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Solar Cell Module
Problem/Failure Reporting Procedure

Operations Area

January 12, 1979

Prepared for
Department of Energy
by
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California
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A-1  LSA Project/Field Organization Problem/Failure Report Form --------- A-2
1.1 GENERAL

This document describes the procedure for initiation, review, and closeout of a Problem/Failure Report (PFR).

1.2 SCOPE

This Problem/Failure Reporting and Analysis (PFRA) procedure covers solar cell module problems/failures resulting from the following activities:

1. Environmental, electrical, or mechanical tests.
2. Problems/failures experienced in JPL field test operations.
3. Field test and application experiments conducted by Lewis Research Center, MIT Lincoln Lab, DOD, Sandia Laboratories, and other field organizations using a solar module supplied by JPL/LSA.
4. Sandia/ALO solar photovoltaic flat panel application experiments.

1.3 REQUIREMENTS

The Low-Cost Solar Array Project and the PRDA applications require a comprehensive problem/failure reporting program in which emphasis and control effort shall be placed upon (a) complete coverage of reportable problems/failures; (b) timeliness, completeness, and accuracy of reporting; (c) adequacy, completeness, and depth of analysis; and (d) adequacy of corrective action following verification that corrective action has been taken.

1.3.1 Reporting Requirements

A PFR shall be initiated for any observed problem/failure as defined in paragraph 1.3.2 when such problem/failure is the result of test or service during those activities enumerated in paragraph 1.2.

1.3.2 Reportable Problems/Failures

In general, a PFR should be initiated for any observed condition which either potentially or actually causes the failure of a
module to perform satisfactorily. Such anomalies include but are not limited to:

(1) Performance parameter out of specified limits.

(2) Delamination of encapsulant.

(3) Discoloration of encapsulant/cells.

(4) Cracking of cells/encapsulation.

(5) Test problem or operator problems (JPL only).

(6) Inoperative modules.

(7) Electrically degraded modules:
   
   (a) Greater than 5% after any environmental/engineering test.

   (b) In excess of 25% for field or demonstration application.

(8) Major structural, mechanical, or material problems.

(9) Electrical isolation problems between active circuits and mounting structures.

(10) Major degradation caused by the environment.
SECTION 2

LSA PFRA SYSTEM OBJECTIVES AND RESPONSIBILITIES

2.1 OBJECTIVES

The purpose of the problem/failure reporting and analysis system at JPL is to provide a mechanism for reporting anomalies, to focus the talents of qualified specialists in the analysis of observed problems and failures to determine causes and remedies, and to make these findings known to the module manufacturers to enable them to improve the quality and reliability of their product.

2.2 RESPONSIBILITIES

The JPL/LSA Operations Area is responsible for assigning and coordinating all PFR verifications and analyses, for overall maintenance of the Project PFRA system, and for interface with other field organizations.

Prior to implementation of proposed corrective actions by the manufacturer, the effectiveness, cost, and schedule impact must be evaluated by the appropriate cognizant manager and other support personnel who are involved with the procurement of the modules which have experienced a problem or a failure.
SECTION 3
JPL-INITIATED PFR PROCEDURES

3.1 GENERAL

This section of the LSA PFR Procedure is applicable to those problems or failures arising from activities directly under the cognizance of JPL personnel and associated with environmental testing, special engineering tests, and field testing.

3.2 DESCRIPTION OF PROBLEM/FAILURE

Upon observing a problem or failure, the originator completes Section I of the LSA PFR form. Anyone may originate a PFR; normally, the originator will be the engineer or inspector with responsibility for the module at the time the problem or failure is detected. After completion of Section I, the originator gives the PFR to the module performance analyst, who provides copies to the PFR distribution list within one working day of its initiation. The original PFR will be retained by the module performance analyst until Section II is completed. (See Appendix A, Instructions for Completing Problem/Failure Report Form).

3.3 VERIFICATION AND ANALYSIS

The module performance analyst performs a preliminary failure analysis and enters the results in Section II of the PFR. If in his judgment further analysis is required, he will send the PFR and the module to the appropriate specialist as noted below, as dictated by the apparent problem.

