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9 March 1964

**EVALUATION OF POTENTIAL
BALLCON MATERIALS**

Scientific Report No. 1

Survey of Currently Available
Plastic Films

by W. B. Parsons

Prepared for:

Air Force Cambridge Research Laboratories
Office of Aerospace Research
United States Air Force
Bedford, Massachusetts

Contract AF 19(628)-2944
Project No. 6665; Task No. 666501

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NOTICE

The Aerospace Engineering and Research departments of General Mills' Electronics Division were purchased by Litton Industries, Inc., on 11 September 1963. This acquisition is now known as the Applied Science Division of Litton Systems, Inc.

This sale has transferred all facilities, personnel and capabilities which have been involved in the research directed toward Evaluation of Potential Balloon Materials under Contract AF 19(628)-2944. Work on this contract, which has now been novated, will continue without interruption or adverse effects.

Much of the survey work reported herein was conducted while this division was a part of General Mills, Inc., hence, many references will be made to GMI rather than to Litton's Applied Science Division.

ABSTRACT

In a survey of currently available plastic films (supported and unsupported) for potential balloon use, 419 firms were contacted, of which 156 responded. Of these responses, 118 must be classified as negative, while 15 are classified "miscellaneous"--which for practical purposes is negative. Eleven firms made no special effort other than forwarding either samples or sales literature. Twelve firms made some effort that involved some combination of submitting samples or literature and returning the questionnaire (only three of these made a substantial attack on the questionnaire). So far as can be determined, only one firm (Foster Grant) performed any actual testing in order to supply data not already in their possession, which were requested by the questionnaire. Data are presented herein on 18 materials--two not suggested by the survey--the products of 12 companies. Of these, 11 materials are commercial items, one appears en route to this status, and six will probably not advance beyond the experimental stage unless a use is found for them.

FOREWORD

This report was prepared by the Applied Science Division, Litton Systems, Inc., under Contract No. AF 19(628)-2944. This contract was initiated under Project No. 6665, Task 666501. The work was administered under the direction of the Air Force Cambridge Research Laboratories, Office of Aerospace Research, with Mr. James F. Dwyer, CREB as Contract Monitor.

This report covers work involved in performing Item I--Survey of Currently Available Plastic Films (for potential balloon use).

Staff members of the Applied Science Division who have directed and performed the work described herein include Messrs. A. A. Anderson and W. B. Parsons.

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	1359	
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Scientific Report No. 1
Contract AF 19(628)-2944

SURVEY OF CURRENTLY AVAILABLE PLASTIC FILMS

I. INTRODUCTION

This report documents results of the survey carried out as Item 1 under Contract AF 19(628)-2944 entitled "Research Directed Toward Evaluation of Potential Balloon Materials."

Under this contract, the Applied Science Division, Litton Systems, Inc., has conducted a survey of available plastic films including unsupported, supported, and laminated. Tests will be conducted on the most promising. The goal is to consider these materials in relation to those presently used for balloons (zero pressure and superpressure, but not including extendable weather, tethered, or space applications) and determine whether any are superior to and should supplant those now in use. The test program also encompasses balloon load tapes.

The work described herein was performed during the period 1 May 1963 through 15 March 1964.

Nearly 420 firms were contacted in the initial, and two subsequent alternate surveys, with responses being received from more than 150 of these. Sufficient data were received on 18 materials to permit their listing, although not all of these meet minimum stated requirements. While a much higher response might have been desired and expected (since even negative responses were requested and facilitated by enclosure of self-addressed postage-free envelopes), it is believed that returns are consistent with other well conducted surveys. As a contractor who is called upon, rather persistently, by representatives of a number of firms that are potential suppliers of materials for balloon applications, our primary surprise and disappointment was in the failure of the film suppliers to seize this opportunity to pit their products against one another. Particularly did we expect these firms to pit their

products against those presently used in balloons--first, in a fair comparison of data relative to pertinent characteristics and second, in the competitive test phase to follow. Having previously contacted many laminators regarding potential reinforced-film materials suitable for consideration, we were not surprised that there were so few materials available at a stage that would permit submission of data and samples. Little proprietary effort can be expected with no assurance of a market for that new composite which meets certain clearly defined minimum specifications and is superior to competitive materials from the standpoint of technical excellence and moderation of cost. Lack of composites especially "concocted" for consideration in this survey and the subsequent test program would bear out this assumption.

It is believed that this survey has performed a beneficial function in discovering that there are not great numbers of potential balloon materials presently available, which are not already familiar to those firms and agencies concerned with their use. This demonstration provides reassurance that any possible funded development, whether in the area of unsupported or supported film, would probably not be duplicating work on some existing product.

It is suggested that consideration be given now to action which might reasonably be taken should the test phase of this program fail to demonstrate that any of the candidate materials offers advantages over those presently used. Such action might take the course of (1) formulating minimum and desired standards relative to all pertinent characteristics of materials for the three types of balloons under consideration, and (2) contacting technical directors of selected suppliers of (a) film, (b) lamination service, (c) resin, and (d) adhesives--regarding feasibility of conforming to the stated requirements.

II. INITIAL SURVEY PACKAGE

A Survey Package was prepared including (1) a letter of introduction and explanation, (2) a statement of the contract program, (3) information on presently used materials, and (4) a questionnaire. This package was submitted for approval by the Contract Monitor. Upon return, suggested modifications were made.

Initial distribution was investigated. Major attention was devoted to Thomas Register of American Manufacturers (53d ed., 1963) and Modern Plastics Encyclopedia (issue for 1963, 40:1A, September 1962). The latter includes a register of firms active in specific categories and a master alphabetical list. We selected the following categories for distribution: (1) biaxially oriented film and sheets; (2) cast film and sheets; (3) extruded or calendered sheets; (4) extruded film; (5) film laminates, thermoplastic; (6) coating of component parts; and (7) coating, web. Excluded, were firms specializing in materials (as indicated by code letter) which are known to be inappropriate. Selections were transferred to the master list for complete address and elimination of duplication.

The alphabetical list was scanned in its entirety in order to determine whether any firms known to be active in appropriate fields had not been selected because they were not included in any of the categories chosen for consideration. This process added approximately 10 firms to the 300 originally selected. Review was made of firms with which we have previously been in contact regarding films and scrim-reinforced film. This effort yielded 23 additional contacts. Two contacts were later suggested by our Contract Monitor and one by a contacted firm. A spot-check was made against the categories of interest in Thomas Register, such as: plastic extruders; plastic film, flexible; laminating paper and cloth; plastic sheeting; laminated plastics; and plastics, transparent. It was found that many of the listed firms had previously been selected, but that many had not. Believing that a survey of some 333 firms should prove adequate, at least initially, no attempt was made to increase further the list of contacts.

A copy of the Survey Package is to be found in Appendix A. Appendix B gives an alphabetical list as extracted from Modern Plastics Encyclopedia to which has been added 27 additional contacts (Appendix C). Following each firm name is a brief summary of its response, if any.

Response to the Survey Package was somewhat slower than expected. By including a self-addressed envelope by which a negative response could conveniently be made with little effort and at no cost, we expected that those firms having no products meeting the minimum requirements would respond quickly and in large numbers. This was not the case, and the following situations are considered possible causes of the poor initial response:

- 1) There was so much explanatory material included with the questionnaire that many recipients either gave up and discarded the package before coming to the questionnaire and return envelope, or set the material aside, perhaps with good intentions to respond when time permitted.

In preparing the questionnaire, we were torn between a desire to keep it brief and simple, and the need to provide information which would really explain the program--and perhaps sell some firms on making substantial effort to participate.

