DOE/NASA TECHNICAL
MEMORANDUM

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DEVELOPMENT, TESTING, AND CERTIFICATION OF LIFE SCIENCES ENGINEERING SOLAR COLLECTOR -- FINAL REPORT

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U.S. Department of Energy

Solar Energy

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DEVELOPMENT, TESTING, AND CERTIFICATION OF LIFE SCIENCES ENGINEERING SOLAR COLLECTOR – FINAL REPORT

SUMMARY

The primary goal of the information contained in this report is to aid those who desire to remain abreast of the present state-of-the-art of solar energy, as well as those in the process of selecting a solar energy collector subsystem for space and hot water heating of residential size dwellings.

To meet this primary goal, the contractual efforts of Life Sciences Engineering to further the development of a solar collector using air as a heat transport medium are described.

Some highlights included are the orientation of the development as a portion of the national program, contract goals, accomplishments, design and application information, and actual test results.

Upon completion of the development phase, the following final certification was obtained from an independent contractor:

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

I. INTRODUCTION

The work done under this development effort was authorized by the Solar Heating and Cooling Demonstration Act of 1974 (PL 93-409). The act provides for the following:

1) Demonstration, within 3 years, of the practical use of solar heating technology.

2) Demonstration, within 5 years, of the practical use of combined heating and cooling technology.

Responsibility for implementing the Demonstration Act was given to the Energy Research and Development Administration (now the Department of Energy). The National Aeronautics and Space Administration, George C. Marshall Space Flight Center (MSFC) managed this work.

To aid in accomplishing the goals previously listed, MSFC awarded contracts in each of the following areas:

Number	Title	Purpose
AP32-75-408	Solar Heating and Cooling Marketable Subsystems	Procure marketable subsystems unique to solar heating and cooling systems (multiple contracts)
AP32-75-407	Solar Heating and Cooling Existing Subsystems that Require Additional Development	Procure development of existing solar heating and cooling subsystems to make them marketable, and delivery of the subsystems (multiple contracts)
AP32-75-406	Solar Heating and Cooling Existing Systems that Require Additional Development	Procure development of existing solar heating and cooling systems (including hot water systems) to make them marketable, and delivery of systems (multiple contracts)
AP32-75-405	Solar Heating and Cooling Systems Integration of Marketable Subsystems	Procure (1) integration of Government furnished subsystems, test and delivery of marketable prototype solar heating and cooling systems; (2) development of Site Data Collection subsystem and Central Data Processing subsystem; and (3) system analysis support efforts (single contract)

AP32-75-404	Solar Heating and Cooling Systems Design and Development	The complete design and development of solar heating and combined heating and cooling systems, and the delivery of prototype systems (two or more contracts)

The work described in this report was funded, after competitive bidding, under AP32-75-407.

II. CONTRACT SCOPE AND REQUIREMENTS

A. Purpose

The contract was for the additional development of an existing air flat plate collector subsystem for solar heating and/or hot water application for efforts to make a marketable product, and for the procurement of a limited quantity of the developed collectors.

B. Products

The work consisted of development and fabrication of a prototype air flat plate collector panel containing 320 ft^2 (ten 4 × 8 ft panels) of collector area. Three (instrumented) panels were to be completely assembled with glazing and insulation.

Delivery was to be October 1977, 1 year after contract award. In addition, the contractor was to deliver the data handling equipment used in collector development.

C. Product Requirements and Criteria

During the development of the collector, the contractor was required to:

1) Meet the applicable parts of the interim performance criteria as defined in a verification plan.

2) Meet the subsystem performance specification, SHC-3058.

3) Provide test data/analysis to verify that hardware meets the subsystem performance specification.

4) Provide drawings and specifications in sufficient detail to define the configuration and to ensure manufacturing repeatability.

5) Have provisions to monitor performance.

6) Provide installation, operation, and maintenance manual(s).

7) Provide subsystem and/or component hardware certified by independent laboratory (such as Underwriters Laboratory and American Gas Association) to meet nationally recognized standards and codes (such as American Society of Heating, Refrigeration and Air Conditioning Engineers; American Society of Mechanical Engineers; American National Standards Institute; and American Refrigeration Institute).

D. Contractor Tasks

The contractor was to provide the necessary effort to meet the product requirements and criteria set forth in Section II.C of this report. In addition, the contractor was to provide analysis results and reports necessary to fulfill contract requirements.

III. PROPOSAL

A. Response to Request for Proposal

The company was responsive to the RFP and was selected on a competitive basis.

B. Origin of Design

The design was based on a prototype collector developed for Mr. Ralph Hillman of Aurora, Colorado, by Life Sciences Engineering.

C. Development Schedules

Development schedules are shown in Figure 1.

D. Hardware Description

The proposed design was for a double glaze air flat plate collector. Three sizes were proposed: 4 × 10 ft, 4 × 8 ft, and 48 × 22 in. Figures 2, 3, and 4 show details of the proposed construction.

E. Material Selection

Following is a list of materials with the rationale for their selection:

1) Inner Glazing

a) Materials and Selection Rationale — Glass to withstand temperatures in excess of 250°F.

b) Type and Identification — Pittsburgh Plate Glass, double strength (1/8 in. nominal), float.

c) Available Characteristics — Transmissivity: 0.94.

d) Durability/Performance Degradation — Will survive temperatures of 250°F.

e) Replacement Method — Remove the outer frame, remove and replace glass.

f) Edge Treatment — Provide 1/8 in. expansion space and pressure tape.

g) Physical Properties — Brittle; may crack if installed improperly.

2) Outer Glazing

a) Materials and Selection Rationale — Plastic film affords better protection than the 1/8 in. glass; safer on ground level where children may accidentally fall against outer glazing.

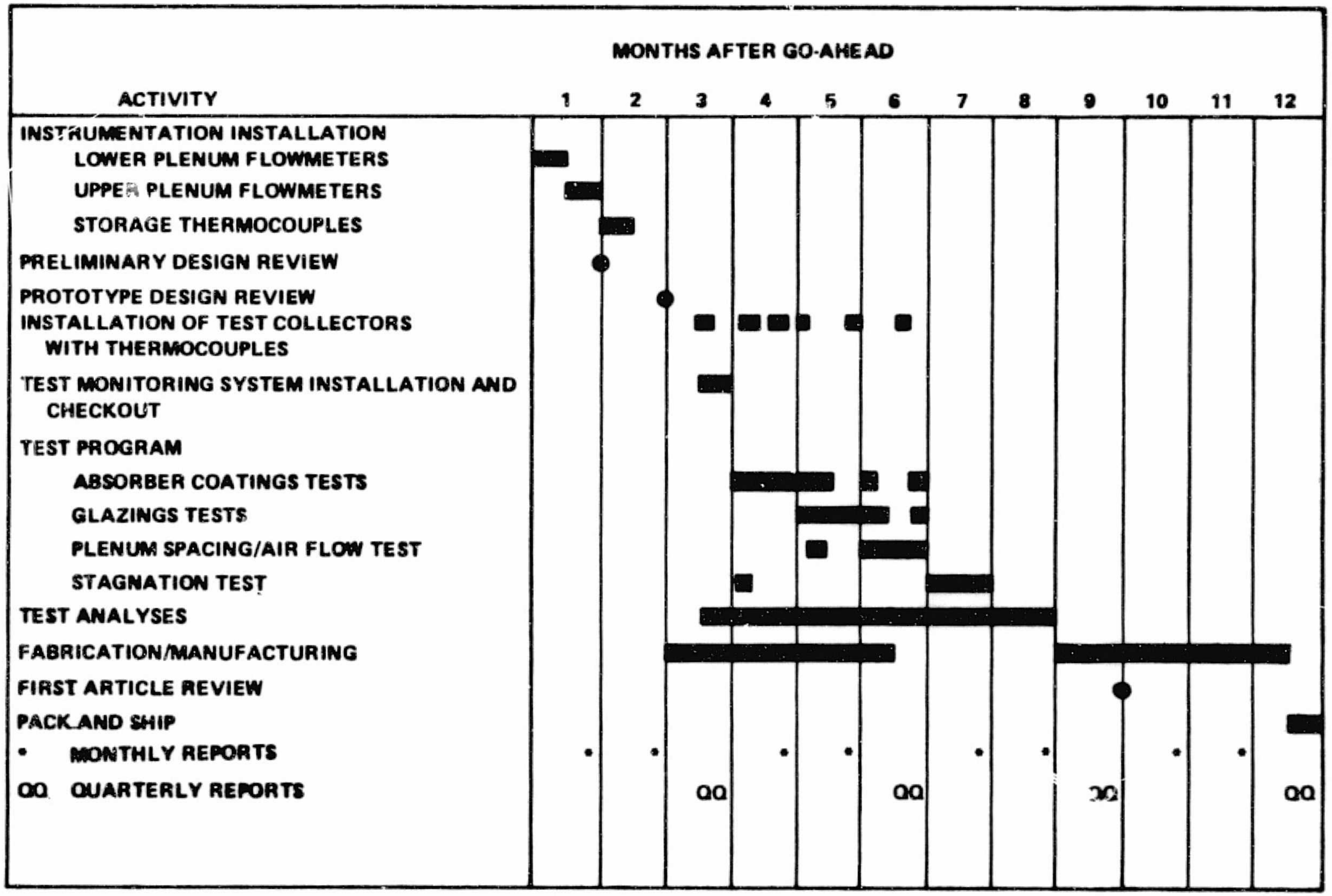

Figure 1. Development plan.

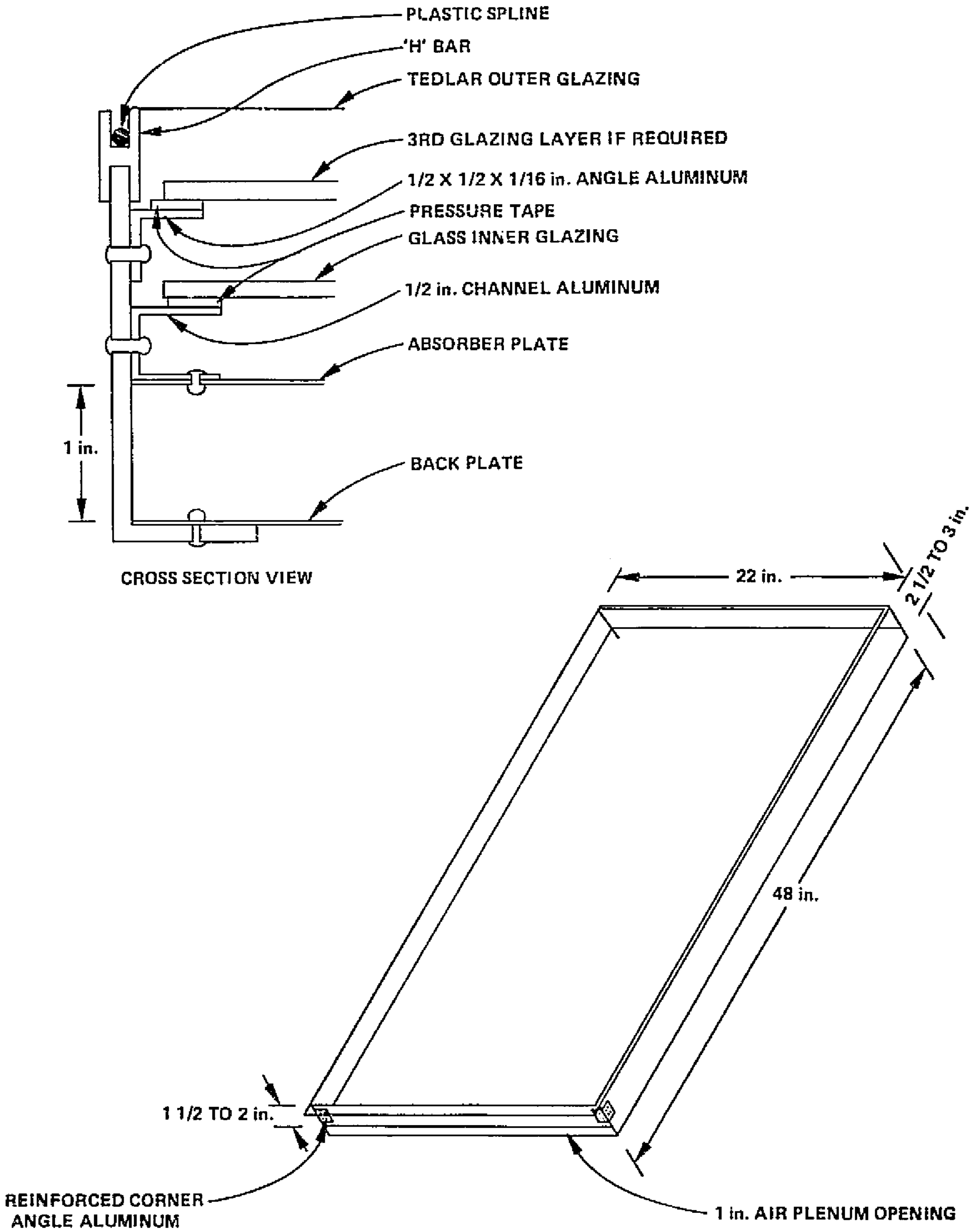

Figure 2. Solar II collector frame and detail Pt. No. CF 22 × 48 in.
(Life Sciences Engineering proposed solar collector).

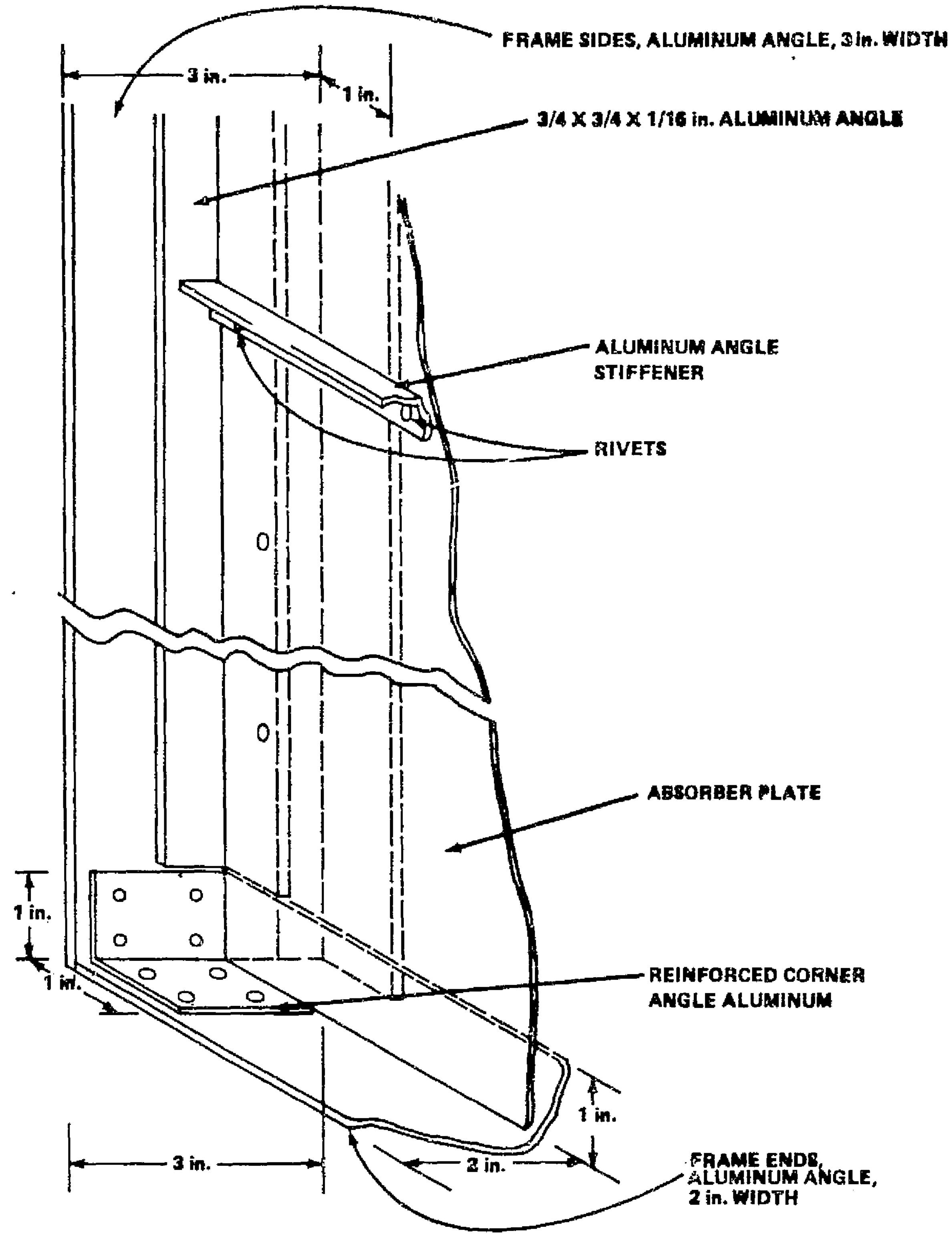

Figure 3. Solar II collector frame and detail Pt. No. CF 4 × 10 ft (Life Sciences Engineering proposed solar collector).