<table>
<thead>
<tr>
<th>Problem Area</th>
<th>Cognizant JPL Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Performance</td>
<td>Measurements Group (341)</td>
</tr>
<tr>
<td>Cell and Interconnects</td>
<td>Failure Analysis Laboratory (365)</td>
</tr>
<tr>
<td>Materials and Processes</td>
<td>LSA Encapsulant Task (341, 354)</td>
</tr>
<tr>
<td>Packaging and Cabling</td>
<td>LSA Engineering Area (353)</td>
</tr>
</tbody>
</table>

When doubt as to origin of the problem arises, the module will be submitted to the Failure Analysis Laboratory (Section 365) for analysis. After a preliminary determination of cause has been made, the PFR may be reassigned by the module performance analyst, or Section 365 may consult with other specialists for assistance as needed to complete an in-depth analysis. With the concurrence of the appropriate task manager, the problem/failure analysis may be supported or performed by the affected module manufacturers. The person who completes the detailed failure analysis will furnish the module performance analyst with a written report. The module performance analyst will complete and sign Section II of the PFR and distribute a copy of the completed Section II for information to those on the distribution list. (See Appendix D, Problem/Failure Cause Classification.)
3.4 CORRECTIVE ACTION

After receipt of the PFR and failure analysis from the module performance analyst, the cognizant task manager will insure that the module manufacturer understands the contents of the PFR. If appropriate, he may direct contacts between the manufacturer and the module performance analyst and/or the JPL specialists who participated in the problem/failure analysis. When he is satisfied that appropriate actions have been taken, he or his designated alternate will note these actions in Section III of the PFR, and will close out the PFR with his signature and return the original PFR to the module performance analyst. It is expected that in many cases no action will be required other than informing the manufacturer of the problem/failure and of the results of the JPL problem/failure analysis.

3.5 PFR CLOSURE DISTRIBUTION

The module performance analyst will submit to the PFR Control Center the original PFR with all sections completed and copies of analyses performed. The PFR Center will log the PFR in the PFR Summary and effect distribution to the LSA distribution list. The PFR Center will issue a monthly Summary Status of all PFRs in the system and special listing as requested by the module performance analyst.

3.6 PFR FLOW DIAGRAM

A basic flow diagram of JPL-initiated PFR procedures is shown in Figure 3-1.
Figure 3-1. PFR Flow Diagram (JPL)
SECTION 4
FIELD ORGANIZATION PFR PROCEDURE

4.1 GENERAL

This section of the LSA PFR Procedure is applicable to those problems or failures arising from endurance testing, field tests, and applications for JPL-procured modules supplied to LeRC, MIT/LL, Sandia, and DOD, and for modules used in the Sandia/ALO flat panel photovoltaic experiments.

The intent of this procedure is to provide a common base for reporting problems/failures and to provide a comprehensive and consistent feedback of problems/failures, recommendations, and corrective actions to the applicable Project Office, cognizant managers, and manufacturers of the modules.

JPL will furnish PFR forms to the field organizations to allow uniform reporting.

JPL will distribute a monthly status summary of all new PFRs and a complete summary update semiannually.

4.2 DESCRIPTION, VERIFICATION AND ANALYSIS

Upon observing a module problem failure, the originator completes Section I of the LSA PFR form. After confirming the circumstances of the problem/failure and verifying that the problem/failure was module-related and not system-induced, the PFR will be forwarded to JPL. The field organization may at its discretion perform nondestructive analysis of the problem/failure and relate the findings in Section II of the PFR form. Final analysis, including destructive analysis where indicated, will be accomplished at JPL. In those cases where the recall of modules to JPL is needed to complete the analysis, JPL and the field organization will mutually determine the quantity of modules and schedule for return based on the needs of the application experiment and the urgency of completing the analysis. (See Appendix A, Instructions for Completing Problem/Failure Report Form, and Appendix D, Problem/Failure Cause Classification.)

4.3 SUBMITTAL OF PFR TO JPL

After Section I has been completed, a copy of the PFR will be submitted to JPL within 5 working days of the problem/failure occurrence. The original will also be submitted if no analysis is planned. In the event that the field organization carries out verification and analysis, the original and copies of the findings will be forwarded to JPL. Mail to: LSA Operations Module Control, Bldg. 248, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91103.
4.4 CLOSEOUT OF FIELD ORGANIZATION PFR

After JPL review of the analysis accomplished and further diagnostics as necessary, closeout will be accomplished by JPL in the same manner as that for JPL-initiated PFRs. Copies of the completed PFR will be made available to the field organization and the affected manufacturer.

