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BLOCK V DOCUMENTATION AND SOLAR CELL MODULES

FINAL REPORT

CONTRACT NO. 956335

MOBIL SOLAR ENERGY CORPORATION
WALTHAM, MASSACHUSETTS

MODULE PERFORMANCE AND FAILURE ANALYSIS AREA

FLAT-PLATE SOLAR ARRAY PROJECT

JET PROPULSION LABORATORY

(NASA-CR-175669) MODULE PERFORMANCE AND FAILURE ANALYSIS AREA: FLAT-PLATE SOLAR ARRAY PROJECT Final Report (Mobil Tyco Solar Energy Corp.) 29 p HC A03/MF A01 CSCL 10A G3/44

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By: E Tornstrom
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Date: November 21, 1984

"The JPL Flat-Plate Solar Array Project is sponsored by the U.S. Department of Energy and forms part of the Solar Photovoltaic Conversion Program to initiate a major effort toward the development of low-cost solar arrays. This work was performed for the Jet Propulsion Laboratory, California Institute of Technology by agreement between NASA and DOE."

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ABSTRACT

A redesign of the initial (Group I) Block V module was done and documented. Manufacturing experience and accelerated test data from Group I formed the basis for the redesign. Ten Block V Group II modules were submitted for evaluation and the results are presented.

1. SUMMARY

The objective of this contract is to redesign and document Mobil Solar's Block V module. A previous contract documented and submitted 10 modules of the initial (Group I) design. Manufacturing experience, technical innovations and accelerated test results served as the basis for the redesign (Group II).

Several problems existed with the initial design. Among them were delamination of the backskin, power loss due to cracked cells, Hipot failure, oxidation of electrical hardware and weather seal integrity. Solutions to many of the problems were identified, even prior to the completion of the Group I modules. A new backskin eliminates delamination, plastic molded J-boxes and non-conductive gasketing corrected the Hipot failures, redundant interconnects stop power loss due to cracked cells and tinned electrical hardware prevent oxidation. The weather seal integrity is still a problem because of the -50 psf mechanical loading. Lifting of the two short module edges from the roof structure occurs at this loading and breaks the weather seal. It is felt that ±20 psf is a more appropriate loading level for residential applications.

The manufacturing experience was excellent with the Group II modules. The design changes were incorporated smoothly and helped simplify the assembly.

Accelerated testing showed only two design areas which are questionable. Both involve the roof structure's ability to withstand the temperature cycling and mechanical loading. At 90°C during the temperature cycling, the PVC drip troughs softened and allowed the module to shift slightly and the negative 50 psf mechanical load violated the weather seal at the short ends of the module. Solutions can be found to both of these problems; however, since it is extremely unlikely that either of these two conditions would ever occur in a real installation, it would only be adding an unnecessary expense.

Delays in obtaining Group I test results and manufacturing the Group II modules have extended this contract seven months.

Additional work may be warranted to investigate the grounding of the backskin foil or removal of it and to evaluate realistic accelerated tests for integral mount roof structures.

2. INTRODUCTION

Mobil Solar's approach to residential photovoltaics is to provide a low cost module and installation method for the system owner. EFG ribbon solar cells assembled in large area modules integrally mounted to the roof can reduce the system cost substantially. Several installations have been completed and are functioning well using these modules and very similar mounting methods.

The basic design of the Block V modules has remained the same for both Group I and Group II. Shortcomings of the Group I modules were detected early and solutions were well underway at the completion of the modules. The Group II modules and mounting system offer reliability, simplicity, potential low cost and aesthetic appeal.

3. MODULE DESIGN

3.1. GENERAL DESCRIPTION (Figures 1, 2, and 3)

The module construction typifies current laminated construction technology. Tempered low iron glass is used as the superstrate and load bearing member. The cell array is laminated to the glass using EVA. The back side of the array is encapsulated with a second layer of EVA and the final weather barrier is a composite laminate. All power buses are run internal to the module and exit the backskin directly into the junction box. The cell array consists of 432 EFG ribbon solar cells, interconnected with redundant copper tabs into an array of 12 parallel by 36 series. Cross ties are provided every 12 cells.

3.2. SOLAR CELL (Figure 4)

The solar cells are made from silicon EFG (Edge Defined-Film Fed-Growth) ribbon. The junction is N+ on P and the metallization system is a base metal plating. A solder coating facilitates bonding between cell and interconnect. Nominal dimensions are 3.735 x 1.885 x 0.012 in.

3.3. INTERCONNECTS/WIRING

Solder plated copper straps are reflowed soldered across the entire front and back of each cell. Two 0.078 in. x 0.002 in. straps are used per cell which provide redundancy in the event of cell breakage. String cross ties are a solder plated copper mesh. The mesh also serves as a transition between the cell interconnects and the insulated copper power bus.

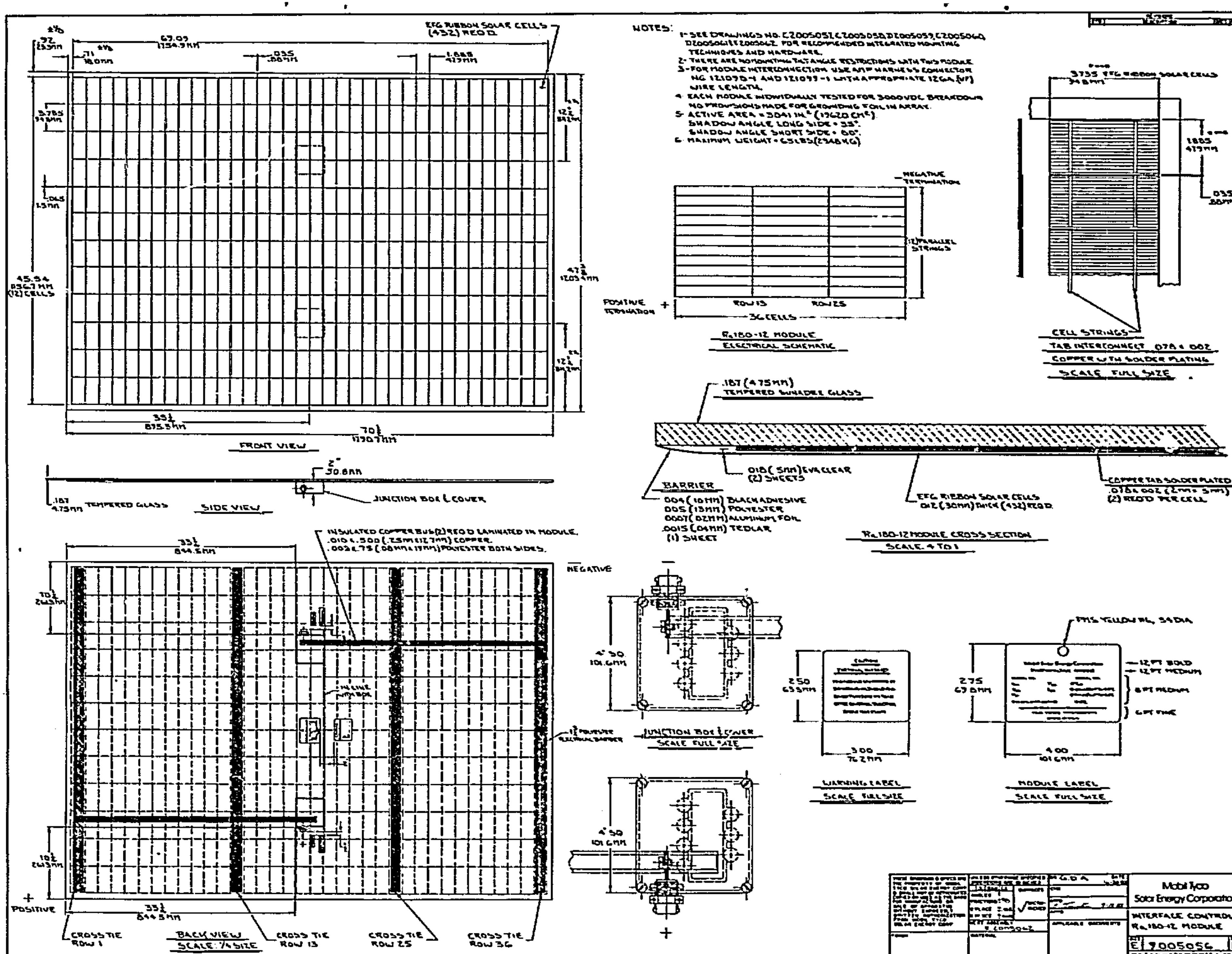
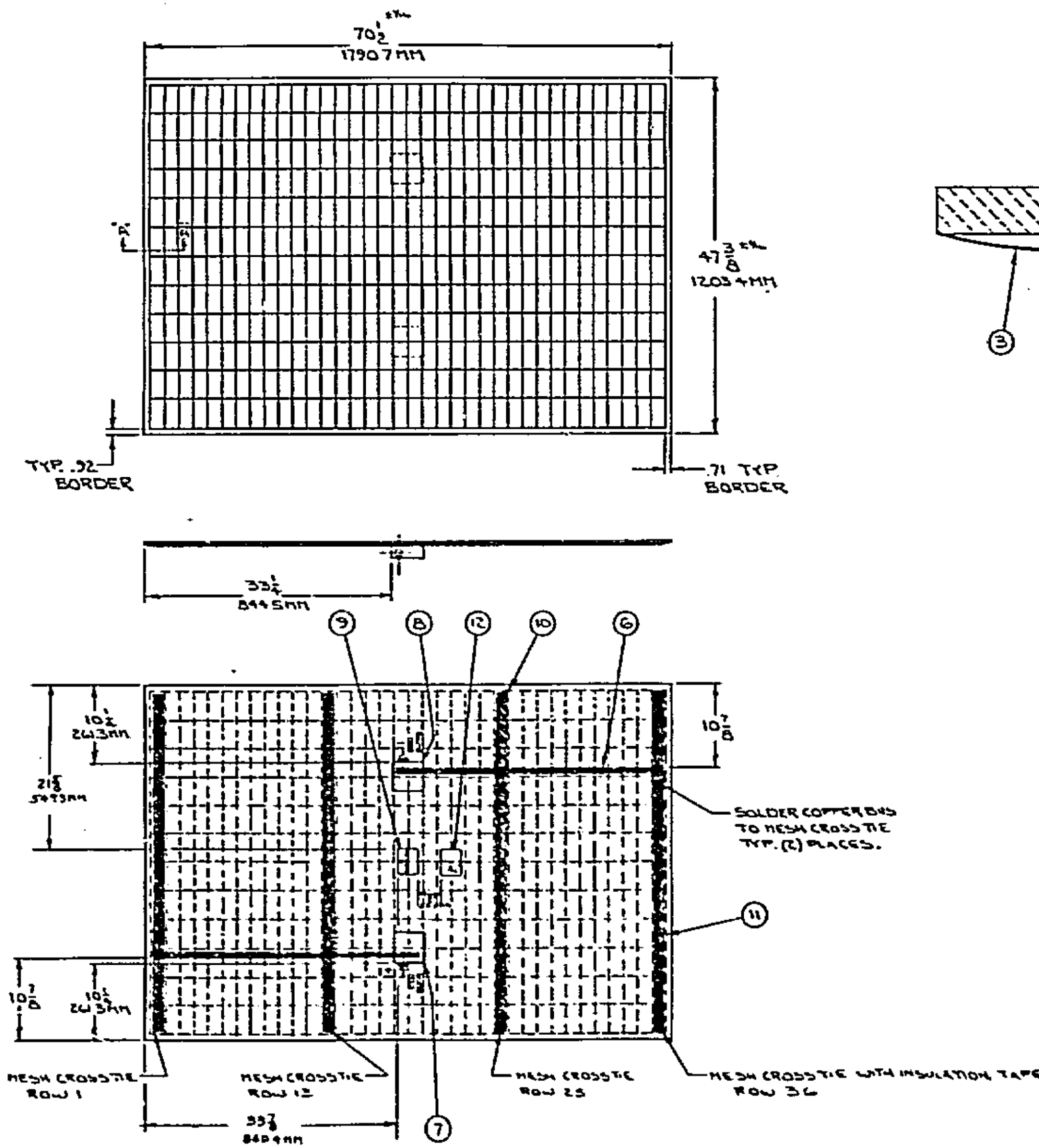
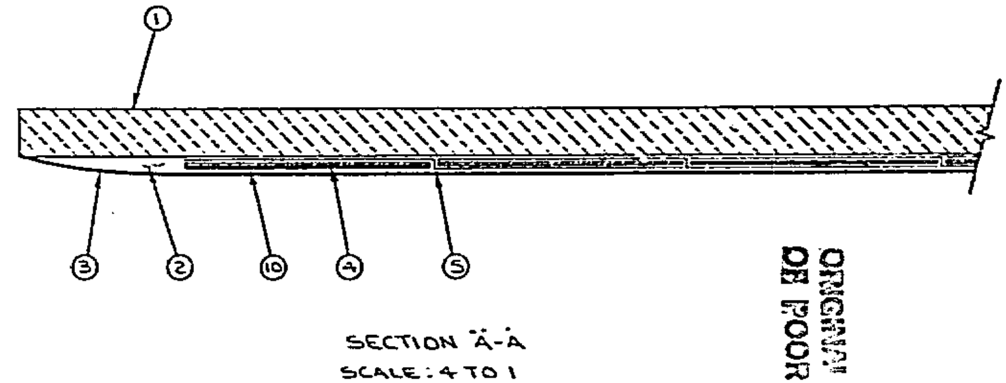