- 2) The "Package" may have impressed the initial recipient, yet required information not available to him. He may then have forwarded it either within his department or to another department for response. In this manner it may have fallen into the hands of a research-director type who was busy with other things and not inclined to be overly concerned with prompt attention to such correspondence.
- 3) Although a firm may have had nothing that could meet the requirements, it may have been reluctant to go on record, preferring to remain silent.
- 4) Some firms may have planned to perform tests needed to supplement available sales data in order to make a complete response. This is rather doubtful, however, because such a firm would probably have made an initial response, advising us of this action. This is particularly likely in view of the fact that a reply within two weeks was requested.
- 5) Some companies may have honestly believed that they had a candidate material and sought management approval to incur the cost of additional testing required to obtain data needed to complete the questionnaire.
- 6) Lack of an attention line on the inquiry may have contributed to a light response. Had the inquiries been directed to sales departments, our correspondence might have been "logged in" prior to forwarding to a technical group for needed data. Sales would then have a follow-up responsibility, if only because of the nature of their record-keeping.

III. AIR FORCE FOLLOW-UP

During a project conference at our division on 26 June 1963, Mr. Tom Kelly suggested the use of a questionnaire follow-up, drafted by GMI and issued on Air Force Stationery. The draft, a copy of which is appended (Appendix D): (1) emphasizes Air Force interest in balloons, (2) points out that GMI is not a competitor of firms being contacted, (3) advises that the report will be available to all fabricators (all potential customers of firms contacted), (4) offers the incentive of a copy of the report to firms submitting a complete questionnaire, (5) provides further information on market potential, and (6) indicates that even a partially completed questionnaire could, under certain circumstances, lead to inclusion of an apparently promising material in the test phase of the program. This draft was modified by the Contract Monitor and a follow-up was submitted. Appendix E is a copy of the follow-up letter.

Response to the Air Force Follow-up was considerably greater than might have been expected based on returns from any of the other three* approaches. This may be taken to indicate that the low level of return from the other three approaches may not be attributed simply to lethargy on the part of recipients. It is obviously easier to write "no" on a questionnaire and return by postal card or self-addressed envelope than to dictate an independent response. That 53 firms from a group of 260 (those who failed to respond to the first questionnaire) would make the effort to write in response to the follow-up (when only 83 of the original 333 replied) must be attributed to a desire to cooperate with the Armed Forces. It is not considered surprising that almost without exception, the writers disclaimed knowledge of having received a questionnaire. In many cases these were probably not the same individuals who took no action except to "round file" the Survey Package; if they were, they would not be likely to admit it.

While direct replies to the Air Force in response to the follow up exceeded expectations, the response direct to GMI was quite the contrary.

* Two subsequent approaches are described hereinafter

1) Two telephone calls, including one from a firm (Foster Grant) whose initial response had been received too late to delete them from the follow-up list, 2) One letter to our general office, and 3) One casual mention by a vendor representative, in the course of conversation on other matters. Samples were received from Facile in late August with no reference to the follow-up. No other response of any kind was received.

IV. GMI FOLLOW-UP

Several firms declined to submit a questionnaire on the grounds that too much of the requested information was not available. Some firms taking this approach may have really believed that they had a material suitable for consideration, although in many cases this answer may have been merely a hedge against admission that no materials were available which could possibly meet minimum requirements. Form Letter No. 2 (Appendix F) was prepared for use in following up this type of response. Its principal purpose was to offer possibility of consideration--in case there were not sufficient attractive materials on which complete data were available. No responses were received in instances where this follow-up was used.

V. ALTERNATE SURVEY

Other possibilities for improvement of survey responses suggested themselves. A small-scale survey could have been made by contacting some firms which had not responded--in an effort to determine the reason. An obvious difficulty would have been in making contact with the particular person within a given organization who, by conscious decision or inaction, had been responsible for the lack of response to the original inquiry. It was decided to conduct two small-scale surveys by contacting firms different from those included in the original mass mailing. Responses were then to be evaluated. If one of these alternate approaches had achieved a worthwhile response, all firms who had failed to respond to other approaches could have been recontacted in the manner that proved most effective. The approaches were

- 1) Advised by double postcard (one half self-addressed and provided to facilitate response), that GMI (as contractor for the Air Force) was conducting a survey on the subject of potential balloon materials meeting certain minimum requirements which were set forth. Firms were asked to indicate whether they produce a material meeting the stated minimums. They were advised that an affirmative response would cause them to be supplied with detailed information and a questionnaire. The Survey Package would then be mailed to a designated recipient of the responding firm. Having acknowledged existence of a potential candidate material, he would then feel some obligation to complete the questionnaire.
- 2) Submitted a streamlined Survey Package consisting of a 1-page letter (in lieu of the original 3-page letter, 3-page explanation of program, and 4-page properties of presently used materials) and a simplified questionnaire which sought data on the same characteristics, but designated neither test method nor desired units for reporting data. The letter advised that more complete information was available on request (this to consist of the 3 June 1964 cover letter--modified to meet the new situation--along with the original "GMI Assignment" and "Properties of Presently Used Materials" from the first Survey Package). Upon receipt of questionnaires returned under this approach, an attempt was to be made to evaluate and compare the various materials. Should more appear promising than could be included in the test phase, suppliers could be frankly advised of the need for data on certain characteristics. By that time we expected to be in a position to offer to perform certain tests for the suppliers on a purchase-order basis, should they care to avail themselves of this service.

These two small-scale surveys had the disadvantage of not covering the most promising firms included in the initial mailing. They were intended, however, to answer these questions:

- 1) Did our request for a reply at the close of the original letter of 3 June get lost in the mass of information presented? This would appear to have been the case if the response to either or both the alternates suggested above was good.
- 2) Were firms simply reluctant to say they didn't have anything suitable? This would appear to have been the case if the response was low on the double postcard approach. In that case there was no mass of material to "swamp" the recipient, and no possibility that our desire for a response could go unnoticed.
- 3) Were firms reluctant to complete a questionnaire which is at all comprehensive? This would be apparent if firms indicating suitable products on the postcard survey failed to return completed questionnaires when supplied with proper forms.

- 4) Had we scared out our contacts by specifying test methods and reporting units in the initial questionnaire? This would seem to be the case if the response on the streamlined questionnaire had been appreciably better than that on the detailed survey.

The distribution was drawn from Thomas Register; we selected the larger firms. Twenty-seven firms were selected from the Plastic Sheeting category, 14 from Plastic Film, Flexible, and 42 from Plastics, Transparent. From the total of 83, every other one was sent the double postcard, and the alternates received the streamlined survey package.

A list of the firms contacted by these two approaches (together with their responses and copies of the materials distributed in carrying out these approaches) make up Appendices G, H, I, and J. Results of the alternate surveys indicate:

- 1) Neither of these more streamlined forms of contact produced a drastically higher percentage of returns than the original Survey Package. The pre-follow-up response on the original survey was 85/333, while the postcard produced 12/41, and the streamlined Survey Package 6/42.
- 2) Since the combined rate of return (18/83) was not quite as high on the alternate surveys, it is unlikely that the voluminous nature of the original Survey Package was primarily responsible for the small number of returns therefrom. (It has been speculated that some might have given up on the Survey Package before coming to the self-addressed return envelope and the request that the questionnaire be returned, even if the firm had no suitable products to report.)
- 3) Small return, even on the simple postcard approach where the desire for return could not be overlooked, may be taken as evidence in support of a theory that many firms do not desire to go on record as having no suitable products even when such is obviously the case. There may be a fear of appearing on a list of firms with no suitable products, and that this could somehow damage their competitive position.
- 4) Carrying this thinking from negative to positive, it should be noted that of the twelve postcard responses, only two indicated the existence of potentially suitable products and requested questionnaires. One could then assume that most of the non-responders believed that they had no suitable products, since there could be no fear of appearing on a list of firms which claim to have suitable products. This reasoning can be extended to support a belief that those firms which did not respond to the original Survey Package or to the Air Force follow-up probably have no suitable products.

