DOE /NASA CONTRACTOR REPORT

DOE/NASA CR 150536

INSTALLATION PACKAGE FOR AIR FLAT PLATE COLLECTOR

Prepared by

Life Sciences Engineering
Route 1, Box 746
Morrison, CO 80465

Under Contract NAS8-32261 with

National Aeronautics and Space Administration
George C. Marshall Space Flight Center, Alabama 35812

for the Department of Energy

U.S. Department of Energy

Solar Energy

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This work was done under the technical management of John M. Caudle, Marshall Space Flight Center, Alabama.

16. ABSTRACT

Life Sciences Engineering, under Contract NAS8-32261, developed the Solar II Air Flat Plate Collector, Model SC4X8, under the direction of the National Aeronautics and Space Administration.

The Solar II dimensions are 4 feet by 8 feet by two and 1/2 inches. The collector weighs 130 pounds and has an effective solar collection area (aperture) of over 29.5 square feet. This area represents 95 percent of the total surface of the collector.

The Installation, Operation and Maintenance Manual, Safety Hazard Analysis, Special Handling Instructions, Materials List, Installation Concept Drawings, Warranty and Certification Statement are included in the installation package.

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SECTION I

WARRANTY AND CERTIFICATION STATEMENT

WARRANTY

The Solar II Collector is warranted for 1 year from time of delivery. This warranty covers manufacturing craftsmanship and mormal environment conditions. It does not cover installation mishandling or wilful damage. If the collector was purchased without glass from the factory, the local distributor/subcontractor shall warrant the glass for breakage and leakage for 1 year. In the event of a failure, a replacement component will be supplied for the failed component.

CERTIFICATION STATEMENT

The Solar II, Air Flat Plate Collector, was tested for operational performance and structrual conformance to specifications directed by the National Aeronautics and Space Administration. The design and structure of the collector are consistant with applicable national standards. The Solar II Collector successfully passed all tests and was evaluated as efficient and safe for public use.

NORMAN L. FAST, PE
STRUCTURAL ENGR.

NORMAN LESLIE FAST REGISTERED 7006 PROFESSIONAL ENGINEER & LAND SURVEYOR STATE OF COLORADO

Professional Engineer
Certification Agency

Colo #5674
Test Engineer
Life Sciences Engineering

Colo PE 8616
Test Director
Life Sciences Engineering

BENEDICT JAMES SEVERAN REGISTERED 10999 PROFESSIONAL ENGINEER STATE OF COLORADO

Architectural Engineer
Installation Drawings
Installation, Operations,
Maintenance Manual Sections

SECTION II

SPECIAL HANDLING INSTRUCTIONS

SPECIAL HANDLING INSTRUCTIONS

1. Procedure for removing the Solar II Collectors from this shipping container.

1.1 This shipping container is made with 8 plywood, triangular corners. Four of these corners are nailed down on one side. On the other side, the corners are screwed down.

1.2 To remove the collectors, place the shipping container with the screw side up. Remove the 4 small screws in the corner triangles and screws holding down the three cross braces. DO NOT REMOVE THE LARGE MACHINE BOLTS (6) which are located inside the screws; one in each corner triangle and one in each end of the center cross brace.

1.3 Two men are needed to lift the plywood corners with the collector attached. With one man at each end holding the plywood triangles, gently lift the collector up and out. Place the collector with the plywood side down on some 2x4's.

1.4 Remove the cardboard cover by removing the duct tape.

1.5 To remove the plywood back support, remove the 6 machine bolts and the collector can be lifted free. The duct tape holding the Tedlar frame and plenum chamber opening may be removed at any time. However, it is recommended that the tape be left on until the collector is to be put in operation or test.

1.6 To remove the second collector in the shipping case, place the case on a table where the 6 machine bolts may be removed from underneath. It may be necessary for a second man to hold the nut while the first man removes the bolt.

1.7 When all 6 machine bolts are removed, two men are needed to lift the collector from the case. The plywood back support is pushed up at each end gently until the collector is raised where the men can get a good grip on the ends of the collector.

CAUTION: DO NOT LIFT THE COLLECTOR BY THE TEDLAR FRAME ALONE. LIFT THE ENTIRE COLLECTOR.

1.8 The collector should be placed with the Tedlar side up. The cardboard covering the Tedlar may be removed as described in step 1.5.

SECTION III

SAFETY HAZARD ANALYSIS

SAFETY HAZARD ANALYSIS

1. Scope

1.1 Purpose

The purpose of this report is to identify and evaluate significant hazards to the installation crew, resident occupants and visitors.

