EXPOSURE TESTING AND EVALUATION OF
SOLAR UTILIZATION MATERIALS

(Semiannual Report)

May 1, 1975 through October 31, 1975

Prepared by

J.E. Gilligan
J. Brzuszkiewicz

Solar Energy Division
U.S. Energy Research and Development
Administration
Washington, D.C. 20545

IIT Research Institute
Technology Center
10 West 35th Street
Chicago, Illinois 60616

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FOREWORD

This is Report No. IITRI C6342-1 (Semiannual Report) of IITRI Project C6342, ERDA Contract No. E(11-1)-578, entitled "Exposure Testing and Evaluation of Solar Utilization Materials". It covers the period from May 1 to October 31, 1975.

Major contributors to the program during this period were Mr. J.E. Gilligan, Project Leader, and Mr. J. Brzuskiwicz. The work reported was accomplished for the Solar Energy Division of ERDA under the technical cognizance, initially of Dr. John Leech and more recently of Dr. Stephen Sargent. Mr. Charles Younger of NASA-Lewis provided technical liaison between IITRI and ERDA.

Respectfully submitted,
IIT RESEARCH INSTITUTE

J.E. Gilligan
Senior Engineer-Group Leader
Polymer Chemistry Research

APPROVED:

A.M. Stake
Manager
Polymer Chemistry Research

JEG:ge

ABSTRACT

The initial efforts of a program of research and experimental testing is described in which the optical performance of materials for use in solar energy utilization devices will be determined before and after exposure to outdoor weathering tests. Materials which are currently in use and others which are being considered or developed for these applications will be characterized and exposed to natural solar radiation. Outdoor testing will be accomplished in Phoenix (Ariz.), Miami (Fla.), and Chicago (Ill). The results of these tests, primarily the effects of outdoor exposure on optical and physical properties, will be compiled in a handbook, along with cost, availability and other pertinent information. These data are vital to the intelligent selection of solar utilization materials, since a knowledge of the cost performance and lifetime characteristics of candidate materials will greatly assist the design of efficient and reliable solar energy utilization devices. Primary accomplishments include the definition of sample requirements, specification of test samples and test configurations, formulation of acceptance/rejection criteria and contacts with numerous potential materials suppliers.

TABLE OF CONTENTS

	<u>Page</u>
FOREWORD	iii
ABSTRACT	iii
1.0 INTRODUCTION	1
2.0 PURPOSE OF PROGRAM	2
3.0 DEVELOPMENT OF THE MATERIALS TEST SCHEDULES	3
3.1 Review of Basic Requirements	3
3.2 Site Visits	3
4.0 REVIEW BOARD	4
4.1 Membership	4
4.2 The Review Board Meeting (July 1975) - Recommendations	5
5.0 RESPONSES TO MATERIALS REQUESTS	9
5.1 Materials	9
5.2 Telephone Conversations	10
5.3 IITRI Response to Suppliers Questions	10
5.4 Supplier Visit Policy	11
6.0 MATERIALS TESTING	13
6.1 Exposure Schedules	13
6.2 Materials Testing Rationale and Policy	13
6.2.1 OPTICAL PROPERTIES	14
Transmittance Measurements	14
Reflectance Measurements	15
Directional Measurements	15
6.2.2 Mechanical Properties of Polymeric Materials	16
Tensile Properties of Plastics	17
Impact Testing	17
Abrasion Resistance	18
7.0 PROGRAM SCHEDULE	19
8.0 ADMINISTRATIVE STATUS	20
REFERENCES	21
EXHIBITS 1-9	22

OUTDOOR TESTING OF SOLAR ENERGY UTILIZATION MATERIALS

J.E. Gilligan and J. Brzuskiwicz
IIT Research Institute

1.0 INTRODUCTION

The U.S. Energy Research and Development Administration (ERDA) has prime responsibility for the exploitation of solar energy and for the development of efficient and reliable solar energy harvesting systems. Understandably, ERDA is concerned not only with their efficiencies and costs, but also with the performance characteristics and lifetimes of the individual solar utilization (SU) materials comprising them. An important factor, therefore, in the selection of such materials is their cost-effectiveness. This report describes the accomplishments in the organizational stages of a program in which materials will be exposed to natural solar radiation at three sites and to accelerated natural solar radiation at one of them.

The development of failure/degradation criteria, test philosophy and overall program policy are discussed in detail. Many additional aspects of the program, such as sample mounting, test statistics, exposure configurations, and testing of systems of materials are also considered. The program is very important to the entire solar energy community not only because of the obvious need for weatherability data but also because its conception and execution involve objective testing and evaluation.

2.0 PURPOSE OF PROGRAM

The primary purpose of this program is to determine the relevant properties of solar energy utilization materials before and after exposure to varying durations of outdoor weathering, to obtain all other relevant information including materials cost and availability, and to compile these data in a handbook or similar document. Ultimately, this program will provide designers and manufacturers of Solar Utilization (SU) devices with the appropriate data to select the most cost effective materials for their particular engineering designs, location(s) and environment(s). Since many applications differ in their materials requirements, the criteria for acceptability do likewise. In addition, it is hoped that long term weathering performance can be predicted over time periods of 20 years or more.

3.0 DEVELOPMENT OF THE MATERIALS TEST SCHEDULES

3.1 Review of Basic Requirements

Upon close examination of the basic requirements of this program and of the available means of satisfying them, it became apparent that many of the ideas advanced in the proposal document would require modification and further definition. In one of its first steps, therefore, IITRI developed a tentative test schedule, which has since been revised many times. Before the sample procurement process could be initiated, sample quantities and configurations, exposure schedules, and configurations, and measurement schedules had to be established.

3.2 Site Visits

Since the many possible variables of exposure conditions easily translate to an unmanageable array of samples, we, therefore, initiated an effort to design a test scheme which would accommodate all the samples anticipated and yet produce meaningful information. Visits were made to the facilities of Desert Sunshine Exposure Tests (DSET) in New River, Ariz. and to those of South Florida Test Services (SFTS), Inc. in Miami, Fla. to obtain first-hand information regarding the general practices of outdoor exposure testing, and of their capabilities and procedures, in particular. These visits were of great importance, primarily because of the understanding of the specific exposure configurations that should be requested. Both DSET and SFTS can provide an extremely large number of exposure options. The essential requirement that the exposure configurations should be correlatable from one site to another was discussed with the technical personnel of both facilities. Suggestions were made regarding the format for reporting of data. Observations of the degree of sample security, of the equipment for monitoring and recording insolation rates, and of the general routine of sample management at each site were

made. These visits greatly aided also the physical design of IITRI's outdoor exposure facility, so that a maximum of data correlation would exist. Many of the tips given us regarding the correct and incorrect techniques for mounting samples will prove very important. It was apparent that incorrect sample mounting might lead to loss of samples (e.g., in high winds) or to an interaction with the sample holder or with another sample resulting in unrealistic deterioration of the samples.

4.0 REVIEW BOARD

4.1 Membership

After completion of the preliminary planning of the program, we drafted a proposed program plan which included the sample requirements, exposure schedules, performance criteria and related policy matters. We contacted a number of people who had earlier expressed an interest in serving on this program's Review Board to determine their continued interest, and also their opinions on the draft program plan. As a result of these contacts we retained Dr. James Ramsey, Dr. John Yellott and Burt-Hill Assoc. as members of the Review Board. Mr. William F. Carroll, Mr. Charles Younger and Mr. Gene A. Zerlaut (ex-officio) also accepted our invitation to serve on the Review Board (see Exhibit I for brief biographies). As a further result of these contacts we found that individual members were not agreed on the tentative program plan. Thus, before commencing any requests or orders for materials we arranged to hold a Review Board Meeting in Phoenix Ariz. on July 21-22, 1975. Approximately 10 days prior to the meeting each of the board members was contacted by letter (Exhibit II) and given a copy of the agenda (Exhibit III), a copy of the discussion of agenda items (Exhibit IV) and a copy of the proposed materials request letter (Exhibit V). A primary reason for holding this meeting in Phoenix was to provide the Review Board members with an opportunity to appreciate the nature

and complexity of operations of an outdoor exposure facility, in this case the facilities of Desert Sunshine Exposure Test, Inc.

4.2 The Review Board Meeting (July 1975) - Recommendations

The Review Board Meeting was highly instructive and very valuable to IITRI. For this reason, we will summarize the discussions and results of this meeting.

Both the role and the importance of the Review Board as an advisory body to IITRI was made very clear. Although the responsibility for the management and direction of the program remains with IITRI, it was emphasized that the opinions and recommendations of the Review Board would be carefully and thoroughly considered. As exhibits II - V show, the Review Board had a lot of material to study prior to the meeting. After much deliberation and discussion, the Board recommended as follows:

1.) Preliminary emphasis should be given to materials for flat plate collectors.

2.) A News Release be issued by IITRI indicating the nature and purpose of the program and encouraging industrial participation.

3.) In addition to the samples scheduled for exposure and evaluation during the present program, a set of samples be installed for removal after 2 years exposure. To lessen sample requirements, allow return of certain samples to exposure racks after non-destructive and/or non-interfering tests.

4.) The board agreed that one standard exposure configuration, 45° south conventional, be utilized at all sites. Some experimental configurations should be utilized, particularly where the possibility exists of improving data correlation. Accelerated testing, which can be accomplished only at the DSET, Inc. facilities in Arizona, should be carried out in order to establish a correlation between real-time and accelerated weathering data. Testing of systems of materials, e.g., a selective black under a transparent cover,

was suggested, but this possibility would involve specific design details and, since it could be done only on a very limited number of materials, would discriminate against many possibly equally satisfactory materials and combinations of them.

As to the number of specimens to be tested, the board agreed that because of the different purpose involved, the specific specimen requirements of ASTM test methods would unduly increase the total volume of test specimens. The number of tensile test specimens therefore was reduced from 10 (ASTM) to 5; other specimen requirements established by the relevant ASTM methods were diminished similarly. The Board agreed that 2 optical measurements would be satisfactory. The lowered specimen measurement requirements should retain nearly the same confidence level as that of the ASTM methods, especially the optical measurements.

5.) In requesting materials from suppliers, IITRI should
a) require manufacturer's recommendations on operating limits (especially temperature), b) if applicable, request that manufacturers supply two thicknesses of each sample, one at 1X recommended, the other at 2X recommended, c) request that the supplier indicate the substrate (if any); and d) request the supplier to prepare the materials for test and to supply information on their preparation and use.