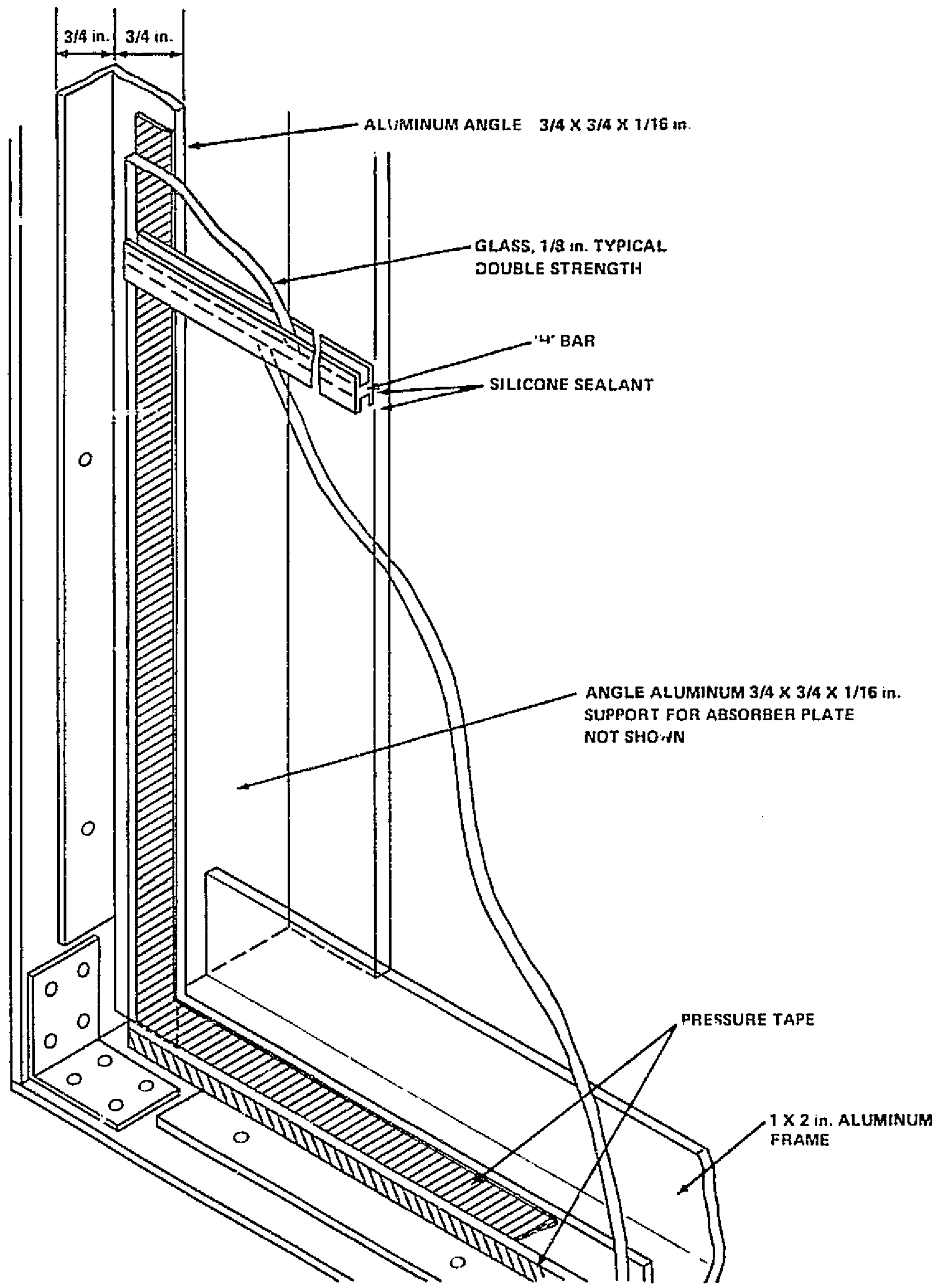

Figure 4. Solar II glazing frame, inner, detail Pt. No. GFI 4 × 10 ft (Life Sciences Engineering proposed solar collector).

b) Type and Identification — Tedlar, DuPont 400 BG 20 TR.

c) Available Characteristics — Transmissivity: 0.92 to 0.94.

d) Durability/Performance Degradation — Withstand hail; may lose half its strength in 10 years.

e) Replacement Method — Remove outer frame, remove and replace Tedlar. Allow to shrink in Sun.

f) Edge Treatment — Tedlar is bonded to frame with metallic silicone GE 2564-51EP.

g) Physical Properties — Pliable film deforms over 225°F (per manufacturer's engineer).

3) Absorptive Coating[1]

a) Materials and Selection Rationale — Flat black velvet paint for economy.

b) Commercial Identification — 3M "Nextel" velvet coating, series 101.

c) Available Characteristics — Absorption: 0.98; IR emittance: 0.89.

d) Application Procedure — After etching, spray a single coat and oven dry at 250°F.

e) Manufacturing Tolerance — Single coat of 0.002 to 0.003 in.

f) Durability and Performance Degradation — Expected life: 10 years.

g) Physical Properties — Velvet texture provides good absorption.

4) Absorber Plate and Base Plate

a) Selection Rationale — Aluminum 0.025 in. thick for durability and conductance.

b) Fabrication Procedures/Process — Riveted to frame.

1. The final selection of the absorptive coating will depend on the results of the test program.

c) Physical Properties and Dimensions — Three sizes: 4 × 8 ft, 4 × 10 ft, and 22 × 48 in., all 0.025 in. thick.

d) Thermal Properties — Selected for high conductance.

e) Manufacturing Tolerances — Length and width; +0, -1/32, respectively.

5) Insulation — Insulation is not provided. Life Sciences Engineering will supply a list of recommended insulation materials that will not outgas or contaminate the air. The builder or subcontractor will supply a minimum of 2 in. between the rafters and under the collector subsystem. The thermal expansion spacers will be recommended (e.g., masonite and celotex). The width of these thermal expansion/insulation spacers depends on the accuracy of the builder in setting the rafters.

6) Enclosure — Aluminum Frame

a) Materials and Selection Rationale — Aluminum angle for lightweight strength and long life.

b) Type and Commercial Identification — 2025T6, nontapered aluminum.

c) Thermal Properties — High conductance.

d) Fabrication Process — Riveted with corner braces for prototype and test models. An investigation is planned to evaluate the use of aluminum soldering techniques for fabrication of the deliverable system.

F. Collector Performance Predictions

The final contract performance specification is included as Appendix A. This represents some change from that initially proposed. This small change represents some maturation of design and includes the results of one erroneous calculation made during the precontract period.

G. Test Facilities

At the time of proposal submission, the company had in place a test stand capable of simultaneously testing three solar collectors. Each position contained an engineering model collector with adjustable plenum and a flow control damper. A 1500 ft^2 house was used to provide a load when needed. Performance monitoring was by the utilization of manual measuring techniques.

IV. DEVELOPMENT

A. Development Objective

The company had developed the collector to a state where it was usable, but was not ready for a full marketing effort. The objectives of the development were as follows:

1) Determine the optimum plenum spacing for a maximum hot air outlet temperature of 140°F.

2) Determine the most efficient absorber coatings to obtain maximum performance.

3) Determine the optimum flow rates for the collector.

4) Determine the optimum number of glazings for conservation of heat.

5) Determine the capability of the collector materials and coatings to survive worse case conditions (stagnation of air flow due to an inoperative blower or a power failure).

6) Verify that the performance of the developed collector equaled or exceeded applicable contract requirements.

7) Obtain certification by an independent agency that the collector was ready for use by the public.

8) Improve test facility to provide more accurate measurements and to permit automatic data acquisition.

B. Development Events and Results

1. Introduction. The development was successful in that all requirements and criteria were met and a marketable product evolved. The following paragraphs give a brief description of work in the several development areas.

2. Schedules. The developmert was accomplished with only minor deviations in timing of events within the overall schedule. Hardware shipment was completed 6 days later than scheduled.

3. Development Results. Seven 4 × 8 ft collectors without insulation and three of the same size collectors with insulation and special temperature monitoring probes were delivered, a total of 320 ft^2. The final configuration is shown in Figure 5.

4. Details of Design Development.

a. Performance — The engineering units were used to measure performance throughout the development period. The original design was for a collector 10 ft in length. Based on this, a goal of 50°F temperature rise in the collector performance predictions was made and the initial specification was written.

b. Plenum Spacing — Performance calculations or tests were made for plenum spacings of 1, 5/8, 1/2, and 3/8 in. From the performance curves plotted from these calculations, an optimum plenum spacing of 1/2 in. was selected.

c. Absorber Coating Selection — The coating originally proposed was for "Nextel," a flat black paint manufactured by 3M Company. At the beginning of development a different type of paint, "Solarsorb," manufactured by Caldwell Chemical Coating Company, appeared to be promising. This type offered the advantage of having some selectivity ($a/e > 1$) and was low cost. Comparative performance tests by Life Sciences Engineering indicated a slightly improved performance with the Solarsorb coating. The Solarsorb coating proved to be difficult to apply; careful coating thickness control was required. In addition, some trouble was experienced with aluminum panel preparation. The Solarsorb paint peeled badly during high temperature stagnation testing, possibly due to inadequate preparation. Also a report was received from the vendor that the paint would peel at temperatures of -20°F or below. The problems previously listed, combined with only modest performance improvement, led to a decision to use the "Nextel" paint as an absorber coating.

Black chrome was considered as an absorber coating, but was not deemed cost effective for the modest (140°F) temperature requirements of this collector design.

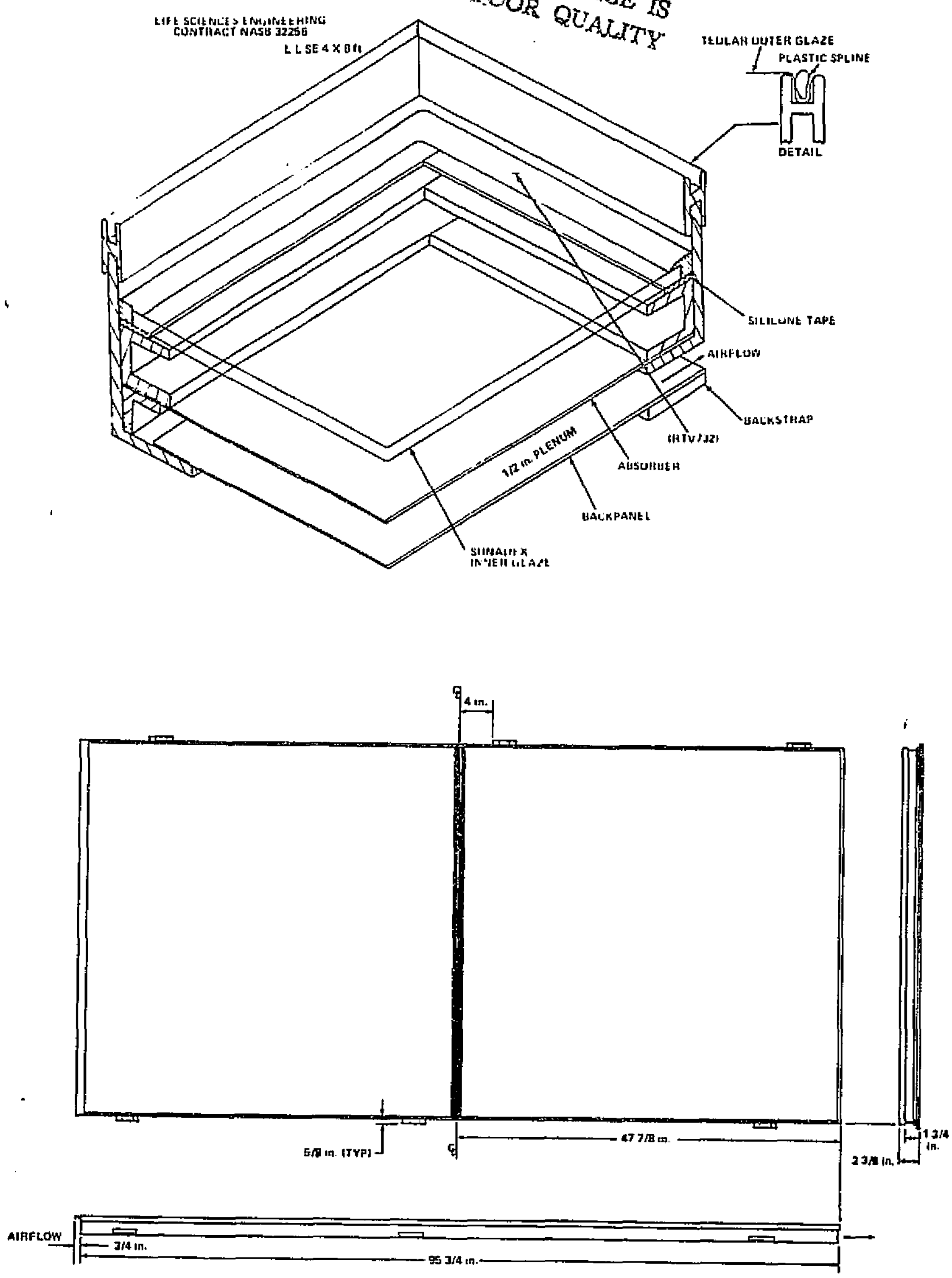

Figure 5. Life Sciences Engineering final collector configuration.

d. Flow Rate Determination — Using a criterion of a temperature rise in a single collector of ~50°F, collector performance with flow rates of 60, 120, and 240 ft^3/min was calculated. From these calculations, a nominal flow rate of 120 ft/min was selected. Performance tends to fall more rapidly at rates less than 120 ft/min and very rapidly at rates <60 ft/min. The performance tends to be asymptotic at rates >240 ft/min.

e. Number and Types of Glazings — Two glazings were selected at the beginning of the development. "Tedlar" was selected as the outer glazing to make the collector lighter and to protect the inner glazing of glass.

Glass stress calculations using standard wind loads and safety factors led to selection of 5/32 in. thick tempered glass. For additional safety and ease of installation, two panels each 4 × 4 ft were used.

Later performance considerations led to selection of 5/32 in. thick "Sunadex" high transmissivity glass manufactured by ASG Industries. Comparative testing confirmed the correctness of this selection.

f. Other Development Items.

(1) Back Panel Paint — The back side of the absorber panel was painted, as an experiment, to improve heat transfer. There was no measurable improvement in performance.

(2) Thermal Expansion and Buckling — There was an initial problem with absorber plate buckling. Tests and analysis resulted in the use of oval-shaped holes for rivets holding the panel in place. During riveting, temporary shims were placed between the plate and structure to allow plate movement after riveting.

(3) Weld Versus Solder — Initial plans were to use solder to assemble the aluminum frame. Comments regarding the difficulty of process control problems were made during design reviews. This caused the contractor to change to the use of welding.

g. Instrumentation Development.

(1) Hook Gauge — As a means of calibrating other air flow measuring devices, a special instrument was procured to measure very small amounts of differential pressure between closely spaced ports in the air conduit. This device called "Micro Tector Electronic Hook Gauge with Kiel Probes" is a

laboratory type instrument requiring time consuming setup and warmup procedures. The device was self-calibrated by comparing readings of ports in the center and midway from the sides of the air conductor and by comparing it with other flow measuring devices.

(2) Thomas Meter — Due to the unusually low air flow rate and the requirement for being compatible with automatic data recording, a special type of flowmeter was constructed. The device, originated by Mr. C. C. Thomas in the early part of the century, utilizes the temperature rise caused by a known amount of heat applied at the measuring point to determine air flow.

(3) Automatic Data Recording — The Thomas Meter, blower fan speed indicator, solar insolation measuring devices, weather monitors, as well as various temperature measuring devices were connected to a Doric Scientific Digitrend automatic data recorder to record information from various tests.

C. Design Reviews

Design reviews were held at four stages of design. The review titles (self-explanatory) and dates were as follows:

Title	Date
Preliminary Design Review	January 19, 1977
Prototype Design Review	June 7, 1977
First Article Review	October 6, 1977
Acceptance Review of Three Collectors	October 6, 1977
Acceptance Review of Seven Collectors	November 4, 1977

At each review, questions and comments about the design were recorded on a standard MSFC Form No. 487, "Review Item Discrepancy" (RID). The contractor provides a response to each RID. Four RID's were written by NASA against the preliminary design, thirteen against the prototype design, and four (none involving hardware design) against the final design as represented by the first (production) article. Copies of all RID's and responses are included as Appendix B.

D. Verification (Qualification) and Certification

1. Verification. Verification was made against the criteria established in the performance specification which, in turn, is based on applicable requirements of the interim performance criteria. The following four methods of performance verification were used:

a) By similarity to another item which has been qualified.

b) By analysis of worst-case exposure conditions and of maximum safe permissible exposure with a comparison of the two.

c) By inspection to insure that dimensions and assembly methods were correct.

d) By test.

Sixty-five items or facets of performance were verified.

2. Certification. The contract required that the collector be certified by an independent test laboratory. Initial correspondence (November 1976) with several national organizations indicated that they were not yet ready to provide the certification service. Therefore, arrangements were made with a local registered professional engineer to monitor the company's efforts, to be responsible that performance was as claimed, and to certify that the item was ready for use by the general public.

A combined verification and certification is included as Appendix C. Thermal performance test results with a comparison to requirements is shown in Figure 6.

3. MSFC Test Facility Results. One of the collectors was subjected to thermal performance tests at the indoor test facility at MSFC in Huntsville, Alabama. The test report from MSFC is being published separately (see Section V).