1.2 Scope

This report presents an assessment of hazards peculiar to this equipment. The hazards have been identified and categorized. The possible causes and effects have been listed, together with the methods or safeguards required to control or limit the hazard. This analysis does not consider facility or manufacturing features that are required to be made safe under the local codes and regulations.

1.3 Summary

The Hazards Analysis identified no potentially catastrophic hazards and one critical hazard. A catastrophic hazard (Category 1) is one in which death or severe injury to personnel or system loss can occur. A critical hazard (Category 2) is one which could result in personnel injury or cause major damage.

ITEM NO.	NOMENCLATURE OF HARDWARE/ACTIVITY	POTENTIAL/INHERENT HAZARD CAUSES AND EFFECTS	HAZARD CATEGORY	PROPOSED METHOD OF HAZARD CONTROL OR ELIMINATION	REMARKS
1	Solar Panel Assembly	1. Large areas of dielectric (Tedlar) surface exposed to sky could build up sufficient static charge to act as flat plate capacitance attractor for lightning. Large amounts of metal in frames could also attract lightning.	2 marginal	Installation will require electrical busing of panel assemblies together and to ground per standards and codes for locality	Lightning rods may be required by code in areas of high strike potential (ie. Colorado Springs)
		2. Aluminum frame of panels will conduct stagnation temperatures to surrounding structure if forced convection air flow is inhibited. High stagnation temp. (500^{o}F) could cause local charing or combustion.	marginal 2	Installation will provide for adequate insulation between panel assembly frame and surrounding structure.	
		3. Toxic outgassing of materials could have debilitating effect on residents	3 marginal	Materials used in solar panel assembly shall not produce toxic or noxious products when exposed to expected temperature.	

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2	Installation of Solar Panel Assembly to Supporting Structure	1. Installation personnel could be burned by hot frame or panel when handling.	3 negligible	Personnel should wear gloves whenever working around exposed panel frames. Panel storage prior to installation should be in a shady area. Panels should be transported with collector face away from direct sunlight.	
		2. Large panel assemblies (4 x 8 ft.) will be heavy (100 lbs.) and act as sails in wind. Above ground installations present potential for severe injury to personnel by being blown off or by dropping panel on self or another.	2 critical	Installation should be designed to maximize use of lifting apparatus	
		3. Improper sealing of panel/ supporting structure could result in water leaks.	3 negligible	Installation manual will recommend proper installation techniques/requirements.	Local codes may take precedent.

SECTION IV

INSTALLATION, OPERATION AND MAINTENANCE MANUAL

1. Installation

Introduction

Installation of the Solar II, Air Flat Plate Collector is a 4 step operation consisting of Roof Preparation, Collector Preparation, Collector Installation and Closing Up. The Solar II Collector is shipped normally without glass or insulation to save shipping costs.* Glass and insulation weigh more than two thirds of the total collector weight. Hence to save costs, the installer can purchase the glass and insulation locally. A List of Materials at the end of this manual supplies the necessary details.

1.1 Roof Preparation

As shown in the installation drawings, the roof must have roughing holes cut in the sheathing. The holes should be a minimum of $2\frac{1}{2}$" to 3" by 45" for the plenum/ducting connections. For new construction, just installing the sheathing that will be under the collectors will provide some room for making connections. If the roof has 24" o.c. rafters do not cut them, but notify the factory in your order so that air blocks will be installed free of charge. Longitudinal supports made of 2x4's, 8' long, and laid flat, must be centered over each rafter to support the side sections of the collectors. It is important that these supports be nailed to the sheathing directly over the rafters to support and distribute the collector weight. If rafters are irregular (bowed or warped), use a wider support board such as a 2x6" support. Additional rafters may have to be installed.

After the 2x4 supports are completed, install $1\frac{1}{2}$" insulation with an

* Note: Completely assembled Solar II Collectors are available at additional cost and shipping charges will be higher.

R value of 9 or better between the supports and the rough openings. Board type insulation is recommended.

1.2 Collector Preparation

The Solar II Collector has 'built in' end connectors. Sleave connectors to connect the collector to the ducting/plenum should be installed on the ground. Sleave Connectors may be purchased from Life Sciences Engineering or made by the installer. The sleave connector fits over the End Connector and is riveted in place. All connections should be caulked with standard air conditioning caulking.