VI. SUMMARY OF SURVEY RESPONSE

Responses may be categorized as follows:

- 1) Negative.
- 2) Negative, literature included to illustrate type of business done.
- 3) Custom operator, might be able to produce to specification.
- 4) Decline to participate because lack data on product, as well as test equipment, funds to conduct tests, or both.
- 5) Literature forwarded with idea that we may find products suitable.
- 6) Sample forwarded with idea that we may find it suitable.
- 7) Sample and literature forwarded with idea that we may find suitable. Sketchy questionnaire included in some cases.
- 8) Positive, sample and questionnaire fairly complete.
- M) Miscellaneous--send survey forms, will forward samples and data soon, etc.

(Table 1 summarizes the survey returns)

VII. INFORMATION RECEIVED FROM SURVEY

Data obtained as a result of the survey are presented in Table 2. Since data were received on a fairly limited number of materials, it has been possible to include virtually all those on which a reasonable amount of information was submitted. These consist of:

Polycarbonates

Lexan - General Electric Company, Chemical Materials Department
Celanex - Celanese Plastics Company, Division of Celanese Corporation of America.

Polyamides

Fosta Stabilized Nylon XN622 - Foster Grant Company, Inc.
RILSAN - (Nylon 11) - May Industries
Capran - Allied Chemical, General Chemical Division

Polyethylenes

Data Sheets 1359, 1360, 1362 (1, 2, and 1-1/2 mil)
1971 (E-263-43A)
1972 (E-263-43B)
1973 (E-263-43C)
EO-59-32

} VisQueen Film
Division, Ethyl
Corporation

Polypropylenes

Y Film - W. R. Grace & Co., CyroVac Division
Dow Oriented Polypropylene QX-4265.2 - The Dow Chemical Company

Polyesters

Kodak - Eastman Chemical Products, Inc., Subsidiary of Eastman Kodak
Company
Scotchpak Brand Polyester Film - 3M Company, Film Division Laboratory

Miscellaneous

Seilon UR-29E (polyurethane) - Plastics Division, Seiberling Rubber
Company
Tedlar (polyvinyl fluoride) - E. I. duPont deNemours & Company, Film
Department
Teflon FEF (fluorocarbon) - E. I. duPont deNemours & Company, Film
Department
Scotchpak Brand Heat Sealable Polyester Film (Exp. Film 50441L84
reinforced) - 3M Company, Film Division Laboratory

Of these only the Dow polypropylene, the 3M reinforced heat sealable polyester film, and the Visking polyethylenes are experimental. We have departed slightly from contract instruction to group experimental and commercial materials separately. The Dow polypropylene is included with that of W. R. Grace & Company. The Visking polyethylenes are grouped naturally, being the only films of that type. The 3M product is included with miscellaneous duPont films rather than being made the object of an entirely separate sheet.

In addition to the materials included in Table 2, partially completed questionnaires were also received from the G. T. Schjeldahl Company covering their GT-12 Mylar reinforced with Dacron scrim, and GT-21 Mylar Bilam. Data on these products are not presented since they are the currently used materials for very heavy load carrying and superpressure balloons. As such, they together with Visking polyethylene, will be included in the test phase of the program, having been designated by the Contract Monitor as the materials to be tested under Item 5 of the Work Statement.

Table 1. Survey Summary

Description*	Mailed	Number	Total Responses										
			1	2	3	4	5	6	7	8	M		
"Survey Package", a 3-page letter, 3-page description of GMI program, 4-page discussion of presently-used materials, and 3-page questionnaire seeking data obtainable only by test methods, some of which are not common in the industry.	6/4/63	336	56	7	1	5	2	3	5	3	3	3	3
Air Force follow-up.	8/5/63 est.	260 approx.	20	4	0	1	3	1	3	0	21		
Double postcard, one side explaining program, and the return constituting a request for questionnaire by indicating the number of potentially suitable materials produced.	8/7/63	41	12	10									2
One-page letter and a single sheet (2 sides) questionnaire which eliminated most data requirements calling for unusual test equipment.	8/13/63	42	6	6									
Form letter distributed to firms that declined to complete original questionnaire because of cost and effort involved.	7/16/63	4	0										
Form letter distributing "Survey Package" to those firms responding to the Air Force follow-up saying they did not have a questionnaire.	9/15/63	15	6	0	1	1	2	0	1	0	0		
Composite, corrected for duplication.	-	419	98	11	2	7	7	4	9	3	15		

*A copy of each of these documents may be found in the appendix.

Table 2. Physical Properties of Plastic Films

Vendor (1)* Identification	Type	Thickness (Data Basis) (mil)	Cold Brittle Temperature (°C)
1. Celanese Plastic Co. Celanex	Polycarbonate	3	<-137 (3a)
2. General Electric Co., Chem. & Metallurgical Div. Lexan Type 900	Polycarbonate	1-12	<-100 (4)
3. Foster Grant Co., Inc. Fosta Nylon XN662	Polyamide	3	<-68 (5)
4. May Industries, Inc. RILSAN (Nylon 11)	Polyamide	-	<-46
5. Allied Chemical Corp. Capran	Polyamide	1	-73
6. 3M Company Scotchpak	Polyester	1	-62 (use)
7. Eastman Chemical Products, Inc. Kodar	Polyester	1	<-68
8. Seiberling Rubber Co. Seilon UR-29E	Polyurethane	-	<-73.3 (3b)
9. E. I. duPont deNemours & Co., Inc., Film Department Teflon FEP	Fluorocarbon	-	-254
10. E. I. duPont deNemours & Co., Inc. - Tedlar	Polyvinyl fluoride	-	low (6)
11. W. R. Grace & Co., Cryo-Vac. Div. Y Film	Polypropylene	-	variable
12. The Dow Chemical Co. QX-4265. 2	Biaxially oriented polypropylene	-	(7)
13. VisQueen Film Div. Ethyl Corporation 1971(E-263-43A)	Polyethylene ?	1	<-68
14. VisQueen Film Div. 1972(E-263-43B)	Polyethylene ?	0.9	<-68
15. VisQueen Film Div. 1973(E-263-43C)	Polyethylene ?	0.9	<-68
16. VisQueen Film Div. 1359	Polyethylene	1.1	<-68
17. VisQueen Film Div. EO-59-32	Polyethylene ?	0.8	<-74
18. 3M Company, Film Div. Exp. 50441 L84	Heat sealable polyester (scrim reinforced)	-	-
19. VisQueen Film Div. Ethyl Corporation Polyethylene (Balloon Grade)	Polyethylene (Union Carbide) (DFD 5500 resin)	2	<-68
20. E. I. duPont deNemours & Co. Film Department Mylar	Polyester	-	-62 (8)
21. G. T. Schjeldahl Co. GT 12	Mylar + Dacron scrim	1/2 + 12 x 4 220 denier Dacron leno	-196

* See pages 19 and 20 for numbered notes

Table 2. Physical Properties of Plastic Films (Continued)