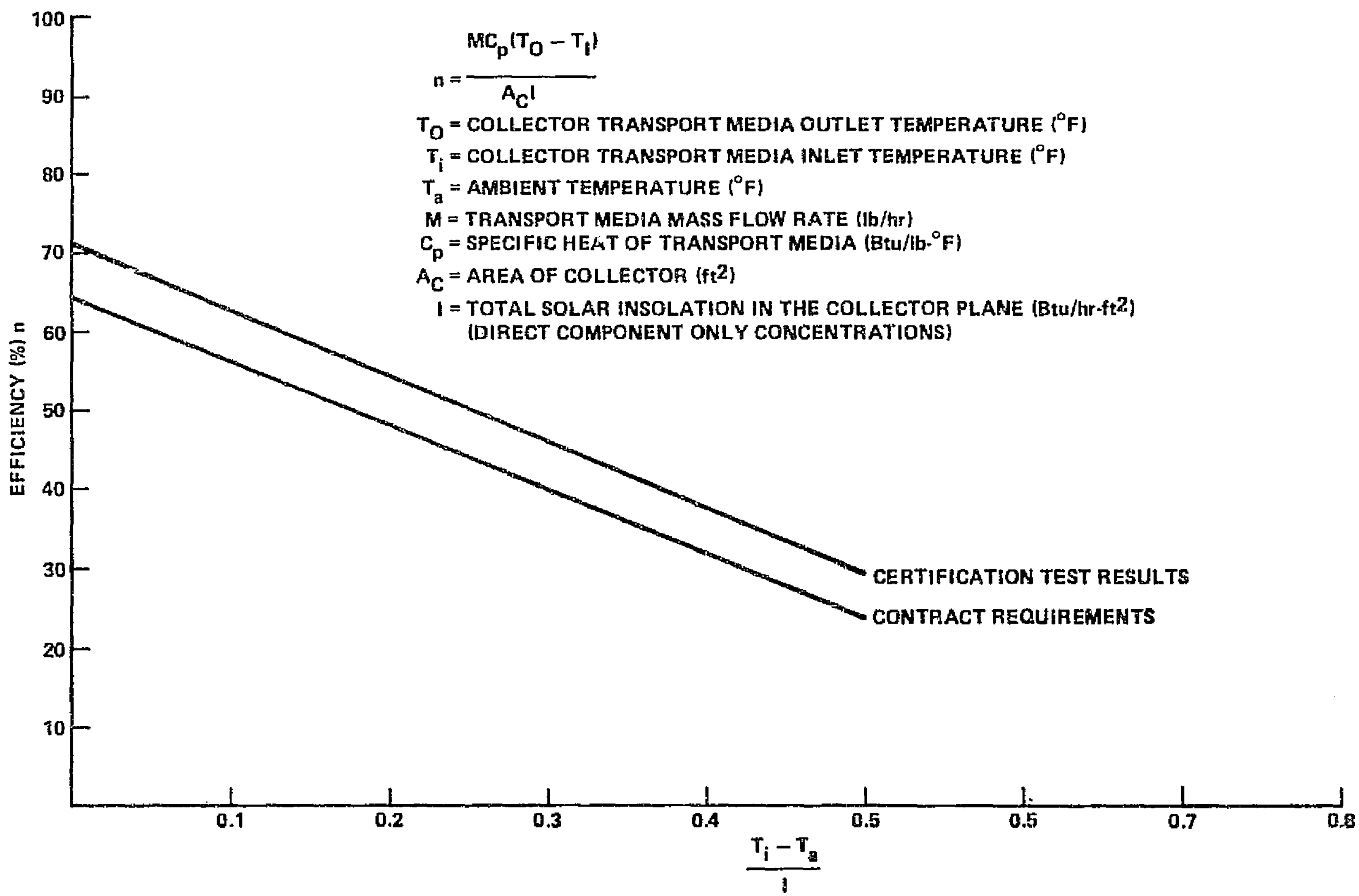

Figure 6. Efficiency as a function of operating conditions; performance must be above line.

V. OTHER AVAILABLE INFORMATION

The following is a list of contractor reports which can be obtained from the Department of Energy, Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830. Telephone Number (615) 483-8611, Extension 34672.

Title	Document Number
Life Sciences Engineering System Design Package	DOE/NASA CR-150611
Life Sciences Engineering Installation Package	DOE/NASA CR-150536
Life Sciences Engineering Quarterly Reports (Collation)	DOE/NASA CR-150519
Life Sciences Engineering Preliminary Design Package	DOE/NASA CR-150601
Wyle Test Report	DOE/NASA CR-150665

VI. CONCLUSION

It is apparent that the primary goal of the contract was attained. The solar collector was brought from a prototype stage to marketable maturity, and all tasks and efforts were met within negotiated costs and schedules.

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APPENDIX A

PERFORMANCE SPECIFICATION
SPEC NO. SHC-3058
FINAL ISSUE

REVISION 1
Dated 11/30/76
CCBD 301-76-0057

REVISION 2
Dated 5/24/77
CCBD 301-77-0144

REVISION 3
Dated 12/6/77
CCBD 301-77-0241

REVISION 4
Dated 12/20/77

REVISION 5
Dated 6/1/78

SUBSYSTEM PERFORMANCE IDENTIFICATION

1. Introduction

This Performance Specification establishes the requirements for the design and performance of the Solar II Collector Subsystem for use in solar heating only of single family residences and mobile homes. It designates the Interim Performance Criteria applicable to this subsystem and defines the deviations. This appendix specifies the performance of the collector subsystem and the installation drawings.

2. Applicable Documentation

2.1 Government Documents

Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems and Dwellings, Jan. 1, 1975. U. S. Department of Housing and Urban Development.

2.2 Contractor Documents

SHC-3070, Installation, Operation and Maintenance Manual, 9/15/77.
SHC-3094, Design Data Brochure, 9/10/77.

3. Application of Interim Performance Criteria by Type of Subsystem

The Interim Performance Criteria in Table I are applicable.

4. Deviations from Interim Performance Criteria

None

5. Government Furnished Property

None

6. Government Directed Requirements

Government directed requirements have been incorporated into this specification.

7. Subsystem Appendices

None

8. Warranty (Limited)

The Solar II Collector is warranted for 1 year from time of delivery. This warranty covers manufacturing craftsmanship and normal environment conditions. It does not cover installation mishandling or willful 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.

SPECIFICATION NO SHC-3058
REVISION 3
DATE 12/6/77

TABLE I

RESIDENTIAL SUBSYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

SHEET 1 OF 6

SUBSYSTEM APPLICATION

A – APPLICABLE TO TYPE SYSTEMS INDICATED

NA – NOT APPLICABLE

TYPE SYSTEMS

H – HEATING

HC – HEATING AND COOLING

HW – HOT WATER

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS H	HC	HW	RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS H	HC	HW
1.1 H and HC Performance	NA	NA	NA	1.3.1 Collector Efficiency	A	A	A
1.1.1 Heating Design Temperatures	NA	NA	NA	1.4 Thermal Storage	NA	NA	NA
				1.4.1 Storage Capacity	NA	NA	NA
1.1.2 Cooling Design Temperatures	NA	NA	NA	1.5 Habitability of Occupied Spaces	NA	NA	NA
1.1.3 Relative Humidity and Water Vapor Pressure	NA	NA	NA	1.5.1 Heat or Humidity Transfer Effects	NA	NA	NA
1.1.4 Solar Contribution	NA	NA	NA	1.6 Energy Transport Efficiency	NA	NA	NA
1.1.5 Operation Impairment	NA	NA	NA	1.6.1 Thermal Losses and Electrical Power	NA	NA	NA
1.2 HW System/Subsystem Performance	NA	NA	NA	1.7 Control	NA	NA	NA
				1.7.1 Installation and Maintenance	NA	NA	NA
1.2.1 Water Design Temperature	NA	NA	NA	1.7.2 Manual Adjustment	NA	NA	NA
1.2.2 Storage Design Capacity	NA	NA	NA	1.7.3 Inhabited Space Temperature	NA	NA	NA
1.2.3 Solar Contribution	NA	NA	NA	1.7.4 Hot Water Temperature	NA	NA	NA
1.2.4 Operational Impairment	NA	NA	NA	1.8 Auxiliary Energy	NA	NA	NA
1.3 Collector Performance	A	A	A	1.8.1 Design Loads	NA	NA	NA

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TABLE I

RESIDENTIAL SUBSYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

SUBSYSTEM APPLICATION

A – APPLICABLE TO TYPE SYSTEMS INDICATED
NA – NOT APPLICABLE

TYPE SYSTEMS

H – HEATING
HC – HEATING AND COOLING
HW – HOT WATER

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS H	HC	HW	RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS H	HC	HW
2.1 System Design Conditions	A	A	A	2.3.1 Pressure Test: Nonpotable Fluids	NA	NA	NA
2.1.1 Equipment Capabilities	A	A	A	2.3.2 Pressure Test: Potable Water	NA	NA	NA
2.1.2 Noise or Erosion - Corrosion	A	A	A	2.3.3 Air Transport Systems	A	A	A
2.1.3 Operating Conditions	A	A	A	2.4 Collector Adjustment	NA	NA	NA
2.1.4 Fluid Flow in Collectors	A	A	A	2.4.1 Orientation and Tilt	NA	NA	NA
				2.4.2 Mutual Shadowing	A	A	A
2.1.5 Entrapped Air	NA	NA	NA	2.5 Subsystem Isolation	NA	NA	NA
2.1.6 Thermal Expansion of Fluids	NA	NA	NA	2.5.1 Shutdown in Multi-family Housing	NA	NA	NA
2.1.7 Pressure Drops	A	A	A	2.6 Heat Transfer Fluid Quality	A	A	A
2.1.8 Condensate Removal	NA	A	NA				
2.2 Mechanical Stresses	A	A	A	2.6.1 Liquid Quality	NA	NA	NA
				2.6.2 Air Quality	A	A	A
2.2.1 Vibration Stress Levels	A	A	A	2.6.3 Fluid Quality	NA	NA	NA
2.2.2 Vibration from Moving Parts	A	A	A	2.6.4 Freezing Protection	NA	NA	NA
				2.7 Piping Supports	NA	NA	NA
2.2.3 Water Hammer	NA	NA	NA	2.7.1 Applicable Plumbing Standards	NA	NA	NA
2.2.4 Vacuum Relief Protection	NA	NA	NA	2.8 Excessive Pressure and Temperature Protection	NA	NA	NA
2.2.5 Thermal Changes	A	A	A	2.8.1 Relief Valves and Vents	NA	NA	NA
2.2.6 Flexible Joints	NA	NA	NA				
2.3 Leakage Prevention	A	A	A	3.1 Structural Design Basis	A	A	A

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REVISION 3
DATE 12/6/77

TABLE I

RESIDENTIAL SUBSYSTEMS. INTERIM PERFORMANCE CRITERIA SUMMARY

SHEET 3 OF 6

SUBSYSTEM APPLICATION

A – APPLICABLE TO TYPE SYSTEMS INDICATED

NA – NOT APPLICABLE

TYPE SYSTEMS

H – HEATING

HC – HEATING AND COOLING

HW – HOT WATER

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS		
	H	HC	HW
3.1.1 Applicable Standards *	A	A	A
3.1.2 Service Loads	A	A	A
3.2 Failure Loads and Load Capacity	A	A	A
3.2.1 Ultimate Load Combinations	NA	NA	NA
3.2.2 Ice Loads	NA	NA	NA
3.2.3 Vehicular Loads	NA	NA	NA
3.2.4 Load Capacity	NA	NA	NA
3.3 Damage Control	A	A	A
3.3.1 Resistance to Damage	NA	NA	NA
3.3.2 Glazing Design	A	A	A
3.4 Cyclic Loads	NA	NA	NA
3.4.1 Deflection Limitations	NA	NA	NA
3.5 Cutting of Structural Elements	NA	NA	NA
3.5.1 Design Provisions	NA	NA	NA
3.6 Creep and Residual Deflection	NA	NA	NA
3.6.1 Deflection Limitations	NA	NA	NA
3.7 Hail Resistance	A	A	A
3.7.1 Hail Size and Loading	A	A	A
3.8 Constraint Loads	NA	NA	NA
3.8.1 Foundation Settlement	NA	NA	NA
3.9 Ponding Condition	A	A	A
3.9.1 Design Provisions	A	A	A
4.1 Plumbing and Electrical Installation	NA	NA	NA
4.1.1 Plumbing Codes	NA	NA	NA
4.1.2 Electrical Codes	NA	NA	NA
4.2 Fail-Safe Controls	NA	NA	NA
4.2.1 System Failure Prevention	NA	NA	NA
4.2.2 Automatic Pressure Relief Valves	NA	NA	NA
4.3 Fire Safety	A	A	A
4.3.1 Applicable Fire Standards	A	A	A
4.3.2 Penetrations through Fire Rated Assemblies	NA	NA	NA
4.4 Toxic	NA	NA	NA
4.4.1 Provisions of Catch Basins	NA	NA	NA
4.4.2 Detection of Toxic and Flammable Fluids	NA	NA	NA
4.5 Safety	NA	NA	NA
4.5.1 Emergency Egress and Access	NA	NA	NA
4.5.2 Identification and Location of Controls	NA	NA	NA

SPECIFICATION NO. SHC-3058
REVISION 3
DATE 12/6/77

TABLE I

RESIDENTIAL SUBSYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

SHEET 4 OF 6

SUBSYSTEM APPLICATION

A – APPLICABLE TO TYPE SYSTEMS INDICATED

NA – NOT APPLICABLE

TYPE SYSTEMS

H – HEATING

HC – HEATING AND COOLING

HW – HOT WATER

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS		
	H	HC	HW
4.6 Protection of Potable Water & Circulated Air	A	A	A
4.6.1 Contamination by Materials	NA	NA	NA
4.6.2 Separation of Circulation Loops	NA	NA	NA
4.6.3 Backflow Prevention	NA	NA	NA
4.6.4 Growth of Fungi	A	A	A
4.7 Excessive Surface Temperatures	A	A	A
4.7.1 Protection from Heated Components	A	A	A
5.1 Effects of External Environment	A	A	A
5.1.1 Solar Degradation	A	A	A
5.1.2 Soil Corrosion	NA	NA	NA
5.1.3 Airborne Pollutants	A	A	A
5.1.4 Dirt Retention on Cover Plate Surface	A	A	A
5.1.5 Abrasive Wear	A	A	A
5.1.6 Fluttering by Wind	A	A	A
5.2 Temperature & Pressure Resistance	A	A	A
5.2.1 Thermal Degradation	A	A	A
5.2.2 Deterioration of Heat Transfer Fluids	NA	NA	NA

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS		
	H	HC	HW
5.2.3 Thermal Cycling Stresses	A	A	A
5.2.4 Leakage	NA	NA	NA
5.2.5 Deterioration of Gaskets and Sealants	A	A	A
5.2.6 Transmission Losses Due to Outgassing	A	A	A
5.3 Chemical Compatibility of Components	A	A	A
5.3.1 Materials/Transfer Fluid Compatibility	NA	NA	NA
5.3.2 Corrosion of Dissimilar Materials	A	A	A
5.3.3 Corrosion by Leachable Substance	NA	NA	NA
5.3.4 Effects of Decomposition Products	A	A	A
5.4 Components Involving Moving Parts	NA	NA	NA
5.4.1 Wear and Fatigue	NA	NA	NA
6.1 Accessibility for Maintenance	A	A	A
6.1.1 Access for System Maintenance	A	A	A
6.1.2 Access for System Monitoring	A	A	A
6.1.3 Draining and Filling of Liquids	NA	NA	NA
6.1.4 Flashing of Liquids Subsystems	NA	NA	NA

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SPECIFICATION NO. SHC-3058
REVISION 3
DATE 10/1/76

TABLE I

RESIDENTIAL SUBSYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

SHEET 5 OF 6

SUBSYSTEM APPLICATION

A – APPLICABLE TO TYPE SYSTEMS INDICATED

NA – NOT APPLICABLE

TYPE SYSTEMS

H – HEATING

HC – HEATING AND COOLING

HW – HOT WATER

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS			RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS		
	H	HC	HW		H	HC	HW
6.1.5 Filters	NA	NA	NA	7.2.2 Storage Area	NA	NA	NA
6.1.6 Potable Water Shutoff	NA	NA	NA	7.2.3 Utility Chases	NA	NA	NA
6.2 Installation, Operation and Maintenance Manual	A	A	A	7.3 Functioning of Dwelling Site	NA	NA	NA
6.2.1 Installation Instructions'	A	A	A	7.3.1 Space Use	NA	NA	NA
6.2.2 Maintenance and Operation Instructions	A	A	A	7.3.2 Shading of Adjacent Structures	NA	NA	NA
6.2.3 Maintenance Plan	A	A	A	7.3.3 Impace of Environment	NA	NA	NA
6.2.4 Replacement Parts	A	A	A	7.3.4 View	NA	NA	NA
6.3 Repair and Service Personnel	A	A	A	8.1 Interference with Mechanical Operation	NA	NA	NA
6.3.1 Maintenance of H and HC Systems	A	A	A	8.1.1 Blockage of Solar Subsystem	NA	NA	NA
6.3.2 Maintenance of DHW System	A	A	A	8.1.2 Shading of Collector	NA	NA	NA
7.1 Design	NA	NA	NA	8.1.3 Sensor Location	NA	NA	NA
7.1.1 Dwelling Design	NA	NA	NA	8.2 Mechanical & Electrical Functioning of Dwelling and Site	NA	NA	NA
7.1.2 Mobile Home Design	NA	NA	NA	8.2.1 Exhaust and Venting	NA	NA	NA
7.1.3 Site Design	NA	NA	NA	8.2.2 Utilities	NA	NA	NA
7.1.4 Passive Use of Solar Energy	NA	NA	NA	8.3 Mechanical & Electrical Functioning of Connections	NA	NA	NA
7.2 Adequate Space	NA	NA	NA	8.3.1 Plumbing Connections	NA	NA	NA
7.2.1 Collector Area	NA	NA	NA				

ORIGINAL PAGE IS
OF POOR QUALITY

Spec No. SHC-3058
Revision 3
Date 12/6/77

TABLE I

RESIDENTIAL SUBSYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

SHEET 6 OF 6

SUBSYSTEM APPLICATION

A – APPLICABLE TO TYPE SYSTEMS INDICATED

NA – NOT APPLICABLE

TYPE SYSTEMS

H – HEATING

HC – HEATING AND COOLING

HW – HOT WATER

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS		
	H	HC	HW
8.3.2 Electrical Connections	NA	NA	NA
9.1 Structural Integrity	NA	NA	NA
9.1.1 Movements in Adjacent Structures	NA	NA	NA
9.2 Structural Integrity of Dwelling	NA	NA	NA
9.2.1 Loads	NA	NA	NA
9.2.2 Penetration of Structural Members	NA	NA	NA
9.3 Structural Connections	NA	NA	NA
9.3.1 Structural Connections	NA	NA	NA
9.3.2 Brittle Subsystem	NA	NA	NA
9.3.3 Strength and Stiffness	NA	NA	NA
10.1 Safety of Dwelling and Site	NA	NA	NA
10.1.1 Fire	NA	NA	NA
10.1.2 Accidents	NA	NA	NA
11.1 Durability	NA	NA	NA
11.1.1 Vegetation	NA	NA	NA
11.2 Durability and Reliability of Dwelling and Site	NA	NA	NA
11.2.1 Chemical Corrosion	A	A	A

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS		
	H	HC	HW
11.2.2 Heat and Moisture	A	A	A
11.2.3 Exterior Penetrations	NA	NA	NA
11.3 Durability and Reliability of Connections	NA	NA	NA
11.3.1 Material Compatibility	NA	NA	NA
12.1 Maintainability of H, HC, HW Systems	NA	NA	NA
12.1.1 Accessibility	NA	NA	NA
12.1.2 Misuse	NA	NA	NA
12.1.3 Permanent Maintainance Accessories	NA	NA	NA
12.2 Maintainability of Dwelling and Site	NA	NA	NA
12.2.1 Accessibility	NA	NA	NA
12.2.2 Ice Dams	NA	NA	NA
12.3 Connections	NA	NA	NA
12.3.1 Accessibility	NA	NA	NA
13.1 Visual Characteristics of Dwelling and Site	NA	NA	NA
13.1.1 Dwelling	NA	NA	NA
13.1.2 Neighborhood	NA	NA	NA

SUBSYSTEM PERFORMANCE SPECIFICATION
APPENDIX A

Spec No. SHC-3058
Revision R- 5
Date 6-1-78

A SUBSYSTEM IDENTIFICATION

This specification defines the performance and installation drawings for the Solar II Collector Subsystem, Life-Sciences Engineering Subsystem Model Number SC4X8.