6.) Failure policy and criteria are as follows:

- a.) A failure at one site should be interpreted as a failure at that site only and not as a general failure.
- b.) Failure criteria must be sensitive to environment-induced degradation rates and to saturation damage.

c.) Specific Criteria:

<u>Material Covers</u>	<u>Criteria Initial</u>	<u>Post Exposure</u>	<u>Remarks</u>
Glazings	$\tau \geq 75\%$	$\tau \geq 65\%$	
Transparencies	"	"	
<u>Absorbers</u>			
Flat Blacks	$\alpha_s \geq 85\%$	$\alpha_s \geq 80\%$	ε not specified
Selective	$\alpha_s \geq 75\%$		
<u>Mirrors</u>			
Metallized Plastics	$R_s \geq 80\%$	$R_s \geq 70\%*$	

*not defined by Review Board.

7.) Selective Absorbers should not be exposed to a water spray environment, either conventional or accelerated.

8.) 1st and 2nd surface mirrors should not be distinguished, i.e. the emittance, ϵ , of these materials is not consequential.

9.) The materials request letter should be amended to show clearly the number and size of samples required, the bases for determining the number and size requirements, and it should present a brief rationale for the selection of tests involved. The request letter otherwise appears satisfactory (with minor editorial and technical changes).

10.) IITRI should implement plans to determine the directional optical properties of certain selected materials such as transparencies and selective coatings. (These measurements would be in addition to those proposed).

11.) IITRI should request a cover letter from ERDA encouraging potential suppliers to participate in the program by supplying materials.

12.) The program will be very important to ERDA and to users of SU materials, provided that the materials are tested and evaluated as objectively as possible. Even though the program has an eighteen (18) month duration, the program plan, especially the sample exposure schedules, should not be lapsed such that a discontinuity would prevent longer term evaluations of materials which warrant them. (This is consistent with #3, above).

13.) The next meeting of the Review Board should be after the accumulation of the first exposure test data, i.e., after the 3 month exposure samples have been evaluated. Review Board members should be given the opportunity to review the technical data prior to that meeting.

14.) The categories of materials should not be used strictly as a means of prioritizing sample submissions but rather as a general means of classifying them with respect to their utilization in solar collection systems.

15.) The determination of sample failure rests solely with IITRI. A material which obviously discolours severely must be brought to IITRI's attention by exposure site personnel, whereupon IITRI may give approval for removing the samples and returning them to IITRI for final evaluations.

These recommendations, opinions and suggestions have been largely adopted. A News Release was made (Exhibit VI). A cover letter (Exhibit VII) was obtained from Dr. John Leech of ERDA for the materials request letter (Exhibit VIII). The request letters with the ERDA cover letter were then mailed to every potential supplier of SU materials and/or systems. The addressees are listed in Exhibit IX, along with the responses obtained. Exhibit X lists those suppliers who have contributed materials, and gives a brief description of those materials.

5.0 RESPONSES TO MATERIALS REQUESTS

5.1 Materials

The materials responses to our letters have taken very much longer than we anticipated. In some of the larger industrial organizations, the process of obtaining approvals for preparing and shipping "free" samples prepared to specific specifications has been extraordinarily involved and time-consuming. In some instances we indicated our willingness to purchase the materials or defray the costs of their preparation but were advised that this would not materially affect the lead time, since a reimbursement would serve only to insure approval and not to hasten it. Several organizations have offered to sell us materials which cost as much as \$500 per sample. We have refused such offers on two bases: first, the program cannot afford to purchase even the barest minimum of such samples, and, second, such costs militate heavily against the choice of such materials in practical SU devices. For the most part, although very slow to respond, the participating respondents have been very cooperative.

In contacting the large number of potential suppliers that we have, we expected that there would be multiple identifications of prime sources, and indeed this expectation was realized. Many suppliers, primarily in telephone conversations, indicated their sources of materials. In a few instances they identified several (apparently alternative) sources of the same end-use material.

We should also like to note that the process of contacting suppliers is an on-going one. We are continually up-dating our contact list as new suppliers and as new materials enter the market. It is clear from correspondence with many of the late-comers that they too would like to have their materials evaluated.

5.2 Telephone Conversations

The materials request letter generated a great number of telephone responses and as we have noted comparatively few offers of materials. In the majority of these telephone conversations (well over 150, as of Nov. 1, 1975) the respondents wanted to clarify sample requirements (do we really need 35 sets of rigid plastic materials- and why?), or they wanted some justification or explanations for the choice of test methods. Almost every respondent indicated that this program would be valuable to his company and to the industry as a whole, even though some had their reservations about specific test methods. Of many letters received, only one addressed the question of test methods. All in all, the appraisals have been highly favorable and encouraging.

5.3 IITRI Response to Suppliers Questions

The test methods that we have chosen are, in our judgement and that of the Review Board, more objective and much more meaningful than those commonly employed. In this respect, the two most frequent questions relate to the type of optical measurements we make, i.e., the spectral reflectance measurements, and to the choice of the notched Izod for impact testing. In a subsequent section we will describe each of the proposed tests.

Since the above two questions have been frequently raised, let us address them here by answering the typical question(s) about them. The common method of measuring the solar transmittance of a transparent material involves the use of a calibrated pyranometer. A reading is made with and without the sample in front of the pyranometer. The ratio of the two is accepted as the solar transmittance. In IITRI's method we will measure the normal, spectral (external) transmittance of the sample in the wavelength range from 325nm (0.325μ) to 2600nm (2.6μ). In addition, hemispherical, spectral (total) transmittance will be measured in the case of hazy or translucent samples. These data have

accuracies of at least $\pm 2\%$ and reproducibilities of better than $\pm 1\%$. These measurements are also independent of source spectral distribution, where the pyranometer method obviously is not. Similarly, normal, spectral reflectance measurements will be made in the same wavelength range (with slightly better accuracy and reproducibility characteristics).

Of all the impact tests available, the one which IITRI believes will give best results is the notched Izod, in which the sample is "broken" in one swing of the impact arm. The data are quantitative and reasonably reproducible. In other methods the sample is repeatedly struck until it fails; in many of these the impact parameter is the height of the impact arm before release. The uncertainty in the effect of repeated attempts to fail the samples and the arbitrary choice of impact parameters associated with each attempt make these types of tests unreliable for comparison of different materials even though they may provide good correlation between samples of the same material. Therefore, the notched Izod test, while it may not be ideal for each and every material, does provide a uniform and reproducible test for all of them. We believe that, since we are primarily interested in the inter-comparison of materials, this method is the one in which objectivity is best achieved.

5.4 Supplier Visit Policy

A difficult question that, fortunately, comes up only infrequently, is in regard to the suppliers' visiting IITRI to discuss our program. We have developed some ground rules pertinent to such visits. First, the dissemination of all information obtained by IITRI under an ERDA contract must be approved by ERDA. Second, we will gladly discuss the results of our tests on those materials - and only those materials - supplied by the visitor (or the company he represents). Third, we will not discuss any weathering

performance data obtained by the supplier. In many instances we have been requested to consider, even publish, data obtained by the supplier. We are, of course, aware of some of these data since the suppliers send them to us. Nevertheless, we believe that our objectivity must not be compromised; certainly we can not vouch for data we ourselves did not obtain.

6.0 MATERIALS TESTING

6.1 Exposure Schedules

The outdoor exposure tests are scheduled to begin on Feb. 15th, 1976 at all three sites - the same materials in the same configurations in each case. Post-exposure testing schedules call for sample returns after 1 month (accelerated test samples only), 3 months, 6 months, 12 months and 24 months. The 2 year samples will be installed, but are not covered by the current contract.

As they become available new samples will be added to the test program. This policy was apparently misunderstood by some potential suppliers; they thought that their samples had to be received prior to Oct. 1, 1975 (the date indicated in the materials request letter as the test initiation date).

6.2 Materials Testing Rationale and Policy

The rationale for the choice of tests and test methods was developed on the basis that the measurements made should reflect more fundamental properties of materials than those customarily measured in outdoor exposure testing. This rationale thus recognizes that changes in integrated macroscopic properties generally result from the action of several mechanisms. Consequently, the more information that can be obtained regarding individual mechanisms, the greater will be the probability of successfully predicting the useful lifetimes of individual materials. Retains of all materials submitted for exposure testing will be maintained at IITRI in order that any tests which were not accomplished as part of the pre-test measurement schedule may be carried out, if and as indicated. This latter provision, the transmittance measurements in two modes, and the directional measurements were added to the measurements schedule in order to increase the validity of the exposure tests and the ability to correlate degradation with exposure. Before testing, samples are examined to determine thickness uniformity, optical defects and other possible imperfections.

The data to be gathered are of two general types - optical and physical. Environment-induced changes in optical properties can be analyzed to determine the resulting change in energy absorption rate in the entire collector system by referring the spectral change to the incident solar energy spectrum. Physical changes such as those in strength are very important: the ability of the material to maintain its integrity, especially in shape and size may be critical. A material which stretches, warps, shrinks or otherwise changes its shape under the influence of intense solar radiation can drastically affect the overall efficiency of the collector system.

6.2.1 OPTICAL PROPERTIES

Any loss in the transmittance of transparent cover materials or in the absorptance of the collector surface translates to a decrease in efficiency of the overall collector system. The optical measurements, therefore, will afford a means of evaluating the effect of environment -induced changes. The basic measurements are of the spectral transmittance of transparent and translucent materials and of the spectral reflectance of opaque coatings and surfaces. In both cases the spectrum is scanned from 350 to 2600nm, (0.35-2.6 μ) using an integrating sphere optically connected to a Beckman DK-2A spectrophotometer.

Transmittance Measurements

The standard mode in which transmittance measurements are made in this program is usually termed the "normal", extrinsic transmittance. The sample is mounted outside the integrating sphere in such a way that only the directly transmitted beam will enter the sphere and be detected and compared to an unobstructed reference beam. In a second mode, used primarily with hazy and translucent materials, the sample is center-mounted in the sphere. In the standard mode the first surface reflectance (gloss) and diffusely scattered components are not detected; in the second,

both of these components are detected to yield the absolute total transmittance. The difference in the two transmittance values at any given wavelength affords a means of distinguishing mechanism(s) of transparency loss and thus an increased probability of correlating degradation with environmental exposure. A further distinction will be possible by making these measurements before and after cleaning surface dirt and other contaminants accumulated during exposure.

