Btu}{ft^2\ °F})$	Heat transfer loss coefficient for the solar collector
$X(\frac{°F\ hr\text{-}ft^2}{Btu})$	$\frac{T_{f,i}-T_a}{Q_{inc}}$
η	Actual useful energy collected/solar energy incident upon the collector transparent frontal area

Indoor Test Result (single pane collector)

The efficiency curve for this collector was determined inside. This table summarizes the results:

Run No.	I	II	III	IV	V	VI
$T_a (°F)$	83.7	86.8	88.2	89.0	91.8	92.5
$T_{f,i} (°F)$	86.2	111.7	128.5	141.8	163.9	186.0
$T_{f,o} (°F)$	103.6	127.2	143.1	155.2	176.2	195.7
$\dot{m} (\frac{lbm}{hr\text{-}ft^2})$	12.28	12.28	12.3	12.4	12.54	12.68
$Q_{inc} (\frac{Btu}{hr\text{-}ft^2})$	208.0	208.0	211.0	211.0	216.0	202.0
$C_p (\frac{Btu}{lbm\,°F})$	0.776	0.79	0.80	0.81	0.82	0.83
$X (\frac{°F\ hr\text{-}ft^2}{Btu})$	0.012	0.123	0.199	0.261	0.357	0.463
η	0.79	0.724	0.675	0.637	0.578	0.517

The test results for this collector can be represented by:

$$\eta = F_R (\tau\alpha)_e - F_R U_L \left(\frac{T_{f,i} - T_a}{Q_{inc}}\right)$$

$$\eta = 0.80 - 0.61 \left(\frac{T_{f,i} - T_a}{Q_{inc}}\right)$$

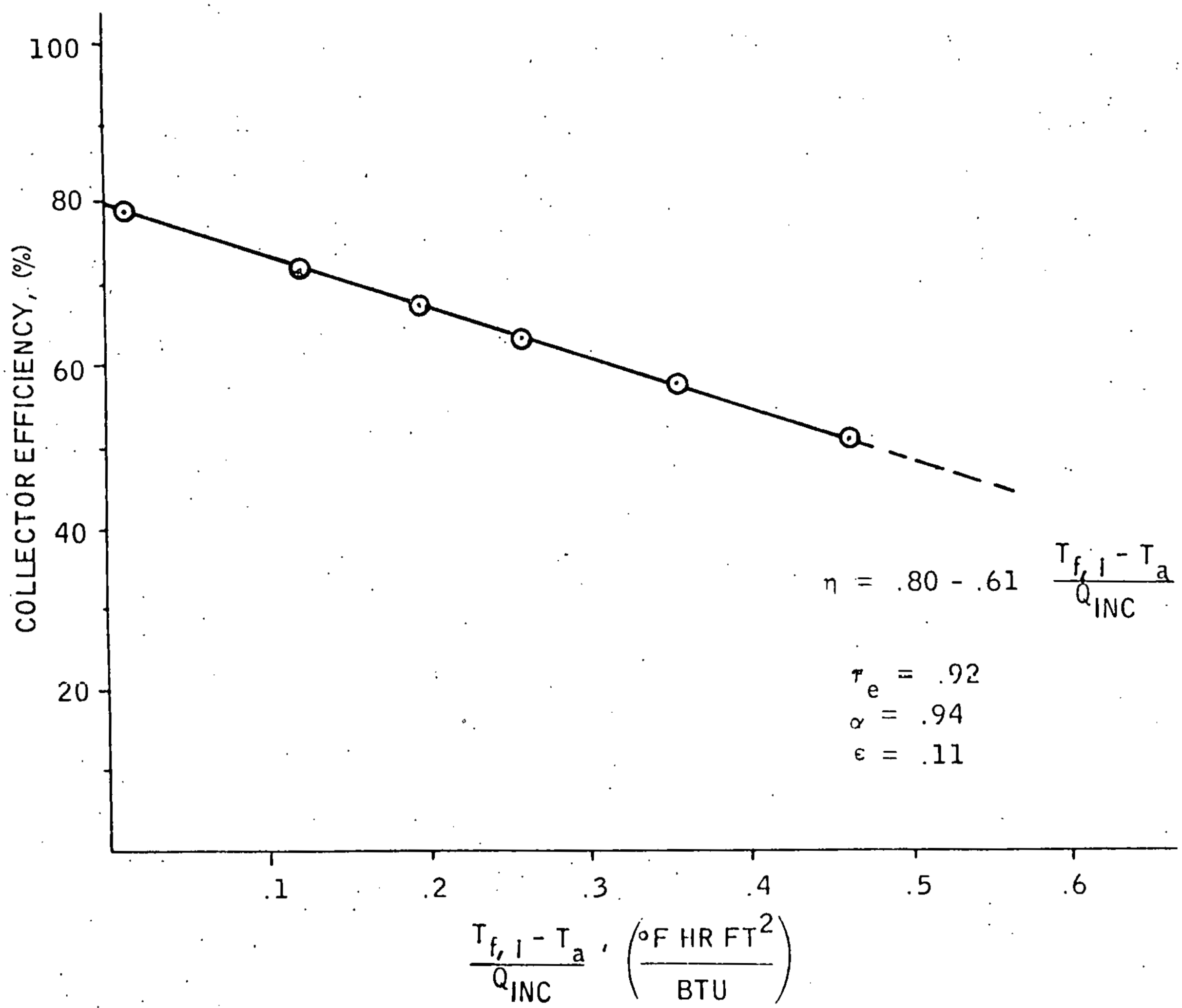
The measured parameters are shown in the Nomenclature sheet.