1.2.1 Glazing Installation

If the Solar II is purchased without glass, glass should be purchased locally and installed prior to installation. Carefully remove the Tedlar® frame using a rubber mallet and a piece of 1/8" angle aluminum to tap the frame loose from under the H-Bar. Insert the silicone rubber U-channel on the 46½" edge of the glass. Gently push the glass with U-channel attached into the H-Bar for a tight fit. With suction cups attached to the glass, gently lower the glass into position. The glass should have a 5/32" space around the 3 outside edges. Force Dow Corning 732 Silicone Adhesive into this 5/32" space and allow to cure. After curing 1 hour, put a covering layer of 732 from 3/32" over the glass to the frame edges. Then allow the 732 to cure over night. The Tedlar frame may be re-installed at this time or after installation.

1.3 Collector Installation

After completing steps 1.1 and 1.2, the collector is ready for

installation. Installers should wear gloves during installation as collectors standing in the sun become too hot to hold. They should be kept in the shade until ready for installation.

Installation is a 2 man process due to the size and weight (130lbs.) of the collectors. A hoisting device is recommended to position the collector over the prepared location and lower it into position. Make sure that the collectors are evenly spaced between the rafters which can be seen through the rough openings. Spacing between collectors in parallel is 7/8" at the H-Bar level, on the sides. Drill holes in the 2x4" supports for the aluminum round head #10 screws that go through the mounting brackets to hold the collector. Use aluminum washers under the screw head. Do not tighten down fully as it is necessary to allow some panel movement.

Standard sheet metal ducting can be attached to the Sleave Connector at this time.

1.4 Closing Up

Closing up consists of installing insulation and flashing between the collectors and around the perimeter of the collector subsystem. Fesco board insulation is recommended in 3/4"x2½"x48" strips to insulate between the sides of the collectors. This insulation is covered with 1¼" plastic U-channel that is screwed down about every foot with 3½" aluminum screws. The interface between the 1¼" plastic U-channel and the H-Bar should be carefully caulked. The plastic U-channel legs fit into the H-Bar channel and this area is caulked before the screws are tightened.

The outer perimeter of the Collector Subsystem must be enclosed with insulation. Fesco board 4" Face Cant Strips are recommended

to gradually slope the roof to the collectors. Standard commercial aluminum flashing 19 or 20 gage is recommended to cover the insulation in accordance with standard practice. Recommended flashings include Tremline, ALCOA and John's-Manville.

2. Operations

2.1 Introduction

The Solar II Air Flat Plate Collector is designed to be compatible with current and future solar heating systems. It is capable of accepting air flows at various rates for different operational modes.

Solar energy passes through 2 glazing layers on the front of the collector and strikes the flat black coating on the absorber panel. The coating is designed to absorb most of the incident solar radiation. The glazings prevent motion of air called convection currents, across the surface of the absorber. Convection currents are the primary heat loss mechanism. Energy absorbed by the coating is transferred through the aluminum panel by means of conduction or molecular vibrations. To enhance the transfer of energy to the moving air stream behind the absorber, the back side of the panel is painted black. The air stream extracts heat from the absorber in 2 ways. The primary mechanism is due to the forced air convection across the back of the absorber. The secondary effect is the emission of radiant energy, (Infra-red radiation) which is emitted by any body that is hotter than its surroundings. Some of this radiation is absorbed directly by the air and some is absorbed by the back panel and transferred to the air by convection.

Solar II was designed for a 50°F increase in air outlet temperature

which is a nominal 120°F temperature into the home. This temperature was considered safe for the outlet air to heat the house directly. However above 140°F outlet air temperature from the collector, this energy should go to storage only. Directing and controlling air flow must be regulated by a control subsystem. While Life Sciences Engineering is developing a control subsystem, there are several control systems available on the market.

2.2 Operational Checkout

After the collector has been installed and connected to the ducting, this system should be checked with the other parts of the heating system. In operation, the collector was designed for an air flow of 120CFM although other air flow rates can be used such as 240CFM. The blower motor* air flow should be measured at the collectors at 120CFM each. The pressure drop across the collector should not be more than .1 inch of water. If the pressure drop is greater than .1 inch of water, there is a blockage which should be removed.

When collecting heat to heat the home directly, the outlet temperature of the collector should not be more than 140°F for an inlet temperature of 70°F. If temperatures over 140°F are found for the 70°F inlet air, the blower motor should be increased in speed until the outlet air temperature is less than 140°F. This condition is unlikely but should be checked. Outlet air temperatures above 140°F should go to storage only.