	Ultimate Strength (psi)		Tensile Properties		Elongation (Ultimate) (%)	
	MD	TD	Yield Strength (psi)		MD	TD
			MD	TD		
1. Celanese Polycarbonate	10,500	10,500	8,000	8,000	110 (9a)	110
2. General Electric Polycarbonate	10,200	10,500	8,500	8,200	120 100 (10)	120 100 (10)
3. Foster Grant Polyamide	9,710	10,800	5,510	5,720 (11) 2,840 (12)	370 (9b) 14 (10)	350 15 (10)
4. May Polyamide	10,000 (13)		4,300 (13)		250-400 (13) 10 elastic	
5. Allied Chemical Polyamide	6,700	5,800	4,400	4,300	310 (9c)	290
6. 3M Polyester	26,000	26,000	15,200	15,200	110 5 (10)	110 5 (10)
7. Eastman Polyester	17,000	17,000	10,000	10,000	45	45
8. Seiberling Polyurethane	5,000 (13)				410 (13)	
9. duPont Fluorocarbon	3,000 (13)		1,700 @ 3%		300 (9a+13)	
10. duPont polyvinyl fluoride	7-18,000 (13)		4,900- 6,000 (13)		115-250 (9d, 13)	
11. W. R. Grace Polypropylene	21-28,000 (13)				45-85 (13)	
12. Dow Polypropylene	22,100	29,300			85	50 (9e)
13. VisQueen 1971 polyethylene	3,828	5,280			294	406
14. VisQueen 1972 polyethylene	4,409	6,512			220	393
15. VisQueen 1973 polyethylene	3,670	5,623			308	438
16. VisQueen 1359 polyethylene	3,221	3,656			406	672
17. VisQueen EO-59-32 Polyethylene	8,600- 10,500 (14)	11,400- 12,900		9,950	229- 207	149- 119
18. 3M Reinf. polyester	23 lb/inch	25 lb/inch				
19. VisQueen Polyethylene	3,293 (15)	3,432 (16)	(17)	(17)	691 (18)	764 (19)
20. duPont Mylar	17-25,000 (13, 20)		13,000 (13, 21)		70-130 (13, 20)	
21. Schjeldahl GT-12	40 lb/inch	30 lb/inch	30 lb/inch	20 lb/inch	-	-

Table 2. Physical Properties of Plastic Films (Continued)

	Tear Strength			
	Initiation		Propagation	
	MD	TD	MD	TD
1. Celanese Polycarbonate	1510 lb/inch (13, 22a, 23)		180 g (5 mil film) (13, 23, 24a)	
2. General Electric Polycarbonate	1150-1570 lb/inch (13, 22a)		10-16 g/mil (13, 24b)	
3. Foster Grant Polyamide	1290 lb (22b)	1320 lb (22b)		
4. May Polyamide	16.8-19.6 kg/mm ² (25)	15.4-19.1 kg/mm ² (25)	400-500 g/mil (13, 24c)	
5. Allied Chemical Polyamide	975 lb/inch (22c)	850 lb/inch (22c)	75 g/mil (24d)	50 g/mil (24d)
6. 3M Polyester	2.6 lb (22a)	2.6 lb (22a)	85 g (1 mil) (13, 23, 24e)	
7. Eastman Polyester	-	-	10 g (24b)	10 g (24b)
8. Seiberling Polyurethane	600 lb/inch (13, 22d)		380 pli. min (13, 26)	
9. duPont Fluorocarbon	600 lb/inch (13, 22d) 270 g/mil (13, 22d)		125 g/mil (13, 24a)	
10. duPont Polyvinyl fluoride	450-600 g/mil (13, 22e)		12-40 g/mil (13, 24c)	
11. W. R. Grace Polypropylene	-		1-2 g/mil (27) 8-12 g/mil (13, 24a)	
12. Dow Polypropylene	high		-	
13. VisQueen 1971 polyethylene	-		-	
14. VisQueen 1972 polyethylene	-		-	
15. VisQueen 1973 polyethylene	-		-	
16. VisQueen 1359 polyethylene	-		-	
17. VisQueen EO-59-32 Polyethylene	-		-	
18. 3M Reinf. polyester	-		-	
19. VisQueen Polyethylene			50-300 g (13, 28)	
20. duPont Mylar	-	-	15 g (1 mil) (29)	
21. Schjeldahl GT-12	-	-	68 lb (30)	69 lb (30)

Table 2. Physical Properties of Plastic Films (Continued)

	Toughness	Sealability		
		Heat	Thermoplastic	Liquid
1. Celanese Polycarbonate	400 g 1/2 mil (31a) 50% fail	Impulse & ultrasonic	-	Methyl alcohol Ethylene dichloride
2. General Electric Polycarbonate	-	Impulse & hot air 8,000 psi	-	Methylene chloride
3. Foster Grant Polyamide	0.87 lb (2-1/2 mil) (31b) or 1.88 ft lb	Impulse	-	Goodyear CPA-619A
4. May Polyamide	-	Impulse	-	Yes
5. Allied Chemical Polyamide	300 g/mil (32)	Impulse & dielectric	-	Phenol
6. 3M Polyester	-	No	Yes	-
7. Eastman Polyester	230 g (31b)	Impulse	-	-
8. Seiberling Polyurethane	-	Impulse or radiation	-	B. F. Goodrich 0165MB 109/0500 MB 112
9. duPont Fluorocarbon	2 kg-cm/mil (33)	Yes	-	-
10. duPont Polyvinyl fluoride	2.7-5.6 kg-cm/mil (33)	Dielectric, jet, impulse, band, hot wheel	Yes, if treated	-
11. W. R. Grace Polypropylene	-	Impulse or knife	-	-
12. Dow Polypropylene	270 g/26 inches (31c)	150-200 g/inch when coated	-	-
13. VisQueen 1971 polyethylene	41.1 millisec (34)	-	-	-
14. VisQueen 1972 polyethylene	40.3 millisec (34)	-	-	-
15. VisQueen 1973 polyethylene	40.2 millisec (34)	-	-	-
16. VisQueen 1359 polyethylene	39.5 millisec (34)	-	-	-
17. VisQueen EO-59-32 Polyethylene	47.1 millisec (34)	Impulse 6450 psi peel 5750 psi shear	-	-
18. 3M Reinf. polyester	-	375°, 40 psi 10 lb/inch peel 25 lb/inch shear	-	-
19. VisQueen Polyethylene	42.2 millisec (35)	70% material strength, peel	-	-
20. duPont Mylar	60 kg-cm (1 mil) (35)	No	100% material strength, shear	Benzyl alcohol (with heat)
21. Schjeldahl GT-12	-	No	30 lb/inch peel 40 lb/inch shear (37)	-

Table 2. Physical Properties of Plastic Films (Continued)

	Aging	Transparency	Weight (lb/ft ² -mil)	Specific Gravity (g/cc)
1. Celanese Polycarbonate	-	Good - 0.2 to 2.2 microns 90% to visible	0.00624	1.2
2. General Electric Polycarbonate	No problem except UV	(41)	0.00624	1.2
3. Foster Grant Polyamide	-	Vendor curve 200-900 millimicrons (41)	0.006	1.15
4. May Polyamide	-	(41)	0.0054	1.04
5. Allied Chemical Polyamide	-	(41)	0.006	1.15
6. 3M Polyester	No problem	-	0.0067 (23) 0.007	1.4
7. Eastman Polyester	Avoid high temperature & low humidity	-	0.00635	1.22
8. Seiberling Polyurethane	-	-	0.0065	1.25
9. duPont Fluorocarbon	No problem	-	0.0112	2.15
10. duPont Polyvinyl fluoride	Excellent	~90% from 0.4- 15 microns ex- cept 40% 6.1 to 12.5 microns	0.008	1.38 to 1.57
11. W. R. Grace Polypropylene	-	1.2% haze	0.00472	0.9
12. Dow Polypropylene	-	83-88 Scatter- master (42)	-	-
13. VisQueen 1971 polyethylene	-	-	0.00478	0.921
14. VisQueen 1972 polyethylene	-	-	0.00478	0.921
15. VisQueen 1973 polyethylene	-	-	0.00477	0.918
16. VisQueen 1359 polyethylene	-	-	0.00476	0.916
17. VisQueen EO-59-32 Polyethylene	-	-	-	-
18. 3M Reinf. polyester	Avoid high temperature	-	0.015 as is	-
19. VisQueen Polyethylene	Avoid high temperature storage (43)	Very good (44)	0.00485	0.935
20. duPont Mylar	Avoid high temperature storage (45)	Good (46)	0.00725	1.39
21. Schjeldahl GT-12	No problem	-	0.00974 as is	-