Reflectance Measurements

The standard reflectance measurement also utilizes the equipment described above. Samples are center-mounted in the integrating sphere and the absolute hemispherical (total diffuse) spectral reflectance is measured. The spectral range is from 350nm to 2600nm (0.35-2.60 μ).

Directional Measurements

The directional optical properties of a select few samples will be measured in order to further enhance the probabilities of obtaining useful correlations between optical property changes and outdoor exposure. In these measurements the sample is illuminated with a normally incident, highly collimated laser beam (Argon, $\lambda=0.514\mu$). The reflected radiation is measured as a function of angle (measured from the sample normal) from near normal ($\theta_r \approx 0$) to near grazing ($\theta=90^\circ$) incidence. This measurement gives the angular distribution of reflected radiation. In the case of non-opaque samples, the scan is continued to $\theta_r = 180^\circ$, thus measuring the directional transmittance. Note that from reciprocity requirements, this measurement is also a measure of the normally transmitted component of a diffusely illuminated surface.

Directional measurements, even though more fundamental, provide important, practical information. Typically, directional transmittance begins to decrease sharply at angles of the order

of 45° - 60° , depending upon the effective index of refraction. The less the index of refraction, the greater is this angle and thus the larger is the acceptance angle for solar energy collection. The importance here is two-fold: first, with respect to initial properties, and, second, with respect to weathering effects. If ageing decreases the acceptance angle, then the net effective time for solar energy collection also decreases, even though there may be no apparent decrease in solar transmittance. In the case of selective solar absorbers, though possibly less significant in terms of acceptance angle, these directional reflectance properties are also important.

6.2.2 Mechanical Properties of Polymeric Materials

The mechanical properties of polymeric materials (plastics) are important in applications where they are to be used as structural materials or where changes in these properties could affect overall system performance. The change in mechanical properties due to environmental conditioning (weathering) is of primary importance to the design engineer when selecting materials for use in the fabrication of solar utilization devices. Unlike conventional structural materials such as glass and metals, the mechanical properties of polymeric materials are more readily affected by environmental conditions such as solar radiation, temperature and humidity, airborne abrasive particles, air pollutants etc. For this reason, it is of utmost importance to determine the deleterious effects, if any, that long term outdoor exposure may have on their mechanical properties - to determine whether the material, after long term exposure will retain sufficient strength to satisfy its intended use. By monitoring changes in mechanical properties due to outdoor exposure to real, as well as, accelerated, weathering we can correlate changes versus time (with environment as a parameter) and hopefully project changes in properties over extended periods of time.

Tensile Properties of Plastics

The tensile properties of plastic materials will be determined in accordance with either ASTM Test Method D1708 or D638. The actual test method used depends upon the test method followed in preparing test specimens, or if in raw form, upon the nature (thick sheet or thin film) and the quantity of material submitted.

ASTM Test Method D638 is intended for use in determining the comparative tensile properties of plastics in the form of standard test specimens, when tested under defined conditions of pretreatment temperature, humidity and test speed. ASTM D1708 is for plastics in the form of standard microtensile test specimens. This latter method can be used for sheet materials up to 1/8 in. thick (including thin films), and is designated primarily for use where limited amounts of material are available.

Whichever test method is used, the tensile properties of the materials will be determined before and after outdoor weathering, for specific periods of time, in three different geographical areas.

Impact Testing

The impact strength of plastic materials submitted for evaluation will also be determined before and after outdoor weathering in accordance with ASTM Method D256, Method A, (Izod impact test). This method is a cantilevered beam test in which the specimen is held as a cantilevered beam (usually vertical) and is broken by a blow delivered at a fixed distance from the edge of the specimen clamp. The test requires a notched specimen, the notch being intended to produce a standard degree of stress concentration and to prevent plastic deformation.

Impact tests are intended to measure the toughness or the resistance to breakage of materials under high velocity impact conditions.

Abrasion Resistance

The abrasion resistance of materials advocated for use in those portions of flat-plate solar collectors which will be exposed to the weather is of importance from the standpoint of optical quality and durability.

Transparent materials for use as the outer window are subject to the abrasive action of airborne particles as well as that due to wiping or cleaning. In this case, the maintenance of optical quality is of primary concern and the change in this property due to weathering will be determined by measuring the amount of transmitted light which is diffused by weathered specimens as opposed to non-weathered or control specimens.

The abrasion resistance of materials for use as exposed structural members or components of the collector is of importance from the standpoint of durability. In this case, the materials will be comparatively evaluated in accordance with ASTM Test Method D1044 utilizing a Taber Model 503 Abraser. The results obtained, however, will be expressed as a wear factor or numerical abrasion index rather than as the percentage light scattered vs. wear cycles. The test method is thus suitable for evaluating all materials whether transparent, translucent or opaque; even maintenance coatings on some substrates may be accommodated.

7.0 PROGRAM SCHEDULE

The chart in Table 1 depicts the status of the program in terms of its achievements. In general, it indicates that the exposure schedule is six months behind the schedule originally proposed, three of which are purposely added because of two considerations: an anticipation of a continued slow, even though positive, response to our requests for materials, and the inadvisability of initiating the outdoor exposure test program during the 3 month period of lowest average daily insolation. An under-assessment of the organizational difficulties, administrative problems in arranging subcontracts and consultant agreements, and a very slow response to our requests for materials contributed to the delay. Since the schedule of the overall program is tied to the exposure schedule, the program will be approximately six months behind schedule. The chart also indicates a revised schedule of tasks based on a six month overall delay. While our projections are intentionally conservative, it is difficult to determine that they will remain that way. This is particularly true in view of the fact that in the last month of the reporting period, we received numerous calls requesting information on sample preparation.

Because of the delays in obtaining test samples, we believe that a no-cost extension of the program will be necessary. The exposure start-up date has been changed from Oct. 1, 1975 to Feb. 15, 1976. An extension to Mar. 31, 1977 appears necessary in order to accomplish the program objectives.

TABLE 1
PROGRAM SCHEDULES

Task	1975							1976										
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Review Board Meetings	X	0								X	Ø						X	
Materials Selection and Procurement	X	X	0	0	0	0	Ø											
Pre-Exposure Tests			X	X	0	0	Ø	Ø	Ø									
Exposure Tests			X	X	X	X	X	X	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
Post Exposure Tests							X		X		Ø		Ø		Ø	X	Ø	
Data Review and Analysis			X			X			X			X			X			
Reports (Semi-annual)			X			X		Ø	X			X			X			
Final Report (Handbook)																X	X	X
Research Services	0	0	0	0	0	0	0	Ø	Ø	Ø	Ø	Ø	X	X	X	X	X	X

X - As proposed

0 - Actual

Ø - Expected

8.0 ADMINISTRATIVE STATUS

As of November 30, 1975 a total of 1443 man-hours and of \$39,348 have been expended on the program. Travel costs for IITRI personnel total \$1908. A total of \$18,900 is committed to the reimbursement of the Review Board for consultant fees and their travel costs. Subcontracts for outdoor exposure testing have been let or committed as follows: \$46,428 to Desert Sunshine Exposure Tests, Inc. and \$3600 to South Florida Test Services Inc. The available funds (total contract appropriation less actual costs and commitments) therefore amounts to approximately \$54,000.

REFERENCES

1. Catalog on Solar Energy Heating and Cooling Products
Energy Research and Development Administration
Division of Solar Energy, ERDA Report No. 75, October, 1975.
2. Solar Energy Directory (1975)
Compiled by Jerry Kingery of Centerline Precision Mfg. Corp.
Phoenix, Arizona 85034
3. Solar Directory (Jan. 1975)
Ed. by Carolyn Pesko
Ann Arbor Science Publishers Inc., Jan. 1975.
4. Solar Utilization Now
Seminar held at Arizona State University,
Tempe, Arizona, May 19-23, 1975.

EXHIBITS

1. Review Board Membership
2. IITRI Letter to Program Review Board
3. Proposed Agenda For Review Board Meeting
4. Preliminary Discussion of Agenda Items
5. Proposed Materials Request Letter
6. News Release
7. ERDA Cover Letter (to IITRI-Materials Request Letter)
8. IITRI's Materials Request Letter (with addendum)
9. List of Materials Suppliers Contacted
10. Materials Submitted for Evaluation

Exhibit I
Review Board Members

William F. Carroll. Mr. Carroll is a materials supervisor at the Jet Propulsion Laboratory of Calif. Inst. of Technology, Pasadena, Calif. He is widely recognized as an expert in the radiative and physical properties of materials.

Alva L. Hill. Mr. Hill is a principal in the firm of Burt-Hill Associates, Butler, Pa. He will alternate with Mr. Rittleman of the same firm in providing the board with expertise in evaluating the program from an architectural point of view. Mr. Hill and his firm are involved in the architectural design of large commercial building projects which directly utilize solar energy for heating and/or cooling.

Dr. James Ramsey. Dr. Ramsey, formerly with Minneapolis Honeywell Co. in Minneapolis, Minn, is a professor of Mechanical Engineering at the Univ. of Minn. Dr. Ramsey has been directly involved in the development and testing of flat plate solar collector systems for several years. He has considerable familiarity with and understanding of the engineering and systems considerations of such devices.

Richard C. Rittleman. Mr. Rittleman, also of Burt-Hill Associ., will alternate with Mr. Hill in providing architecturally oriented appraisals of program results.

Dr. John I. Yellott. Dr. Yellott, a professor at Arizona State Univ. in the College of Architecture enjoys an international reputation for his contributions to solar energy utilization. His interest in and work in this area extends over many years.

Charles W. Younger. Mr. Younger, an engineer at the NASA-Lewis Research Center, Cleveland, Ohio has a background in NASA Spacecraft Thermal Control Materials Development. Mr. Younger was designated by NASA-LeRc as NASA-Hq. director.

Gene A. Zerlaut. Mr. Zerlaut is the president and technical director of Desert Sunshine Exposure Tests, Inc., an outdoor test facility, in New River, Ariz. He has an extensive background in the development and testing of materials, especially with respect to their thermal radiative properties.