* Solar heating systems have blower motors separate from the regular home heating system or backup system. The blower motor for the solar heating subsystem usually operates in series with the regular heating system blower.

When collecting heat for storage, the temperature of the outlet air will often be much higher than when heating air for the home directly. For a 140°F inlet air temperature, an outlet air temperature of 172°F can be expected. In this increase is not being achieved, the control system requires adjustment to attain this temperature change.

3. Maintenance

Introduction

Maintenance consists of two parts, periodic maintenance and repair maintenance.

3.1 Periodic Maintenance

Periodic maintenance consists of occasional inspections for problems such at tears in the Tedlar® or cracks in the glass. Inspection should include checks for water leakage, especially at the caulking interfaces. Inspections are recommended once per month.

During long duration dry spells, the outer glazing should be washed with water or sprayed with a hose on the average of once per month under these conditions. If the Tedlar® is very dirty, a mild soap may be used to wash down the Tedlar®.

3.2 Repair Maintenance

Repair maintenance consists of minor and major repairs.

3.2.1 Minor Repairs

Tedlar® punctures should be repaired as soon as noticed. Repair consists of applying a small dab of GE silicone glue and seal. A Tedlar® repair kit of 2 mil Tedlar is also available with adhesive already attached to the 2 mil Tedlar®.

If a leak is noticed, inspect all caulking, especially the interfaces. Caulk these cracks and test with a spray of water. Spraying one small section at a time will isolate the leak area.

3.2.2 Major Repairs

3.2.2.1 Tedlar® Repair

Major Tedlar tears require replacement of the entire glazing at ground level. Remove the Tedlar by removing the plastic spline and pull/cut out the Tedlar in the H-Bar channel. Clean out the H-Bar channel with a mixture of isopropenol-trichloroethylene. Insert a 1/8" bead of Gelva 1752 into the H-Bar channels. Brush the Gelva into a thin coating (1 mil) on each side. Allow the Gelva to air dry for a minimum of 15 minutes. Extend the new Tedlar a minimum of $\frac{1}{2}$" beyond the H-Bar edges. With an assistant holding one end of the Tedlar taut, and the installer holding the other end taut, the convex wheel of the screening wheel is used to force the Tedlar into the H-Bar channel. Start in the middle of one side as shown in Figure 1. By keeping the ends taut over the U-channel, the Tedlar will go in smoothly, and uniformly taut. Next insert the .145" plastic spline into the Tedlar/H-Bar channel. Use the concave wheel to install 8' of spline. When one side is completed, install the Tedlar in the opposite side, followed by the 8' length of spline. Repeat this procedure for the 2 remaining ends. The Tedlar corners require a bias cut to fit properly which should be completed after the Tedlar is installed in all 4 channels. The spline is also cut on a 45° bias and pressed down in each corner with a 1/8" flat bar. Place the Tedlar frame back on the collector by carefully fitting the corners. Setting the collector with the Tedlar frame attached in the sun until the Tedlar reaches $150^{\circ}F$ will shrink the Tedlar when put in a cool location immediately.