The absorptance and effective transmittance were

α = 0.94 (measured)

τ_e = 0.92 (measured)

The collector area used in all the data reduction is 14.94 ft^2, which is the frontal transparent area of the collector. The transfer fluid was a mixture of water and glycol (60 percent glycol by weight).



LSC 18-1S (Single Pane Etched) Performance Indoor Test

Outdoor Test Results (double pane collector)

The efficiency curve for this collector was determined outside. The table below summarizes the results:

Run No.	I	II	III	IV	V	VI
T_a (°F)	89.0	83.0	94.0	74.0	73.0	86.0
$T_{f,i}$ (°F)	92.0	100.0	146.0	146.0	146.0	184.0
$T_{f,o}$ (°F)	112.0	122.0	164.0	165.0	165.0	200.0
$\dot{m}\left(\frac{lbm}{hr\text{-}ft^2}\right)$	11.82	12.75	11.93	12.77	12.77	12.8
$Q_{inc}\left(\frac{Btu}{hr\text{-}ft^2}\right)$	291.4	337.0	303.0	329.0	325.4	317.5
$C_p\left(\frac{Btu}{lbm\ °F}\right)$	0.806	0.81	0.835	0.835	0.835	0.855
$X\left(\frac{°F\ hr\text{-}ft^2}{Btu}\right)$	0.009	0.05	0.173	0.218	0.223	0.307
η	0.715	0.68	0.61	0.591	0.590	0.556

The test results for this collector can be represented by:

$$\eta = F_R(\tau\alpha)_e - F_R U_L \left(\frac{T_{f,i} - T_a}{Q_{inc}}\right)$$