Exhibit 2

IITRI Letter to Program Review Board
IIT Research Institute
10 West 35 Street, Chicago, Illinois 60616
312/567-4000

REFERENCE: IITRI Project C6342
"Outdoor Exposure Testing and Evaluation of Solar
Utilization Materials"

I am enclosing a copy of a letter which we propose to send out to prospective suppliers of materials for the cited project. Your comments and criticism will help us greatly. We would like to have them as soon as possible. Please call (collect X5075) or write Mr. John Brzuskiwicz.

The first meeting of our review board will take two days and will begin at 8:30a.m. at the Arizona Biltmore Hotel in Phoenix, Arizona on July 21, 1975. The first day will be general and will include an orientation trip to Desert Sunshine Exposure Test Facilities. The agenda items are presented in an appended letter.

Hopefully, you will have sufficient time to review all this material and to develop questions, criticisms, comments and opinions regarding the various questions of policy and procedure. The letter to potential suppliers establishes the basic ground rules, the purpose and ultimate goals of the project, and I think its basic philosophy will be a good guideline for your review.

Lastly, I would like to get your reaction to the question of allowing guests/visitors to attend our review board meetings. Several requests have been made by representatives of trade organizations, some who are highly knowledgeable. I have some reservations but no serious objections. Please let me know as soon as possible; in my absence, please contact John Brzuskiwicz (X5075 collect).

Page 2

I want to thank you in advance for your cooperation and help, and, of course, look forward to seeing you in Phoenix.

Very truly yours,

A handwritten signature in dark ink, appearing to read "J. E. Gilligan". The signature is fluid and cursive, with a large, stylized initial "J" and a long, sweeping underline.

J. E. Gilligan
Senior Engineer-Group Leader
Polymer Chemistry Research

JEG:dfp

P.S.: Please excuse my using a form letter to communicate with you.

Copies to:

W.F. Carroll
J.W. Leech
J. Ramsey
R. Rittleman
J.I. Yellott
C. Younger
G.A. Zerlaut

Exhibit 3
Proposed Agenda for Review Board Meeting

AGENDA

C6342 Review Board Meeting
July 21-22, 1975
Phoenix, Arizona

Introductions

Introductory Remarks & Discussions

Program Purpose and Goals

Review Board Purpose and Goals

Review Board Guidelines (Rules & Procedures)

Re-imbursement Policy

Vistors/Guests Policy

Agenda Amendment

Visit to Desert Sunshine Exposure Tests, Inc.

Lunch

Technical Discussions

Basic Project Plan

Priorities

Materials

Exposure Schedules

Failure Policy

Criteria

Material Substitution

Notification of Supplier(s)

Exposure Testing

Conditions

Configurations

Experimental Sample Statistics

Correlation of Data

Miscellaneous

Materials Request Letter(s)

Meeting Schedule

Reports/Communications

Other Technical or Administrative Items

Adjourn

Exhibit 4

JULY 1975 AGENDA ITEMS

IITRI Project C6342

We discuss here the items that relate to basic procedures and policies whose definition the program will require in order to assure maximum objectivity and validity. Some decisions - mostly administrative - have already been made and are not subject to review. The Review Board will be called upon to examine questions/issues which are primarily technical in nature. The different backgrounds of individual Review Board members covers a wide spectrum of expertise. Accordingly, we look forward - and hope that you do also - to considerable "cross-fertilization" of ideas and philosophies.

The issues and questions we raise here represent our current thinking, but we certainly do not represent that they are a complete list. In the absence of a review board they would - at least initially - become permanent policy.

1. PRIORITY MATERIALS

Considerations of resources, technical return and logistics make it clear that materials to be tested be ranked according to a priority system. Such a priority system will discriminate between "practical" materials and those which are "hopefuls." The materials request letter outlines the four classifications of materials, ranging from those which are in current use to those which are speculative. A major question in this connection is whether the established priority ranking is practical and whether it can be effectively promulgated.

2. PRIORITY MATERIALS EXPOSURE SCHEDULES

We propose to examine samples at exposure periods (natural and accelerated) of 0, 1, 3, 6 and 12 months. Priority 1 materials would be subjected to the full schedule; Priority 2 materials, to 0, 6 and 12 months; Priority 3 and 4 materials to periods dictated by their 1 month performance results, which to some extent will be dictated by our failure policy.

3. FAILURE POLICY

Par 2.4.1 of our proposal reads as follows:

A firm policy that will prevail will be to remove failed (to some pre-determined degree) specimens when detected during the routine periodic inspection and to replace them with new and/or improved, or alternative, candidate materials in accordance with policies and criteria established by the Review Board. It shall also be incumbent upon the contractor to continuously monitor the state-of-the-art in order that the best available alternative candidates can always be inserted into the test schedule upon demonstrated proof of unacceptability of an original or prior candidate.

Specific criteria of failure must be defined in order to remove from further consideration those materials whose performance is clearly inferior. Unquestionably, the issue of inferiority is highly subjective. Because the end-use becomes a major factor in the ultimate decision of acceptance/rejection, factors such as cost, critical properties affected and extent, other affected properties and extent, priority classification, exposure conditions, and relative performance will definitely require analysis. Nevertheless, there must be some criteria which will readily permit determination and discrimination of unacceptable materials; it should be understood that acceptance/rejection at one exposure site will not substantially affect similar decisions at the other exposure sites. The following criteria of failure are therefore proposed for the types of materials noted:

<u>Materials</u>	<u>Indices of Evaluation*</u>						
	<u>V</u>	<u>T</u>	<u>A</u>	<u>R₁</u>	<u>R₂</u>	<u>E_t</u>	<u>I</u>
Transparencies - glass (inorganic)	X	X					X
Transparencies							
Rigid Plastics	X	X				X	X
Thin Films	X	X				X	
Flat Black Absorbers	X			X	X		
Selective Absorbers	X		X	X	X		
Mirrors - First Surface	X		X	X	X		
Mirrors - Second Surface	X		X	X	X		X
White Coatings	X			X			

*Failure Criteria - General Outlines

- V = Visual Appearance (discoloration, cracking, disintegration, blistering, etc; warping, etc.). Strongly judgment-oriented; some ranking would be required to establish which effects are more important than others for each material class.
- T = Solar Transmittance - 20% loss.
- A = Solar Absorptance - 10% loss.
- R₁ = Solar Reflectance - 10% loss.
- R₂ = Thermal Reflectance - 20% gain.
- E_t = Tensile Strength - 50% loss, or degradation below a minimum value.
- I = Impact Resistance - 50% loss, or degradation below a minimum value.

The visual examinations which exposure test facilities (subcontractor) personnel perform will be the basis for rejection if (and/or when) at least 25% of the samples exposed evidence mechanical failure (loss of integrity, severe cracking, warping, etc.). A further basis of rejection are the results of physical tests performed at IITRI; a change in the transmittance spectrum, for example, would require evaluation relative to the solar spectrum to determine whether a total 20% loss in solar transmission has occurred or is possible.

4. STANDARD EXPOSURE CONDITIONS AND CONFIGURATIONS

All materials will be exposed in Chicago, Phoenix and Miami. The exposure condition of 45° South will be standard. The configurations employed for each class of materials will relate as much as possible to end-use. Some experimental configurations are planned in which materials (primarily priority 1) performance will be examined in both backed and unbacked exposures and also with and without water spray (DSET only).

5. CORRELATION OF EXPOSURE DATA

A primary goal of the project is to predict the long term performance of materials. The EMMA(QUA) machines at DSET will therefore be employed to obtain a radiation exposure, which may provide the equivalent of 10 years natural exposure. The ability to predict long term materials property performance will thus depend upon the quality of the correlation between "accelerated" and "natural" data. The experimental configurations mentioned above will be designed primarily to increase the quality of these correlations by providing interpretative data, particularly those which will elucidate effects of subtle (but inevitable) differences in test conditions.

6. SAMPLE STATISTICS

ASTM Procedure for mechanical testing of samples such as we will study are noted in the request for samples letter. We have tentatively determined, however, that following the ASTM practice would unduly burden the project with sample and sample measurement costs. We propose, therefore, to reduce the number of tensile samples to five; the abrasion samples, to two; and the optical samples, to two. Alternatively, but not preferably, the full ASTM sample schedule could be utilized for tests after exposures of 0 and 12 months and reduced (as above) schedules for tests at 1, 3 and 6 months. The reductions should have little or no effect on the validity of the data, especially if the samples are relatively uniform, if they are not, they may be subject to rejection on that basis alone. In any event two optical samples are easily sufficient.

GENERAL GUIDELINES

The materials involved are primarily (but not entirely) those useful in flat plate solar collectors and whose optical properties are important to the operation of such systems. The project plan provides a uniform, systematic and comprehensive test scheme to generate comparative properties vs time data. The environments at the three test sites are not totally representative but the conditions at each are probably as severe in particular ways as anywhere in the continental U. S. Accordingly, we expect to obtain somewhat conservative performance estimates.

Exhibit 5

Proposed Materials Request Letter

IIT Research Institute
10 West 35 Street, Chicago, Illinois 60616
312/225-9630

Subject: Request for Samples of Solar Energy Utilization Materials

Dear Sir:

IIT Research Institute (IITRI) is conducting a program for the U.S. Energy Research and Development Administration (ERDA), entitled "Exposure Testing and Evaluation of Solar Utilization Materials". The purpose of this program is to comparatively evaluate materials before and after exposure to outdoor weathering tests. Exposures of varying lengths of time and in different geographical areas will be employed.

IITRI is a not-for-profit Research and Development Corporation with no facilities for, or interest in, manufacturing or other commercial/industrial activities. In this program IITRI will thus objectively evaluate all materials tested. While we can not guarantee that all the evaluation criteria would be acceptable to all materials suppliers, we can assure that the materials in the various categories and priority areas will experience the same exposure and test conditions and will be evaluated with respect to common performance criteria.

IITRI will accept any material which is currently being used, or being considered for use, in a SU program/project and which has a reasonable expectation for successful employment in the particular area in which it is being considered or used. Materials of interest are transparent plastics (both rigid sheet and film), glass plate, absorber coatings, radiator coatings,

and mirrors (first and second surface). In general, any material of actual or potential use in flat plate solar collectors, solar concentrators and other solar-driven systems is being sought for inclusion in our test and evaluation program.