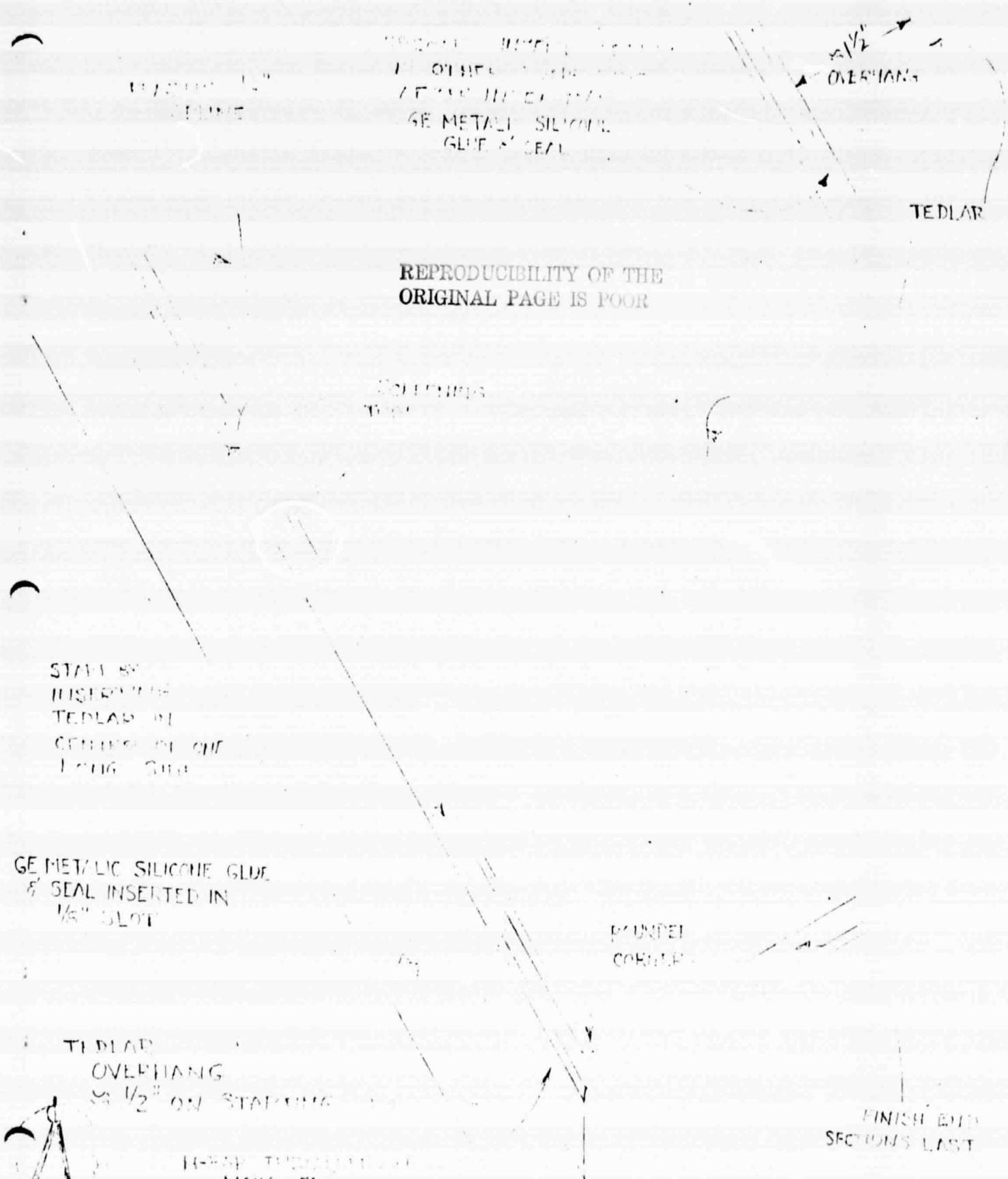


Figure 1, SOLAR ARRAY INSTALLATION SKSC4-50C-29

4.2.2.2 Cracked Glass

If the inner glazing of glass breaks, repair should be made at ground level. Remove the Tedlar frame by taking off the plastic U-channel and the insulation. The Tedlar frame is removed by gently forcing the H-Bar up with a 1/8" piece of aluminum angle. Remove the broken glass and Dow Corning 732 silicone rubber seal. The 1/16"x 5/8" silicone rubber strip may have to be replaced. The replacement is glued with a thin coating of 732. The silicone rubber U-channel is reuseable and is installed on the 46½" side of the glass. Insert the glass/U-channel into the H-Bar on the support bar. A suction cup is used to move this leading edge of the glass up and down as it moves into the H-Bar. When the glass fits snugly into the H-Bar and there is a 5/32" space around 3 sides, move the suction cup to the opposite edge of the glass and gently lower the glass onto the silicone rubber strip. After checking all 3 sides for the 5/32" spacing, insert Dow Corning 732 into this spacing and allow to cure for a minimum of 1 hour. A second bead of 732 is placed over the last 3/32" of glass and over to the collector edges. Allow to cure in the sun or at room temperatures for several hours, preferably 8 hours for the 732 to outgas and harden. It is recommended that the collector be installed before replacing the Tedlar frame. Replacement of the Tedlar frame consists of fitting the corners of the frame over the collector and then gently tapping the frame in place with a rubber mallet.

Glass may often contain markings in crayon from the manufacturer. These markings can be removed with a wet cloth and Bon Ami. Isopropyl alcohol will remove fingerprints for final cleanup.

3.2.2.3 Paint Repair

In the event of a paint repair problem, which is not expected for a minimum of 10 years, repainting should be done at ground level. The collector must be removed from the roof and disassembled by removing the Tedlar® frame and tempered glass.