4.5 PFR FLOW DIAGRAM

A basic flow diagram of field organization PFR procedures is shown in Figure 4-1.
Figure 4-1. PFR Flow Diagram (Field Organization)
APPENDIX A

INSTRUCTIONS FOR COMPLETING JPL PROBLEM/FAILURE REPORT FORM 2505R 7/76
# LSA PROJECT/FIELD ORGANIZATION PROBLEM/FAILURE REPORT

<table>
<thead>
<tr>
<th>WITTEN BY</th>
<th>REPORTING FACILITY</th>
<th>PROBLEM/FAILURE DATE</th>
<th>IR NO.</th>
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<table>
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<th>MODULE DESCRIPTION</th>
<th>MFR</th>
<th>S/N</th>
<th>TEST ACTIVITY</th>
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<table>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>TIME IN FIELD/APPLICATION SITE (YRS/MONTHS)</th>
</tr>
</thead>
<tbody>
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<td></td>
</tr>
</tbody>
</table>

## I. DESCRIPTION OF PROBLEM/FAILURE

- [ ] Design
- [ ] Workmanship
- [ ] Part Failure
- [ ] Manufacturing
- [ ] Damage (i.e., mishandling)
- [ ] Adjustment
- [ ] Other

<table>
<thead>
<tr>
<th>PERSON COMPLETING SECTION II</th>
<th>SIGNATURE</th>
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## II. VERIFICATION AND ANALYSIS

<table>
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</table>

<table>
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<th>DATE</th>
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</table>

## III. CORRECTIVE ACTION TAKEN

<table>
<thead>
<tr>
<th>DISPOSITION</th>
</tr>
</thead>
</table>
| [ ] Reworked
| [ ] Redesigned
| [ ] Readjusted
| [ ] Scraped
| [ ] Retested
| [ ] Other |

<table>
<thead>
<tr>
<th>PERSON COMPLETING SECTION III</th>
<th>SIGNATURE</th>
<th>DATE</th>
<th>TASK MANAGER SIG.</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
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</table>
Form Key

<table>
<thead>
<tr>
<th>Block No.</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Name of originator.</td>
</tr>
<tr>
<td>2</td>
<td>Insert the location where the PFR was initiated.</td>
</tr>
<tr>
<td>3</td>
<td>Insert date of failure. If unknown, insert the date the report is initiated with a prefix &quot;X.&quot;</td>
</tr>
<tr>
<td>4</td>
<td>Insert inspection report (IR) number.</td>
</tr>
<tr>
<td>5</td>
<td>Insert module description including the vendor name and block buy (e.g., Solarex Block I).</td>
</tr>
<tr>
<td>6</td>
<td>Insert three letter coded vendor designation.</td>
</tr>
<tr>
<td>ARCO Solar</td>
<td>SJG</td>
</tr>
<tr>
<td>Sensor Tech</td>
<td>SNT</td>
</tr>
<tr>
<td>Spectro Lab</td>
<td>SQB</td>
</tr>
<tr>
<td>Solar Power</td>
<td>SLP</td>
</tr>
<tr>
<td>Solarex</td>
<td>SLX</td>
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<td></td>
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</tbody>
</table>

Additional vendor codes will be assigned as procurements are placed.

| 7         | Insert true serial number of module as designated by vendor. |
| 8         | Describe test activity at time of failure (e.g., humidity/heat, temp cycle, field procurement/installation/checkout/test). |
| 9         | Detail the failure site, including building/application and contractor, as applicable. |
| 10        | Insert the total time the module was in the field/application site in years, months, or days, as applicable. |
| 11        | Describe what was observed and what was expected to be observed. Reference test procedure as applicable. Include comment on actions taken at the time to verify or investigate the problem and any other information the person observing the problem thinks may help resolve it. If module is part of field exposure include date of original installation. |
| 12        | Supply an accurate and clear verification of the described problem/failure and supporting analysis. The final verification/analysis of Section II will be supplied by the module performance/analyst with the support of an appropriate specialist as needed. |
13 Check the block(s) that describe the cause of the problem/failure.

14 Module performance analysts will sign and date completed verification and analysis (Section II).

15 The task manager or designee will supply a complete description of the corrective action taken. Reference and attach supporting documentation, as required.

16 Check the proper box describing the disposition of the problem module.

17 Signature of person responsible for completing corrective action (Section III).

18 Concurrence signature of task manager.
**Failure:** Performance outside the limits of specified requirements. This term includes intermittent or complete cessation of performance from mechanical, electrical or material failure.

**Problem:** Any anomaly or occurrence which may adversely affect module performance. Anomalies not affecting functional performance, such as physical degradation, can be considered as problems where such effects can lead to functional degradation.

**Problem/Failure Analysis:** The study of a specific problem/failure which has occurred to determine the circumstances which caused the problem/failure and to arrive at a course of corrective action which will prevent its recurrence.