The intent of our overall effort is to provide manufacturers of Solar Utilization (SU) devices and/or systems with practical design data - primarily those which relate to cost effectiveness. The end result of our program will be a handbook which lists materials, their relevant properties, weathering effects, source and cost information and other significant data. We want to make it very clear that the handbook will not recommend one material over another; it will provide information with which a user can assess the relative merits of each candidate material in his particular application over an extended lifetime.

The tests which will be performed are primarily optical (reflectance and transmission) and physical (strength); in general, they are those which measure and compare the initial and long-term properties most important to their successful usage in SU applications.

IITRI in conducting this program will follow these policy guidelines:

- 1.) All samples submitted to IITRI will be acknowledged.
- 2.) To be considered for testing each material must be described in terms of its generic composition; its name and other identification must be provided. Any proprietary information will be treated as such, if clearly and specifically so indicated. Cost, availability, and source information must also be provided.
- 3.) IITRI will make all necessary tests without charge to the suppliers.
- 4.) IITRI will furnish, without charge, test data on those materials submitted by an individual company provided that such materials are submitted without cost to IITRI and, are in sufficient number and in "ready-to-test" forms described in this letter.

5.) Each material accepted for testing will be exposed to real time outdoor weathering in Arizona, Southern Florida and Chicago; and to accelerated outdoor exposures (EMMAQA) at DSET Inc. Phoenix, Arizona.

6.) Test results will be published in handbook form and, if possible, in related trade journals and society publications.

7.) IITRI recognizes that this program represents an opportunity to obtain "free" testing. Accordingly, we request a statement that the materials submitted are: a) currently in use on (or in) SU devices or systems; or, in the case that they are not, that they are b) commercially available and contemplated for such use, c) experimental and specifically tailored/developed for SU applications (but not yet commercially available) or d) are experimental and long range R&D materials (not necessarily SU applications).

8.) This priority system will operate primarily in the choice of original materials. As materials fail, they will be replaced with lesser priority (which are not necessarily less stable) candidates. The following is from par. 2.4.1 of IITRI's proposal:

2.4.1 Failure Policy

A firm policy that will prevail will be to remove failed (to some predetermined degree) specimens when detected during routine periodic inspection and to replace them with new and/or improved, or alternative, candidate materials in accordance with policies and criteria established by the Review Board. Sample requirements are rather large because of requirement that each sample be exposed for different periods at 3 different locations in two different configurations.

9.) Each material will be considered to be a separate sample if any of the following differences occur: thickness, production batch (or lot) number, manufacturer.

If your organization is not a manufacturer of any of the materials we have indicated, we would appreciate your telling us who your suppliers of these materials are.

Samples in either bulk or "ready-to-test" forms should be sent to the following address:

Mr. John Brzuskiwicz
Polymer Chemistry Section
IIT Research Institute
10 West 35th Street
Chicago, Illinois 60616

If at all possible, especially in the case of rigid plastic sheet materials, we would appreciate receiving test specimens conforming to the dimensional and other requirements of the ASTM specifications listed in the addenda. Receipt of such specimens in "ready-to-test" form will expedite the incorporation of the material into the test program. Questions or comments are welcomed; please feel free to contact either myself (X5074) or Mr. Brzuskiwicz (X5075).

We look forward to hearing from you at your earliest convenience.
Thank you very much for your consideration.

Sincerely,

IIT RESEARCH INSTITUTE

J.E. Gilligan
Senior Engineer-Group Leader
Polymer Chemistry Research

JEG:ge

ADDENDUM
SAMPLE REQUIREMENTS

<u>Exposure Site</u>	<u>Exposure Duration (Mo.)</u>	<u>Sample Sets</u>		<u>Condition</u>			<u>Sets Required</u>
		<u>Backed</u>	<u>Unbacked</u>	<u>45°S</u>	<u>45°S+QUA</u>	<u>EMMAQUA*</u>	
Chicago	0	Control					1
	1	X	X	+	-	-	2
	3	X	X	+	-	-	2
	6	X	X	+	-	-	2
	12	X	X	+	-	-	2
Florida	1	X	X	+	-	-	2
	3	X	X	+	-	-	2
	6	X	X	+	-	-	2
	12	X	X	+	-	-	2
Arizona	1	X	X	+	+	+	6
	3	X	X	+	+	+	6
	6	X	X	+	+	+	6
	12	X	X	+	+	+	6

*Accelerated test method employed at Desert Sunshine Exposure Testing, Inc.

Total Sets = 41

Sample sets in "ready-to-test" form consist of the following specimens prepared in accordance with ASTM specifications.

<u>Test Parameter</u>	<u>Specimens/Set</u>
Abrasion Resistance	3
Tensile Strength	10
Impact Strength	10
Optical Properties	4

Pertinent ASTM Test Methods include the following. If these specifications are not readily available to you, please contact us and copies will be supplied.

*1.) Materials up to 1/8" thick

Tensile Specimens to be prepared in accordance with ASTM Test Method D1708-59T.

2.) Materials 1/8" to 1/4" thick

Tensile specimens to be prepared in accordance with ASTM Method D638-58T.

3.) Impact specimens to be prepared in accordance with ASTM Method D256-56.

4.) Abrasion resistance test specimens to be prepared in accordance with ASTM Test Method D1044-56 (4" diam. or 4" square samples).

5.) Optical Measurement - 1" diam. discs, or 1" x 1" squares.

*Preferred type of tensile specimens.

Materials which cannot be supplied in the above test specimen configurations should be supplied in the following quantities.

<u>Material</u>	<u>Total Area, ft²</u>	<u>Preferred Dimensions</u>
Rigid Plastics (Sheet)	150	6" x 12" (300 pcs)
Semi-Rigid and Thin Film Plastics	100	6" x 200' (a roll) or 6" x 12" (200 pcs)
Glass	100	6" x 6" (400 pcs)
Coatings on a Metallic Substrate (Paints, Electrodeposits Selective Surfaces)	100	6" x 6" (400 pcs)
Metals*	100	6" x 6" (400 pcs)
Metallized Plastics*	150	6" x 12" (300 pcs)

*Can be supplied as a 6" wide roll.

IIT Research Institute
10 West 35 Street, Chicago, Illinois 60616
312/225-9630

NEWS-RELEASE

July 23, 1975

SOLAR UTILIZATION MATERIALS TEST PROGRAM AT IITRI

IIT Research Institute, under contract to the U.S. Energy Research and Development Administration, is conducting a program entitled "Exposure Testing and Evaluation of Solar Utilization Materials". Manufacturers of materials such as glass, transparent plastics, mirrors and, coatings (absorptive and/or reflective) are urged to participate in this program by submitting samples of their materials for evaluation.

Materials will be exposed, without charge, to outdoor weathering in three geographical areas in the continental United States. After exposure for varying lengths of time, the materials will be evaluated by means of relevant test procedures (optical and/or physical) to determine the changes in the materials due to weathering.

The ultimate goal of the program is to prepare a handbook listing the relevant properties of the materials and the results of outdoor weathering on them. Cost, availability and similar information will also be included. The handbook will not rank or recommend materials, but will present data which a "user" can utilize in the selection of materials for his particular application.

For further information, please contact Mr. J.E. Gilligan (X5074) or Mr. J. Brzuskiwicz (X5075).

Exhibit 7

ERDA Cover Letter (To IITRI-Materials Request Letter)

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

Dear Sir;

The US Energy Research and Development Administration (ERDA) holds the prime responsibility for development of this nation's solar energy utilization technology. An important goal of our overall program is to maximize the efficiency and reduce the cost of solar energy utilization devices and systems. To do this, of course, we must identify cost effective materials. Accordingly I urge your organization to respond favorably to the enclosed request by IIT Research Institute (IITRI) for materials and to cooperate as fully as possible with this important endeavor.

If you have any questions or comments I would appreciate your responding directly to IITRI. Your assistance and cooperation will help to assure the success of this program and I would like to thank you in advance for your participation.

Sincerely,

A handwritten signature in dark ink, appearing to read "John W. Leech, Ph.D.", is written over the typed name and title.

John W. Leech, Acting Chief
Heating and Cooling Branch
Division of Solar Energy

Exhibit 8

IITRI's Materials Request Letter (with addendum)

IIT Research Institute
10 West 35 Street, Chicago, Illinois 60616
312/567-4000

Subject: Request for Samples of Solar Energy Utilization Materials

Dear Sir:

IIT Research Institute (IITRI) is conducting a program for the U.S. Energy Research and Development Administration (ERDA), entitled "Exposure Testing and Evaluation of Solar Utilization Materials". The purpose of this program is to comparatively evaluate these materials (SUMS) before and after exposure to outdoor weathering. These exposures will vary in duration and in geographical areas. Even though this is an 18 month program, we are scheduling some samples for exposure well into 1977.

IITRI is a not-for-profit Research and Development Corporation with no facilities for, or interest in, manufacturing or other commercial/industrial activities. IITRI can thus objectively evaluate all materials tested. While we can not guarantee that all the evaluation criteria would be acceptable to all materials suppliers, we can assure that the materials in the various categories and classifications will experience the same exposure and test conditions and will be evaluated with respect to common performance criteria.

IITRI will accept any material which is currently being used, or being considered for use, in a Solar Utilization (SU) program/project and which has a reasonable expectation for successful employment in the particular area in which it is being considered or used. Materials of interest are transparent plastics (both rigid sheet and film), glass plate, absorber coatings, radiator coatings, and mirrors (first and second surface).

IITRI....

In general, any material of actual or potential use in flat plate solar collectors, solar concentrators and other solar-thermal systems is being sought for inclusion in this program.

The intent of our overall effort is to provide manufacturers of SU devices and/or systems with practical design data - primarily those which relate to cost-effectiveness. The end result of our program will be a handbook which lists materials, their relevant properties, weathering effects, source, cost and availability information and other significant data. We want to make it very clear that the handbook will not recommend one material over another; it will provide information with which a user can assess the relative merits of each candidate material in his particular application.

The tests which will be performed are primarily optical (reflectance and transmission) and physical (strength); in general, they are those which measure and compare the initial and long-term properties most important to their successful usage in SU applications.