A complete absorber panel repainting should be done in a paint shop which has the proper equipment. The old paint should be removed with paint remover. The panel is then cleaned with xylene. In should be refinished with chromic acid. An undercoat of a wash primer such as Sherman Williams which is mixed with their Catalyst Reducer and sprayed on to a thickness of 0.25 to 0.35 mils. After the wash primer has dried for ½ hour, the Nextel paint is sprayed on to a thickness of 1 to 3 mils. Nextel may be thinned with up to 10% xylene. After spraying, allow to dry for 1 to 2 minutes and then bake in an oven at 250°F for ½ hour. If an oven is not available, place the collector in full sunlight, cover with a plastic sheet and allow to bake in the sun for several hours with a plastic heet covering it. Solar baking should reach a minimum of 225°F in a closed container for several hours around solar noon. It may be necessary to insulate around the collector to reach this temperature. Baking permits the new paint to outgas which may collect on the inexpensive plastic sheet.

After baking, the collector must be reassembled. It may be necessary to replace the silicone rubber strips that cover the U-channel that supports the glass. Glass replacement is described in paragraph 3.2.2.2. Be sure to keep the collector free of dust and dirt, etc.

Minor scratches can be repaired with a paint brush or a spray can of Nextel paint.

SECTION V

MATERIAL LIST AND INSTALLATION CONCEPTS

DRAWING NO. SC4X8106

LIST OF MATERIALS

Glass - Sunadex® tempered glass, ASG Industries, size 46½"x47-5/16" x5/32" or equivalent low iron glass (approx. .01% iron).

Plastic U-Channel - Life Sciences Engineering, size 1¼"x1/8"x12' of Noryl® plastic or equivalent.

Paint - 3M Nextel® Black, (Black Velvet) 101-C10 or equivalent.

Primer - Sherwin-Williams P60G2 with W/R7K44 Catalyst or equivalent.

Adhesive - Dow Corning RTV 732 silicone rubber or equivalent.

Tedlar® - Du Pont, 4 mil, 400XBR160-50", or equivalent.

Spline, plastic - Anson .145 diameter or equivalent.

Side Insulation - Johns-Manville Fesco Board 3/4", R value 4.17 or equivalent insulation.

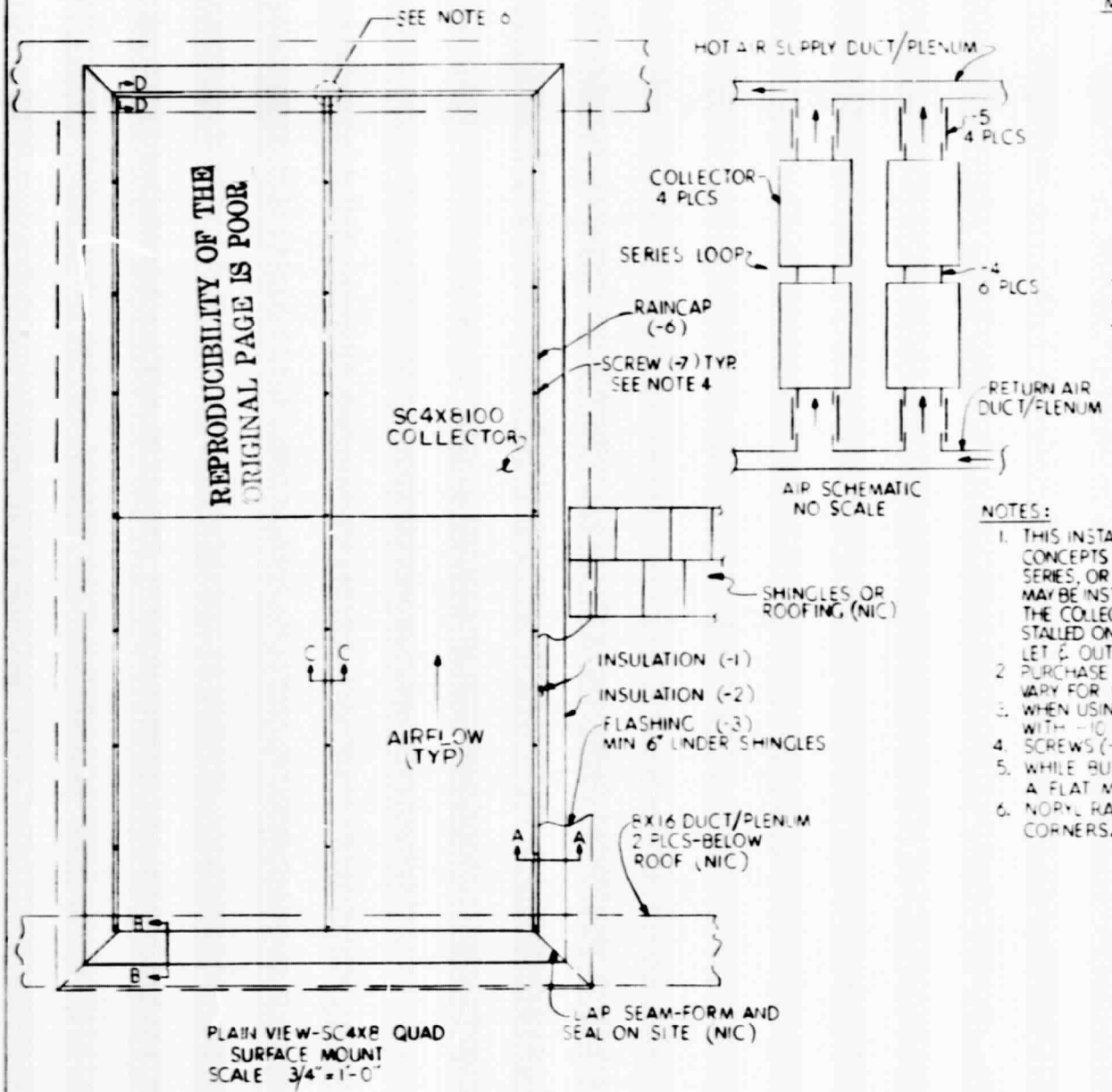
Perimeter Insulation - Johns-Manville Fesco Cant Strips or equivalent onsulation with 4" diagonal facing. Also use side insulation.