$$\eta = 0.71 - 0.53 \left(\frac{T_{f,i} - T_a}{Q_{inc}}\right)$$

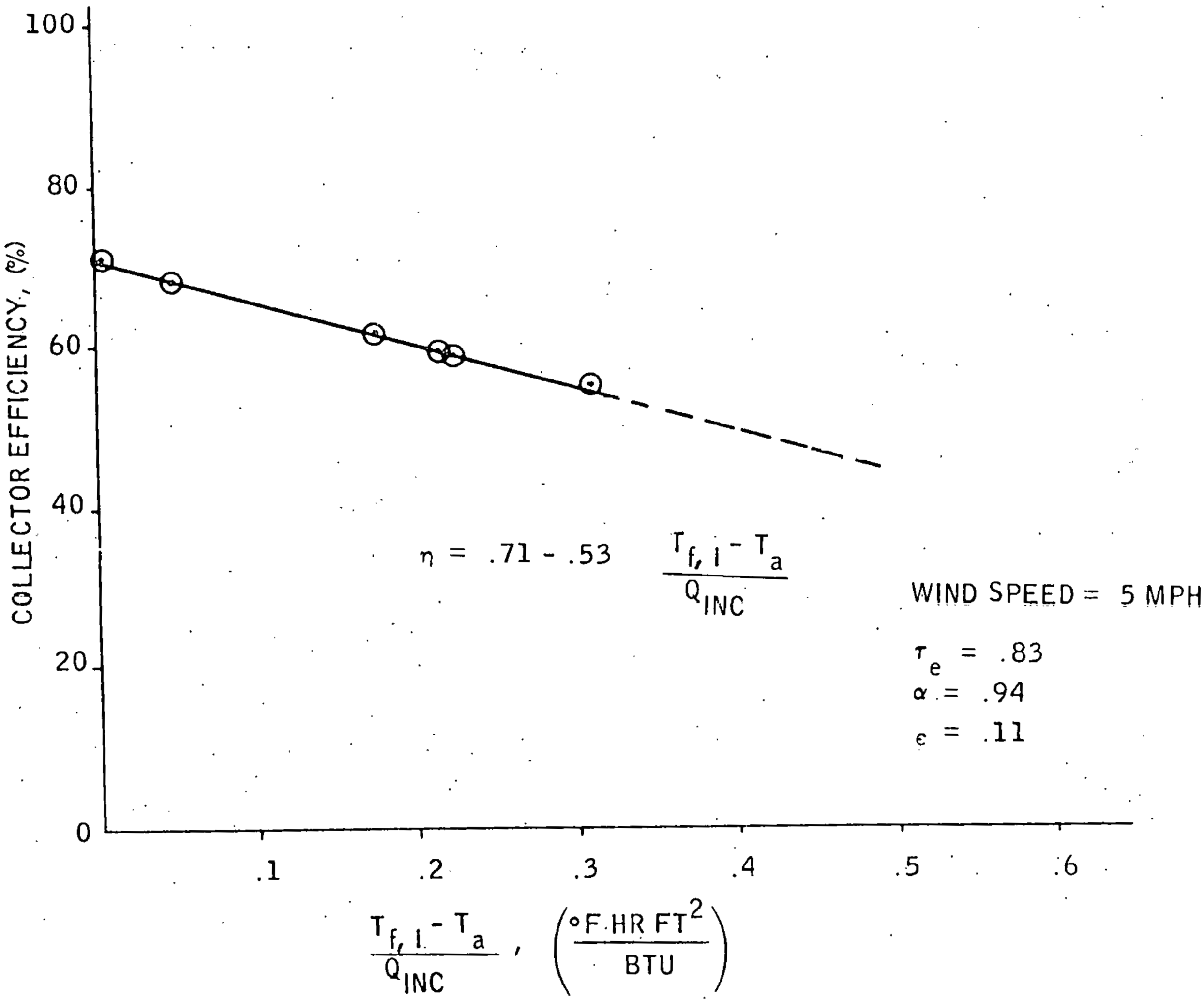
The measured parameters are shown in the Nomenclature sheet.

The absorptance and effective transmittance were

α = 0.94 (measured)

τ_e = 0.83 (measured)

The collector area used in all the data reduction is 14.94 ft^2, which is the frontal transparent area of the collector. The transfer fluid was a mixture of water and glycol (55 percent glycol by weight).



Collector Performance (Double Pane) Outdoor Test

Table of Indoor Results for the Same Collector Tested Outdoor (indoor procedure followed).

Run No.	I	II	III	IV	V	VI	VII
T_a (°F)	77.0	81.0	81.0	85.0	86.0	88.0	89.0
$T_{f,i}$ (°F)	70.0	100.0	130.0	160.0	169.0	180.0	193.0
$T_{f,o}$ (°F)	90.0	117.0	145.0	173.0	182.0	193.0	205.0
$\dot{m}\ (\frac{lbm}{hr\text{-}ft^2})$	12.3	12.4	12.5	12.6	12.7	12.7	12.8
$Q_{inc}\ (\frac{Btu}{hr\text{-}ft^2})$	245.0	245.0	245.0	245.0	245.0	245.0	245.0
$C_p\ (\frac{Btu}{lbm\ °F})$	0.767	0.785	0.800	0.818	0.823	0.829	0.837
$X\ (\frac{°F\ hr\text{-}ft^2}{Btu})$	0.028	0.077	0.20	0.306	0.338	0.375	0.424
η	0.746	0.700	0.629	0.567	0.540	0.543	0.524