A-1 SUBSYSTEM PERFORMANCE SHEETS (When installed in accordance with the Installation Manual.)

Total Heating Capacity

The total heating capacity for a 96 square feet collector in 3 panels of the collector subsystem shall be no less than 14400 BTU/Hr under the following Conditions (a) Air entering at a temperature of 70°F dry bulb, 50% RH (b) Air exit temperature of 120°F dry bulb. (c) Flow rate 350 CFM when measured at in b. (d) Clear day conditions at sun position as of December 21 at solar noon.

Exposed heated panel (baseboard or ceiling) temperature shall not exceed 120°F.

Solar Collector

The Solar Collector will collect a minimum of 795 BTU/ft^2/day of energy at an outlet fluid temperature equal to or greater than 172 °F into storage where 140°F air in-flow from storage to the collector for the following conditions:

Tilt Angle 60° Azimuth Angle 187-1/2°
Ambient Temperature 40°F (outside)
Wind Velocity 440 Ft/Min
Date 12/21/75
Noon Solar Flux Normal to the Collector Surface 300 BTU/Hr/Ft^2
Longitude and Latitude 105W, 39.5°N

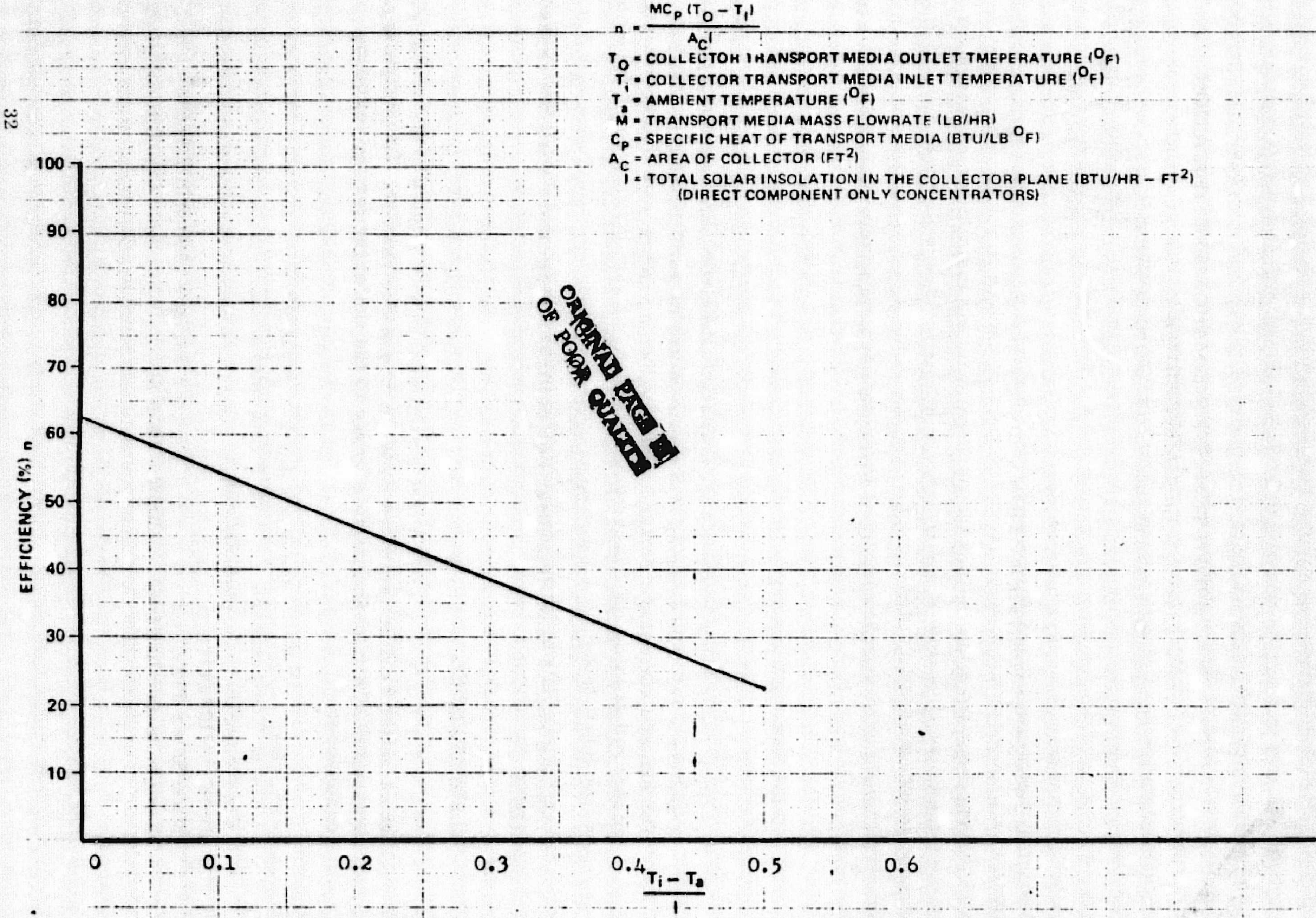


FIGURE 1 EFFICIENCY AS A FUNCTION OF OPERATING CONDITIONS
PERFORMANCE MUST BE ABOVE LINE

APPENDIX B

REVIEW ITEM DISCREPANCIES

REVIEW ITEM DISCREPANCY (RID)

[illegible] NO. 7LS-1	DATE: 1-18-77	PAGE 1 OF 1
[illegible]TOR: Herndon/EP12	SCHEDULED COMPL:	RID NO.
[illegible]D TO:	NASA CHAIRMAN:	[illegible]
ACC[illegible]ED BY:	J. Caudle	REVIEW:

[illegible]: Life Sciences PDR

Drawings

[illegible]TION:

The glass is installed in such a manner as to allow the glass to touch the metal frame. This condition is very susceptible to glass breakage.

ORIGINAL PAGE IS OF POOR QUALITY

REFERENCE:

CLOSEOUT

ACTION TAKEN:

The glass will be protected on the edges to preclude glass to metal contact. Reference Drawing SKSC4X8200-X.

R.W. Scarlata	Earl Herndon	John M. Caudle

ACTION BY (ACTIONEE):	APPROVAL (SUPERVISOR):	ORGINATOR:	NASA PROJECT CLOSURE:
[illegible]	[illegible]	[illegible]	[illegible]
DATE: 1-19-77	DATE:	DATE: [illegible]	DATE: 1/31/77

MSFC - Form 187 (January 1975)

REVIEW ITEM DISCREPANCY (RID)

TRACKING NO. 7LS-2	DATE: 1-18-77	PAGE 1 OF 1
[illegible] Herndon/EP12	SCHEDULED CO[illegible]:	RID NO.
[illegible] TO:	NASA CHA[illegible]: J. Caudle	[illegible] ITEM NO.
[illegible] BY:		REVIEW:

[illegible]: Life Sciences PDR

[illegible]TION:

There is a potential trouble area in installing the tedlar in the "H" groove.

If too much glue is put in the groove, it could become entroped when installing the tedlar, making it difficult to push the spline and tedlar into the groove.

ORIGINAL PAGE IS OF POOR QUALITY

REFERENCE:

CLOSEOUT

ACTION TAKEN: Our technique was tried with approximately 100% excess glue on one side. We found installation of the tedlar more difficult but satisfactory.

On a special 1 foot section, 200% excess glue was used. A 1/16" smear of glue appeared above and on the inside of the tedlar.

Installation instructions wil describe this process in detail.

ACTION BY (ACTIONEE):	APPROVAL (SUPERVISOR): R.W. Scarlata	ORGINATOR: Earl Herndon	NASA PROJECT CLOSURE: John M. Caudle
DATE:	DATE:	DATE:	DATE: 1/21/77

REVIEW ITEM DISCREPANCY (RID)

[illegible] NO. TLS-3	DATE: 1-18-77	PAGE 1 OF 1
[illegible]: Herndon/EP12	[illegible]:	RID NO.
[illegible]	NASA [illegible]:	[illegible]
[illegible] BY:	J. Caudle	REVIEW:

Life Sciences PDR

Drawings

[illegible]TION:

Absorber plate is mounted directly to frame, thus causing a direct heat short. Some type of isolator should be between the absorber plate and the side of the collector. Absorber plate should not be mounted directly to frame thermal expansion will buckle plate.

ORIGINAL PAGE IS OF POOR QUALITY

[illegible]ENCE:

CLOSEOUT

ACTION TAKEN:

Design philosophy dictated insulation on the outside of the frame. See reference Drawing SK834X8200-X.

The absorber plate retention technique will provide for slip joint type expansion in both length and width. Also, the plenum support spacers are expected to provide additional stiffness to preclude buckling.

ACTION BY (ACTIONEE):	APPROVAL (SUPERVISOR):	ORGINATOR:	NASA PROJECT CLOSURE:
	[signature]	Earl Herndon	John M. Caudle
DATE: 1-19-77	[illegible] 77	DATE:	DATE: [illegible]

TRACKING NO. 7LS-4	DATE: 1-18-77	PAGE 1 OF 1
ORGINATOR: Herndon/EP12	SCHEDULED COMPL:	RID NO.
ASSIGNED TO:	NASA CHAIRMAN:	END ITEM NO.
ACCEPTED BY:	J. Caudle	REVIEW:

SUBJECT: Life Sciences PDR

Insulation

DESCRIPTION:

No insulation is evident in this collector. Surely performance is adversely affected by this lack of insulation.

REFERENCE:

CLOSEOUT

ACTION TAKEN: DESIGN PHILOSOPHY DICTATED INSULATION ON THE OUTSIDE OF THE FRAME. SEE REFERENCE DRAWING SK-SC 9X8200-X

ACTION BY (ACTIONEE):	APPROVAL (SUPERVISOR): R.W. Scarlata	ORGINATOR: Earl Herndon	NASA PROJECT CLOSURE: John M. Caudle
DATE: 1/19/77	DATE:	DATE:	DATE: 1/31/77

MSFC - Form 4?7 (January 1975)

REVIEW ITEM DISCREPANCY (RID)

TRACKING NO. 7LS-5	DATE: 5/31/77	PAGE 1 OF 1
ORGINATOR: E. Simon/EP45	SCHEDULED COMPL: 6/24/77	RID NO.
ASSIGNED TO:	NASA CHAIRMAN:	END ITEM NO.
ACCEPTED BY:	J. Caudle	REVIEW:

SUBJECT: Life Sciences SDR

Collector Installation

DESCRIPTION:

Hold down "T" section of "FESCO" board does not have the strength required.

REFERENCE:

Dwg No. SC4x8106 Sheet 2

CLOSEOUT

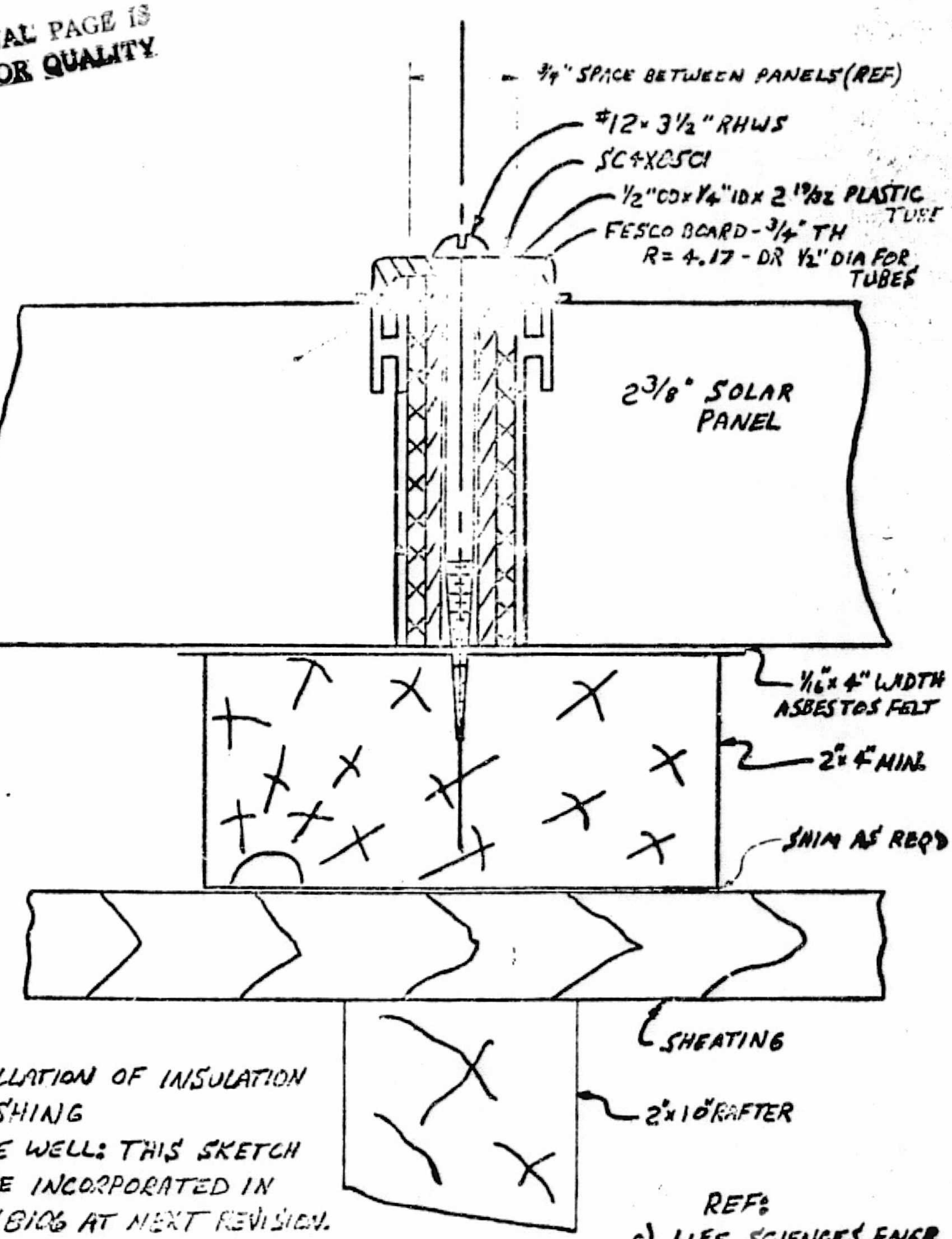
ACTION TAKEN: The rigid plastic/fiberglass 'U' channel discussed at the 5/24 Technical Conference will provide the necessary strength to hold down the Fesco board. A 2 5/8" rigid plastic standoff tube will maintain proper pressure on the gasket/Tedlar interface.

The design imposed no strength requirement on the Fesco board.

See attached sketch.

Glenn K. Condit	C.H. Murriser	W.E. Simon	John M. Caudle
ACTION BY (ACTIONEE): [signature]	APPROVAL (SUPERVISOR): C H Murriser	ORGINATOR:	NASA PROJECT CLOSURE: [signature]
DATE 4-JUN77	DATE: 6-14-77	DATE:	DATE: 6/20/77

[illegible] Form 847 (January 1975)



INSTALLATION OF INSULATION & FLASHING

NOTE WELL: THIS SKETCH TO BE INCORPORATED IN SC4X8106 AT NEXT REVISION.

DWN: G. CONDIT, 8 JUN 77

APP'D: C[illegible] [illegible]

REF:

a) LIFE SCIENCES ENGR DWG SC4X8106, SH 2/3.

b) RID 7LS-5

REVIEW ITEM DISCREPANCY (RID)

TRACKING NO. 7LS-6	DATE: 5/31/77	PAGE 1 OF 1
ORGINATOR: E. Simon/EP45	SCHEDULED COMPL: 6/24/77	RID NO.
ASSIGNED TO:	NASA CHAIRMAN: J Caudle	END ITEM NO.
ACCEPTED BY:		REVIEW:

SUBJECT: Life Sciences SDR

Installation

DESCRIPTION:

Installation is complex for average field installer - more factory pre-assembly needs to be done.

REFERENCE:

Installation, Operation and Maintenance Manual SHC-3070

CLOSEOUT

ACTION TAKEN: The plastic/fiberglass 'U' channel and special curved end connectors will simplify installation. These extra cost items are listed in the Spare Parts List. The Pedlar/H-Bar frame can be pre-assembled as provided on the 1st 3 delivered items. As an extra cost option, a complete assembly with custom designed insulation, end connectors and a complete installation kit can be provided. This custom design requires the customer to supply detailed drawings.