Table 2. Physical Properties of Plastic Films (Continued)

	Availability Experimental (E) Commercial (C)	Thickness (mil)		Width (inches)		Tolerances	
		Min.	Max.	Min.	Max.	Thickness	Width
1. Celanese Polycarbonate	C	1 plan less	187 plan 250		34 plan 60	±10%	±1/16 inch
2. General Electric Polycarbonate	C	0.5	12 plan 15		33 plan 56	±10%	±1/2 inch
3. Foster Grant Polyamide	C (?)	1	5		54 plan 56	±0.2 mil	±1/16 inch
4. May Polyamide	C tube C sheet	2 1	5.9 39.4	1.18 19.7	25.6 27.5	- -	- -
5. Allied Chemical Polyamide	C	1 (38)	10		36 (39)		
6. 3M Polyester	C sheet	0.5 plan 0.25	3.0 plan 5.0	0.5	55 plan 108	±10%	±1/16 inch
7. Eastman Polyester	C sheet	0.5 plan 0.25	3.0		54	±1/10 mil	±1/32 inch
8. Seiberling Polyurethane	C	5	60		52	±10%	
9. duPont Fluorocarbon	C	0.5	20				
10. duPont Polyvinyl fluoride	C	0.5	2		72		
11. W. R. Grace Polypropylene	C	0.3	0.75		48		
12. Dow Polypropylene	Being sampled						
13. VisQueen 1971 polyethylene	E						
14. VisQueen 1972 polyethylene	E						
15. VisQueen 1973 polyethylene	E						
16. VisQueen 1359 polyethylene	E tube				54	+0.2 -0.1	
17. VisQueen EO-59-32 Polyethylene	E						
18. 3M Reinf. polyester	E						
19. VisQueen Polyethylene	C	0.5	3.0		72 center fold	±0.3 mil	±0.5
20. duPont Mylar	C	0.15	10	0.5	80	+0.22 (40) -0.24	±1/16 inch
21. Schjeldahl GT-12	C	0.15	0.5		60 plan 84	-	-

Table 2. Physical Properties of Plastic Films (Continued)

	Samples	Cost (\$/lb)	Comments	Data Source Proprietary Data (P) Questionnaire (Q) Vendor Literature (VL)
1. Celanese Polycarbonate	No	1.60-1.80 1 mil	Excellent cold flex claimed in questionnaire, yet failed 370 folds D643-43 (23)	Q except as noted
2. General Electric Polycarbonate	Yes	1.70-2.15		Q
3. Foster Grant Polyamide	Yes	2.10	Creepocity 20.9% @ 1420 psi	Q
4. May Polyamide	No		Survived 850,000 transverse folds & 10 ⁶ longitudinal ASTM Q-0 3,001	VL
5. Allied Chemical Polyamide	No (47)	1.85-4.00 1/4 mil	Survived 100,000 folds ASTM D643 (MIT)	VL
6. 3M Polyester	Yes	1.80 1 mil		Q except as noted VL
7. Eastman Polyester	No	2.30 - 1/2 mil 1.55 - 3 mil		Q
8. Seiberling Polyurethane	No	2.00		VL
9. duPont Fluorocarbon	No	10.00-15.00		VL
10. duPont Polyvinyl fluoride	No (47)	4.50-5.00		VL
11. W. R. Grace Polypropylene	Yes	0.70	Excellent cold temperature flexibility claimed	VL
12. Dow Polypropylene	No	-		Correspondence 10/21/63 & 2/20/64
13. VisQueen 1971 polyethylene	Yes		Extra low melt index; would be difficult to run on production equipment	P
14. VisQueen 1972 polyethylene	Yes		Extra low melt index; would be difficult to run on production equipment	P
15. VisQueen 1973 polyethylene	Yes		Extra low melt index; would be difficult to run on production equipment	P
16. VisQueen 1359 polyethylene	Yes		Run on production equipment; may be good at lower temperature	P
17. VisQueen EO-59-32 Polyethylene	No			General Mills Mechanical Div. Report No. 1917*
18. 3M Reinf. polyester	Yes		8 x 4 nylon leno scrim, Geon stabilized, reinforcement	Q
19. VisQueen Polyethylene	Yes	0.73		General Mills test data
20. duPont Mylar	Yes	1.80 1 mil	Data based on single ply Mylar rather than 2 ply laminate actually used in superpressure balloons	VL except as noted
21. Schjeldahl GT-12	Yes	\$.69/yd ²		Q

Table 2. Physical Properties of Plastic Films (Continued)

NOTES:

1. Vendor identification and type are set out fully on the first page of the table, while on succeeding pages this information is limited to a minimum needed for identification.
2. Test methods, ASTM unless otherwise noted, are included in these notes when identified by vendor in literature or questionnaire.
3.
 - a. D746-57T
 - b. D746
4. D1790-60T.
5. Proprietary.
6. Known to be low by author.
7. Outstanding low temperature strength claimed.
8. Vendor claims flexible to indicated temperature; however, film known to be useful at cryogenic temperatures.
9.
 - a. D882-61T
 - b. D882-56T, 2 inches/min
 - c. D882
 - d. D882A, 100% elongation/min
 - e. D882-56T
10. Yield.
11. 10 inches/min.
12. 0.1 inch/min.
13. No indication as to whether data apply to machine, transverse, or both directions.
14. First value @ 0.95 inch/inch/sec and second value for 0.017 inch/inch/sec.
15. Balloon Barrier Materials, GMI Report no. 1904, p. 25, average, ASTM D882-54T Method C except 13,200 psi/min.
16. Balloon Barrier Materials, GMI Report no. 1904, p. 30, average.
17. No lower yield point at room temperature; Balloon Barrier Materials, GMI Report no. 1525, p. 27, Table II.
18. Balloon Barrier Materials, GMI Report no. 1904, p. 34, average.
19. Balloon Barrier Materials, GMI Report no. 1904, p. 39, average.
20. Instron.
21. Litton test.
22.
 - a. D1004-61 Graves
 - b. D1004-49T Graves
 - c. D1004 Graves
 - d. D624 Graves
 - e. D1004-59T Graves
 - f. Graves
23. Vendor Literature
24.
 - a. D689-44 Elmendorf
 - b. D1922-61T Elmendorf
 - c. Elmendorf
 - d. D689 Elmendorf
 - e. Elmendorf TAPPI T-414
 - f. D1004-49T, Para 2(a), Elmendorf. Although this reference was used in the report from which data on this material were taken, the author of the present report is not aware that an Elmendorf test has ever been included in the D1004 classification.
25. D638-54T (D638-60T makes no reference to tear testing).
26. FED SPEC FTMS 601 M-4221.
27. This inconsistent value found in other literature by vendor.
28. High-Altitude Platform Study, Interim Report, GMI Study of a High-Altitude Airship, p. 4-11.
29. Cellophane tester.
30. 1/4-inch hook in 3-inch slot, 8-1/2 x 11 inch sample strained 50 inches/min.
31.
 - a. D1709-62T
 - b. D1709-59T
 - c. Dart

Table 2. Physical Properties of Plastic Films (Continued)

32. D1248.
33. duPont pneumatic.
34. Modified duPont falling ball (MIL-P-4640).
35. Balloon Barrier Materials, GMI Report no. 1904, p. 19, average; or 37 inch-lb, p. 53, modified duPont falling ball tester.
36. Falling ball, typical.
37. 2 inches/inch/min.
38. Literature indicates 1 mil but available to 1/4 mil, with which Litton has been sampled.
39. Literature indicates 36 inch but available to 54 inch, with which Litton has been sampled.
40. Balloon Barrier Materials, GMI Report no. 1911, p. 34 (1 mil).
41. Litton has checked this material on Beckman Spectrophotometer (IR 4) on another program and has recorded information on transparency.
42. D1746-60T.
43. Balloon Barrier Materials, GMI Report no. 1837, p. 41.
44. Balloon Barrier Materials, GMI Report no. 1525, p. 45, Figure 16, and pp. 49-52.
45. Contractor experience on Project Mercury.
46. Balloon Barrier Materials, GMI Report no. 1525, p. 105, Figure 33.
47. Litton generally has some stock of this material.