IITRI in conducting this program will follow these policy guidelines:

- 1.) All samples and pertinent data submitted to IITRI will be acknowledged.
- 2.) Each material must be described in terms of its generic composition; its name and any other appropriate identification must be provided. Proprietary information and materials, etc. will be treated as such, if clearly and specifically so indicated. Cost, availability, source information and application (preparation) procedures must also be provided. Technical data, especially operating temperature limits, which would be useful to thermal designers are also requested.
- 3.) IITRI will make all necessary tests without charge to the suppliers.
- 4.) IITRI will furnish, without charge, test data on those materials submitted by an individual company, provided that such materials are submitted without cost to IITRI and in the "ready-to-test" form(s) described in the addendum to this letter.

IITRI....

5.) Each material accepted for testing will be exposed to real time outdoor weathering in Arizona, Southern Florida and Chicago; and to accelerated outdoor exposures in Arizona.

6.) Test results will be published in handbook form and, if possible, in related trade journals and society publications.

7.) IITRI recognizes that this program represents an opportunity to obtain "free" testing and evaluation. Accordingly, we request a statement for each material submitted relative to its utilization/development status in terms of the following categories defined:

<u>Category</u>	<u>Availability</u>	<u>Utilization in SU Applications</u>
A	Commercial	Current
B	Commercial	Planned or Potential
C	Limited/Experimental	Planned
D	Limited/Experimental	Long Range/R&D

8.) When materials fail, they will be replaced with other candidate materials as they become available.

9.) Each material will be considered to be a separate sample when any of the following differences occur: thickness, production batch (or lot) number, manufacturer, or specialized surface treatment (e.g. acid etching, anti-reflection coatings, etc).

If your organization is not a manufacturer or supplier of any of the materials we have indicated, we would appreciate your telling us who your suppliers are.

Outdoor exposure testing will be initiated on Oct. 1, 1975; new samples will be installed at monthly (possibly more frequent) intervals thereafter. For maximum exposure, however, samples should be received at IITRI sufficiently before Oct. 1st, in order to characterize them and to prepare them for testing. In the addendum are guidelines to the quantities, dimensions and related requirements of each sample. Recognizing that the availability and cost of category C&D materials may severely limit the quantity and/or

IITRI....

form of the samples, we will treat these materials on an individual basis and ask that you call us (collect) to discuss the situation accordingly. Samples should be sent to the following address:

Mr. John Brzuskiwicz
Polymer Chemistry Section
IIT Research Institute
10 West 35th Street
Chicago, Illinois 60616

If at all possible, especially in the case of rigid plastic sheet materials, we would appreciate receiving test specimens conforming to the dimensional and other requirements of the ASTM specifications listed in the addendum. Each supplier is encouraged to prepare his material(s) for testing to assure that their preparation indeed follows his recommendations and practice. Furthermore, receipt of such specimens in "ready-to-test" form will expedite the early incorporation of the material into the test program. Questions or comments are welcomed; please feel free to contact either myself (312/567-4325) or Mr. Brzuskiwicz (312/567-4326).

We look forward to hearing from you at your earliest convenience. Thank you very much for your consideration.

Sincerely,

IIT RESEARCH INSTITUTE

J.E. Gilligan
Senior Engineer-Group Leader
Polymer Chemistry Research

JEG:ge
Addendum

ADDENDUM

GENERAL SAMPLE REQUIREMENTS

The total number of test specimens required for an individual sample material will depend upon which tests and measurements are relevant to the material involved. The basic unit of test specimens required is termed a "set". The specific number of test specimens per set and pertinent dimensional or test specifications are shown in Table 1.

Table 1

SPECIMEN QUANTITIES AND DIMENSIONAL REQUIREMENTS

<u>Test Parameters</u>	<u>Specimens/Set</u>	<u>ASTM Specification or Sample Dimension</u>
Optical	4	0.75"x0.75" or 0.75" diam.*
Tensile Strength	5	D1708-59T**
Impact Strength	5	D256-56
Abrasion Resistance	3	D1044-56
Other	1	4"x4"

*"Regular" size optical test specimen

**This specification is recommended and preferred for all sample thicknesses; however, D638-58T is an acceptable alternative specification (for sample preparation).

If the above ASTM Test Specifications (which apply to plastic materials only) are not readily available to you, please contact us and copies of specimen dimensions will be supplied.

Table 2 lists the various materials classifications, the types of tests and measurements each will receive, the exposure conditions to which each will be subjected, and the total number of "sets" required for each particular material according to its

Table 2

MEASUREMENT AND EXPOSURE SCHEDULE REQUIREMENTS

Material Classification	Test & Measurements					Exposure Conditions				Total Sets
	Optical ²	Tensile	Impact	Abrasion	Other ³	45°S		Accel.		
						b	t	R	H	
Plastics										
Rigid (sheet)	+	+	+	+		X	X	Y	Y	35
Semi-Rigid & Thin Film	+	+					X	Y		18
Glass										
Single Pane	+						X		Y	18
Multi-Pane	+					X			Y	18
Coatings										
Flat Black ⁴	+					X			Y	18
Selective ^{4,5}	+				+	X		Y		18
White	+			+		X		Y		18
Reflectors										
Metals	+			+		X		Y		18
Metallized Plastics	+	+		+		X			Y	18
Miscellaneous										
AR Coated surface	+			+	+	X	X	Y		30
Etched surfaces	+	+			+	X	X	Y		30

Notes:

1. All specimens will be exposed on a standard 45° South rack in Arizona, Florida and Illinois. X designates that 3 sets of specimens are needed at each of 3 locations where the samples will be exposed in either a "backed" (b) or a "through" (t) configuration, or in some cases both. Y designates accelerated exposures; these will be accomplished only in Arizona, either on machines without water spray (R), or on those with water spray (H), or both.

IITRI....

Notes: (Cont'd)

2. The term Optical refers both to reflectance of opaque surfaces and to transmittance of transparent materials, as appropriate.
3. All specimens will be visually inspected, but some will be subjected to special testing or observation which may be highly material-and/or environment-related.
4. Selective absorber and flat black coatings (but not electrodeposits) should be supplied in two thicknesses, viz., 1x and 2x recommended thicknesses.
5. For selective surfaces in addition to "regular" size samples, two 4"x4" specimens must be supplied per set (see note 4).

IITRI....

classification. The number of required sets as shown in Table 2 is based on the following formula:

$$\text{Sets} = \text{Control} + 45^{\circ}\text{S}(\text{b}+\text{t})\times 12 + \text{Accel}(\text{R}+\text{H})\times 5$$

This formula reflects the fact that one set of specimens will be retained under normal "indoor" (unexposed) conditions as a control. Each sample material will be exposed at three locations (Chicago, Phoenix and Miami) for four (4) durations (3,6,12 and 24 months), making 12 sets per sample in conventional 45°S exposure "backed" (b) and/or 12 sets per sample in conventional 45°S exposure "through". (t), as indicated in Table 2. In addition, 5 sets per sample will be utilized in accelerated exposures (1,3,6,12 and 24 months). Accelerated exposures will be carried out with water spray (H) and/or without water spray (R).

As an example, in the case of rigid plastic sheet material, 35 sets of specimens should be provided, each set consisting of 4 optical, 5 tensile, 5 impact and 3 abrasion specimens. As a further example, 18 sets of selective black absorber surface should be provided, each set consisting of 4 regular size optical specimens of 1x thickness, 4 regular size specimens of 2x thickness, 1-4"x4" specimen of 1x thickness and, 1-4"x4" specimen of 2x thickness.

In those cases in which a material is not supplied in "ready-to-test" form(s), the preparation of specimens would be aided if the material were supplied in 6"x6" squares, each square corresponding to a set. In any case, at least one dimension of the material supplied should be 6" min. A roll or coil, for example, of 6" width would be acceptable.

Table 1

Material Suppliers Contacted

<u>Company</u>	<u>Reply</u>
1. American Cyanamid Co. Building 4C, Rm. C146 Bound Brook, N.J. 08805 Attn: Dr. C. Savides Alan Sherr	(0 - no response, - netative reply) Not applicable. Make UV Absorbers only.
2. American Cyanamid Co. Stanford, Conn. Attn: Dr. G. Haake Chem. Res. Div.	0
3. ALCOA Aluminum 1501 Alcoa Building Pittsburgh, Pa. 15219 Attn: Mr. W.S. Lewis	0
4. ALCOA Technical Center Alcoa Center, Pa. 15069 Attn: Mr. J. Powers	0
5. Alcan Booth Industries, Ltd. Banbury Oxfordshire England	0
6. Amelco Window Corp. 77 Rt. 17 Box 333 Hasbrouck Heights, N.J. 07604 Attn: Mr. R.C. Current, Jr.	-
7. Acorn-Glas Tint International 1123 W. Century Blvd. Los Angeles, Calif. 90044 Attn: Mr. A. Allen	Not applicable. Reflective glass only.
8. Argus Chemical Corp. Div. of Witco Chem. Corp. 633 Court Street Brooklyn, N.Y. 12231 Attn: Mr. S.D. Brilliant	0

9.	ASG Industries, Inc.
1 B Belmar Rd.
Cranbury, N.J. 08512
Attn: Mr. C.W. Clarkon	0
10.	Atlantic Research Corp.
5390 Cherokee Avenue
Alexandria, Va. 23314
Attn: Mr. G.D. Summers	0
11.	Allied Chemical Corp.
Materials Research Center
P.O. Box 1021 R
Morristown, N.J. 07960
Attn: Mr. A.J. Nozik	0
12.	American Saint-Gobain
P.O. Box 929
Kingsport, Tenn. 27662	0
13.	BASF Aktiengesellschaft
6700 Ludwigshafen
Federal Republic of Germany
Attn: Dr. R. Steppan	0
14.	Beasley Industries Pty. Ltd.
Bolton Avenue
Devon Park, SA Australia
Attn: Mr. E.L. Beasley	0
15.	Beutels Solar Heater Inc.
1527 N. Miami Avenue
Miami, Fla. 33136	0
16.	Bausch & Lomb
Vacuum Coating Div.
10 Champeney Terrace
Rochester, N.Y.
Attn: Mr. D. Hoagland	0