C.H. Murriser	R.W. Scarlata	E. Simon	John M. Caudle
ACTION BY (ACTIONEE): C H Murriser	APPROVAL (SUPERVISOR): [signature]	ORGINATOR:	NASA PROJECT CLOSURE: John M. Caudle
DATE 6-9-77	DATE: 6/17/77	DATE:	DATE: 6/20/77

MSFC Form 487 (January 1975)

REVIEW ITEM DISCREPANCY (RID)

TRACKING NO. 7LS-7	DATE: 5/31/77	PAGE 1 OF 1
ORGINATOR: E. Simon/EP45	SCHEDULED COMPL: 6/24/77	RID NO.
ASSIGNED TO:	NASA CHAIRMAN: J. Caudle	END ITEM NO.
ACCEPTED BY:		REVIEW:

SUBJECT:

Life Sciences SDR

Collector Installation

DESCRIPTION:

Inadequate insulation between flashing and collector

REFERENCE:

Dwg No. SC4X8106 Sheet 3

ORIGINAL PAGE IS OF POOR QUALITY

CLOSEOUT

ACTION TAKEN: Dwg. SC4X8106 Rev A Sheet 3 has been changed to increase insulation between the flashing and the collector. The 'Z' end connector has been changed to a curved end connector. The change permits and additional 2"x2"x 44" Fesco insulation above this curved end connector. The Fesco cant strip has been increased in size for additional insulation.

C.H. Murriser	R.W. Searlata	E. Simon	John M. Caudle
ACTION BY (ACTIONEE):	APPROVAL (SUPERVISOR):	ORGINATOR:	NASA PROJECT CLOSURE:
DATE: 6-9-77	DATE: 6/14/77	DATE:	DATE: 6/20/77

MSFC - Form 457 (January 1975)

REVIEW ITEM DISCREPANCY (RID)

TRACKING NO. 7LS8	DATE: 5/31/77	PAGE 1 OF 1
ORGINATOR: E. Simon/EP45	SCHEDULED COMPL: 6/24/77	RID NO.
ASSIGNED TO:	NASA CHAIRMAN: J Caudle	END ITEM NO.
ACCEPTED BY:		REVIEW:

SUBJECT: Life Sciences SDR

Collector Stagnation Tests

DESCRIPTION:

Collector stagnation tests should have openings closed (not stacked flow)

REFERENCE:

Second Quarterly Report 4.3.2

CLOSEOUT

ACTION TAKEN: Stagnation test were made with the openings closed. These tests were conducted on 4/6/77 and 4/22/77 as identified in the Second Quarterly Report on pages 4-11 and 4-12.
At many other times when the collectors were not being used for testing, they were in a stagnation condition with just stack flow (convection flow).

Harry R. Null	R. W. Scarlata	E. Simon	John M. Caudle
ACTION BY (ACTIONEE): [signature]	APPROVAL (SUPERVISOR): [signature]	ORGINATOR:	NASA PROJECT CLOSURE: [signature]
DATE: 6/14/77	DATE: 6/14/77	DATE:	DATE: 6/20/77

REVIEW ITEM DISCREPANCY (RID)

TRACKING NO. 7LS-9	DATE: 5/27/77	PAGE 1 OF 1
ORGINATOR: M. L. Roberts / EH43	SCHEDULED COMPL: 6/24/77	RID NO.
ASSIGNED TO:	NASA CHAIRMAN:	END ITEM NO.
ACCEPTED BY:	J Caudle	REVIEW:

SUBJECT:

Life Sciences Engineering
Soldering Aluminum Solar Collector structure

DESCRIPTION:

Aluminum soldering to obtain a reliable structural joint is very complex process and requires strict control of time, temperature, and surface preparation. Development of technique and experience will involve considerable expenditure of time and materials. Complete removal of the very aggressive fluxes, to prevent corrosion could be difficult. Corrosion protection after soldering would be helpful.

REFERENCE:

Dwg. No. SC4X8102

RID CLOSEOUT

ACTION TAKEN: Aluminum welding will be used instead. This is shown on revised drawings. The welding process will be either MIG or TIG which does not use flux.

Glenn K. Condit	R.W. Scarlata	Marion L. Roberts	John M. Caudle
ACTION BY (ACTIONEE): [signature]	APPROVAL (SUPERVISOR): [signature]	ORGINATOR: Marion L. Roberts	NASA PROJECT CLOSURE: John M. Caudle
DATE: 14JUN77	DATE: 6/[illegible]/77	DATE: 6-20-77	DATE: 6/20/77

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REVIEW ITEM DISCREPANCY (RID)

TRACKING NO. 7LS-10	DATE: 5-27-77	PAGE 1 OF 1
ORGINATOR: M. L. Roberts	SCHEDULED COMPL: 6/24/77	RID NO.
ASSIGNED TO:	NASA CHAIRMAN:	END ITEM NO.
ACCEPTED BY:	J Caudle	REVIEW:

SUBJECT: Life Sciences Engineering
Securing Tedlar Glazing to "H" bar

DESCRIPTION:

Forcing tedlar glazing into the "H" bar especially at the corners of the collector will place concentrated loads on the material and possibly decrease expected life. The sharp edge on the "H" bar and the corner joints of the "H" bar are places where the tedlar could be cut or abraded during installation and use.

REFERENCE: Drawing No. SC4X8106 and SC4X8101

CLOSEOUT

ACTION TAKEN: The inner corner of the H-Bar channel is rounded to 1/16"as shown in the IOM Manual.drawing. The inner edges of the H-Bar will be checked for roundness and rounded where necessary. This is also noted on SC4X8101 Sheet 2.

The inner edge of the H-Bar will be rounded to a 0.062 radius.

We have not experienced any cutting of the Tedlar to date.

ACTION BY (ACTIONEE):	APPROVAL (SUPERVISOR):	ORGINATOR:	NASA PROJECT CLOSURE:
[signature]	[signature]	Marion L. Roberts	[signature]
DATE: 14JUN77	DATE: [illegible]/77	DATE: 6-20-77	DATE: 6/2[illegible]/77

OK

REVIEW ITEM DISCREPANCY (RID)

REVIEWING NO. 7LS-11	DATE: 5/26/77	PAGE 1 OF 1
ORIGINATOR: Herndon, Anthony	SCHEDULED COMPL: 6/24/77	RID NO.
ASSIGNED TO:	NASA CHAIRMAN:	END ITEM NO.
ACCEPTED BY:	J Caudle	REVIEW:

SUBJECT:

Life Sciences
Drawing SC4X8101 (Sheets 1 - 3)

DESCRIPTION:

1. H-Bar should have rounded edges to prevent damage to tedlar.

2. Glass is shown with silicone U-channel in H-Bar (1-2) but not around remaining edges. How is glass restrained in collector? There should never be any glass to metal contact. This is unacceptable.

ORIGINAL PAGE IS OF POOR QUALITY

ORIGINAL PAGE IS OF POOR QUALITY

REFERENCE:

CLOSEOUT

ACTION TAKEN: 1. The inner corner of the H-Bar channel is rounded to 1/16" as shown in in the ICH Manual drawing. See also 7LS-10. The inner edge of the H-Bar will be rounded to a 0.052 radius.

2. Glass is protected on the 3 remaining sides by a silicone rubber strip or appropriate material preventing glass to metal contact with the 5/8" 'U' channel. Dow-Corning RTV 732 adhesive is used to prevent glass to metal contact with the frame sides and ends. It is also used to retain the glass as shown in SC4X8101 sheet 2, Rev A show this in 1-10. Sheet 2 also shows the silicone rubber strip in 1-11.

Glenn K Condit	R.W. Scarlata	Earl Herndon	John M. Caudle
ACTION BY (ACTIONEE): [signature]	APPROVAL (SUPERVISOR): [signature]	ORGINATOR: [signature]	NASA PROJECT CLOSURE: [signature]
DATE 14JUN77	DATE: [illegible]/77	DATE: 6-23-77	DATE: [illegible]

REVIEW ITEM DISCREPANCY (RID)

TRACKING NO. 7LS-12	DATE: 5/26/77	PAGE 1 OF 1
ORGINATOR: Herndon, Anthony	SCHEDULED COMPL: 6/24/77	RID NO.
ASSIGNED TO:	NASA CHAIRMAN: J Caudle	END ITEM NO.
ACCEPTED BY:		REVIEW:

SUBJECT:

Life Sciences
Drawing SC4X8101

DESCRIPTION:

Drawings do not show installation of glass and gasket. How is gasket and glass retained?

REFERENCE:

CLOSEOUT

ACTION TAKEN: The gasket will be retained by a silicone adhesive such as Dow-Corning RTV 732 or appropriate adhesive. The glass will be retained with Dow-Corning RTV 732 as shown in SC4X8101 Rev A sheet 1, item 1-10.

Glenn K. Condit	R.W. Scarlata	Earl Herndon	John M. Caudle
ACTION BY (ACTIONEE): [signature]	APPROVAL (SUPERVISOR): [signature]	ORGINATOR: Earl Herndon	NASA PROJECT CLOSURE: [signature]
DATE: 14 JUN 77	DATE: [illegible]	DATE: 6-23-77	DATE: 6/[illegible]/77

REVIEW ITEM DISCREPANCY (RID)

TRACKING NO. 7LS-13	DATE: 5/26/77	PAGE 1 OF 1
ORGINATOR: Herndon, Anthony	SCHEDULED COMPL: 6/24/77	RID NO.
ASSIGNED TO:	NASA CHAIRMAN:	END ITEM NO.
ACCEPTED BY:	J Caudle	REVIEW:

SUBJECT:

Life Sciences
Dwg. SC4X8103

DESCRIPTION:

1. Right hand projection is reversed (channels on wrong side).

2. Method of attaching U channels and cross channel to absorber (rivets) is very suspect to cause local buckling of absorber plate.

ORIGINAL PAGE IS OF POOR QUALITY

REFERENCE:

CLOSEOUT

ACTION TAKEN: 1. Projection was corrected on SC4X8103 Rev A Sheet 1.
2. Method of attaching 'U' channels to absorber panel was revised at the Technical Review on 5/24 with 1/4"x5/32" obround holes for rivets with washers. The Technical Review also recommended 2 bolts to hold the absorber panel to the cross brace with the 'U' channel, as shown on SC4X8103, Sheet 1, Rev B, Sheet 2 Rev A and Sheet 3 Rev A.

Glenn K. Condit	C.H. Murriser	Earl Herndon	John M. Caudle
ACTION BY (ACTIONEE):	APPROVAL (SUPERVISOR):	ORGINATOR:	NASA PROJECT CLOSURE:
[signature] 6-14-77	[signature] 6-14-77	[signature] 6-23-77	[signature] 6/23/77

REVIEW ITEM DISCREPANCY (RID)

TRACKING NO. 7LS-14	DATE: 5/26/77	PAGE 1 OF 1
ORIGINATOR: Herndon, Anthony	SCHEDULED COMPL: 6/24/77	RID NO.
ASSIGNED TO:	NASA CHAIRMAN: J. Caudle	END ITEM NO.
ACCEPTED BY:		REVIEW:

SUBJECT:

Life Sciences
Dwg. SC1X3102

DESCRIPTION:

Views and sections on Sheet #2 are not drawn in the correct orientation in relationship to the cutting plane on Sheet #1 and are not complete.

[illegible] A-A & B-B are still not drawn in the correct orientation in relationship to the cutting plane on sheet #1. But, since this relates [illegible] procedures and not design, RID can be closed. EH

REFERENCE: Engineering Graphics for Design and Analysis, Hammond, Buck, Rogers, Walsh, & Ackert, The Ronald Press, New York, 1964, Chapt. 7, Lib. Cong. #64-13335.

CLOSEOUT

ACTION TAKEN: Section A-A is taken looking transversely into a corner. This places the vertical (2") leg of 1-1 to the viewers left. Section B-B is taken looking longitud- into a corner. This places the vertical (1 1/2") leg of 1-2 to the viewers left. View C-C in the unrevised drawing is a view of the lower (inlet) end from the bottom (roof) plane. This places the end member (1-2) to the viewers left. View D-D in the unrevised drawing is a view of the lower (inlet) end from th top (solar side) plane. This places the end member (1-2) to the viewers right. The view was the only incorrect drawing, the sheet was obsoleted and replaced.

Glenn K. Caudit	C.H. Musriser	Earl Herndon	John M. Caudle
ACTION BY (ACTIONEE): [signature]	APPROVAL (SUPERVISOR): C H [signature] 6-14-77	ORGINATOR: Earl Herndon 6-23-77	NASA PROJECT CLOSURE: [signature] 6/[illegible]

REVIEW ITEM DISCREPANCY (RID)

TRACKING NO. 7LS-15	DATE: 5/26/77	PAGE 1 OF 1
ORIGINATOR: Herndon, Anthony	SCHEDULED COMPL: 6/24/77	RID NO.
ASSIGNED TO:	NASA CHAIRMAN:	END ITEM NO.
ACCEPTED BY:	J Caudle	REVIEW:

SUBJECT:

Life Sciences
Dwg. SC4X8106, sheet 2

DESCRIPTION:

The cover flashing as showing is crimping the tedlar covers. It should be made as to not bear directly on the tedlar. Tedlar crimped between 2 pieces of metal would be very suspect to failure at this point. If more details had been drawn on this drawing, the above would have been more obvious.

ORIGINAL PAGE IS OF POOR QUALITY

REFERENCE:

CLOSEOUT

ACTION TAKEN: Revised drawing SC4X8106 sheet 2 shows a 1 1/4" plastic/fiberglass 'U' channel for the flashing. It will hold down the Fesco board. Where the 'J' channel/Fesco board interfaces with the H-Bar/Tedlar, gaskets will be used.

C.H. Murriser	R.W. Scarlata	Earl Herndon	John M. Caudle
ACTION BY (ACTIONEE):	APPROVAL (SUPERVISOR):	ORIGINATOR:	NASA PROJECT CLOSURE:
C.H. Murriser	[signature]	Earl Herndon	[signature]
6-9-77	[illegible]	6-23-77	6/2?/77

REVIEW ITEM DISCREPANCY (RID)

[illegible] NO. 7LS-16	DATE: 5/25/77	PAGE 1 OF 1
[illegible]: [illegible]rndon, Anthony	SCHEDULED COMPL: 6/24/77	RID NO.
[illegible]D TO:	NASA CHAIRMAN: J. Caudle	END ITEM NO.
[illegible]TED BY:		REVIEW:

[illegible]CT:

[illegible] Sciences

[illegible] SC4X10106, sheet 3

[illegible]SCRIPTION:

The flashing is to close to the "Z" flow channels and does not allow adequate space for insulation. The "Z" channel could be made as a curved piece and/or the flashing could be moved further away from the "Z" channel to allow space for insulation.

[illegible]NCE:

CLOSEOUT

[illegible]TION TAKEN: Dwg SC4X8106 Rev A Sheet 3 shows a curved end connector replacing the 'Z' connector. This drawing also shows an additional 2"x2"x44" Fesco insulation above this curved section. The Fesco cant strip has been increased in size for additional insulation.

C.H. Murriser	R.W. Scarlata	Earl Herndon	John M. Caudle
[illegible]TION BY (ACTIONEE):	APPROVAL (SUPERVISOR):	ORGINATOR:	NASA PROJECT CLOSURE:
[signature]	[signature]	[signature] [illegible]-77	[illegible]

OK

REVIEW ITEM DISCREPANCY (RID)

TRACKING NO. 7LS-17	DATE: 5/26/77	PAGE 1 OF 1
ORGINATOR: Herndon, Anthony	SCHEDULED COMPL: 6/24/77	RID NO.
ASSIGNED TO:	NASA CHAIRMAN: J Caudle	END ITEM NO.
ACCEPTED BY:		REVIEW:

SUBJECT:

Life Sciences
Installation Dwg. SC4X8106 (sheets 1-3)

DESCRIPTION:

This drawing depicts rafters on what looks like 48" centers. This is not normally the case, older construction was 16" centers and some later construction is 24" centers. If the inlet and outlet ducts are routed as shown, from half to two-thirds of the rafters would have to be cut. This would be unacceptable. Please explain.

ORIGINAL PAGE IS OF POOR QUALITY

REFERENCE:

CLOSEOUT

ACTION TAKEN: The SC4X8 Collector was baselined for rafters spaced 4 feet on centers. It was primarily designed for stand-alone units and roofs with rafters spaced 4' o.c. However, air blocks can be welded into the openings where the 24" rafter or 16" rafter would pass underneath. These air blocks would be installed at the factory. Special 22" and 14" end connectors would also have to be ordered from the factory. In no way should rafters be cut.

ACTION BY (ACTIONEE):	APPROVAL (SUPERVISOR):	ORGINATOR:	NASA PROJECT CLOSURE:
C.H. Murriser	R.W. Scarlata	Earl Herndon	John M. Caudle
DATE: 6-9-77	DATE: [illegible]	DATE: 6-23-77	DATE: 6-[illegible]-77

REVIEW ITEM DISCREPANCY (RID)

TRACKING NO. 7LS-18	DATE: 9/23/77	PAGE 1 OF 1
ORIGINATOR: E. Simon/EL22	SCHEDULED COMPL: 10/24/77	RID NO.
ASSIGNED TO:	NASA CHAIRMAN:	END ITEM NO.
ACCEPTED BY:	J. Caudle	REVIEW:

SUBJECT: Life Sciences FAR

Solar Efficiency Calculations

DESCRIPTION:

All efficiency calculations must be based on gross collector area.

REFERENCE:

ASHRAE Standard #93, 77. Methods of Testing to Determine the Thermal Performance of Solar Cls.

CLOSEOUT

ACTION TAKEN:

The Acceptance Test data contains an extra collumn, entitled, Efficiency @ Total Area, which meets this requirement.

Harry R. Null	C.H. Murriser	E. Simon	John M. Caudle
ACTION BY (ACTIONEE): [signature]	APPROVAL (SUPERVISOR): C H Murriser	ORIGINATOR: [signature]	NASA PROJECT CLOSURE: [signature]
DATE: 6 Oct 1977	DATE: 9/6/77	DATE: [illegible]	DATE: [illegible]

MSFC Form ...

REVIEW ITEM DISCREPANCY (RID)

TRACKING NO. 7LS-19	DATE: 9/23/77	PAGE 1 OF 1
ORGINATOR: E. Simon/EL22	SCHEDULED COMPL: 10/24/77	RID NO.
ASSIGNED TO:	NASA CHAIRMAN:	END ITEM NO.
ACCEPTED BY:	J. Caudle	REVIEW:

SUBJECT: Life Sciences FAR

Design Brochure

DESCRIPTION:

Statement, "one half of the Ft^2 of the house will save 75% of the fuel costs." This is not the optimum condition economically and it is felt that a statement saying that collector sizing should be individually based on local economics (fuel costs, etc.) Climatic conditions and house heat loads and usually runs between 1/3 to 1/2 the house square footage.