NOTES:
1- SEE DRAWINGS NO. C2005051, C2005058, D2005059, C2005060, D2005061 E2005062 FOR RECOMMENDED INTEGRATED MOUNTING TECHNIQUES AND HARDWARE.
2- THERE ARE NO MOUNTING TILT ANGLE RESTRICTIONS WITH THIS MODULE
3- FOR MODULE INTERCONNECTION USE AMP HARNESS CONNECTOR NO. 121070-1 AND 121093-1 WITH APPROPRIATE 12GA (UF) WIRE LENGTH.
4- EACH MODULE INDIVIDUALLY TESTED FOR 3000VDC BREAKDOWN NO PROVISIONS MADE FOR GROUNDING FOIL IN ARRAY.
5- ACTIVE AREA = 3041 IN.² (19620 CM²). SHADOW ANGLE LONG SIDE = 35°. SHADOW ANGLE SHORT SIDE = 60°.
6- MAXIMUM WEIGHT = 65LBS (29.48KG)
EFG RIBBON SOLAR CELLS (432) REQ'D
FRONT VIEW
SIDE VIEW
TEMPERED GLASS
JUNCTION BOX & COVER
BACK VIEW
SCALE: 1/4 SIZE
CROSS TIE ROW 1
CROSS TIE ROW 13
CROSS TIE ROW 25
CROSS TIE ROW 36
POSITIVE
NEGATIVE
INSULATED COPPER BUS (2) REQ'D LAMINATED IN MODULE. .010 × .500 (.25MM × 12.7MM) COPPER. .002 × .75 (.05MM × 19MM) POLYESTER BOTH SIDES.
NEGATIVE TERMINATION
POSITIVE TERMINATION
(12) PARALLEL STRINGS
ROW 13
ROW 25
36 CELLS
Ra180-12 MODULE
ELECTRICAL SCHEMATIC
CELL STRINGS
TAB INTERCONNECT .078 × .002
COPPER WITH SOLDER PLATING
SCALE FULL SIZE
.187 (4.75MM)
TEMPERED SUNADEX GLASS
.018 (.5MM) EVA CLEAR (2) SHEETS
BARRIER
.004 (.10MM) BLACK ADHESIVE
.005 (.13MM) POLYESTER
.0007 (.02MM) ALUMINUM FOIL
.0015 (.04MM) TEDLAR
(1) SHEET
EFG RIBBON SOLAR CELLS .012 (.30MM) THICK (432) REQ'D
COPPER TAB SOLDER PLATED .078 × .002 (2MM × .5MM) (2) REQ'D PER CELL
Ra180-12 MODULE CROSS SECTION
SCALE 4 TO 1
JUNCTION BOX & COVER
SCALE FULL SIZE
WARNING LABEL
SCALE FULL SIZE
MODULE LABEL
SCALE FULL SIZE
12 PT BOLD
12 PT MEDIUM
8 PT MEDIUM
6 PT FINE
Mobil Tyco
Solar Energy Corporation
INTERFACE CONTROL
Ra180-12 MODULE
E 7005056 D

FIGURE 1





SECTION A-A
SCALE: 4 TO 1

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ITEM	QTY	DRAWING NO.	DESCRIPTION
12	1	B2005044	WARNING LABEL
11	1	B2005041	INSULATION TAPE
10	4	B2005040	MESH CROSSTIE
9	1	B2005033	MODULE LABEL
8	1	C2005052	JUNCTION BOX ASSEMBLY NEGATIVE
7	1	C2005051	JUNCTION BOX ASSEMBLY POSITIVE
6	2	B2005048	POWER BUS ASSEMBLY
5	864	B2005039	INTERCONNECT
4	432	D2005030	EFG SOLAR CELLS
3	1	C2005046	WEATHER BARRIER
2	2	C2005037	ENCAPSULANT
1	1	C2005036	MODULE SUPERSTRATE

MATERIAL LIST

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UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ±; FRACTIONS ±; 2 PLACE ±.03; 3 PLACE ±
SURFACES: MICRO-INCHES
NEXT ASSEMBLY
MATERIAL
FINISH