17.	Ball Chemical Co.
1486 Butler Plank Rd.
Glenshaw, Pa. 15116
Attn: Mr. H.P: Ball	Materials not applicable
18.	Cobalt Engineering Co.
164 Penington-Highbouton
Pennington, N.J. 08534
Attn: Mr. B. Owen	0
19.	Colspan Environmental Systems
P.O. Box 3467
Boulder, Colo. 80303
Attn: Mr. A.M. Frank	0
20.	Corning Glass Works
Corning, N.Y. 14830
Attn: Mr. P.B. Adams
Res. & Development	0
21.	Univ. of Colorado
Boulder, Colo. 80303
Attn: Mr. M. Uberoi	0
22.	Certain-Teed Products Corp.
P.O. Box 860
Valley Forge, Pa. 19482
Attn: Mr. P.W. Bacon	0
23.	Chemalloy-Electronics Corp.
7947 Towers - PO DR10
Santee, Calif. 92071
Attn: Mr. Friedman	0
24.	Coating Products Inc.
580 Sylvan Avenue
Englewood Cliff, N.J. 07632	0

25.	Combustion Engineering Inc.
Raymond Div.
405 E. Highland
Villa Park, Illinois	0
26.	Daylin Inc.
9606 Santa Monica Blvd.
Beverly Hills, Calif.
Attn: Mr. D.L. Collins	0
27.	Deko Labs
Box 12841 University Station
Gainesville, Fla. 32604
Attn: Mr. D.F. Dekold	0
28.	Dome East Corp.
325 Duffey Avenue
Hicksville, N.Y. 11801
Attn: Mr. D.A. Robinson	0
29.	Dayco Corp.
Dayflex Plastics Div.
333 W. First St.
Dayton, Ohio 45402	0
30.	Englehard Industries, Inc.
Hanovia Liquid Gold Div.
East Newark, N.J.
Attn: Mr. R.C. Langley	0
31.	Enthone, Inc.
Div. of ASARCO
Frontage Road
West Haven, Conn. 06516	0
32.	ECO-Solutions, Inc.
P.O. Box 4117
Boulder, Colorado 80302
Attn: Mr. R. Hess	Letter returned to addressee

33.	E.I. DuPont de Nemours
Film Dept.
Chestnut Run Laboratory
Wilmington, Del. 19898
Attn: Mr. J.H. Rogers	0
34.	E.I. DuPont de Nemours
Plastics Dept.
Experimental Station
Wilmington, Del. 19898
Attn: Mr. K.M. Hudson, Jr.	0
35.	E.I. DuPont de Nemours
Coatings Dept.
Wilmington, Del. 19898
Attn: Mr. H. Beardsley	0
36.	Filon Corporation
Div. of Vistron
12333 South Van Ness Ave.
Hawthorne, Calif. 90250
Attn: Mr. D. Samuelson	0
37.	FABCO
809 E. 18th St.
Los Angeles, Calif. 90021	0
38.	Fortin Plastics, Inc.
28687 Golden State Highway
Valencia, Calif. 91355	-
39.	Flex-O-Glass, Inc.
1100 N. Cicero
Chicago, Illinois 60651	0
40.	Fourco Glass Company
Box 4147 Station B
Fort Smith, Ark. 72901
Attn: Mr. H.E. Walker	0

41. Gardner Mirror Co. P.O. Box 638 North Wilkesboro, N.C. 28659 Attn: Mr. R.D. Pohl	+
42. Glidden Company Coatings and Resins Group 900 Union Commerce Bldg. Cleveland, Ohio	0
43. General Electric Company Plastics Dept. 1 Plastics Ave. Pittsfield, Mass. 01201 Attn: Mr. R. Corhardt	0
44. General Electric Company 1 Plastic Avenue Pittsfield, Mass. 01201 Attn: Mr. G.C. McCartha	0
45. General Electric Company Energy Systems P.O. Box 8661 Philadelphia, Penn. 19101 Attn: Mr. D.L. Kirkpatrick	+
46. Grumman Aerospace Corp. Energy Programs Plant 30 Bethpage, L.I. , N.Y. 11714 Attn: Mr. G. Knowles	0
47. Gomar Manufacturing Co. 1501 W. Blancke St. Linden, N.J. 07036	0

48. Glass Tinters, Inc. 4155 N. Dixie Highway Fort Lauderdale, Fla. 33308	0
49. Guardian Industries 43040 W. Nile Rd. Northville, Mich. 48167	0
50. General Dynamics Corp. Convair Aerospace P.O. Box 748 Fort Worth, Texas 76101 Attn: Dr. R.O. Doughty	-
51. General Motors Corp. Harrison Radiator Div. Upper Mountain Road Lockport, N.Y. 14094 Attn: Mr. V.L. Ericksen	0
52. G.L. Scheldahl Co. 231 Fries Avenue East Providence, R.I. 02916 Attn: D.E. Anderson	0
53. Hooker Chemical & Plastics Corp. Durez Div. North Tonawanda, N.Y. 14120 Attn: Mr. P.W. Vacarella	0
54. Harshaw Chemical Co. 1933 E. 97th St. Cleveland, Ohio 44106	0
55. Heliotec Inc. 33 Edinboro St. Boston, Mass. 02160	0

56. Hermetic Refrigeration Co., Inc. 2522 W. Holly Phoenix, Ariz. 85009 Attn: Mr. J.L. Hoyer	+
57. Honeywell Inc. 2600 Ridgeway Pkway Minneapolis, Minn. Attn: Mr. H. Mar	0
58. Ickes-Braun Glasshouse, Inc. Aptakisic Road Aptakisic, Illinois	0
59. Koro Corporation 560 Main St. Hudson, Mass. 01749	0
60. Kurz-Hastings, Inc. Dutton Road Philadelphia, Pa. 19154	0
61. Lockheed Missiles and Space Co., Inc. Palo Alto Research Laboratory 3251 Hanover Street Palo Alto, Calif. 94304	0
62. LOF Bros. Solar Appliances P.O. Box 10594 Denver, Colorado 80210	0
63. Martin Processing Co., Inc. 919 Third Avenue New York, N.Y. 10022	0
64. Martin Marietta Aerospace P.O. Box 179 Denver, Colorado Attn: Mr. J.F. Wade	0

65. Mobay Chemical Co.
Div. of Baychem. Corp.
Pittsburgh, Pa. 15205
Attn: Mr. G. Ong.
66. Materials Engineering
Research & Devpt. Lab.
Fort Belvoir, Va.
Attn: Dr. G. Haas
67. Milton Ribbeck, Inc.
20 E. 35th Street
New York, N.Y. 10016
68. Monsanto Company
P.O. Box 150
St. Louis, Mo. 63166
Attn: Dr. K. Sears
69. NASA
G.C. Marshall Space
Flight Center
MSFC, Ala. 35812
Attn: Mr. D.R. Bowden
70. Nichols-Homeshield Inc.
1035 E. State St.
Geneva, Illinois 60234
Attn: Mr. M.E. Gohnson
71. Northrup, Inc.
2208 Canton St.
Dallas, Texas 75201
Attn: Mr. L.L. Northrup
72. NASA Lewis Research Center
Power Applications
Mail Drop 500 201
Cleveland, Ohio 44142
Attn: Mr. R. Ragsdale

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73. National Sun Control	0
P.O. Box 205	
Miami, Fla. 33133	
74. Optical Coatings Laboratory, Inc.	-
P.O. Box 1599	Will not supply materials free
Santa Rosa, Calif. 95403	of charge. Very expensive.
Attn: Mr. R. Winegarner	
75. Univ. of Arizona	0
Optical Sciences Center	
Tucson, Ariz. 85721	
Attn: Dr. B. Seraphin	
76. OEM Products, Inc.	0
Barlow Pump Div.	
1518 Dierker Dr.	
Valrico, Fla. 33594	
Attn: Mr. D.W. Barlow	
77. Polyset, Inc.	+
7 Summer St.	
Manchester, Mo. 01944	
Attn: Mr. J. Broadley	
78. PPG Industries	0
Glass Div.	
632 Fort Duquesne Blvd.	
Pittsburgh, Pa. 15222	
79. PPG Industries	-
One Gateway Center	
Pittsburgh, Pa. 15222	
Attn: Mr. N. Barker	

80. Reynolds Metals -
Extrusion Div.
6601 W. Broad St.
Richmond, Va. 23230
Attn: Mr. S. Hoover
81. Raypak, Inc. -
31111 Agoura Rd.
West Lake Village Calif. 91361
Attn: Mr. A. Boniface
82. Revere Copper and Brass, Inc. 0
Bdlg. Prod. Dept.
P.O. Box 151
Rome, N.Y. 13440
Attn: Mr. W.J. Heidrich
83. Rockwell International 0
Space Div.
12214 Lakewood Blvd.
Downey, Calif. 90241
Attn: Mr. C.L. Gould
SF-26
84. Rowland Products, Inc. 0
34 Fairview Lane
Kensington, Conn. 06037
85. Swedlow, Inc. 0
12242 Western Avenue
Garden Grove, Calif. 92642
Attn: Mr. J. Hardy
Dept. 49
86. Sherwin Williams Co. -
101 Prospect Ave. N.W.
Cleveland, Ohio
Attn: Mr. J.L. Weaver

87. Solar Power Corp. 0
186 Forbes Road
Braintree, Mass.
Attn: Mr. R.W. Willis
88. Selective Radiation Surfaces -
Plating Co.
P.O. Box 8364
San Jose, Calif. 95155
Attn: Mr. R.T. Avalon

(now called)
Sunshine Mfg. Co.
2560 Seaboard Avenue
San Jose, Calif. 95131
89. Solar Sunstill Inc. 0
Setauket, N.Y. 11733
Attn: Mr. C.J. Raseman
90. Saint Gobain, Industries 0
Vertexil S.A. 18
route de Acacias
Geneva, Switzerland
91. Steelcraft Corp. 0
Environmental Design
P.O. Box 12408
Memphis, Tenn. 38112
Attn: Mr. G. Ford
92. Solar Power Supply 0
Rt. 3 Box A-10
Evergreen, Colorado 80439
Attn: Mr. M. Lillywhite