REFERENCE:

Design Brochure under Typical Installation Arrangements

CLOSEOUT

ACTION TAKEN:

The Design Brochure will be changed to include this wording.

Harry R. Null	C.H. Murriser	E. Simon	John M. Caudle
ACTION BY (ACTIONEE): Harry R. Null	APPROVAL (SUPERVISOR): C H Murriser	ORGINATOR: [illegible]	NASA PROJECT CLOSURE: [illegible]
DATE: 6 Oct 1977	DATE: 9/6/77	DATE: [illegible]-20-77	DATE: 11/7/77

MSFC Form 447 (January 1975)

REVIEW ITEM DISCREPANCY (RID)

TRACKING NO. 7LS-20	DATE: 9/23/77	PAGE 1 OF 1
ORIGINATOR: E. Simon/EL22	SCHEDULED COMPL: 10/24/77	RID NO.
ASSIGNED TO:	NASA CHAIRMAN: J. Caudle	END ITEM NO.
ACCEPTED BY:		REVIEW:

SUBJECT: Life Sciences FAR

Collector Glass

DESCRIPTION:

The collector would be better to be assembled with the glass to assure a weather proof unit. This function is better performed in a regular assembly area, not in the field. The savings in shipping would be offset by assembly. Manufacturer must warrant the service of the unit which would be extremely risky for a field assembled unit.

REFERENCE:

Design Brochure

CLOSEOUT

ACTION TAKEN:

Glass installation will be at the distributor level or at the sub-contractor's facility/plant. It is not recommended as a field operation. The warranty will reflect this policy.

Harry R. Null	C.H. Marriser	E. Simon	John M. Caudle
ACTION BY (ACTIONEE): [illegible]	APPROVAL (SUPERVISOR): [illegible]	ORIGINATOR: [illegible]	NASA PROJECT CLOSURE: [illegible]
DATE: 6 Oct 1977	DATE: 9/6/77	DATE: [illegible]	DATE: [illegible]

MSFC - Form [illegible]

REVIEW ITEM DISCREPANCY (RID)

TRACKING NO. 7LS-21	DATE: 9/23/77	PAGE 1 OF 1
ORGINATOR: M. Roberts/EH43	SCHEDULED COMPL: 10/24/77	RID NO.
ASSIGNED TO:	NASA CHAIRMAN:	END ITEM NO.
ACCEPTED BY:	J. Caudle	REVIEW:

SUBJECT:

Life Sciences FAR

Weatherability

DESCRIPTION:

Need more information (data sheet) on Noryl and its weatherability.

ORIGINAL PAGE IS OF POOR QUALITY

REFERENCE:

CLOSEOUT

ACTION TAKEN:
A General Electric data sheet on Noryl EN-185 will be supplied as soon as received.
Mr. John Boyer, Vice President of Thermo Plastics Inc. will send a statement on why he chose EN-185 Noryl plastic for our collector.

Harry R. Null	C.H. Murriser	M. Roberts	John M. Caudle
ACTION BY (ACTIONEE): Harry R Null	APPROVAL (SUPERVISOR): C H Murriser	ORGINATOR: M Roberts	NASA PROJECT CLOSURE: John M Caudle
DATE: 6 Oct 1977	DATE: 9/6/77	DATE:	DATE: 11/7/77

MSFC - Form 487 (January 1971)

APPENDIX C

CERTIFICATION TEST REPORT TO NATIONAL AERONAUTICS AND SPACE ADMINISTRATION FOR AIR FLAT PLATE COLLECTOR QUALIFICATION UNIT MODEL SC4X8

INTRODUCTION

This document constitutes the certification of the Life Sciences Engineering Air Flat Plate Collector, SC4X8. Each major element of the certification plan is delineated, together with test procedures, test results, comments and approval signatures. A separate section is provided for each of the major elements keyed to the pertinent paragraph of the Certification Plan. Each section has a signature block to indicate approval status of the section.

Upon satisfactory completion of the Certification Test, the Certification Agency will affirm the following certification.

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.

N L Fast, PE
NORMAN L. FAST
STRUCTURAL ENGR

Professional Engineer
Certification Agency

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

Colo #5674
Test Engineer
Life Sciences Engineering

Colo PE 8046
Test Director
Life Sciences Engineering

Architectural Engineer
Installation Drawings
Installation, Operations,
Maintenance Manual Sections

BENNETT JAMES SEVERSON
REGISTERED
10989
PROFESSIONAL ENGINEER
STATE OF COLORADO

1.3 COLLECTOR PERFORMANCE

Performance test dates shall be provided for three specific test conditions:

1. Normal operating conditions, nominal input air temperature 70°F.

2. Normal operating conditions, nominal input air temperature 140°F.

3. Stagnation test - input and output ducts blocked.

1.3a TEST DATA

Test Data shall consist of data logger printouts together with an identification listing of each measurement logged. This data shall include primary air flow through collector as determined by a Thomas flow meter; collector air input temperature as measured by copper-constantan thermocouples (3) located no closer than 5 inches from the collector plenum chamber inlet in the direction of primary air flow; collector air outlet temperature as measured by copper-constantan thermocouples (3) located no closer than 18 inches from the collector plenum chamber outlet in the direction of primary air flow; collector absorber plate temperatures as measured by copper-constantan thermocouples cemented to the back-surface of the absorber plate at points indicated in Figure 1; solar radiation as measured by an Eppley Spectral Pyranometer; ambient wet and dry bulb temperatures as measured by copper-constantan thermocouples; relative humidity by calculation; collector efficiency by calculation and time.

1.3.1 COLLECTOR EFFICIENCY

Collector efficiency shall be evaluated from the operational test data collected under 1.3a.

$$\eta = \frac{\text{BTU output}}{\text{BTU input}}$$

$$\eta = \frac{(\text{Mass Flow of Air})(\text{Specific Heat Air})(\text{Outlet Temp.} - \text{Inlet Temp.})}{(\text{Insolation in BTU/ft}^2)(\text{Collector Area})}$$

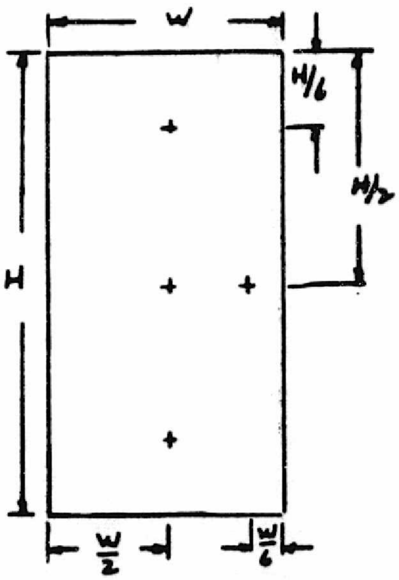


Figure I. Absorber Plate Thermocouple Location

Review of Items 1.3 through 1.3.1 successfully completed.

LSE Test Engineer

LSE Approval

Certification Officer Approval

NASA Approval

2.1 SYSTEM DESIGN CONDITIONS

The collector shall be operated and tested at nominal design temperatures and flow rates in accordance with the following paragraphs:

2.1.1 EQUIPMENT CAPABILITIES

The Life Sciences Engineering Test Facility includes the test equipment listed above in paragraph 1.3a, and in addition, a 100 channel data logger capable of deriving thermal data from RTD's, as well as thermocouples. This data logger is provided with a line printer to record all data in a sequential and repetitive mode. The test facility itself consists of two fully instrumented test cells capable of testing either one 4' x 8' Collector or four 2' x 4' collectors and a third, uninstrumented test cell. Air flow rates are develped by a primary blower with each test cell metered independently.

2.1.2 NOISE OR EROSION, CORROSION

Excessive noise attributed to the collector itself will be subjectively assessed at several different flow rates. Inspection of collector frames, etc., will be made for evidence of erosion and/or corrosion.

2.1.3 OPERATING CONDITIONS

The collector shall be capable of operation under conditions expected in normal service without breakage or significant degradation that could impair their use. Review drawings.

2.1.4 FLUID FLOW IN COLLECTORS

Each test cell air flow rate is metered independently. Should equal flow in each cell be required, dampers are provided for balancing flow.

2.1.7 PRESSURE DROPS

Pressure drops will be measured utilizing a Dwyer Micro Tector Hook Gage (micromanometer) with ports at the collector inlet and outlet.

Review of Items 2.1 through 2.1.7 successfully completed.

Harry R Nuce Colo #5674
LSE Test Engineer

Charles H Murrish, Colo PE 8066
LSE Approval

[illegible] Col 8126
Certification Officer Approval

John M Caudle
NASA Approval

2.2 MECHANICAL STRESS

Mechanical stress on the Solar II Collectors have been minimized by design and will be tested as follows;

2.2.1 VIBRATION STRESS LEVELS

The collector has no moving parts. The only vibration expected in service is that induced by surface winds and primary air flow. Inspection of collector for vibration during blower motor operation.

Review of Item 2.2 through 2.2.1 successfully completed.

ORIGINAL PAGE IS
OF POOR QUALITY

Harry R. Nuce Colo #5674
LSE Test Engineer

Charles H. Merrick, Colo PE 8066
LSE Approval

Cal 8/26
Certification Officer Approval

John M Caudle
NASA Approval

2.6 HEAT TRANSFER FLUID QUALITY

Quality shall be demonstrated in the following paragraphs:

2.6.2 AIR QUALITY

The collector design reflects minimal dust collection. Dust could accumulate over a long time period resulting in reduced efficiency. Inspection of plenum chamber. Review of Items 2.6 through 2.6.2 successfully completed.

Harry R Nuce # Colo #5674
LSE Test Engineer

Charles H Munich, Colo PE 8066
LSE Approval

Cal 8126
Certification Officer Approval

John McCandle
NASA Approval

3.1 STRUCTURAL DESIGN BASIS

The LSE Solar II Collectors were designed to be operated at a fixed tilt angle of between 50° and 70° from the horizontal plane. The following paragraphs delineate the certification requirements:

3.1.1 APPLICABLE STANDARDS

See reference documents in paragraph I, Introduction, Certification Plan

3.1.2 SERVICE LOADS

Simple static testing will be carried out to simulate loading encountered in use such as wind loads, handling and transportation loads, installation, normal operating and stagnation temperature loads.

The following loads shall be used in evaluating the structural design of the collectors:

Dead Loads shall be calculated using the actual weight of the collector. Calculations shall be based on generally accepted engineering practices.

Live Loads shall be evaluated in accordance with MPS 601-4, to consider the weight of all moving or variable loads on the collectors. For the collectors designed for a tilt angle between 50° and 70°, the live load shall be 15 psf, on the horizontal projection of the collector area.

Snow Loads on the collectors shall be evaluated in accordance with ANSI A58.1.

Wind Load effects on the collector structure shall be evaluated in accordance with MPS standards for roofs. The analysis for collectors designed for 50° to 70° tilt angle shall show capability to withstand pressures acting inward normal to the surface, equal to the design wind pressure.

Earthquake Loads analysis for the collectors shall be based on the latest available Uniform Building Code.

Constraint Loads caused by the environment shall be shown in the year history of the prototype collector that has been in daily stagnation testing. Samples of Tedlar are available from indoor storage, the outer glazing and the inner glazing. The inner Tedlar glazing had the more severe constraint load, high stagnation temperatures.

Constraint Loads induced by differential foundation settlement effects on the collector are considered NA as IPC 3.8.1 considers conventional elements as meeting this critereon. All components are considered conventional elements.

Ice Loads shall be analyzed in accordance with IPC load combinations:

(1)	1.4D	1.7L	
(4)	1.1D	1.3L	1.7W

The mean annual number of days with glaze varies from 4 to 8.

The Live Load calculation for ice will be a 3/4 inch thickness.

Hail Loads analysis shall be developed in accordance with IPC which indicated 4 to 6 days of hail per year which estimates the hail size at 1.5". NASA test data on Tedlar is requested to support this analysis.

Vehicular Loads are considered NA as the collectors will be on structures away from roads.

Measurement of deflection on different members due to loads applied (static) with the collector in the horizontal position: An initial pre-load of 10 to 20 percent of design load will be applied as a baseline and additional incremented loads will be applied until maximum load is reached. Observation of connections will be made during this testing.

Sand or water will be used to simulate uniform static loads. Twisting, racking and dropping will be used to simulate shipping, handling and installation loads.

The yield and ultimate strength using appropriate safety factors for the type of materials, glass, tedlar and aluminum alloys together with the deflection limits allowed by design requirements and operation will be used as criteria. Observation of any permanent set affecting performance of the collector will be deemed unacceptable.

3.1.2.1 LIVE LOADS

Dynamic loads such as incurred in handling between final production and actual installation are delineated in the following paragraphs:

DROP TEST

With the collector on a flat horizontal surface one end is raised 6" and allowed to drop to the horizontal surface. Test is repeated for a total of 3 drops from a height of 6".

No permanent deformation shall take place.

3.1.2.2 RACKING TEST

With the collector on a flat horizontal surface one end is raised 6" and total collector weight is supported by only one corner in contact with horizontal surface.

No permanent deformation shall occur.

3.1.2.3 OPERATIONAL TEST

Observe absorber panel for deflection and/or buckling at maximum operating conditions.

No permanent deformation shall occur.

3.1.2.4 PLENUM CHAMBER PRESSURIZATION

With the collector installed at a 60° angle and Tedlar cover removed the air flow rate is adjusted by increasing flow or obstructing plenum outlet until a pressure of up to 0.2" of water is developed in the collector plenum chamber. Absorber panel deflection is measured prior to blower start up, during steady state operation at 0.2" or water and after pressure release at points indicated in Figure 2.

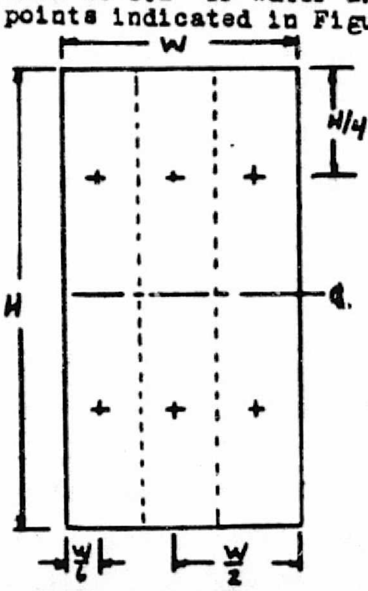


Figure 2. Deflection measurement points of absorber and back plate.

Review Items 3.1 through 3.1.2.4 successfully completed.

Harry R. Nuce # Colo #5674
LSE Test Engineer

Charles H Merrill, Colo PE 8066
LSE Approval

[illegible] Col 8126
Certification Officer Approval

John M Caudle
NASA Approval

3.3 DAMAGE CONTROL

The structural elements and connections of the collectors shall withstand service loads without damage as described in the following paragraphs:

3.3.1 RESISTANCE TO DAMAGE

N/A

3.3.2 GLAZING DESIGN

See the following paragraphs:

3.3.2.1 Glass Loading on Assembly Without Tedlar in Place

With the collector in the horizontal position, the collector is loaded using water ($5.2\ lb/ft^2/in$) up to but not exceeding the design load ($15\ lb/ft^2$+dead load) in 3 measured, equal increments.

Deflections in the glass and supporting members are measured at the points indicated in Figure 3.

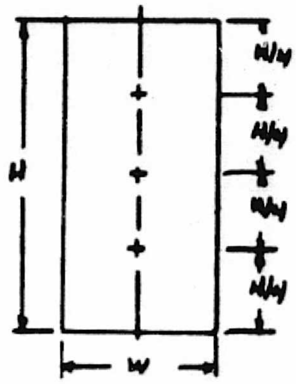


Figure 3. Deflection measurement points on glass mounted in collector without Tedlar.

Upon removal of load collector shall not exhibit any permanent deformation.

3.3.2.2 Loading on Tedlar Outer Glazing Installed in Collector.

With the collector in the horizontal position, the Tedlar is loaded with water until the Tedlar comes in contact with the glass over 50% of its area.

Note: A suitable dam around the perimeter of the collector will be utilized to enable a water depth of at least one inch to be achieved.

Deflections in the supporting members are measured in the horizontal plane at the points indicated in Figure 4. The loading required to cause the Tedlar to first contact the glass is measured.

The collector outer glazing shall also be tested for air leakage and water infiltraion in accordance with ASTM E283 and ASTM E331 respectively.

Physical Load tests shall be conducted in accordance with ASTM E330.

Glazing shall comply with the manufacturers directions for installing Tedlar, and the experience of the NASA test program on Tedlar.

The inner glazing of glass shall have a minimum clearance on all 4 sides equal to the thickness of the glass. Sealer space between the face of the glass and fixed or applied stops shall be sufficient to prevent glass-to-metal contact.

Upon removal of the load, the collector structure and the Tedlar shall not exhibit any permanent deformation.

3.3.2.3 Tedlar Service Loads with the Tedlar mounted in an H-bar frame, the Tedlar is loaded to determine its tear resistance at the corner of the frame and pulling out of the H-bar.

Tedlar shall not pull out of the H-bar or tear at the corners.

This test may be performed in conjunction with that of paragraph 3.3.2.2 or separately on a 2' by 4' collector and will be utilized to verify that H-bar radius and corner stress concentrations are acceptable.