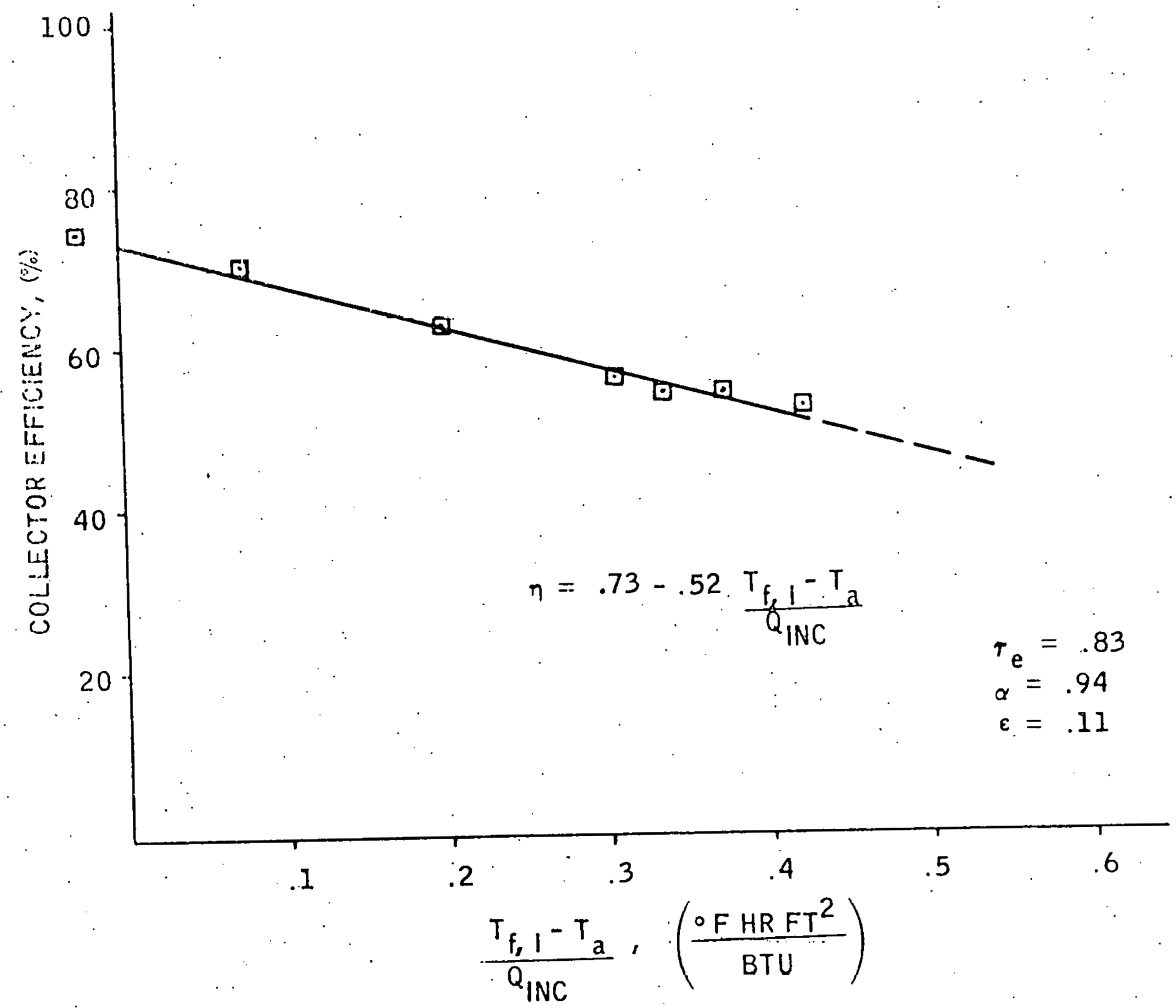
The final results for this collector can be represented by:

$$\eta = 0.73 - 0.52\left(\frac{T_{f,i} - T_a}{Q_{inc}}\right)$$

The absorptance and transmittance are as indicated:

$$\alpha = 0.94$$

$$\tau_e = 0.83$$



Collector Performance (Double Pane) Indoor Test

4. Maximum expected temperature under no flow conditions 400 F.

5. Discuss provisions for protecting collector under no flow conditions. A purge coil prevents operating overtemperature; however, collector can withstand no flow temperature without physical degradation.