Back Insulation - Poly-Urethane board, R value 9 or better, Owens-Corning or equivalent.

Tedlar Adhesive - Gelva 1753, Monsanto or equivalent

Tedlar Repair Adhesive - General Electric Silicone Glue and Seal

Silicone Rubber Strip - 1/16"x5/8", Rubbercraft



AIR SCHEMATIC
NO SCALE

MATERIALS (ALL NIC)

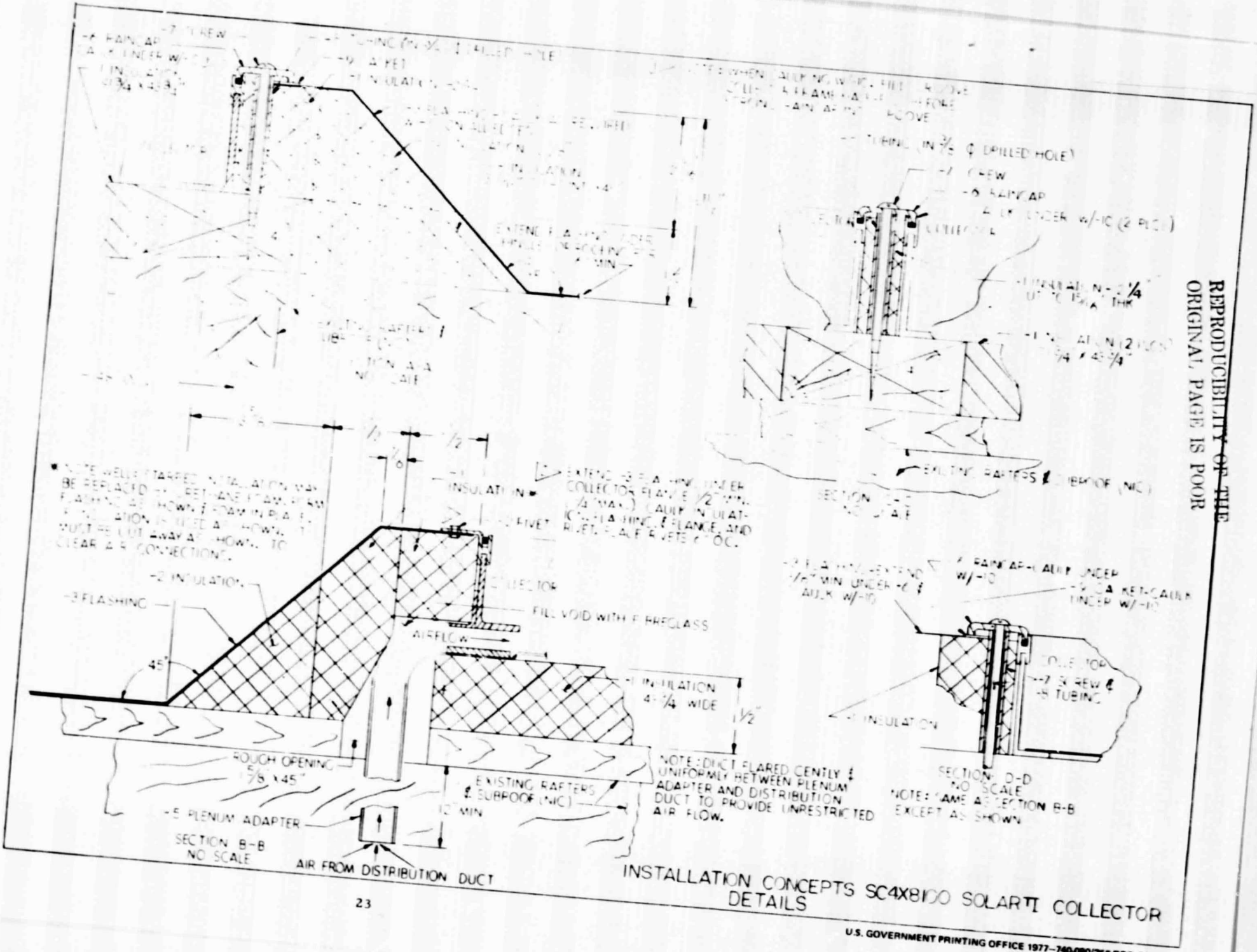
-1 J.M. EXTERIOR ROOF INSULATION (FESCO) OR EQUIVALENT, 1½" THICK. (R=2.78 INCH THICKNESS MINIMUM)
-2 SAME, 4" FACE CANT
-3 AL. ALL FLASHING, .019 X 15 WIDE, AS REQ'D.
-4 DELETED
-5 SC4X8ESC-5 PLENUM ADAPTER
-6 SC4X8501 RAINCAP
-7 SCREW, # 2 X 4" RHWS
-8 TUBING, RIGID ACRYLIC PLASTIC, 3/8"ODX 1/4" IDX 2½ LG.
-9 GASKET, ½", CONN. HARD RUBBER R10470
-10 CAULKING COMPOUND, NON-HARDING, RUBBER BASE
-11 DELETED
-12 RIVET, POP, 1/8" DIA X 1/8" GRIP
-13 FINISH LMBR, 2X4-8, CONSTRUCTION GRADE
-14 SCREW, #10 X 1¼" RHWS
-15 3/16" OVERSIZE WASHER

NOTES:

1. THIS INSTALLATION CONCEPTS PLAN VIEW SHOWS 3 INSTALLATION CONCEPTS ON 1 DRAWING. COLLECTORS MAY BE INSTALLED IN PARALLEL, SERIES, OR SERIES-PARALLEL CONFIGURATIONS. THE SOLAR II COLLECTORS MAY BE INSTALLED IN NEW OR EXISTING ROOFS, OR IN STAND-ALONE UNITS. THE COLLECTORS ARE SHOWN ON RAFTERS 4'-0" O.C. THEY MAY BE INSTALLED ON RAFTERS SET 2'-0" O.C. IF A 3" AIRBLOCK IS USED AT THE INLET & OUTLET OPENINGS OF THE COLLECTOR.
2. PURCHASE -1 IN 4' X 8' SHEETS & CUT ON SITE. DIMENSIONS GIVEN MAY VARY FOR INDIVIDUAL INSTALLATIONS.
3. WHEN USING RANDOM LENGTHS OF -1, -2, OR -13, BUTT ENDS & SEAL WITH -10 OR EQUIVALENT.
4. SCREWS (-7) SHALL BE APPROX. 2'-0" APART.
5. WHILE BUILDING FRAME (-13), SHIM AS NECESSARY TO OBTAIN A FLAT MOUNTING SURFACE.
6. NORYL RAINCAP (-6) JOINTS TO BE MITRED & CAULKED AT CORNERS. BUTT JOINTS TO BE CAULKED. USE -10. (ABOVE)

INSTALLATION CONCEPTS SC4X8100 SOLAR II COLLECTOR

PER DWG SC4X8106



INSTALLATION CONCEPTS SC4X8100 SOLARTI COLLECTOR DETAILS

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