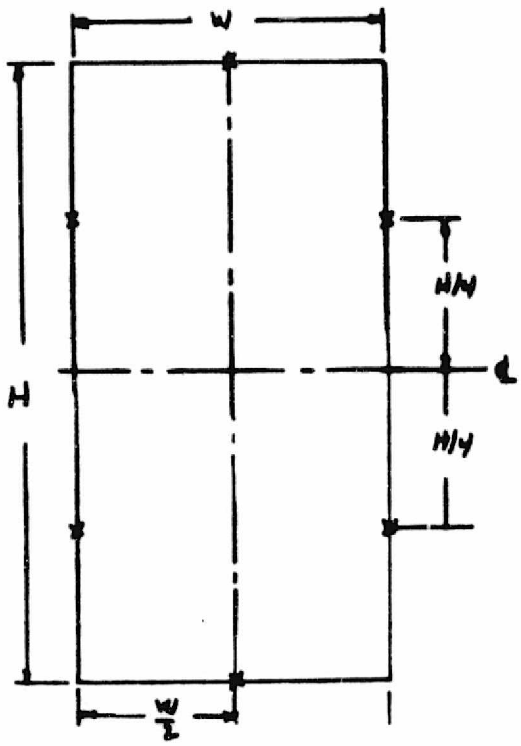


Figure 4. Deflection measurement points on collector supporting members.

Review of 3.3 through 3.3.2.4 successfully completed.

LSE Test Engineer

LSE Approval

Certification Officer Approval

NASA Approval

3.7 HAIL RESISTANCE

The collectors shall be capable of resisting impact of hail without unacceptable damage as described in the following paragraphs:

3.7.1 HAIL SIZE LOADING

Evaluation of the Tedlar glazing to withstand the hail impace will be based on the results of the NASA Tedlar test program.

Review of 3.7 through 3.7.1 successfully completed.

Harry R. Nue * Colo #5674
LSE Test Engineer

Charles H Murrih, Colo PE 8066
LSE Approval

Cal 8/26
Certification Officer Approval

John McConnell
NASA Approval

3.9 PONDING CONDITIONS

The only surface of the collectors in a horizontal plane capable of ponding is the 1/8" groove in the aluminum H-bar. However, this groove contains Tedlar and a 1/8" plastic spline. Hence, inspections will show there is little room for ponding. There is expected to be minimal collection of water on the taut Tedlar at angles between 50° and 70°. Observation of test article under rain conditions will reveal such to be the case.

3.9.1 DESIGN PROVISIONS

The only surface of the collector in a horizontal plane is the 1/8" channel in the aluminum H-bar. This channel contains silicone Glue and Seal, Tedlar and a 1/8" plastic spline. In addition, on the bottom edge of each collector a drip flange is provided to overlap this groove in the next inline collector or the collector-roof interface.

Spray collector in place with garden hose and inspect for ponding.

3.9.3 Deformation resulting from stagnation temperatures with the blower not operating. A steady state stagnation temperature will be achieved. (Observed maximum temperature achieved with insolation at rate of 300 BTU/ft² for at least 30 minutes) as determined by thermocouples as in paragraph 2.2. (Constant temperature 5° over 45 minute time period). Determine the amount of deflection and buckling in the absorber panel. Immediately upon completion of the stagnation test, nominal airflow is to be established (120 CFM). The deflection and buckling of the absorber panel is again determined until normal steady state air flow conditions are established.

No permanent set in the absorber panel shall occur. The absorber paint surface shall incur no degradation.

3.9.4 Thermal Shock with the collector mounted in operating position and shaded from the sun, deflection buckling is observed when the collector is suddenly exposed to the sun (insolation at rate of 300 BTU/ft²).

No permanent set in absorber panel shall occur. Paint surface shall not show degradation.

Review of Items 3.9 through 3.9.4 successfully completed.

Harry R. Nuce Sr Colo #5674
LSE Test Engineer
Charles F. Murrish, Colo PE 8066
LSE Approval
Cal 8126
Certification Officer Approval
John M. Caudle
NASA Approval

5.0 HAZARD ANALYSIS

The following paragraph delineates the required hazard analysis. Paragraphs are keyed, in parenthesis, to the Verification Plan.

5.1 FIRE SAFETY

The design and installation of the collectors shall provide a minimum level of fire hazard.

Review of materials list and manufacturers data.

5.1.1(4.3.1) APPLICABLE FIRE STANDARDS

Local building codes will be utilized as well as Factory Mutual, National Fire Protection Association and Underwriters Laboratories Standard will be utilized.

Review drawings, specifications, materials list and Installation, Operation and Maintenance Manual.

5.4(4.6) PROTECTION OF POTABLE WATER AND CIRCULATION OF AIR.

The collector design and development carefully checked that no material, form of construction, appurtenance of item of equipment shall be employed that will support the growth or micro-organisms or introduce substances impurities, bacteria or chemicals into the circulation air system, in quantities sufficient to cause disease or harmful physiological effects. Furthermore, the following applicable items will continue to be monitored.

Same as paragraph 5.1 evaluation.

5.4.1(4.6.1) CONTAMINATION BY MATERIALS

See paragraph 5.4.

5.4.4(4.6.4) GROWTH OF FUNGI

No significant fungi growth will be exhibited.

Inspection of test collectors, after exposure to atmosphere likely to produce fungi growth, and review of materials list for elements that will induce or support fungi growth will establish that fungus growth will be insignificant.

5.5(4.7) EXCESSIVE SURFACE TEMPERATURES

Temperatures of exterior surfaces of the collectors shall not create a hazard and shall be checked as follows:

5.5.1(4.7.1) PROTECTION FROM HEATED COMPONENTS

Only the lower horizontal edge of the collector will be accessible to public traffic. It is not normally expected to reach temperatures of 140°F or more. However, an electric power failure may cause the temperature to reach between 140°F and 160°F. The temperature of this component will be monitored during stagnation tests, if the temperatures reach these limits. Insulation will be provided where the collectors will be installed near public traffic.

Review of Items 5.0 through 5.5 successfully completed.

Harry R. Nuee # Colo #5674
LSE Test Engineer

Charles H Morrish, Colo 15846
LSE Approval

Colo 8126
Certification Officer Approval

John McCandle
NASA Approval

6.1(5) EFFECTS OF EXTERNAL ENVIRONMENT

The collectors shall not be affected by external environment factors to an extent that will significantly impair their function during their life described in the following paragraphs:

6.1. SOLAR DEGRADATION

Collector components and materials have been exposed to UV for 1 year under Colorado weather conditions. The Tedlar outer glazing of our experimental SC4x10 model has undergone extreme stagnation heat testing with temperatures of 180°F every sunny day without degradation.

6.1.3 AIRBORNE POLLUTANTS

No data is currently avaiable as the test facility environment is relatively pollutant free. If airborne pollution contamination is found, analysis of samples will determine the corrective action to be taken.

6.1.4(5.1.4) DIRT RETENTION ON COVER PLATE SURFACE

Dirt retention shall be monitored by photographing a small target behind the outer glazing and recording weather conditions. During long periods without precipitation, dirt may be washed off by hosing after photographic data has been taken.

6.1.5 ABRASIVE WEAR

Engineering analysis and data on the Tedlar glazing that has been in environment testing for the past year and surface hardness specifications will be reviewed.

6.1.6 FLUTTER BY WIND

Outer glazing flutter by wind will be minimized by proper tensioning the film during fabrication. Wind flutter will be checked by inspection during wind conditions. Wind and temperature data will be taken by our instrumentation.

Review of Items 6.1 through 6.1.6 successfully completed.

Harry R. Nuce * Colo *5674
LSE Test Engineer

Charles H. Minnich, Colo PE 8066
LSE Approval

C-19 [illegible] Cal 8126
Certification Officer Approval

John McCandle
NASA Approval

6.2(5.2) TEMPERATURE AND PRESSURE RESISTANCE

Collector components have been designed to perform their intended function of their design life when exposed to maximum temperatures that could be developed in the system as follows;

6.2.1(5.2.1) THERMAL DEGRADATION

Data will be supplied on Tedlar and absorber paint degradation. Effects of thermal degradation will be monitored after stagnation tests and recorded in the test report.

6.2.3(5.2.3) THERMAL CYCLING STRESSES

Thermal cycling is considered an important test as it may stress the inner glazing, if the blower starts while the collector is at sub-zero temperatures.

6.2.5(5.2.6) TRANSMISSION LOSSES DUE TO OUTGASSING

Outgassing is expected to be minimized by oven heating of the absorber coating after painting. Subsequent outgassing during operation would be noticed during inspections as a fine coating on the interior surface of the inner glazing.

Review of Items 6.2 through 6.2.5 successfully completed.

Harry R. Nuce # Colo #5674
LSE Test Engineer

Charles H Murrish, Colo PE 8066
LSE Approval

Cal 8126
Certification Officer Approval

John M Caudle
NASA Approval

6.3(5.3) CHEMICAL COMPATIBILITY OF COMPONENTS

In the design of the collector careful consideration was given to the selection of materials to prevent corrosion and deterioration.

6.3.2(5.3.2) CORROSION OF DISSIMILAR METALS

Inspection of the drawings and prototype collectors will show all metals are either of aluminum or in the same electro-conductive category. Two prototype collectors have been in environment test for one year and have shown no corrosion or deterioration problems.

6.3.4(5.3.4) EFFECTS OF DECOMPOSITION PRODUCTS

This will be monitored by inspections. Two prototypes have not shown any decomposition. Absorber paint may decompose after 10 years, but is retained within an enclosure and cannot affect materials.

Items 6.3 through 6.3.4 successfully completed.

LSE Test Engineer

LSE Approval

Certification Officer Approval

NASA Approval

7.0 MAINTENANCE

Accessibility for maintenance will be demonstrated by review of drawings, and specifications and protype collectors and is detailed below.

7.1(6.1) ACCESS FOR SYSTEM MAINTENANCE

Access may be required to remove and replace the inner glazing, or repaint the absorber coating after ten years. Inspection of drawings will show that the outer glazing may be removed for access to the inner glazing or absorber coating without removing adjacent units.

7.2(6.1.2) ACCESS OF SYSTEM MONITORING

Access for system monitoring has been included in the test facility design and construction. Thomas flow meters and supporting instrumentation are used to measure flow rates. Temperatures will be monitored on the absorber plate back along with input and output temperatures. Backup thermocouples probes will be used at special points to check regular instrumentation.

Review of Items 7.0 through 7.2 completed.

Harry R. Nuce # Colo # 5674
LSE Test Engineer

Charles H Marmeth, Colo PE 8066
LSE Approval

Cal 8126
Certification Officer Approval

John M Caudle
NASA Approval

7.3 (6.2) Installation, Operations & Maintenance Manual

This manual will be prepared in accordance with similar manuals. Drawings, diagrams and photographs will support written instructions prepared at the appropriate reading level.

7.3.1(6.2.1) Installation Instructions

Installation shall include physical, functional and procedural instructions. Particular attention will be given to safety functions, expecially the output temperatures from the collector into the house will not be more than 140°F. Directions will be supplied for test instruments.

7.3.2(6.2.2) Maintenance and Operation Instruction

Maintenance instructions will describe the relationship of the major components to the collector operation. Collector maintenance is expected to consist of repairing the inner and outer glazings due to willful damage or accidents. Routine maintenance will include occasional washing with a hose and inspection of the outer glazing and caulking for signs of leakage.

7.3.3(6.2.3) Maintenance Plan

The maintenance plan will provide a schedule and procedure for the outer glazing washing and inspections.

Review of items 7.3(6.2) through 7.3.3(6.2.3) is contained in paragraph 8.

7.3.4(6.2.4) Replacement Parts

List of parts, components, special tools and test equipment for service, repair or replacement will be provided along with sources of suppliers.

7.4(6.3) Repair & Service Personnel

A review of the Installation, Operation and Maintenance Manual will demonstrate that the instruction, diagrams and procedures and the collector design can be easily used by qualified service personnel.

Review of items 7.3.4 through 7.4 completed

Harry R. Nuce # Colo #5674
LSE Test Engineer

Charles H Murrill, Colo PE 8066
LSE Approval

C/23 Certification Officer Approval

John McCandlee

8. Architectural Engineer Certification

8.1 Review of Installation Drawings

The Installation Drawings SC4X8106 are compatible with Architectural Engineering standards for the installation of collectors on a roof.

8.2 Review of Installation, Operations & Maintenance Manual

The IOM Manual was reviewed in accordance with the following paragraphs of this document:

6.2 Similarity of the IOM Manual to other IOM Manuals in use.

6.2.2 That the installation instructions are sufficient for installation and contain adequate safety precautions.

6.2.3 The maintenance plan is adequate.

Review of Items 8.1 through 8.2 successfully completed

Bennett J. Severson, P.E.
Architectural Engineer
SME Systems Incorporated
Colorado P.E. No. 10989

CERTIFICATION TEST STATEMENT

1.3 COLLECTOR PERFORMANCE

1.3a TEST DATA

See Data Sheets, Pages 83, 84, 85, 86

1.3.1 COLLECTOR EFFICIENCY

See Data Sheets, Pages 83, 84, 85, 86

2.1 SYSTEM DESIGN CONDITIONS

2.1.1 EQUIPMENT CAPABILITIES

Refer to Test Facility

2.1.2 NOISE OR EROSION, CORROSION

None observed

2.1.3 OPERATING CONDITIONS

Refer to drawings

2.1.4 FLUID FLOW IN COLLECTORS

Refer to Test Facility

2.1.7 PRESSURE DROP

Pressure drop determined to be .1 at 120 CFM flow rate, See Page 89

2.2 MECHANICAL STRESS

Review drawings

2.2.1 VIBRATION STRESS LEVELS

Review drawings. No vibrations observed.

2.6 HEAT TRANSFER AIR QUALITY

2.6.2 AIR QUALITY

Inspection showed no observable dust accumulation.

3.1 STRUCTURAL DESIGN BASIS

Collector tested at 60° tilt.

3.1.1 APPLICABLE STANDARDS

Performance Test #LSE 4x8 Qual

Ambient Air to Inlet

Time	Flow CFM	Insolation BTUH/ft^2	Ambient Air °F	RH %	Inlet Air °F	Outlet Air °F	TC#1 °F	TC#2 °F	TC#3 °F	TC#4 °F	Efficiency % Total Area
1145	120	280	72	40	80	137	183	208	160	177	69
1200	124	290	73	44	82	142	187	214	163	181	72
1230	127	306	74	40	83	145	196	223	167	190	72
1315	115	316	76	37	85	153	201	227	175	197	69
1330	116	318	76	35	84	153	200	227	174	198	70
1345	116	317	75	34	83	152	199	226	172	197	71
1400	114	317	77	36	83	152	200	225	172	198	69
1415	116	311	77	40	84	152	199	225	171	198	71
1430	112	305	76	36	83	151	196	221	168	195	70

September 14, 1977

Performance Test Serial # LSE 4x8-Qual

Recirculated Input Air

Time	Flow CFM	Insolation BTU/ft^2	Ambient Air °F	RH %	Inlet Air °F	Outlet Air °F	Thermo couple#1	Thermo couple#2	Thermo couple#3	Thermo couple#4	Efficiency Gross Area %
12:20	125	328	82	40	94	158	199	225	172	197	69
12:25	117	324	82	"	95	158	200	226	173	198	65
12:30	121	330	82	"	95	159	201	227	174	199	66
12:40	118	323	81	"	96	160	201	227	174	200	65
12:50	116	321	81	36	97	160	201	227	174	200	64
13:00	116	317	81	"	98	160	201	226	174	200	64
13:10	124	312	81	"	98	159	198	223	170	198	68
13:45	116	232	81	"	97	145	175	194	154	175	68

November 3, 1977

Performance Test LSE 4x8 Qual

High Temperature Input

Time	Flow CFM	Insolation BTU/ft²	Ambient Air°F	RH %	Inlet Air°F	Outlet Air°F	Thermo couple#1	Thermo couple#2	Thermo couple#3	Thermo couple#4	Efficiency Gross Area %
1245	117	348	68	43	127	182	228	250	200	220	52
1255	117	325	69	"	129	182	228	250	201	223	54
1305	119	313	72	"	129	182	222	243	198	219	55
1325	111	159	71	"	128	160	176	187	160	170	62
1335	120	222	72	37	128	162	188	201	172	187	53
1355	122	289	72	"	129	170	209	226	189	203	48
1405	114	292	73	29	130	174	215	231	190	209	48
1415	116	278	73	"	130	175	211	227	185	208	52
1425	114	262	74	27	132	175	210	225	185	207	53
1435	107	249	73	"	132	174	207	223	181	204	51

November 4, 1977

STAGNATION TEST SERIAL #LSE 4x8 QUAL

Time	Insolation $BTUH/ft^2$	Ambient °F	TC #1 °F	TC #2 °F	TC #3 °F	TC #4 °F
1420	288	87	271	292	259	266
1430	281	88	282	301	266	277
1440	233	88	288	309	269	286
1450	186	88	270	283	236	268
1500	78	88	234	244	195	236
1510	59	88	218	226	178	220