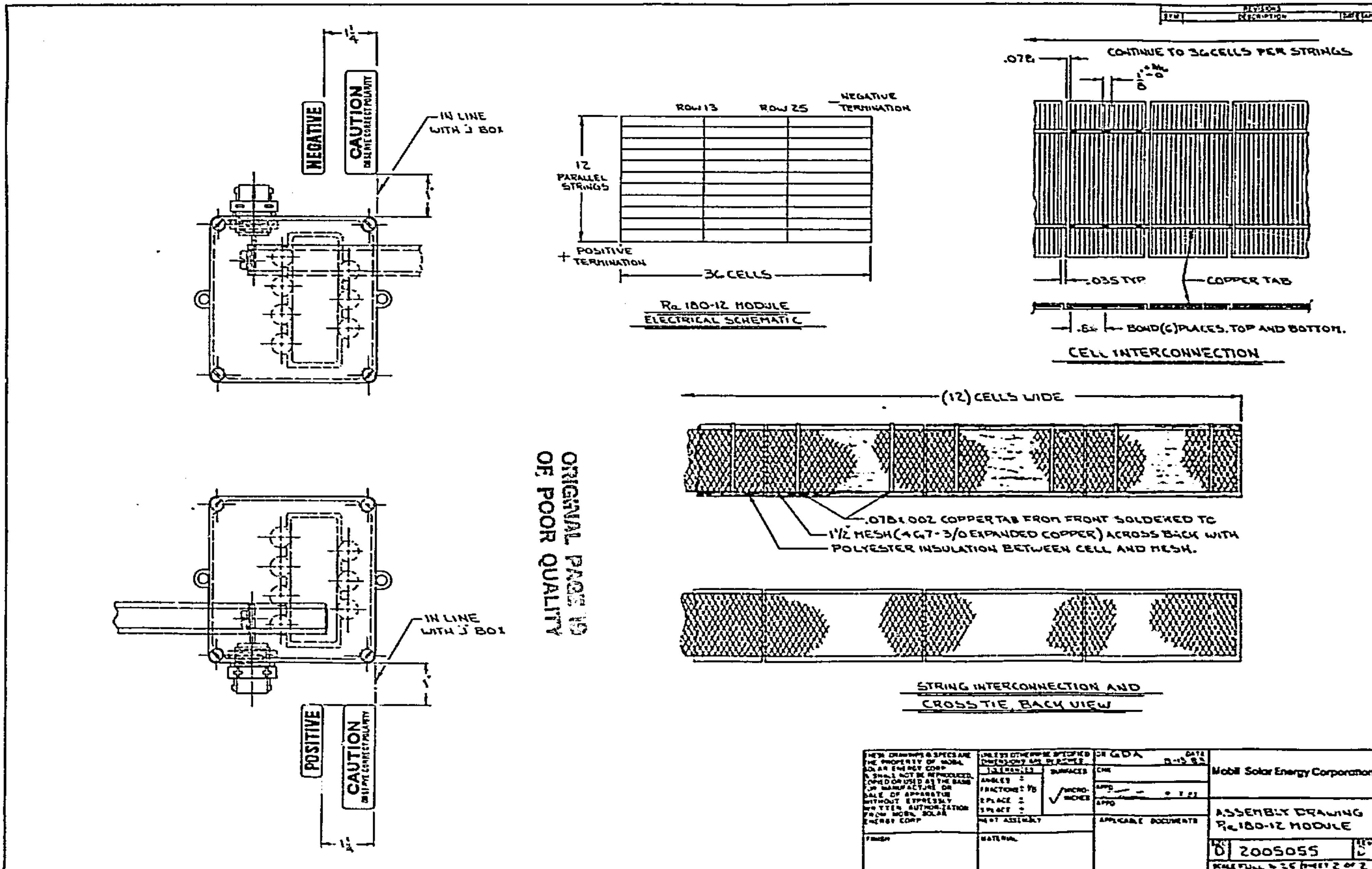
DR G D A DATE
CHK
APPD
APPD
APPLICABLE DOCUMENTS

Mobil Tyco
Solar Energy Corporation

ASSEMBLY DRAWING
RA 180-12 MODULE

2005055
SCALE 1/8 SIZE SHEET 1 OF 2

FIGURE 2



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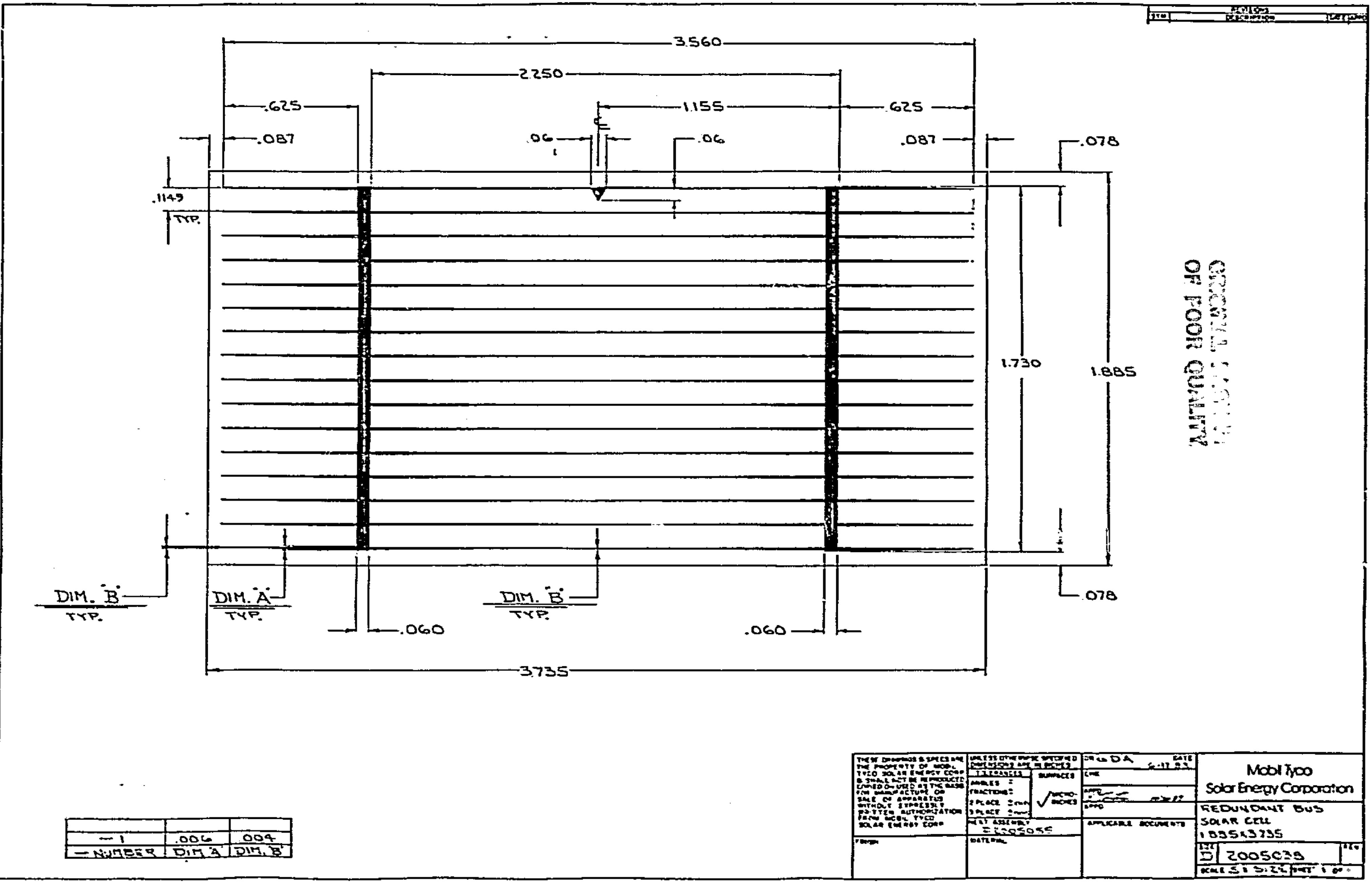


3.560
2.250
.625
1.155
.625
.087
.06
.06
.087
.078
.1149
TYP.
1.730
1.885
.078
DIM. B
TYP.
DIM. A
TYP.
DIM. B
TYP.
.060
.060
3.735
— 1 | .006 | .004
— NUMBER | DIM. A | DIM. B
Mobil Tyco
Solar Energy Corporation
REDUNDANT BUS
SOLAR CELL
1.885x3.735
D 2005035

FIGURE 4

Two junction boxes (one positive and one negative) are adhesively bonded to the back of the module using a silicone RTV. Each power lead enters the J-box through a slot in the bottom of the box and is screwed to the tongue on the bulk head connector. Interconnection of modules is done by plugging them together with male harnesses.

3.4. SUPERSTRATE

Tempered low iron glass was selected as both the structural support and front cover of the module. Light transmission, reliability, cost and compatibility to the lamination process were all factors which made glass the preferred choice. The glass length and width (70-1/2" x 47-3/8") are also the dimensions of the module because it is frameless. The thickness is 3/16". Structurally, 1/8" glass would be adequate; however, sagging of the glass when mounted may be an aesthetic problem.

The glass is prepared for lamination with a wash and subsequent priming of the inside surface.

3.5. POTTANT

Modified commercially available Ethylene Vinyl Acetate (EVA) using standard lamination techniques was chosen as the encapsulation system. The manufacturer's experience with EVA and its proven laboratory performance made it the preferred choice of encapsulants.

3.6. WEATHER BARRIER

A multi-layer laminate of Tedlar, Al foil, polyester and adhesive serves as a final weather barrier. Tedlar is widely used in the industry as the outer skin because of its proven reliability. Aluminum foil is included as the primary vapor barrier offering corrosion protection to the cells and interconnects. A film of polyester serves as an electrical insulator between the aluminum foil and cell array. Finally, an opaque adhesive bonds the composite weather barrier to the EVA during the lamination cycle.

3.7. EDGE SEAL/INSULATION

No special provisions are made for edge sealing the module other than bringing the weather barrier tightly to the glass edge during lamination. The polyester film inside the weather barrier works well as an insulator; however, since the module is frameless, there is no provision for externally grounding the foil to an array support structure.