93. Solar Control Products, Corp. 217 California St. Newton, Mass. 02158 Attn: Mr. G. De' Camp	Materials not applicable, UV&IR Reflective film
94. Southwestern Reflective Film. Co. 7341 E. 6th Ave. Scottsdale, Ariz. 85252	0
95. Standard Solar Control 4807 N. 14th Pl. Phoenix, Ariz. 85014	0
96. Shatterproof Glass Corp. 4815 Cabot Ave. Detroit, Mich. 48210 Attn: Mr. J. Krebs	-
97. Safelite Industries, Inc. 801 Witchita St. Witchita, Kansas 67201	0
98. Thermark Co. 650 W. 67th Pl. Schererville, Ind. 46375 Attn: Mr. E.W. Rose	0
99. Texas Instruments, Inc. MS10-16 Attelboro, Maine 02703 Attn: Mr. V. Savolainen	0 Letter returned to addressee
100. Union Carbide Corp. Plastics Div. Bound Brook, N.J. 08805 Attn: Mr. W.A. Shedden	0

101. Universal Oil Products Co. 0
Wolverine Tube Div.
P.O. Box 2202
Decatur, Ala. 35601
Attn: Mr. J.K. Thorne
102. Uniroyal Inc. -
Plastics Products Dept.
2638 N. Pulaski
Chicago, Ill. 60639
Attn: Mr. T.L. Ether
103. Wyandotte Paint Products Co. -
P.O. Box 255
Norcross, Ga. 30071
Attn: Mr. R.R. Kern
104. Westinghouse Electric Corp. 0
Mfg. Devpt. Lab.
R&D Center
Pittsburgh, Pa. 15235
Attn: Mr. F.J. Michel

Exhibit 10

Table 2
Materials Submitted for Evaluation

<u>Company</u>	<u>Reply</u>
1. RAM Products 1111 N. Centerville Rd. Sturgis, Michigan 49091	a. Plexi-View Clear Acrylic, Mirrored b. Plexi-View Clear Acrylic, Unmirrored
2. Solar Equipment Corporation Woodbridge at Main P.O. Box 327 Edison, N.J. 08817	a. NiO selective coating on 0.007" thick copper. b. NiO selective coating on 0.013" thick copper.
3. Crown Zellerbach Corp. Flexible Packaging Div. Packaging Research & Devpt. 2101 Williams Street San Leandro, Calif. 94577	a. LX-04145-PE Polycarbonate-LDPE- Polycarbonate Coextruded composite film. b. LX-04145-PE. Polycarbonate-HDPE- Polycarbonate Coextruded composite film.
4. 3M Company P.O. Box 33331 St. Paul, Minn. 55133	a. Nextel 101-C10 Black Velvet coating on 6 mil Al foil. Absorber coating. b. Scotchcal No. 5400 film. Weatherable reflector surface. c. Tedlar No. 838 (Non-lined) weather resistant tape for sealing outer windows d. Scotchpar Polyester Film Plain, unocated, inner window material. e. Scotchpar Polyester Film No. 10 UV stabilized, weatherable, for inner window. f. Paramet No. 2601. Non-weatherable

5. Richmond
Div. of Pak-Well
Colton & Opal Streets
P.O. Box 1129
Redlands, Calif. 92373

6. Libby Owens Ford Co.
1701 E. Broadway
Toledo, Ohio 43605

- g. 3M No. 361 Glass Cloth Tape.
for sealing inner windows of
flat plate collectors.
- h. 3M No. 363 Aluminized Glass
Cloth Tape. High temperature
sealing where high reflectivity
is required.
- i. 3M No. 430 Aluminized foil tape.
For sealing outer windows of flat
plate collectors or reflectors.
- j. 3M No. 5411 "Kapton" film tape.
Translucent sealer up to 400°F.
- k. 3M No. 5413 "Kapton" film tape.
Translucent sealer up to 500°F.
- l. "Flexigard" laminated Acrylic-
Polyester film. For outer window
of flat plate collector.
- m. Scotchcal Brand No. 5400B
film. Weatherable, reflector
surface.
- a. Tedlar-UV stabilized polypropy-
lene netting-UV stabilized poly-
ethylene composite film. For
outer window of flat plate collector.
- a. 1/8" thick regular float glass
- b. 1/8" thick regular float glass
filmed with electrically con-
ductive film (Electrapane)
Resistivity 50-60 ohms/cm., annealed.

7. Boeing Engineering & Construction
P.O. Box 3999
Seattle, Washington 98124
 - a. Tedlar Film #7826B. Experimental film with chemical additive changes. Specially processed for high transmittance.
 - b. Tedlar Film #8378. Experimental film with chemical additive changes. Specially processed for high transmittance.
 - c. FEP Teflon film.
8. American Acrylic Corp.
173 Marine Street
Farmingdale, N.Y. 11735
 - a. "Antique Glass". Fiber glass reinforced, high light transmitting, acrylic-alkyd copolymer.
 - b. "Crystal" Fiber glass reinforced, high light transmitting, methacrylate polymer.
9. Rohm & Haas Co.
Plastics Engineering Laboratory
Box 219
Bristol, Penn. 19007
 - a. "Tuffak" extruded polycarbonate sheet.
 - b. Plexiglas DR(61K)-100 molded acrylic polymer.
 - c. Plexiglas V-100 (Type 811) Molded acrylic polymer.
 - d. Plexiglas V-100 (Type 045) Molded acrylic polymer.
10. De Soto, Incorporated
 - a. 528-010-5R Super Koropon, fluid Resistant Flat Black #37038. Non-selective flat black, absorber coating with an epoxy-amine "binder system. submitted in two thicknesses on an aluminum substrate.

11. Kalwall Corporation
1111 Candid Road
Manchester, N.H. 03105

- b. 828X310-7R Desothane Aliphatic Polyurethane Flat Black #37038. Non-selective, flat black absorber coating. Submitted in two thicknesses on aluminum substrates.
- c. 438X301-3N Coil Fluoropon Black. Non-selective, flat black, absorber coating. Submitted in two thicknesses on aluminum substrate.
- d. 438X301-3N Coil Fluoropon Black plus 543-007 Super Koropon primer. Non-selective, flat black, absorber coating. Submitted in two thicknesses on aluminum substrate.
- a. 0.025 "Sun-lite Regular (R5) Acrylic fortified, fiberglass reinforced polyester sheet. Weatherable sheet.
- b. 0.040" Sun-lite Regular (R4) Acrylic fortified, fiberglass reinforced, polyester sheet. Weatherable sheet.
- c. 0.025 "Sun-lite Premium (P5) Fiberglass reinforced, modified polyester sheet.
- d. 0.040 "Sun-lite Premium (P4) Fiberglass reinforced, modified polyester sheet.

12. Reynolds Aluminum
Metallurgical Research Div.
4th & Canal Street
Richmond, Virginia 23261

13. FAFCO Incorporated
138 Jefferson Dr.
Menlo Park, Calif. 94025

- e. 0.040" Regular Experimental (R4K) Fiber Glass reinforced, specially coated, acrylic fortified polyester sheet.
- f. 0.040" Premium Experimental (P4K) Fiberglass reinforced, specially coated, modified polyester sheet.
- g. 0.040" Premium Experimental (T4) Fiberglass reinforced, modified polyester sheet covered with PVF film.
- a. Experimental Selective Surface Coating Pat. pending.
- b. Experimental Selective Surface Coating MS. Pat. pending.
- c. Experimental Selective Surface Coating MO. Pat. pending
- d. Experimental Selective Surface Coating ZM. Pat. pending.

These are high temperature (above 400°F) resistant coatings.

- a. Extruded Plasticboard 80% polypropylene-20% polyethylene copolymer, UV stabilized, flat plate collector material. Weatherable.
- b. Header pipe. Polypropylene homopolymer, UV stabilized.

- c. Coupler Material. EPDM rubber.
- d. Woven Nylon Strap.
- e. Vinyl Strap.
- f. Glass filled nylon tie-down brackets.

DISTRIBUTION

<u>Copy No.</u>	<u>Recipient</u>
	U.S. Energy Research and Development Administration Solar Energy Division Washington, D.C. 20545
1-10	Attn: Dr. Stephen L. Sargent
11	Attn: Dr. John W. Leech
	National Aeronautics and Space Administration Lewis Research Center 21000 Brookpark Road, Cleveland, Ohio 44135
12	Attn: Mr. Charles Younger, M/S 500-201
13	Dr. John Duffie University of Wisconsin 1500 Johnson Dr. Madison, Wisc. 53706
14	Dr. K.G.T. Hollands University of Waterloo Department of Mech. Engr. Waterloo, Ontario, CANADA
15	Dr. Jack R. Howell Department of Mech. Engr. University of Houston Houston, Texas 77004
16	Mr. Jaan Jurisson Honeywell Systems & Res. Ctr. 2600 Ridgway Pkwy Minneapolis, Minn. 55413
17	Mr. D.L. Kirkpatrick General Electric Co.-Solar Technology Program P.O. Box 8661, Rm. 11B11 Philadelphia, Penn. 19101

<u>Copy No.</u>	<u>Recipient</u>
18	Mr. Bernard E. McKenzie Hercules, Inc. Box 98 Salt Lake City, Utah 84044
19	Mr. Kenneth N. Marshall Lockheed MSC - D/52-21, B/205 3251 Hanover Street Palo Alto, California 94304
20	Mr. Teuvo Santala Materials & Electrical Products Group Texas Instruments, Inc. Attleboro, Mass. 02703
21	Dr. Dimiter I. Tchernev MIT-Lincoln Labs., Rm. C-175 P.O. Box 73 Lexington, Mass. 02173
22.	Dr. David Waksman National Bureau of Standards Bldg. 226, Rm. A319 Washington, D.C. 20234
23.	Dr. James W. Ramsey University of Minnesota Dept. of Mech. Engr. M.E./125 Minneapolis, Minn. 55455
24.	Burt-Hill Assoc. 610 Mellon Bank Bldg. Butler, Penn. 16001 Attn: Mr. Alva L. Hill
25.	Dr. John I. Yellott Dept. of Architecture Arizona State Univ. Tempe, Ariz. 85021

<u>Copy No.</u>	<u>Recipient</u>
26	Mr. William F. Carroll CIT/Jet Propulsion Laboratory B/157-507 4800 Oak Grove Drive Pasadena, Calif. 91103
27	Mr. Gene Zerlaut Desert Sunshine Exposure Tests, Inc. Box 185 Black Canyon Stage Phoenix, Arizona 85020
28	IIT Research Institute M.J. Klein
29	Main Files
30-31	P. Caputo/Div. C. Files
32	A.M. Stake
33	J.E. Gilligan
34	J. Brzuskiwicz
35	F.O. Rogers