September 3, 1977

Harry R. Nuce [illegible]
Colo #5674

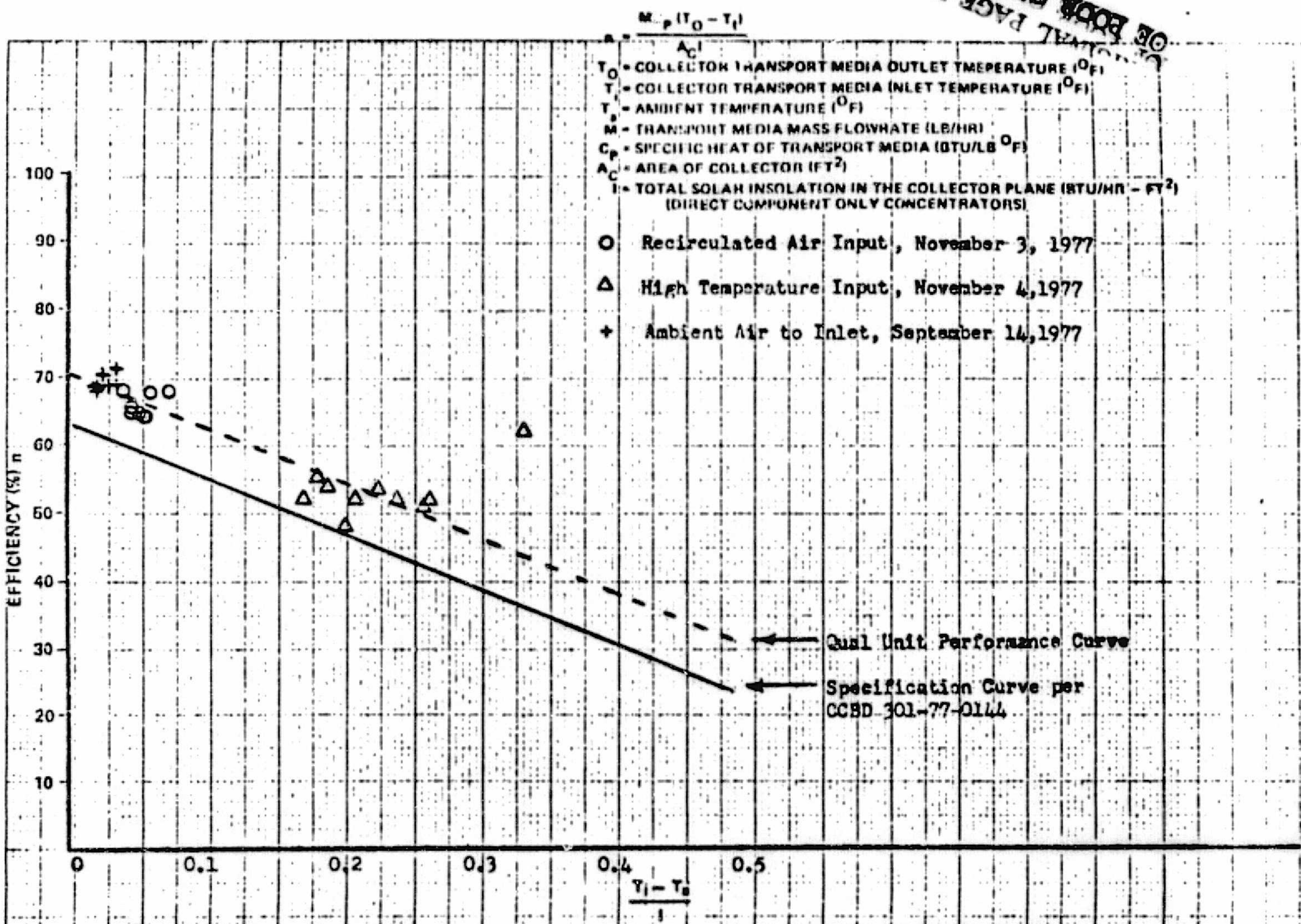
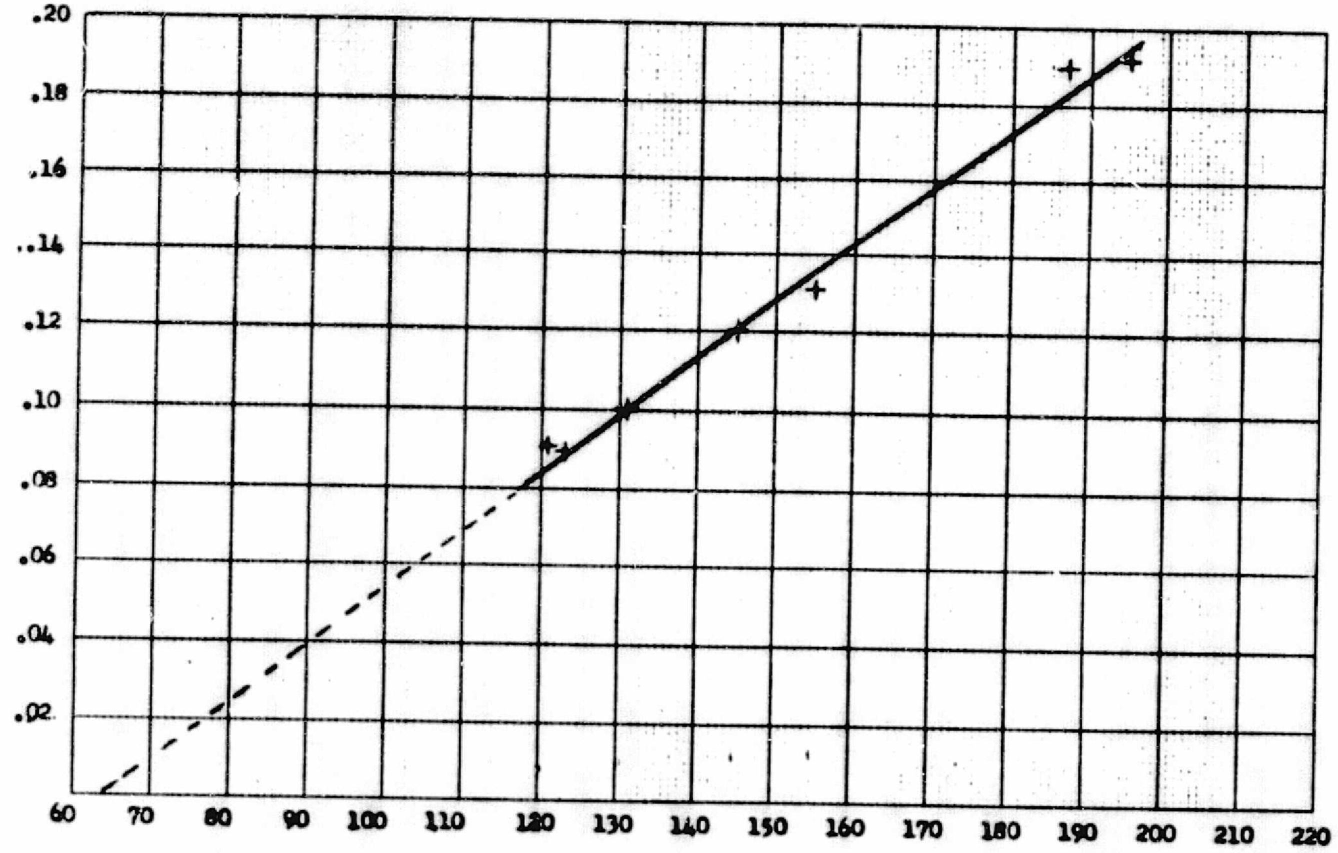


FIGURE 1 EFFICIENCY AS A FUNCTION OF OPERATING CONDITIONS
PERFORMANCE MUST BE ABOVE LINE

Pressure Drop Across 4x8 Solar II Collector

Time	Pressure inches of water	Flow Rate CFM
1038	.196	196
1041	.192	187
1044	.138	155
1046	.090	123
1048	.122	145
1051	.106	132
1054	.098	120

Harry R. Nua
Colo #5674



Harry R Nuce
Colo #5674

3.1.2 SERVICE LOADS

Collector loaded to an average of 16 lbs/ft^2 dead load. This meets all loading standards. No permanent deformation was seen. See data sheet, page 91.

3.1.2.1 LIVE LOADS

Collector was dropped three times from 6" or greater. No permanent deformation or damage was observed.

3.1.2.2 RACKING TEST

Collector was raised several feet by one corner and shaken. No permanent deformation was observed.

3.1.2.3 OPERATIONAL TEST

No buckling has ever been observed with Solar II Collectors.

3.1.2.4 PLENUM CHAMBER PRESSURIZATION

See data sheets. No deformation was observed even at higher pressures. Data sheets, pages 92, 93, 94.

3.3 DAMAGE CONTROL

No damage observed under service.

3.3.2.1 GLASS LOADING ON ASSEMBLY WITHOUT TEDLAR IN PLACE

See Data sheets. No permanent deformation observed.

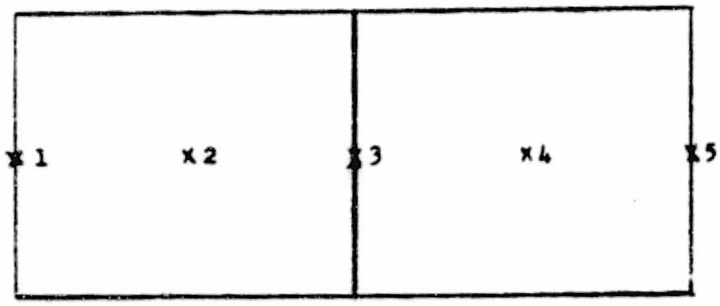
3.3.2.2 LOADING ON TEDLAR OUTER GLAZING INSTALLED IN COLLECTOR.

Tedlar was loaded with approximately one inch of water; in increments of from one gallon to 18 gallons of water. See data sheets. Tedlar was in contact with 52% of glass surface. Upon removal of the water the Tedlar at first showed signs of sagging. After a period of about 1/2 hour the Tedlar had regained its original tautness.

The Tedlar was checked for air leakage while on the collector. A port was made in the side of the collector to pressurize the air gap between the glass and Tedlar glazings. The Tedlar ballooned upward with

COLLECTOR DEFLECTION UNDER H_2O LOAD

Water Depth (inches)	Position Indicated on Diagram Below 1	2	3	4	5
1	0	.109	.016	.12	.0156
2	0	.109	.016	.1876	.0156
3	0	.235	.063	.265	.03



1. Collector edge
2. Center of glass
3. Support bar
4. Center of glass
5. Collector edge

Harry R Nunn
Colo P.E. #5674

ORIGINAL PAGE IS
OF POOR QUALITY

AIR PLENUM PRESSURE TEST

Position of Measurement	Pressure inches of water	Deflection inches
1.	.052	.002
	.122	.004
	.224	.007
	.286	.018
	.318	.022
	.384	.035
	0	.01
2.	.054	.002
	.104	.005
	.14	.009
	.206	.014
	.270	.018
	.30	.025
	.40	.042
	0	0
3.	.052	.003
	.122	.007
	.224	.008
	.286	.013
	.318	.015
	.384	.036
	0	0

Air Plenum Pressure Test

Position of Measurement	Pressure inches of water	Deflection inches
4.	.10	.010
	.20	.015
	.26	.016
	.304	.018
	.302	.022
	.376	.030
	0	.02
5.	.008	.010
	.108	.017
	.178	.026
	.204	.031
	.30	.046
	.338	.054
	.398	.062
	0	0
6.	.008	.005
	.108	.022
	.178	.036
	.204	.039
	.300	.058
	.338	.064
	.398	.075
	0	0

Harry R. Nuce
Colo P.E. #5674

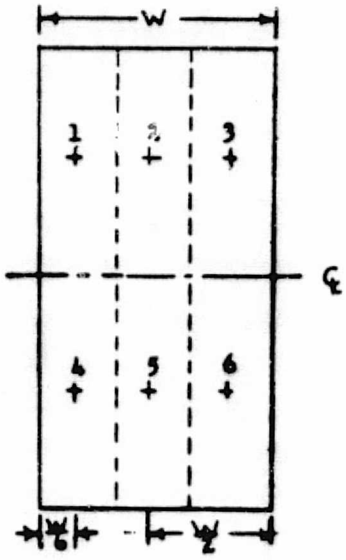


Figure 2. Deflection measurements points of absorber and back panel.

Harry R. Nuee
Colo P.E. #5674

air pressure. Pressure readings were taken with the Dwyer Micro Testor, time readings were taken and deflections were measured as the Tedlar collapsed. It took over 20 minutes for the equilibrium position of the Tedlar to be reached. No permanent deformation was observed; see page 91.

3.3.2.3 TEDLAR SERVICE LOADS

The Tedlar was reloaded with 18 gallons of water. Inward deflections of the Tedlar frame were observed. See data, pages 97, 98.

3.7 HAIL RESISTANCE

NASA Testing

3.9 PONDING CONDITIONS

No ponding observed in rainy weather.

3.9.1 DESIGN PROVISIONS

No ponding observed

3.9.3 DEFORMATION

No deformation observed

3.9.4 THERMAL SHOCK

Collector was shaded with tarp until noon. Tarp was removed and no buckling was seen to occur.

5.0 HAZARD ANALYSIS

5.1 FIRE SAFETY

Refer to manufacturing/installation drawings.

5.1.1 (4.3.1) APPLICABLE FIRE STANDARDS

Review drawings, etc.

5.4(4.6) PROTECTION OF POTABLE WATER AND CIRCULATION OF AIR

Review drawings

5.4.1 (4.6.1) CONTAMINATION BY MATERIALS

No contamination observed.

TEDLAR AIR LEAK TEST

Elapsed Time minutes	Pressure inches of H_2O	Deflection inches
.1	.070	.875
.5	.064	.825
.83	.056	.725
1.83	.050	.665
2.50	.044	.610
3.00	.040	.604
3.83	.036	.595
5.33	.030	.500
6.50	.026	.469
8.00	.020	.345
11.58	.016	.250
12.83	.014	.235
14.75	.012	.145
16.91	.010	.125
22.00	0	0

Harry R. Nuce Jr.
Colo P.E. #5679

TEDLAR LOADING WITH WATER

# Gallon H_2O	Weight (lbs)	Area of Tedlar * Touching Glass (ft^2)	% Total Collector Area
1**	8.3	1	3.22
7	58.1	9.47	30.5
8	66.4	11.67	37.6
10	80.3	12.57	40.5
12	99.6	12.94	41.8
14	116.2	13.40	43.2
16	132.8	15.35	49.5
18	149.4	16.28	52.5

* Measuring error less than 10%

** Water applied to one pane of glass only

Harry R Nuett
Colo P.E. #5674

Inward Deflection Of H-Bar When Tedlar Is Loaded With Water

Water Depth inches	Deflections (inches) Position 1	2	3	4	5	6
1	0	0	.01	.01	.02	.02
2	0	0	.02	.02	.04	.04
3	0	0	.03	.03	.0625	.0625

Harry R. Nuce
Colo P.E. #5674

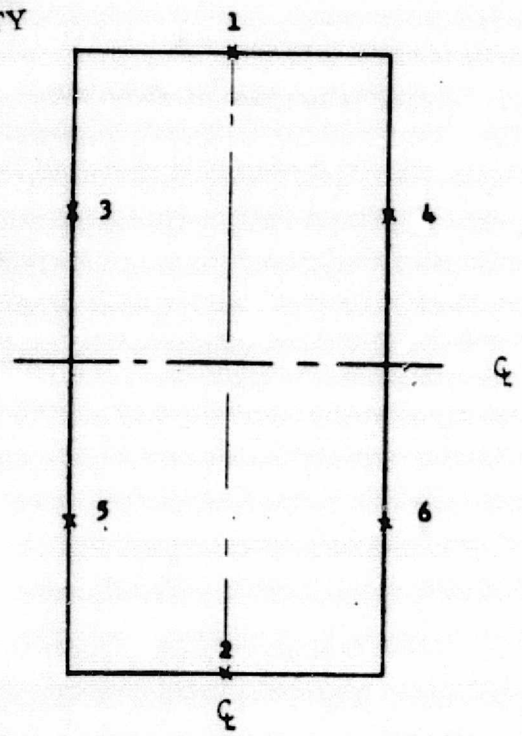


Figure 4. Deflection Measurement points on Tedlar Support Frame.

Harry R. Nuce
Colo P.E. #5674

5.4.4 (4.6.4) GROWTH OF FUNGI

Fungi growth not exhibited after long exposures to the weather.

5.5(4.7) EXCESSIVE SURFACE TEMPERATURES

Collector surface temperatures were found to be 195° F during stagnation. Therefore, surfaces will be insulated if collector is installed near public traffic. Refer to Verification Status Summary to the Verification Plan-Paragraph 4.7.1.

5.5.1 PROTECTION FROM HEATED COMPONENTS

See above paragraph

6.1(5) EFFECTS OF EXTERNAL ENVIRONMENT

6.1 SOLAR DEGRADATION

Tedlar and Nextel paint have been exposed to sun for 1.3 years with no observable degradation.

6.1.3 AIRBORNE POLLUTANTS

None observable

6.1.4 (5.1.4) DIRT RETENTION ON COVER PLATE SURFACE

Dirt retention is observable but is found to be easily removed by hosing.

6.1.5 ABRASIVE WEAR

No observable wear is found after 1.3 years of service.

6.1.6 FLUTTER BY WIND

Photographs of wind flutter have been made. Dial gage measurements were made to determine Tedlar movement by wind. Gusts of 20 m.p.h. resulted in 1/8" deflection amplitudes.

6.2(5.2) TEMPERATURE AND PRESSURE RESISTANCE

6.2.1 (5.2.1) THERMAL DEGRADATION

See paragraph 6.1, above.

6.2.3 (5.2.3) THERMAL CYCLING STRESSES

Thermal cycling has been taken into consideration in the design of the collector. (See drawings) No stresses have been observed; however, sub-zero temperatures have not occured since testing began.

6.2.5 (5.2.6) TRANSMISSION LOSSES DUE TO OUTGASSING

A small hole was placed in the side of the collector below the level of the glass. A light source was placed in the hole and the lights in the room were turned off. A photo electric cell was placed over the light source on the top side of the glass. The electrical response of the cell was noted with a voltmeter. The light source was removed and the bottom of the glass near the hole was cleaned with cotton swabs. No residue was observed on the swabs. The light test was then repeated to see if more light would be transmitted through the glass after cleaning. The electrical response from the photo electric cell was found to be identical with the first test. No transmission losses were noted.

6.3(5.3) CHEMICAL COMPATIBILITY OF COMPONENTS

All metals are aluminum to prevent Galvanic action. The collector was welded where required by TIG process rather than soldered, to prevent chemical action by soldering fluxes. Other materials used were chosen for their weatherability.

6.3.2 CORROSION OF DISSIMILAR METALS

Review drawings and paragraph 6.3.

6.3.4 (5.3.4) EFFECTS OF DECOMPOSITION PRODUCTS

No decomposition has been observed on any material to date.

7.0 MAINTENANCE

Review of IOM Manual and drawings

7.1 (6.1) ACCESS FOR SYSTEM MAINTENANCE

Review of IOM Manual and installation drawings.

7.2 (6.1.2) ACCESS OF SYSTEM MONITORING

Inspect test facility

APPROVAL

DEVELOPMENT, TESTING, AND CERTIFICATION OF LIFE SCIENCES ENGINEERING SOLAR COLLECTOR – FINAL REPORT

By John M. Caudle

The information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

WILLIAM A. BROOKSBANK, JR.
Manager, Solar Heating and Cooling
Project Office

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