3.8. ROOF MOUNTING (Figures 5 and 6)

The module has been designed to be roof integrated; therefore, no self-contained framework exists with the module. The module width is slightly less than 4 ft. which fits with rafter spacings of 16 in. on center. The J-boxes are located such that no interference will exist with framing members.

The mounting system utilizes the rough framing of the dwelling roof as the frame and mechanical support for the module. The module is secured to the rafters with a screw-down batten which runs the length of each side of the module and clamps it to the rafter. Purlins support the module ends from underneath, but there is no batten on top. Debris, rain, snow, etc., are free to slide off the module face without catching on horizontal lips.

Non-conductive gasketing is used around the perimeter of the module as a weather seal and cushion; however, in the event of a leak, drip troughs installed directly over the rafters and purlins will channel water harmlessly to the outside. A silicone RTV is used across the top and bottom of the module as a seal between modules.

It is recommended that louvers run continuously along the top and bottom of the array for proper ventilation.

4. MODULE NOMINAL ELECTRICAL PERFORMANCE

Listed in Table 1 is the nominal performance for two operating conditions for the Group II module.

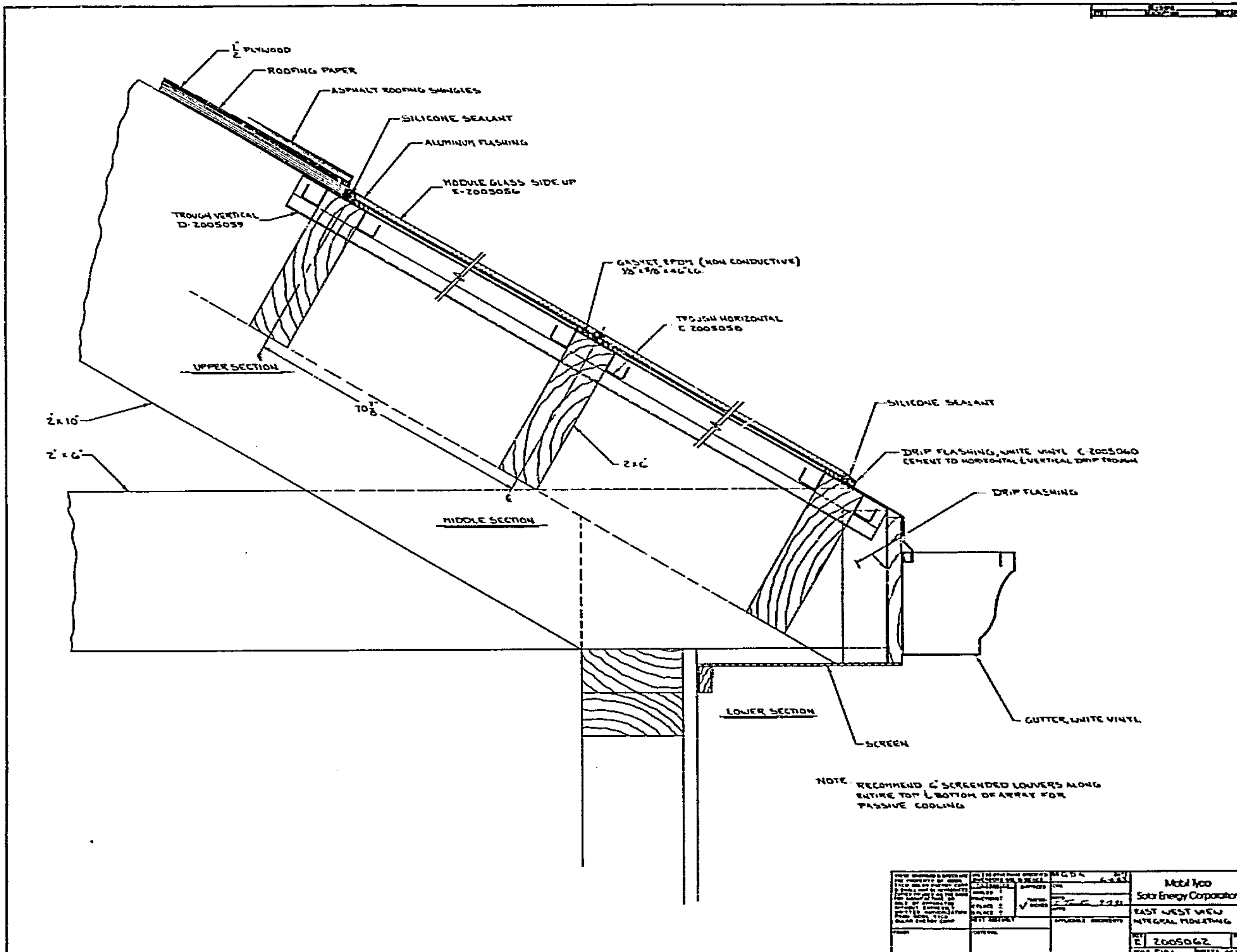
Table 1. Nominal Group II Module Performance.

Parameter	80 mw/cm^2 NOCT AM1.5	100 mw/cm^2 NOCT AM1.5
Peak Power	128.8 W	158.5 W
Voltage, Open Circuit	17.04 V	16.78 V
Current, Short Circuit	10.91 a	13.69 a
$_m$, module efficiency*	7.4%	7.2%
$_c$, encap. cell efficiency**	8.2%	8.1%
PF, Packing Factor	89.4%	89.4%
FF, Fill Factor	0.693	0.690
NOCT	46°C	51.5°C

$V/T = .012\ v/^{o}C$

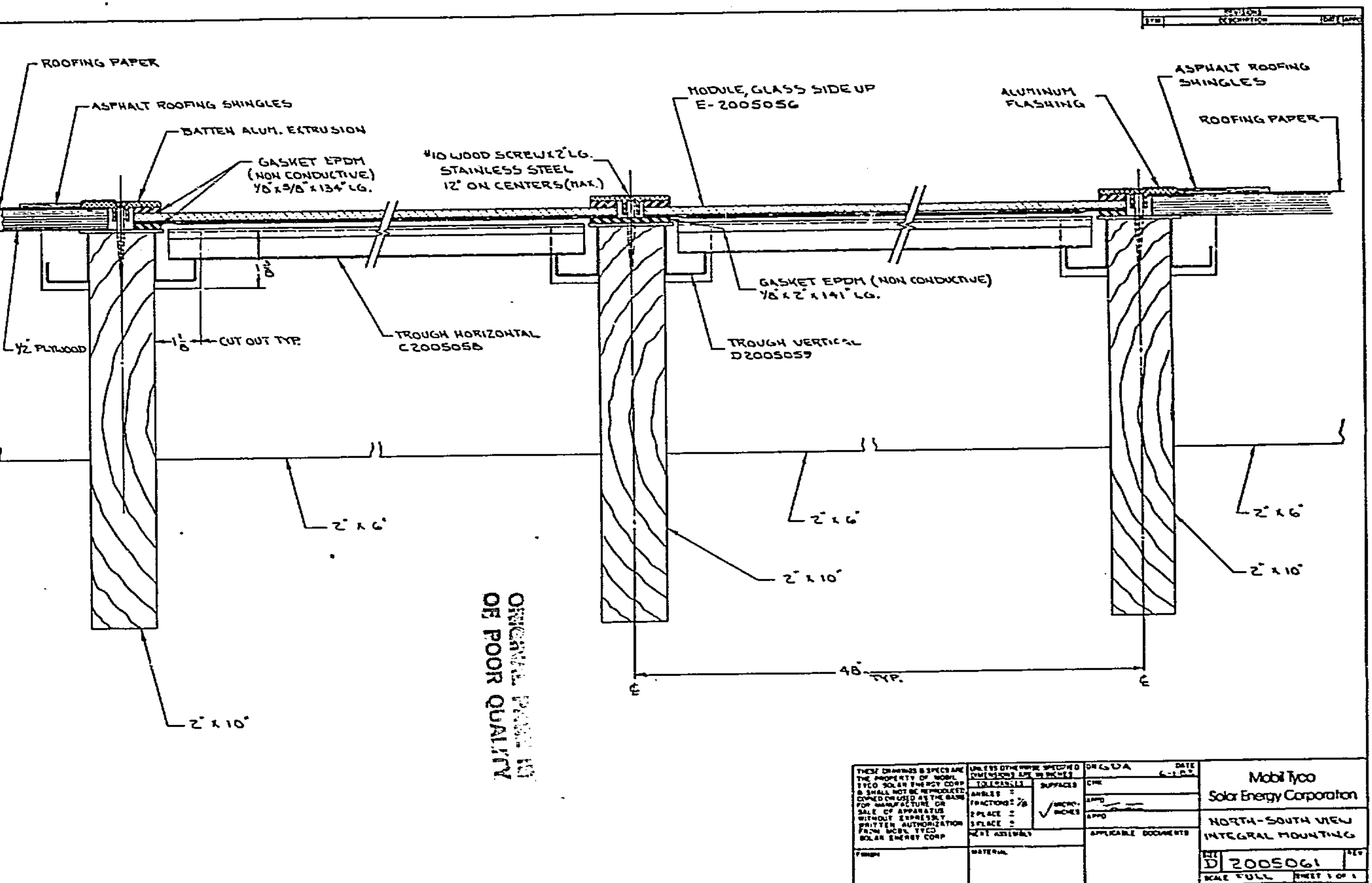
$I/T = .078\ a/^{o}C$

* As mounted in an array. 48" x $70^{7}/8$" on center dimensions.
** Using nominal cell dimensions.