**Module:** An assembly of solar cells installed on a substrate which comprise the smallest order of assembly on a panel.

**Panel:** A grouping of solar cell modules into a structural element for use in a test or demonstration application, i.e., part of an array.

**Substrate:** Underlying support structure of a solar cell module.

**Corrective Action:** Recommended or implemented action taken to correct the cause of a problem or failure.

**PFR:** Problem/Failure Report.

**PFRA:** Problem/Failure Reporting and Analysis.

**Application Experiment:** An assembly of modules operating as a system to perform an experimental function, i.e., water pumping, supplemental power support to buildings, etc.

**Field Test:** Static or powered test bed of assorted modules to study weathering effects at selected geographical locations.

**Field Organization:** National laboratory and its designated contractor(s) having responsibility for implementation of given field tests and applications experiments.
APPENDIX C

RESPONSIBILITIES
Large Scale Production Task

(1) Interface with manufacturers on problem/failure interpretation, coordination of failure analysis efforts, and corrective actions.

(2) Review recommendations of failure analysts, determine solutions and implement corrective actions.

Applied Mechanics Division, Technical Support Disciplines

(1) Provide the module performance analyst with nonelectric failure analyses and associated reports.

(2) Participate in PFR and corrective action related manufacturer briefings, as required.

Electronic Parts Engineering Section

Provide the module performance analyst with electronic failure analyses and associated reports.

Problem/Failure Control Center, Section 513

Provide PFR administration, control, distribution, and summary reporting.

QA and R Manager

(1) Monitor the PFR system and coordinate needed modifications.

(2) Provide technical direction to Section 513 activities.

(3) Assist in establishing inspection requirements for the LSA Project.

(4) Support task managers as required for coordination of corrective actions.

(5) Provide inspection support.

Engineering Manager

(1) Review PFRs for potential user impact, and recommend module design modifications to task managers.
(2) Provide technical direction for the failure analysis efforts of the technical specialists who report to him.

(3) Establish engineering and design requirements for the LSA Project.

Operations Manager

(1) Monitor operation of the PFR system and recommend modifications for improvement.

(2) Provide technical direction for the module performance analyst and Large Scale Production Task.

(3) Coordinate JPL problem/failure efforts with those of LeRC, MIT/LL, DOD, and Sandia.

(4) Participate in PFR-related manufacturer briefings and negotiations as required.

Module Performance Analyst

(1) Perform preliminary problem/failure analyses, and coordinate failure analysis efforts of technical specialists leading to final conclusions and recommendations.

(2) Interface directly with manufacturers as needed to coordinate joint analyses or clarify JPL results.

(3) Correlate and compile results of PFR analyses. Report results in appropriate documentation.

Field Organizations: LeRC, MIT/LL, DOD, and Sandia

(1) Review field problem/failures to determine whether module failures are module-related or system-related.

(2) Provide PFRs and other reports relating to application problem/failures for modules.

(3) Maintain and report operating time statistics to the module level.

(4) Coordinate failure analysis efforts with JPL as needed to allow JPL to effect corrective action with the manufacturers.

(5) Return faulty modules to JPL as required to study problem/failures.
Sandia Program Research and Development Announcement (PRDA) Manager

(1) Provide contractor problem/failure reporting requirement.

(2) Provide a PFR documentation flow between contractors, PRDA managers, and JPL.

(3) Return designated problem modules to JPL for analysis.

(4) Coordinate corrective action with system contractors, as required.
All PFRs are classified according to the cause of the incident to provide a coded correlation of incidents with similar cause factor. The cause noted shall be the single factor considered to be the cause of the incident; combination of factors, or secondary factors are difficult to note and track in the cause analysis. Combinations of possible causes are, in reality, an "unknown" and should be rated accordingly.

The following categories have been established for purposes of classification:

(1) Design

Inclusive of all design deficiencies; may be related to packaging or mounting, specification, producibility, or materials.

(2) Workmanship

Includes defects that occurred during fabrication assembly, rework, testing, or inspection.

(3) Piece/Part

Where defective part or material is primary cause of P/F; inclusive of defects originating or believed to have originated prior to fabrication/assembly of the module.

(4) Manufacturing

Where tooling, tooling design, processes, production drawings, shop planning, or manufacturing paper were deficient or the principal cause.

(5) Handling

For P/F related to incidents occurring during transit, handling, or storage; not including fabrication, assembly, or rework activities.

(6) Adjustment

P/F on test interruption caused by test or environmental test equipment.

(7) Other

Incidents for which cause cannot be determined as a single or predominant factor, but a combination of factors.