6. Collector Array Characteristics

   a. Total Area 1,980 ft^2

   b. Solar Window Area 1,693 ft^2

   c. Weights of Collector and Framing 6.8 lbs/ft^2

System and Subsystem Performance/Technical Data—Continued

capacity shall be no greater than __________ 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 __________kw, Function______________________________
2. Fans __________kw, Function______________________________
3. Controls__________kw, Function______________________________
4. Other __________kw, Function______________________________

2. Design Load Data:

ANNUAL SUMMARY TABLE

Month	Heating (BTU)x10^6	Hot Water (BTU)	Cooling BTU
January	68.7	0	0
February	47.1		
March	44.4		
April	34.7		
May	20.1		
June	10.6		
July	2.5		
August	4.4		
September	14.4		
October	27.3		
November	40.1		
December	44.1		
Yearly Total	358.5		
Peak (BTU/HR)	142400		

System and Subsystem Performance/Technical Data—Continued

3. Provide the following summary of system performance data:

Load/.65

Month	Solar Energy Provided (BTU)	Electrical Energy Req'd for Component	Auxiliary Energy Provided (BTU)	System Heat Loss (BTU)	Equivalent Energy Req'd for Conventional System (BTU)
January	16.6		52.1		105.7
February	17.7		29.4		72.5
March	25.3		19.1		68.3
April	14.3		20.4		53.4
May	12.4		7.7		30.9
June	10.2		0.4		16.3
July	2.5		.0		3.8
August	4.4		.0		6.8
September	12.4		2.0		22.2
October	12.7		14.6		42.0
November	12.4		22.7		61.7
December	18.3		25.8		67.8

4. Provide estimate of yearly energy savings in terms of BTU's and/or Dollars along with the rationale for the estimate. Savings = 164.2×10^6 Btu/yr

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 ____________
2. Size/Rating (BTU) ____________
3. Efficiency ____________
4. Electrical Power Requirements ____________

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

The system is to be installed in Billings, Montana. The calculations for sizing the solar system and calculating the solar supplied portion of the loads were based on actual weather data provided by the Weather Bureau. The weather tape used for this installation was data taken in Rapid City in 1957. This was judged to be the average year for weather conditions.

Use of the weather tape data allows calculation of the heating load based on actual outdoor temperature for each hour of each day of the year. The solar collector capacity is also calculated by using the data provided by the weather tape. The collector efficiency is calculated as a function of the temperature differential between the outdoor temperature and the desired collector operating temperature, and the isolation level. This calculation is made for each hour of sunlight during the year and summed to provide the amount of energy collected by the solar collector array and transfered to the system.

Calculations of the heating load and solar collection rate using the weather tape data enables a more accurate design evaluation than is available from the ASHRAE procedure.

Section 6 - Summary

Key Work Abstract

Application - Space Heating
System Type - Active Hydronic
Collector Type - Flat plate air to liquid
Collector Manufacturer - Lennox
Collector Area - 1890 square feet
Storage Capacity - 2500 gallons
Building Load - 358.5×10^6 BTU/YR
BTU's Produced - 182.8×10^6 BTU/YR
Building Owner - Billings Shipping Corporation
Architect/Designer - CTA Architects Engineers
Contractor - Star Service, Inc.

Introduction

The Billings Shipping Corporation is a nonprofit organization with approximately 150 members which gathers freight at rail terminals around the nation for shipment to Billings where the freight is transferred to trucks for delivery. The members are all prominent and successful businessmen who realized the importance of energy conservation as the plans for their new facility were being developed.