REFERENCES**

Report	
1525	General Mills, Inc., Mechanical Division. Balloon barrier materials, by A. A. Anderson, Jr., et al. Final Report covering April 1955-March 1956. Contract AF 19(604)-1393. AF-CRC-TR-56-262. (April 10, 1956).
1837	----. Balloon barrier materials, by A. A. Anderson, Jr., and G. L. Morfitt. Final Report covering March 1957-March 1958. Contract AF 19(604)-1393. AF-CRC-TR-58-211. (April 14, 1958).
1904	----. Balloon barrier materials, by G. L. Morfitt. Quart. Techn. Report covering April 15 to July 14, 1959. Contract AF 19(604)-3876. AF-CRC-TN-59-456. (July 14, 1959).
1911	----. Balloon barrier materials, by G. L. Morfitt and C. B. Peterson. Quart. Techn. Report covering July 15 to October 31, 1959. Contract AF 19(604)-3876. AF-CRC-TN-59-667. (October 31, 1959).
1917	----. Evaluation of new plastic films for Skyhook program, by G. L. Morfitt. Techn. Note, December 31, 1959. Contract Nonr 1589(04). (January 4, 1960).
High Altitude Platform Study	Raytheon Company. Missile Systems Division. Interim Report: Study of a High-Altitude Airship, by General Mills, Inc. Contract DA-19-020-ORD-4944. BR-867. (March 1, 1960). <u>Confidential</u> .

** Information on these reports can be secured through the Applied Science Division, Litton Systems, Inc., 2295 Walnut Street, St. Paul, Minnesota 55113.

The Schjeldahl Company also submitted a partially completed questionnaire on X-154, a laminate of Mylar and Dacron cloth weighing 3 oz/yd². This was not included since, in the opinion of the Contract Monitor and the Contractor, its properties were not well adapted to any of the three types of balloons for which new materials are being evaluated.

The Facile Division, Sun Chemical Corporation, submitted individual samples of a number of materials. Most of these are not pertinent to the applications under consideration, since they employ a layer of aluminum foil in their makeup. One, Dacron scrim reinforced polyethylene (W. G. 22), was considered by the Contract Monitor to be too low in strength-to-weight ratio and too costly to warrant further consideration. Two of the Facile materials (essentially direct copies of presently used Schjeldahl products) warrant inclusion in the test phase of this program since satisfactory performance could open the way for competition in the areas of superpressure and very heavy payload balloons.

Information presented on two materials in Table 2 did not result from the survey conducted under this contract: Allied Chemical's Capran and Visking's EO-59-32. Allied Chemical did not respond to the Survey Package -- much to the surprise of their regional representative who contacts us frequently and provides us with current data on their products. The Visking material had been provided in sample form several years ago, and was tested along with several others. Despite some indications that it might become a production item, this has not come to pass thus far. Of the experimental materials evaluated over the course of years by our materials group under Litton (and its predecessor General Mills) this is considered one of the most promising for balloon applications.

With exception of products by 3M Company, G. T. Schjeldahl Company, and Facile, it is noteworthy that no mention has been made of scrim or cloth-reinforced film laminates. Sea-Space System, Inc., is understood to have an interesting product of this nature, but has been reluctant to submit data or samples. The Contract Monitor desires that this material be included in the test phase -- provided this company will provide samples.

Uni-Search Engineering Corporation also indicated intent to submit samples of Mylar/Nylon laminates, but these have not been received. A number of other laminators are known to have such capability, including Riegel Paper Corporation, Arvey Corporation, Chase-Foster, Schjeldahl, Facile and Rap Industries--to name but a few. A number of the laminators advised that they do custom specialty work and would be interested in producing to a given specification, but have no standard product meeting needs for balloon application. This position is considered realistic. We believe that development of a superior laminate for balloon use could be accomplished by a funded team effort involving balloon flying, fabricating, and laminating activities, and perhaps even a weaver and film producer.

It is interesting to note that no extruder of polyethylene (other than Visking) responded with data or samples and only Kordite mentioned having a polyethylene. Not many years ago several of the polyethylene producers (including duPont, Spencer, Koppers, and perhaps others) gave serious consideration to an attempt to compete for the balloon film market.

None of the laminators saw fit to suggest composites employing two or more different films. The 3M heat sealable polyester (the original Scotchpak) has been used for various balloon applications over the years, without any great success (so far as is known to the writer). Other programs conducted at Litton have caused us to become familiar with a combination of polyethylene and Capran. It appears to offer the heat sealable features of polyethylene with an improved strength/weight ratio and greater abrasion resistance attributable to the Capran. A number of firms have submitted samples for consideration on another program. It is not presently known whether adhesive or extrusion lamination will be found to be the optimum method of combination--if the former is optimal, the question remains as to which adhesive will prove superior.

A number of samples, identified only by type numbers, were submitted by Griffolyn Company, Inc. These materials were of the type well known by all firms active in balloon fabrication. They employ two layers of film bonded

by a permanently "tacky" adhesive and encasing the characteristic non-woven fiber deployment at 45° angles to the two principal directions of the material. It has been our experience that this combination of tacky adhesive and bias orientation of fibers makes it impossible to obtain high seal strength, particularly on slowly applied or dead loads. The tacky adhesive requires use of two layers of film in order to have a handleable product. This tends toward a lower strength/weight ratio than desirable for this type product. For these reasons, further consideration of this family of materials is not recommended under the present program.

Some information was received on two additional films that have neither been included in Table 2 nor are recommended for the test phase of the program. Aquafilm Corporation forwarded literature on S-Aquafilm (potato starch) and M-Aquafilm (Dow Chemical methyl cellulose), both water soluble. These proved unqualified for further consideration because of low tensile strength, 2280 and 1710 psi, respectively. American Durafilm Company, Inc., submitted a small sample of their PYRE ML film with sketchy questionnaire information, claiming: "OK" for cold brittleness, "?" for tear strength and sealability by liquid adhesive, "Good" for cold flex and absorption of solar radiation, and "No" for sealability by heat and thermoplastic adhesive. They stated that, "Properties should be very similar to H Film--(duPont)." Since a duPont representative has likened H Film to Mylar, except in its ability to retain strength despite exposure to high temperatures and, since we have considered it an exotic and expensive material, it did not appear that PYRE ML warranted further consideration for routine balloon applications.