1/2" PLYWOOD
ROOFING PAPER
ASPHALT ROOFING SHINGLES
SILICONE SEALANT
ALUMINUM FLASHING
MODULE GLASS SIDE UP
E-2005056
TROUGH VERTICAL
D-2005059
GASKET, EPDM (NON CONDUCTIVE)
TROUGH HORIZONTAL
C 2005058
UPPER SECTION
70 7/8"
2"x10"
2"x6"
2x6
MIDDLE SECTION
SILICONE SEALANT
DRIP FLASHING, WHITE VINYL C-2005060
CEMENT TO HORIZONTAL & VERTICAL DRIP TROUGH
DRIP FLASHING
LOWER SECTION
SCREEN
GUTTER, WHITE VINYL
NOTE: RECOMMEND 6" SCREENDED LOUVERS ALONG ENTIRE TOP & BOTTOM OF ARRAY FOR PASSIVE COOLING
Mobil Tyco
Solar Energy Corporation
EAST WEST VIEW
INTEGRAL MOUNTING
E 2005062

FIGURE 5



ROOFING PAPER
ASPHALT ROOFING SHINGLES
BATTEN ALUM. EXTRUSION
GASKET EPDM (NON CONDUCTIVE) 1/8" x 3/8" x 134" LG.
#10 WOOD SCREW x 2" LG. STAINLESS STEEL 12" ON CENTERS (MAX.)
MODULE, GLASS SIDE UP E-2005056
ALUMINUM FLASHING
ASPHALT ROOFING SHINGLES
ROOFING PAPER
GASKET EPDM (NON CONDUCTIVE) 1/8" x 2" x 141" LG.
TROUGH HORIZONTAL C2005058
TROUGH VERTICAL D2005059
1/2" PLYWOOD
1 1/8
CUT OUT TYP.
2" x 6"
2" x 6"
2" x 6"
2" x 10"
2" x 10"
2" x 10"
2" x 10"
48" TYP.
ORIGINAL PAGE IS OF POOR QUALITY
Mobil Tyco Solar Energy Corporation
NORTH-SOUTH VIEW INTEGRAL MOUNTING
D 2005061
SCALE FULL

The above performance data was generated from both individual cell characteristics and actual module data. Shown below in Table 2 is a sampling of typical large area module performance. These modules are a nominal 24V rather than 12V for the Group II modules.

Table 2. Typical Large Area Module Performance.

MODEL		N	PP (W)	VOC (V)	ISC (A)	IP (A)	VP (V)	ITEST (A)	FF	POWER PFV PP (KW)
180-24D	X	21	181.79	38.29	6.30	5.71	31.87	5.639	0.753	3.672
	S		4.98	0.35	0.17	0.20	0.59	0.16	0.016	3.818

5. BLOCK V QUALIFICATION TESTS

5.1. TEST PROCEDURES

The module qualification tests are the standard Block V series as outlined in the JPL document 5101-162 "Block V Solar Cell Module Design and Test Specification for Residential Applications - 1981". They are listed below and further details may be found in JPL document 5101-163, "Block V Solar Cell Module Design and Test Specification for Residential Applications-1981".

- Thermal cycle: 200 cycles, -40 to 90°C.
- Temperature-humidity: 10 cycles, 85°F/85% RH with a -40°C plunge every 24 hrs.
- Hail impact
- Mechanical loading: 10,000 cycles, ±50 psf.
- Twisted mount
- Hot spot heating
- Hi potential: ±3000 VDC

5.2. BLOCK V, GROUP I MODULE TEST RESULTS

The Group I module was the first Mobil Solar design of a roof integrated Block V module. Several significant changes were made to the Group II module as a result of processing experience and Block V qualification tests. The results are as follows:

5.2.1. THERMAL CYCLING

One module of the six cycled (4 for 50 cycles and 2 for 200 cycles) failed due to electrical performance after 50 cycles. Probable cause is broken cells. Non-redundancy of the interconnect system makes the module susceptible to this failure mode.

Thermal cycling aggravated back skin delamination, which existed initially in some modules. Poor adhesion between the polyester insulation layer and EVA caused the problem.

No interconnect fatigue was noted after all cycling was complete.

5.2.2. HI POTENTIAL/CONTINUITY

Initial hipot tests produced failures in all modules. Several factors contributed to this. The backskin foil was not grounded to the metallic drip troughs, the gasketing material was electrically conductive, and the junction box is metallic. Subsequent testing before and after other stress tests resulted in eventual passage.

5.2.3. HUMIDITY FREEZE

The humidity freeze caused more delamination of the backskin and the one module which degraded electrically after thermal cycling continued to degrade. Oxidation of the hardware inside the J- box began to occur.

5.2.4. MECHANICAL LOADING

Two modules of four showed separation of sealant from the module edge at the two short ends. These two edges are not securely fastened to the roof structure and during the -50 psf loading the module edge is lifted up breaking the seal. In addition, in one of the two modules, three of the five wood screws used to secure the bottom to the rafter pulled out. Some additional backskin delamination was observed.

5.2.5. TWISTED MOUNT, HOTSPOT, FINAL HI POTENTIAL

Performance was satisfactory.

5.3. BLOCK V, GROUP II MODULE TEST RESULTS

The Group II modules passed the Block V qualification tests. Their were some changes to the module as a result of the tests, however, they were minor. The suggested mounting system did not pass the qualification tests. Thermal cycling produced module movement and distortion of mounting materials. The results of each test are as follows:

5.3.1 ACTUAL MODULE ELECTRICAL PERFORMANCE

Shown in Table 3 are the actual average electrical parameters as measured at JPL upon receipt.

Table 3 - Actual Group II Module Performance

No. Modules	100 mW/cm^2 PP (W)	Voc (V)	25°C Isc (A)	IP (A)	AM 1.5 VP (V)	FF
10	177.1	18.94	12.92	11.73	15.09	.723

5.3.2 THERMAL CYCLING

Fifty thermal cycles produced no changes to the modules. Two hundred cycles showed fatique stress marks on 20% of the interconnects but no cracking. Average power degradation after all cycling was -.2% with no module more than -2.4%.

Problems occurred during the first fifty cycles with the simulated vinyl drip troughs. The vinyl had softened at the high temperature causing the module to slide in the framework. Continued thermal cycling caused distortion of the vinyl.

5.3.3 HI POTENTIAL/CONTINUITY

There were no hi potential test failures and by design, no continuity.

5.3.4 HUMIDITY FREEZE

This test was satisfactory, however, one module showed a group of small bubbles at one spot in the module. There is no explanation for this.

Power measurements of the four modules showed a consistent 3-3.1% loss for three of the modules and one at +1.5%. The tight consistency of the three was either a very peculiar considence or some unexplained phenomena occurred. Two of the three recovered half of the loss in subsequent tests.

5.3.5 MECHANICAL LOADING

Two of the three modules showed cell cracking after testing, but it had no affect on performance. The cracks may have existed before testing and were aggrevated during the test to the point of becoming visible.

5.3.6 TWISTED MOUNT, HOTSPOT, FINAL HI POTENTIAL

Performance was satisfactory.

6.0. MODULE DESIGN CHANGES

No changes to the module design are warranted as a result of the qualification tests. The cell cracking noticed after mechanical loading is probably best corrected by reducing cracked cells at or prior to encapsulation.

Improvement to the support structure is needed to pass the qualification tests. The major problem was the inability of the simulated vinyl drip troughs to survive the 90°C temperature. The selection of a higher temperature plastic should correct the problem.

7.0. CONCLUSIONS AND RECOMMENDATIONS

Significant improvements were made in the module design between Group I and Group II.

Replacement of the adhesive system used in bonding the backskin to the EVA eliminated the serious delamination seen with Group I modules. The incorporation of redundant interconnects with Group II modules reduced power losses to less than 2-3% even with a signicant number of visibly cracked cells. The change from conductive to non-conductive gasketing, drip troughs and junction boxes corrected the many hi potential failures. These three major changes lead to the successful completion of the Block V qualification tests.

No changes to the module design is recommended. A material substitution for the drip troughs is necessary for the recommended mounting system to pass, however, it is the opinion of MSEC that both the mechanical loading and thermal cycling tests are too severe for an integrated residential roof mounting system. Given realistic tests (± 20 psf mechanical loading; -20 to + 60°C thermal cycling) the current system is satisfactory.

APPENDIX 1

SUMMARY RESULTS OF ENVIRONMENTAL TESTS

OF SOLAR MODULES AT JPL

GROUP I AND GROUP II MODULES

Revision dates
9/2/83
9/27/83
11/30/83
02/13/84
02/22/84

Appr'd.