The freight handling area of the building is 39,000 ft^2 and has the following energy saving features:

1. Gas fired infrared spot heaters with thermostats set at $50^{o}F$.
2. Carbon monoxide removal system to eliminate truck exhaust without large ventilation air requirements.
3. Ventilation air system which is required by code is turned on and off by carbon monoxide sensors.
4. Roof and wall insulation greater than normally use in warehouse construction.
5. Skylights provide all of the general illumination.

The office portion of the building is 4900 ft^2 and calculations show that the solar heating system will provide 51% of the heating requirements.

Design Philosophy

The solar heating system was designed with standard, off the self, components to provide a reliable system which can be maintained without technically trained personnel. The building construction was proceeding rapidly as the solar system grant was approved and only minor modifications to the mechanical equipment were possible. With 44,000 ft^2 of flat roof upon which to mount collectors and an all air heating and cooling system under construction, the flat plate, air to water solar collector was a natural choice. Air conditioning with solar heat was not considered because of the short air conditioning season. The domestic hot water consumption is too low to justify solar heating. Below zero winter temperatures required the use of glycol antifreeze in the collector piping system and a U-tube heat exchanger between the collector loop and the building loop reduces the quantity of antifreeze required.

The air handling unit which provides heating for the office area was modified by deleting the gas fired heat exchanger and adding two hot water heating coils. One coil is piped to the solar heating system. The other coil is piped to a gas fired hot water boiler which provides standby and supplementary heating. The coils are arranged in series so the air passes through the solar coil first where it is heated as much as possible or as much as required. Then the air passes through the standby coil for additional heating if required.

Operation of the System

The solar heating system is scheduled to be put in operation about mid October, 1978. The standby heating system has been in use since the building was occupied in the Spring of 1978 and has been functioning as expected.

Problems Encountered and Solutions

The most difficult problem was to get a temperature control contractor to bid the control work. There are many sources for control components but local control contractors did not want to assume operational responsibility for the entire system. The first control bids were twice as much as the available money. After simplifying the description of the control sequences, we sat down with representatives of two temperature control contractors to help them understand how the system was to operate and define what their responsibility would be. The new control bids were then very near the available money. Money was also saved by not asking the temperature control contractor to do electrical wiring. The wiring was priced separately after the control shop drawings had been prepared and showed exactly how much wiring was required.

Successful Components or Processes

The roof had just been completed when we asked the roofing contractor for assistance in determining the best method of attaching the collector supports. Our first thought was to cut holes in the roofing and insulation, bolt the supports to the precast concrete tees which form the roof structure, and waterproof around each support. Everyone agreed that any method of attachment which required holes in the roofing would produce long range maintenance problems. The final design used precast concrete pads two feet wide by eight feet long by six inches high set on roof walkway material which was laid on top of the roof. The steel support frames were bolted to the top on the pads and roof penetrations were limited to the two for the supply and return pipes. The concrete pads resist sliding and overturning and they distribute the load so the insulation won't be crushed.

Costs

Costs were closely controlled throughout the project. The long delay between the grant request and the actual awarding of the contract created inflationary cost increases. Working closely with the contractors and suppliers the project was completed within the budget and without changing the quality or performance of the system. The collector framing and support system was carefully designed to provide adequate support for the least possible cost. The final temperature control system was the result of close cooperation with the control contractor. The total cost per square foot of collector was under $44.00 which is less than most other equivalent systems.

Lessons Learned

After successfully completing a project of this type, the following is a list of lessons learned.

1. Original cost estimates should allow for 18 months of inflation.
2. Representatives of temperature control companies should be asked to assist in the design of the control system if there are no solar control specialists in the area.
3. Supporting systems should be designed with assistance from suppliers and contractors to get the most economical system.
4. Design fees must be adequate to allow time for required paperwork and detailed involvement in the construction process.

Summary

We are proud to have been involved in the first relatively large scale solar heating project in this area. It is a quality system which will provide many years of service to the Billings Shipping Corporation and it will serve as an example to encourage others to consider the use of solar heating systems. As proof of this, the mechanical contractor who installed the system is also installing a solar heating system in his new home.