VIII. SELECTION OF MATERIALS FOR TEST PHASE OF THIS PROGRAM

A. Philosophy

It is possible to approach the selection of materials for the test phase of the program from a number of different points of view, each capable of some reasonable defense:

- 1) Evaluate selected commercial materials thoroughly in comparison with one another and the presently used materials. By testing all materials under the same conditions, it would be possible to assure all vendors that their products had received fair consideration, silencing any criticism as to possible closed-mindedness in favor of presently used materials. Whether the Air Force is subject to any such clamor and, if so, to an extent which would justify such an approach is not known. As a fabricator, we do experience this kind of response from vendors. It is obvious from the response to the survey, however, that those individuals who handled the responses, or failed to respond, did not seize upon this situation as a golden opportunity to obtain the consideration for their material which their representatives always maintained was warranted.
- 2) Assume that commercially available materials have been individually evaluated by balloon fabricators and found unsuited to replace any of the current standards. Concentrate test effort on experimental materials, even though they may not appear any more promising (on paper) than other better known materials.
- 3) Favor selection of materials submitted by particularly cooperative firms, interpreting their cooperation in the survey as interest which might carry through to willingness to attempt modification in materials that may test well on all but one or two characteristics.
- 4) Attempt to include as many types of materials in the tests as possible, choosing one of each type which appears (on the basis of the reported data) to be superior.
- 5) Attempt to restrict the types tested to those which, on the basis of the survey, have real merit. Utilize the test program as a means of determining which of the various vendors of a given type produces the superior product for balloon applications.
- 6) Eliminate from consideration the extremely high-cost materials, without regard to their apparent technical merit or the fact that a portion of the high cost may be offset through use of production methods less expensive than those required for some presently used materials.

B. Recommendations

A number of vendors did not submit complete data on their products. Since the missing data are frequently in the area of cold brittleness and ability to withstand cold flexing without damage (characteristics on which

poor showing could be considered disqualifying), it is recommended that the test phase effort not be limited (initially) to ten materials plus the three present standards. It is, rather, suggested that a number of alternates be designated. These could be brought into the program in the event the selected materials are disqualified. Where the choice between the selected materials is close, relative performance on a screening test (such as cold brittleness) could actually be the basis for final choice on inclusion in the test program. It is anticipated that the cold brittleness test selected for use on the program will offer a rapid, inexpensive means of screening.

We believe that the ability of a material to be sealed in such a manner as to retain a high percentage of its other desirable properties will prove one of the most important practical means of distinguishing between a useful material and a disappointment. Unfortunately, it is not feasible to provide a fair test on this point. This statement can be appreciated when one considers the tremendous expenditure of time and money which has been devoted over the years to improvement in methods of sealing polyethylene and Mylar. In the case of Mylar, a material with many desirable properties, forced development of a suitable sealing technique. Unfortunately, even a seal which performs well under test conditions is not necessarily suitable in actual use. However, development of sealing techniques and checking seals by other than laboratory testing are beyond the scope of this contract.

Recommendations, alternates, and some justifications for selection follow:

1. Polycarbonate

Celanex, with Lexan as alternate (Celanex offers a lower claimed cold brittle temperature and superior tear resistance).

2. Polyamide

Fosta Stabilized Nylon XN722, with RILSAN and Capran as alternates. Selection is influenced somewhat by the excellent interest shown by the Foster Grant Company. This interest, manifested by several long-distance telephone calls and considerable test effort in order to obtain data on as many characteristics as possible, was unexcelled by any firm contacted in the survey. RILSAN is designated as first alternate, since it appears to differ from Fosta more than does Capran. RILSAN has substantially better tear resistance by the same test method, is less dense, and is stronger. Unfortunately, RILSAN is not available in widths as great as would be desirable.

3. Polypropylene

Y Film, with QX-4265.2 as alternate (Y Film offers claimed advantages of good cold flexibility, impulse sealability, and is in production. QX-4265.2 lists a very low seal strength, even when especially treated).

4. Mylar Bilam

Facile Division, Sun Chemical Corporation #1137, with Arvey Corporation product as alternate. Neither of these products is included in the table because no data were submitted. The Facile product is selected because of its greater clarity and because it has appeared to meet the requirements applicable to GT-21 as used in superpressure balloons.

5. Mylar/Dacron Scrim

Facile #1147 is designated, as a copy of the Schjeldahl GT-12. This product is not described in the table as no data were submitted, although samples were provided.

6. Polyethylene/Capran Laminate

Vendor to be selected from such laminators as Arvey Corporation, Marathon Paper Company, the Dow Chemical Company, and Curwood, Inc., --depending on which submits the most acceptable sample by the time the test phase gets under way. The configuration proposed for test is 1/2 mil Capran and 1-1/2 mil polyethylene.

7-10. Polyethylenes (Experimental)

Four of the five Visking materials (1359, 1971, 1972, 1973, and EO-59-32). An inquiry has been directed to Visking to make sure that they would be willing to produce any one of these materials should it emerge as a desirable item following the test phase. The number of these materials included in the test program may be limited by the response obtained. If all remain candidates, some preliminary screening (including cold brittle investigation) will be required to eliminate one from consideration.

11. Polyvinyl Fluoride

Tedlar--it is recommended that this material be considered as a miscellaneous alternate material in the event that the total of ten is not achieved because some of the above materials are disqualified in the course of the cold brittle screening. Data available, except for price, are encouraging. Its heat sealability offers a chance to overcome at least part of the price drawback, when compared with lower-priced films which require adhesive assembly.

C. Exclusions

It will be noted that no polyester film has been included in the list of those recommended for testing. The Contract Monitor has not indicated interest in checking either of the films (on which data were submitted) against the performance of Mylar, the present standard. Data do not indicate superiority of either the 3M or Eastman products over that of duPont. A check on the claimed impulse sealability of Kodar should be made however

Polyurethane film, while reportedly possessing a low cold brittle temperature, has not been recommended for inclusion because its low modulus of elasticity permits too much elongation under load. The Seiberling material reported was not available in thicknesses below 5 mil, although there is at least one source of 1 mil film.

Should data and samples become available from Sea-Space, that material (Merfab) could be included at the expense of poly/Capran laminate, or one of the Visking polyethylenes.



ELECTRONICS DIVISION • GENERAL MILLS, INC.

2003 EAST HENNEPIN • MINNEAPOLIS 13, MINNESOTA • PHONE 781-6022 • TWX 612-321-1078

3 June 1963

To: Suppliers of Plastic Film
(unsupported, laminated, and supported)

Subject: Request for Product Information - Plastic Film

Reference: Contract No. AF 19(628)-2944

Gentlemen:

Referenced contract requires GMI to survey currently available plastic films (unsupported, laminated, and supported) and to conduct tests on the most promising. The goal of the program is to consider all available materials in comparison with presently used balloon materials, in order to determine whether materials exist which should replace those now in use for some or all purposes. Your cooperation, initially through providing data on properties of your candidate materials, could prove mutually beneficial.

The purposes of this letter are:

- 1) To enlist your participation
- 2) To introduce the attachments
- 3) To indicate action desired by your firm.

The first attachment is entitled "GMI Assignment". It consists in part of extracts from our contract. Details of testing to be conducted under Item 2 have been greatly abbreviated. Note particularly that the survey to which you are asked to contribute is limited under Item 1 to materials possessing certain minimum requirements. Attention to this limitation will permit initial screening of potential candidates in your product line.

The second attachment is entitled "Properties of Presently Used Materials". The government agency responsible for funding this program is particularly concerned with balloon operations involving three types of balloon vehicles: 1) the vented or "zero pressure" free balloon for high altitude use, 2) the super pressure balloon which does not undergo a volume change with change in temperature, hence floats for long periods at constant altitude, and 3) the special heavy load carrying "zero pressure" balloon. Excluded from the area of interest are: 1) weather balloons of extensible material which continue to rise until they burst, 2) tethered balloons, and 3) space inflatables. Based on our previous contacts with material suppliers, it is believed that many will not possess all the information requested in the survey. Since our contract does not

include funds for conducting tests to provide missing information during the survey phase, we hope to inspire you to supplement information available for your regular sales and technical service functions with additional laboratory effort directed at characteristics about which data is not available. By providing information on presently used materials, along with comments on their desirable features and their shortcomings, it is hoped that you will be able to get a realistic "feel" for the possibility that one of your materials may be able to supplant the current standard. This should offer some basis for your decision as to whether to make the effort needed to obtain additional data and to convert all data to the desired standard units.