SUMMA

Results of Environmental Tests

of Solar Modules at JPL

GROUP I

Prepared by: F. . rren
Approved by:
Date: 7/28/83
Rev. 8/15/83
Rev. 8/24/83

Vendor	Module S/Ns	Module Type	Test	Electrical Degrad., %	Comments
MSEC Gr 1 LS5H	3493, 3550, 3551, 3554 (simulated roof sections)	RA-160-12	Hipot/ Continuity		Initially failed hipot & continuity in vendor-built roof section. After several tests were made, module would eventually withstand the 1500V hipot requirement. Rubber gasket is electrically conductive. Roof not designed for continuity test (metal troughs, J-boxes not connected.) Cell string to J-box short, S/N 3551.
	3493, 3550, 3554, 3555		Hipot/ Continuity		Modules mounted in simulated roof installation assembled from vendor-supplied materials. Again failed initial hipot & continuity tests.
	3509, 3567		T-50~	--	Back surface delaminated over a substantial area in one corner, S/N 3509.
	3493, 3550, 3554, 3555		T-50~	-9.7% S/N 3550	Electrical failure, 1 mdl. Five of six modules show back surface delam with 10 x 15 cm spots common.
	3509, 3567		T-200~		Satisfactory. No Interconnect fatigue noted.
	3493, 3550 3554, 3555		HF-10	-11.7 S/N 3550	Resistance to ground dropped to less than 1 Mohm, 4 mdls. More delamination front and back. J-box hardware oxidized, S/N 3550.
	3493, 3550, 3554, 3555		M-10K		Modules had 1, 1, 5, and 6 cells cracked, resp. Glass separated from sealant at ends of 2 modules. S/N 3493 had 3 of 5 screws pulled out of the wooden rafters, one side. S/N 3550 had a 5 X 10 cm area of Tedlar delaminated.
			Twist		Satisfactory.
			Hail-1.0		Satisfactory.
	3493, 3550 3554, 3555		Hipot, Cont'ty		Hipot satisfactory. No continuity by design.
	3558		HS-100		Satisfactory. Testing completed on these modules.

F S A   M O D U L E   T E S T   S U M M A R Y

TEST SPEC 5101-161,162 (100mW/sq cm)

TEST-DURATION
HF = Humidity Freeze-Cycles
HS = Hot Spot-Cycles
HL = Hail-Size/Inches
M = Mech Integrity-Cycles
S/A = Mounted in Subarray
T = Temperature-Cycles

ID NUMBER
Letters = Mfrer/Block/Use
Number = Vendor Serial No.

COEFF = Temp Coefficient
DELAM = Delamination
DSCN = Discoloration
ENCAP = Encapsulation
INTCON = Interconnector

COMMENTS
DPMC = Delta PMAX of Control Module
I = Identifier: J = JPL, V = Vendor
P/FR = Failure Report No.
SAT = Tested Satisfactorily
SBSTR = Substrate

IMP = Current at PM, 25 Deg C, 100mW/sq cm
ISC = Short Ckt Current, 25 Deg C, A
P = Power at Rating V, NOCT

ELECTRICAL
PM = Power Max, 25 Deg C Curve
VOC = Open Ckt Voltage, 25 Deg C, V
VMP = Voltage at PM, V

DELTA, PCT = Difference Percent
FF = Fill Factor, PM/Isc X Voc
FLASH DATE = Date of Elec Test

VENDOR MSEC GR 1
MOD# RA-160-12

PROCUREMENT
BL V 754177

RATINGS
NOT RATED

STATUS AS OF
02/22/84

ID NUMBER	LINE	TEST DURATION	JPL PM, W	DELTA PM, PCT	FLASH DATE	I	P NOCT	DELTA P, PCT	ISC	VOC	IMP	VMP	FF		P/FR
LS5H	1	REMARKS												S/N 3550,3551,3554 & 3493 WERE REC'D IN A SINGLE VENDOR-BUILT	
	2													SIMULATED ROOF SECTION. ALL FAILED HIPOT TEST INTERMITTENTLY,	
	3													ESECIALLY DURING INITIAL HIPOT EXPOSURES. ALL MODULES FAILED	
	4													CONT'TY BECAUSE METAL J-BOX & TROUGHS @ MODDUULE EDGES AREN'T	
	5													CONNECTED. "ROOF" WAS DISASSEMBLED. S/N 3550,3554,3555 & 3493	
	6													INSTALLED IN INDIVIDUAL SIMULATED ROOF MOUNTINGS. HIPOT &	
	7													CONT'TY TESTS SHOWED SIMILAR RESULTS.	
LS5H-3493	1	HIPOT			05/11/83									FAILED HIPOT (VENDOR ROOF).	
LS5H-3493	2	CONT'TY			05/11/83									FAILED CONT'TY (VENDOR ROOF).	
LS5H-3493	3	HIPOT			06/17/83									FAILED HIPOT (JPL-BUILT FRAME).	
LS5H-3493	4	CONT'TY			06/17/83									FAILED CONT'TY (JPL-BUILT FRAME).	
LS5H-3493	5	RCVG	164.05		07/08/83				10.410	23.68	8.740	18.77	.67		
LS5H-3493	6	PRE-TEST	162.92		07/14/83									BASE.	
LS5H-3493	7	T-50	164.37	+0.9	08/03/83									BACKSIDE TEDLAR DELAM BOTH ENDS. 40Mohms RES TO FRAME ALL HOT	
LS5H-3493	8				08/03/83									CYCLES.	3152
LS5H-3493	9	HF-10	161.80	-0.6	09/01/83									400 Kohms RES TO GND, HOT ENDS. 1 CELL CR. MORE DELAM FRONT &	
LS5H-3493	10				09/01/83									BACKSIDE.	3248
LS5H-3493	11	M-10K	157.04	-3.6	11/16/83									SEALANT SEPARATED FROM GLASS BOTH ENDS. 3 SCREWS BROKEN OFF.	
LS5H-3493	12				11/16/83									1 CELL CRACKED.	3172
LS5H-3493	13	TWIST	155.88	-4.3	12/20/83									INSPECTION WAIVED.	
LS5H-3493	14	HL-1.0	153.83	-5.5	01/24/84									SATISFACTORY.	
LS5H-3493	15	HIPOT			01/26/84									SATISFACTORY.	
LS5H-3493	16	CONT'TY			01/26/84									NO CONT'TY BY DESIGN.	
LS5H-3496	1	INITIAL	171.20		04/20/83				10.670	23.90	8.780	19.50	.67	1 CELL CRACKED.	
LS5H-3496	2	PRE-TEST	170.29		04/21/83									BASE.	

LS5H-3509	1	INITIAL	161.40		04/20/83	10.540 23.86 8.350 19.32 .64 3 CELLS CRACKED.	
LS5H-3509	2	PRE-TEST	159.91		04/20/83	BASE.	
LS5H-3509	3	T-50	160.45	+0.3	07/18/83	TEDLAR DELAM 2.5 x .75 cm @ 1 CORNER.	3142
LS5H-3509	4	T-200	157.66	-1.4	08/24/83	SATISFACTORY. NO IC FATIGUE.	
LS5C-3547	1	INITIAL	164.25		04/20/83	10.290 23.88 8.550 19.21 .67	
LS5C-3547	2		165.49		04/21/83	CONTROL MODULE. BASE.	
LS5C-3547	3		163.00	-1.5	07/08/83	CONTROL MODULE.	
LS5C-3547	4		163.60	-1.1	07/14/83	CONTROL MODULE.	
LS5C-3547	5		162.30	-1.9	07/18/83	CONTROL MODULE.	
LS5C-3547	6	RECHECK	162.04	-2.1	07/18/83	CONTROL MODULE.	
LS5C-3547	7		161.47	-2.4	07/18/83	CONTROL MODULE.	
LS5C-3547	8		161.69	-2.3	08/03/83	CONTROL MODULE.	
LS5C-3547	9		162.87	-1.6	08/24/83	CONTROL MODULE.	
LS5C-3547	10		162.38	-1.9	09/01/83	CONTROL MODULE.	
LS5C-3547	11		162.12	-2.0	10/19/83	CONTROL MODULE.	
LS5C-3547	12		160.89	-2.8	10/26/83	CONTROL MODULE.	
LS5C-3547	13		163.76	-1.1	11/15/83	CONTROL MODULE.	
LS5C-3547	14		162.06	-2.1	11/16/83	CONTROL MODULE.	
LS5C-3547	15		161.91	-2.2	12/20/83	CONTROL MODULE.	
LS5C-3547	16		161.57	-2.4	01/12/84	CONTROL MODULE.	
LS5C-3547	17		163.07	-1.5	01/24/84	CONTROL MODULE.	
LS5C-3547	18		161.37	-2.5	02/07/84	CONTROL MODULE.	
LS5C-3547	19		164.77	-0.4	02/21/84	CONTROL MODULE.	
LS5H-3550	1	HIPOT			05/11/83	FAILED HIPOT (VENDOR ROOF).	
LS5H-3550	2	CONT'TY			05/11/83	FAILED CONT'TY (VENDOR ROOF).	
LS5H-3550	3	HIPOT			06/17/83	FAILED HIPOT (JPL-BUILT FRAME).	
LS5H-3550	4	CONT'TY			06/17/83	FAILED CONT'TY (JPL-BUILT FRAME).	
LS5H-3550	5	RCVG	160.89		07/08/83	10.370 23.70 8.550 18.82 .65	
LS5H-3550	6	PRE-TEST	161.89		07/14/83		
LS5H-3550	7	T-50	146.26	-9.7	08/03/83	ELEC DEGRAD. BACKSIDE TEDLAR DELAM. 33Mohms RES TO FRAME, ALL	
LS5H-3550	8				08/03/83	HOT CYCLES.	3150
LS5H-3550	9	RECHECK	146.10	-9.8	08/03/83	DEGRAD VERIFIED.	
LS5H-3550	10	RECHECK	146.17		08/03/83		
LS5H-3550	11	HF-10	143.86	-11.1	08/31/83	497Kohms RES TO GND, HOT END. 1 CELL CR. MORE DELAM 2 SIDES.	
LS5H-3550	12				08/31/83	OXIDATIONS @ J-BOX & SCREWS HOLDING TERM STRIPS.	3098
LS5H-3550	13	RECHECK	142.97	-11.7	08/31/83		
LS5H-3550	14	H-10K	141.11	-12.8	10/19/83	BACKSIDE TEDLAR DELAM 10cm & 5cm @ J-BOX. 1 CELL CRACKED.	
LS5H-3550	15				10/19/83	SEALANT PULLED AWAY FROM GLASS.	3241
LS5H-3550	16	TWIST	144.23	-10.9	10/26/83	SATISFACTORY THIS TEST.	
LS5H-3550	17	RECHECK	143.68	-11.2	10/26/83		
LS5H-3550	18	HL-1.0	142.93	-11.7	11/15/83	SATISFACTORY THIS TEST.	
LS5H-3550	19	HIPOT			11/15/83	SATISFACTORY. NO CONT'TY BY DESIGN.	
LS5H-3551	1	HIPOT			05/11/83	FAILED HIPOT. CELLS SHORTED TO J-BOX. (VENDOR ROOF).	
LS5H-3551	2	CONT'TY			05/11/83	FAILED CONT'TY.	
LS5H-3551	3	INITIAL	163.69		11/16/83	10.120 23.77 8.440 19.39 .68 NOCT MODULE.	

LS5H-3554	1	HIPOT			05/11/83	FAILED HIPOT (VENDOR ROOF).	
LS5H-3554	2	CONT'TY			05/11/83	FAILED CONT'TY (VENDOR ROOF).	
LS5H-3554	3	HIPOT			06/17/83	FAILED HIPOT (JPL-BUILT FRAME).	
LS5H-3554	4	CONT'TY			06/17/83	FAILED CONT'TY (JPL-BUILT FRAME).	
LS5H-3554	5	RCVG	158.62		07/08/83	9.790 23.82 8.450 18.77 .68	
LS5H-3554	6	PRE-TEST	159.96		07/14/83	BASE.	
LS5H-3554	7	T-50	160.06	+0.1	08/03/83	BACKSIDE TEDLAR DELAM @ NEG END. 33Mohms RES TO FRAME, ALL HOT	
LS5H-3554	8				08/03/83	CYCLES.	3151
LS5H-3554	9	HF-10	159.59	-0.2	08/31/83	546Kohms RES TO GND, HOT ENDS. MORE DELAM FRONT & BACKSIDE.	3250
LS5H-3554	10	M-10K	158.40	-1.0	11/16/83	5 CELLS CRACKED.	3175
LS5H-3554	11	TWIST	155.86	-2.6	12/20/83	INSP WAIVED.	
LS5H-3554	12	HL-1.0	155.41	-2.8	01/24/84	SATISFACTORY.	
LS5H-3554	13	HIPOT			01/25/84	SATISFACTORY.	
LS5H-3554	14	CONT'TY			01/25/84	NO CONT'TY BY DESIGN.	
LS5H-3555	1	HIPOT			06/17/83	FAILED HIPOT (JPL-BUILT FRAME).	
LS5H-3555	2	CONT'TY			06/17/83	FAILED CONT'TY (JPL-BUILT FRAME).	
LS5H-3555	3	INITIAL	171.80		04/20/83	10.390 23.86 9.150 18.77 .69 1 CELL CRACKED.	
LS5H-3555	4	PRE-TEST	170.70		04/21/83	BASE.	
LS5H-3555	5	RECHECK	169.81		07/08/83		
LS5H-3555	6	T-50	173.91	+1.9	08/03/83	BACKSIDE TEDLAR DELAM THROUGHOUT. 23Mohms RES TO FRAME, ALL	
LS5H-3555	7				08/03/83	HOT CYCLES.	3149
LS5H-3555	8	HF-10	173.95	+1.9	08/31/83	344Kohms RES TO GND HOT ENDS. MORE DELAM FRONT & BACKSIDE.	3249
LS5H-3555	9	M-10K	167.59	-1.8	11/16/83	6 CELLS CRACKED.	3176
LS5H-3555	10	TWIST	166.67	-2.4	12/20/83	SATISFACTORY.	
LS5H-3555	11	HL-1.0	167.25	-2.0	01/24/84	SATISFACTORY.	
LS5H-3555	12	HIPOT			01/26/84	SATISFACTORY.	
LS5H-3555	13	CONT'TY			01/26/84	NO CONT'TY BY DESIGN.	
LS5H-3558	1	INITIAL	158.26		04/20/83	10.140 23.99 8.110 19.52 .65 3 CELLS CRACKED.	
LS5H-3558	2	PRE-TEST	157.99		04/21/83	BASE. HOTSPOT MODULE.	
LS5H-3558	3	HS-100	156.48	-1.0	02/21/84	SATISFACTORY.	
LS5H-3567	1	INITIAL	178.26		04/20/83	10.410 24.12 9.160 19.45 .71	
LS5H-3567	2	PRETEST	178.56		04/21/83		
LS5H-3567	3	RECHECK	177.45		04/21/83	BASE.	
LS5H-3567	4	T-50	175.76	-1.0	07/18/83	SATISFACTORY.	
LS5H-3567	5	T-200	173.46	-2.3	08/24/83	SATISFACTORY. NO IC FATIGUE.	

ɜvision dates	Appd.
7-25-84	
8-9-84	
9-13-84	
10-11-84	

SUMMARY

Results of Environmental Tests

of Solar Modules at JPL

GROUP II

Prepared by: Frank Ferren
Approved by:
Date: 5-11-84
Rev. 5-25-84
Rev. 6-13-84

/endor	Module S/Ns	Module Type	Test	Electrical Degrad., %	Comments
ɪSEC Bl V, ɜr 2, LS5P	4969, 4971, 4972	RA-180-12	Hipot/ Cont'ty	--	Initial hipot satisfactory. No continuity by design.
	4969, 4971		T-50 ~	--	Laminates slid out of end of JPL fabricated wood frames. Frames simulated MSEC design drawings 2005057, -61, -62. Modules were mounted vertically in chamber. Vinyl softened and distorted. Back surface material shrank 3 mm.
	4972, 5001		T-50~		Modules in frames were positioned in the chamber on their sides. Laminates slipped downward until stopped by batten screws. White vinyl distorted and shrank(.5 to 1 cm). Silicone sealant was torn from laminate for 7 cm at 2 corner of S/N 4972. Laminate itself was satisfactory.
	4976, 5000		T-50~		Modules were tested on their sides. Glass laminate slipped downward, vinyl distorted, silicone sealant torn from laminate at 2 and 3 corners, resp. Slight Tedlar shrinkage.
	4972, 4976 5000, 5001		HF-10~		Silicone roof sealant(N and S ends as mounted on roof) continues to loosen(2 modules). Groups of tiny air bubbles noted between some cells, S/N 5001.
	5083		HS-100~		Satisfactory.
	4969, 4971		T-200		Fatigue stress marks were noted on about 20% of the interconnects of each module but no cracks. Markings that possibly were delaminated spots were observed next to some of the stress marks on S/N 4969. Vinyl is more distorted on the back. S/N 4971 laminate shifted further in the frame and the silicone seal at the end is torn away more than before.
	4972, 5001		H-10K		Satisfactory.
	4969, 4971, 4972, 5001		Hipot/ Cont'ty		Satisfactory. No continuity by design.

..ision dates	App'd.

Prepared by: R. Lee
Approved by: [signature]
Date: 11-1-84
Rev.
Rev.

SUMMARY
Results of Environmental Tests of Solar Modules at JPL

GROUP II

'endor	Module S/Ns	Module Type	Test	Electrical Degrad., %	Comments
ISEC BL V, ır 2, LS5P	4976	RA-180-12	M-10K	--	String resistance increased 60% intermittently. Cell string resistance increased from 430 ohms up to 700 ohms intermittently for 224 cycles during the test. 15 additional cracked cells.
	5000		M-10K	--	7 additional cracked cells.
	4976, 5000		Hipot/ Cont'ty	--	Satisfactory. No continuity by design.
					TESTING COMPLETE.

FSA MODULE TEST SUMMARY

TEST SPEC 5101-161,162 (100mW/sq cm)

TEST-DURATION
HF = Humidity Freeze-Cycles
HS = Hot Spot-Cycles
HL = Hail-Size/Inches
M = Mech Integrity-Cycles
S/A = Mounted in Subarray
T = Temperature-Cycles

ID NUMBER
Letters = Mfrer/Block/Use
Number = Vendor Serial No.

COEFF = Temp Coefficient
DELAM = Delamination
DSCN = Discoloration
ENCAP = Encapsulation
INTCON = Interconnector

COMMENTS
DPMC = Delta PMAX of Control Module
I = Identifier: J = JPL, V = Vendor
P/FR = Failure Report No.
SAT = Tested Satisfactorily
SBSTR = Substrate

ELECTRICAL
IMP = Current at PM, 25 Deg C, 100mW/sq cm
ISC = Short Ckt Current, 25 Deg C, A
P = Power at Rating V, NOCT

PM = Power Max, 25 Deg C Curve
VOC = Open Ckt Voltage, 25 Deg C, V
VMP = Voltage at PM, V

DELTA, PCT = Difference Percent
FF = Fill Factor, PM/Isc X Voc
FLASH DATE = Date of Elec Test

VENDOR MSEC GR 2
RA-180-12

PROCUREMENT
BLOCK V 754177

RATINGS
NOT RATED

STATUS AS OF
11/01/84

ID NUMBER	LINE	TEST DURATION	JPL PM, W	DELTA PM, PCT	FLASH DATE	I	P NOCT	DELTA P, PCT	ISC	VOC	IMP	VMP	FF		P/FR
LS5P	1	REMARKS													
LS5P-4969	1	RCVG	181.84		03/02/84				13.290	19.08	12.020	15.13	.72	8 CELLS CRACKED. BASE.	
LS5P-4969	2	HIPOT			03/30/84	SATISFACTORY.									
LS5P-4969	3	CONT'TY			03/30/84	NO CONT'TY BY DESIGN.									
LS5P-4969	4	T-50	182.57	-0.7	04/11/84	MODULE SLID OUT OF END OF JPL FRAME. SILICONE TORN FROM FRAME									
LS5P-4969	5					EDGE 6cm LONG. ALL WHITE VINYL DEFORMED. TEDLAR SHRUNK 3mm.									
LS5P-4969	6	T-200	181.53	-0.2	08/22/84	B/S WHITE VINYL MORE DEFORMED. STRESS MARKS, 20% OF ICs.									3300
LS5P-4969	7	HIPOT			09/07/84	SATISFACTORY.									
LS5P-4969	8	CONT'TY			09/07/84	NO CONT'TY BY DESIGN.									
LS5C-4970	1	RCVG	182.52		03/02/84				13.190	19.03	11.950	15.27	.73	5 CELLS CRACKED.	
LS5C-4970	2		179.43		03/06/84	CONTROL MODULE.									
LS5C-4970	3		180.47		04/04/84	CONTROL MODULE, BASE.									
LS5C-4970	4		183.21	+2.1	04/11/84	CONTROL MODULE.									
LS5C-4970	5		181.01	+0.9	05/07/84	CONTROL MODULE.									
LS5C-4970	6		181.24	+1.0	06/12/84	CONTROL MODULE.									
LS5C-4970	7		181.07	+0.9	07/02/84	CONTROL MODULE.									
LS5C-4970	8		181.95	+1.4	07/18/84	CONTROL MODULE.									
LS5C-4970	9		182.87	+1.9	08/07/84	CONTROL MODULE.									
LS5C-4970	10		184.72	+3.0	08/22/84	CONTROL MODULE.									
LS5C-4970	13		181.45	+1.1	10/09/84	CONTROL MODULE.									

LS5P-4971	1	RCVG	179.97		03/02/84	13.130 18.93 11.800 15.25 .72 9 CELLS, CRACKED.	
LS5P-4971	2	PRETEST	179.10		03/06/84	BASE.	
LS5P-4971	3	HIPOT			03/30/84	SATISFACTORY.	
LS5P-4971	4	CONT'TY			03/30/84	NO CONT'TY BY DESIGN.	
LS5P-4971	5	T-50	180.21	+0.6	04/11/84	MODULE SLID OUT OF JPL FRAME 4cm. SILICONE TORN FROM FRAME 8".	
LS5P-4971	6					TEDLAR SHRUNK 3mm. ALL WHITE VINYL DEFORMED.	3283
LS5P-4971	7	T-200	181.95	+1.6	08/22/84	MODULE OUT FROM FRAME 5cm. SILICON TORN 13". B/S WHITE VINYL	
LS5P-4971	8					MORE DEFORMED. STRESS MARKS, 20% OF ICs.	3303
LS5P-4971	9	HIPOT			09/07/84	SATISFACTORY.	
LS5P-4971	10	CONT'TY			09/07/84	NO CONT'TY BY DESIGN.	
LS5P-4972	1	RCVG	172.62		03/02/84	12.760 18.75 11.380 15.16 .72 19 CELLS CRACKED.	
LS5P-4972	2	PRETEST	170.68		03/06/84	BASE.	
LS5P-4972	3	HIPOT			03/30/84	SATISFACTORY.	
[illegible]	4	[illegible]TY			03/30/84	NO CONT'TY BY DESIGN.	
LS5P-4972	5	T-50	168.[illegible]		[illegible]	[illegible] DROPPED ABOUT .6cm in JPL FRAME. WHITE VINYL	
LS5P-4972	6					DISTORTION. SILICONE SEALANT PULLED LOOSE @ 2 CORNERS FOR 7cm,	
LS5P-4972	7					PROBABLY FROM VINYL BENDING & SHRINKAGE (.5 TO 1.0cm).	3221
LS5P-4972	8	HF-10	165.34	-3.1	07/18/84	SATISFACTORY THIS TEST.	
LS5P-4972	9	H-10K	168.72	-1.2	09/14/84	SATISFACTORY.	
LS5P-4972	10	HIPOT			09/18/84	SATISFACTORY.	
LS5P-4972	11	CONT'TY			09/18/84	NO CONT'TY BY DESIGN.	
LS5P-4976	1	RCVG	189.11		03/02/84	13.650 19.25 12.180 15.52 .72 6 CELLS CRACKED.	
LS5P-4976	2	PRETEST	188.44		03/06/84	BASE.	
LS5P-4976	3	HIPOT			05/29/84	SATISFACTORY.	
LS5P-4976	4	CONT'TY			05/29/84	NO CONT'TY BY DESIGN.	
LS5P-4976	5	T-50	185.95	-1.3	06/12/84	WHITE VINYL DISTORTION. SILICONE PULLED LOOSE @ 2 CORNERS, 14 &	
LS5P-4976	6					15cm. GLASS LAMINATE DROPPED IN FRAME. 2mm TEDLAR SHRINKAGE.	3286
LS5P-4976	7	HF-10	182.57	-3.1	07/18/84	SILICONE TEARING & LOOSENING PROPAGATED.	3292
LS5P-4976	8	H-10K	182.75	-3.0	10/09/84	15 MORE CRK'D CELLS. STRING RES. INCREASED 60% INTERMITTENTLY.	3318
LS5P-4976	9	HIPOT			10/09/84	SATISFACTORY.	
LS5P-4976	10	CONT'TY			10/09/84	NO CONT'TY BY DESIGN.	
LS5P-5000	1	RCVG	171.96		03/23/84	12.420 18.90 11.490 14.96 .73 4 CELLS CRACKED.	
LS5P-5000	2	RECHECK	170.33		04/04/84		
LS5P-5000	3	PRETEST	173.20		03/38/84	BASE.	
LS5P-5000	4	HIPOT			05/29/84	SATISFACTORY.	
LS5P-5000	5	CONT'TY			05/29/84	NO CONT'TY BY DESIGN.	
LS5P-5000	6	T-50	172.59	-0.4	06/12/84	WHITE VINYL DISTORTION. SILICONE PULLED LOOSE @ 3 CORNERS, 10,	
LS5P-5000	7					11 & 30cm. 2mm TEDLAR SHRINKAGE.	3286
LS5P-5000	8	HF-10	168.09	-3.0	07/18/84	SILICONE TEARING & LOOSENING PROPAGATED.	3292
LS5P-5000	9	H-10K	169.92	-1.9	10/09/84	7 ADDITIONAL CRACKED CELLS.	3317
LS5P-5000	10	HIPOT			10/09/84	SATISFACTORY.	
LS5P-5000	11	CONT'TY			10/09/84	NO CONT'TY BY DESIGN.	

LS5P-5001	1	RCVG	171.44		03/26/84		12.570	18.86	11.590	14.80	.72	3 CELLS CRACKED.	
LS5P-5001	2	RECHECK	171.73		03/26/84								
LS5P-5001	3	PRETEST	169.19		04/04/84	BASE.							
LS5P-5001	4	HIPOT			04/20/84	SATISFACTORY.							
LS5P-5001	5	CONT'TY			04/20/84	NO CONT'TY BY DESIGN.							
LS5P-5001	6	T-50	170.11	+0.5	05/07/84	LAMINATE DROPPED ABOUT .6cm IN JPL FRAME. VINYL END PIECES							
LS5P-5001	7					SHRANK ABOUT .5 TO .7cm.							3220
LS5P-5001	8	HF-10	171.76	+1.5	07/18/84	MINUTE AIR BUBBLES BETWEEN CELLS.							3291
LS5P-5001	9	M-10K	164.41	-1.4	09/14/84	SATISFACTORY.							
LS5P-5001	10	HIPOT			09/14/84	SATISFACTORY.							
LS5P-5001	11	CONT'TY			09/14/84	NO CONT'TY BY DESIGN.							
LS5P-5082	1	RCVG	173.16		04/04/84		12.750	18.80	11.470	15.10	.72	2 CELLS CRACKED.	
LS5P-5082	2	PRE-TEST	171.54		07/02/84	BASE.							
LS5P-5083	1	RCVG	178.45		04/04/84		12.910	18.86	11.840	15.07	.73	1 CELL CRACKED.	
LS5P-5083	2	PRE-TEST	180.36		07/02/84	BASE. HOTSPOT MODULE.							
LS5P-5083	3	HS-100	179.25	-0.6	08/07/84	SATISFACTORY.							
LS5P-5098	1	RCVG	170.05		04/04/84		12.570	18.90	11.590	14.67	.72	2 CELLS CRACKED.	
LS5P-5098	2	PRE-TEST	170.32		07/02/84								