The third attachment is the survey questionnaire. It is considered essentially self-explanatory. For objective comparison, quantitative data is desired insofar as possible. Should you have several candidate materials, it is suggested that you report on all of them, rather than attempting to make your own determination as to which is most suitable. It is difficult to define the relative importance of various characteristics so as to provide any scale by which the materials can be rated in an over-all sense.

Action desired:

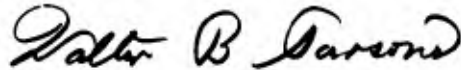
- 1) Complete survey questionnaire on each of your materials which meets the stated minimum qualifications for its type. Additional copies of the survey form may be obtained from the undersigned if required.
 - a) Perform any tests necessary to supply data not previously available.
 - b) Convert data to standard units for comparison, minimizing chance for inaccuracy through misinterpretation.
 - c) Return forms to GMI along with samples of material required for inclusion in our report covering this phase. Twenty pieces 8-1/2 x 11 inches will suffice.
- 2) Indicate willingness to supply approximately 15 sq yd of each material needed for the test phase in the event your material(s) qualify in the top ten. This sample should not be submitted at this time.
- 3) Indicate whether it will be possible for you to submit sample seals for testing, in the event your material qualifies for that phase of the program. Seals are a very important portion of the evaluation, and in fairness to each material it is considered desirable that seals be made by experts thoroughly familiar with the material in question.

In view of the short time allotted for the survey phase of the program, return of the completed questionnaires is desired within two weeks following receipt of this letter. To avoid uncertainty, we would appreciate hearing from you even if you do not submit data on any candidate materials. In order to broaden the base of this inquiry to include all materials worthy of consideration it will be especially appreciated if you could refer us to any remote or obscure supplier who may not have been reached by this inquiry.

Thank you for your assistance.

Very truly yours,

Aerospace Research Department

A handwritten signature in cursive script that reads "Walter B. Parsons".

Walter B. Parsons

Enc.

GMI ASSIGNMENT

Item 1

Conduct a survey of currently available plastic films, both experimental and commercially available. This survey shall include unsupported films (e. g. , polyethylene, Mylar, etc.), laminates (e. g. , Scotchpak, etc.) and supported films (e. g. , Mylar-dacron scrim laminates, etc.). Further, this survey shall be concerned only with films having the following properties:

- | | |
|---|--|
| 1) Cold brittleness temperature | not higher than -68°C |
| 2) Machine direction tensile strength (unsupported films and laminates) | greater than 2000 psi at +20°C |
| 3) Machine direction tensile strength (supported films) | greater than ten (10) pounds per inch of specimen width at +20°C |
| 4) Weight per unit area (supported films) | not greater than 3 oz/sq yd |

This survey shall obtain the following information for those films meeting the above criteria:

- 1) Cold brittleness temperature
- 2) Ultimate strength and ultimate elongation (machine and transverse direction)
- 3) Yield strength and elongation at yield (machine and transverse direction)
- 4) Tear strength
- 5) Cold flex characteristics
- 6) Toughness
- 7) Heat sealability
- 8) Sealability with thermoplastic tape
- 9) Availability of compatible liquid adhesives
- 10) Seam strength (peel and shear)

GMI ASSIGNMENT (continued)

- 11) Aging characteristics (ground environment and high altitude environment)
- 12) Absorption in the 0.2 to 15 micron range
- 13) Creep characteristics under static loading
- 14) Weight
- 15) Construction of supported films
- 16) Available thicknesses and widths
- 17) Sources
- 18) Cost

Notes:

- 1) Test methods, temperatures, rates, etc. shall be specified.
- 2) Units for reporting purposes shall be standardized.

Item 2

Determine the following properties and characteristics for each of ten (10) films selected by the Contracting Officer on the basis of the survey conducted under Item 1.

- 1) Stress-strain curves - machine and transverse direction, +20 and -60°C, 0.2 and 20 inches/minute
- 2) Seam strength - preferably on seams prepared by material supplier, +20 and -60°C, at two loads
- 3) Creep, dead load - machine and transverse direction, +20 and -60°C, at two loads
- 4) Seam strength, dead load - +20 and -60°C, at two loads
- 5) Absorption of radiant energy - 0.2 to 15 microns
- 6) Toughness - as measured by duPont falling ball method

GMI ASSIGNMENT (continued)

- 7) Cold-flex - Gelbo-flexer conditioning for influence on delamination and permeability characteristics, -60°C
- 8) Delamination - at 1 millibar, $+20$ and -60°C , both fresh and cold-flexed specimens
- 9) Blocking - following storage under pressure at $+20$ and $+45^{\circ}\text{C}$, for two to three months, per ASTM 1893-61T
- 10) Modulus of elasticity - $+20$ and -60°C , per ASTM 882-61T
- 11) Cold brittleness - per ASTM 1790-60T, confirmed by MIL-P-4640A (USAF)
- 12) Tolerances - variation in weight per unit area, and in thickness.

PROPERTIES OF PRESENTLY USED MATERIALS

1. Vented Free Balloons

Polyethylene is universally used for this application. Most of this material is procured to MIL-P-4640A (USAF). Visking Corporation, Terre Haute, Indiana supplies the entire requirements of all balloon fabricators, although Chippewa Plastics, Chippewa Falls, Wisconsin is understood to have qualified a film under this specification.

Balloon polyethylene film is extruded from homogenized virgin resin, Bakelite DFD-5500-Natural, or equal.

Melt index < 1.1 grams per 10 minutes per ASTM D 1238-52T

Cold brittleness temperature not higher than -68° C

Toughness, crease, as measured by retardation of falling ball
unretarded interval - .03 seconds
minimum retarded interval - .0335 seconds for 2 mil film

Tensile strength and elongation per ASTM D 882-54T

<u>Minimum Average</u>	<u>Machine Direction</u>	<u>Transverse Direction</u>
Tensile strength, psi	2500	2000
Elongation, percent	250	400

Thickness tolerance - ±0.0003 inch

Width tolerance - ±1/2 inch for lay-flat tube widths greater than 30 inches

Color - natural

Workmanship - clear and free from excessive irregularities such as blemishes, striations, gel particles, pinholes, flow lines, fullness and blocking.

Desirable Features of Polyethylene

Low cost

Readily sealable to at least 70% material strength for fin seals prepared at speeds of 40 ft per min

Low density

Uniform high quality, low pinhole count

Yields to relieve any stress concentrations in fabricated product

Shortcomings of Polyethylene

Low strength for weight

Even lower cold brittle point would be desirable

PROPERTIES OF PRESENTLY USED MATERIALS (continued)

2. Super Pressure Balloons

Mylar is used exclusively for this application. This material, a duPont polyester film, is not covered by a military specification, at least so far as balloon usage is concerned. Data on its properties is provided through the attached reproduction of duPont sales literature. Recent employment of laminates embodying two or more layers of Mylar, bonded with an adhesive of high clarity and good cold temperature properties has apparently been responsible for marked reduction in porosity, enabling unballasted flights to survive for much extended durations. A super pressure balloon becomes pressurized at an altitude somewhat below that at which it floats. The pressure then fluctuates with change in temperature, but with a constant volume the float level remains essentially constant (even at sunset) eliminating requirement for ballast. The three most essential features of a perfect material are: 1) great strength-to-weight ratio to withstand pressure, 2) pinhole free, both as received and after handling associated with balloon fabrication and launch operation, and 3) low in absorption of radiant energy, so as to minimize superheat and attendant pressure build-up.

Desirable Features of Mylar

High in strength-to-weight ratio

Relatively low absorption of radiant energy

Shortcomings of Mylar

Prone to development of pinholes due to handling

Adhesive sealing process applicable to thin films is slow, expensive, and results in seals which though strong in shear are poor in peel

Very low in tear resistance

High cost, particularly in the laminated form

3. Heavy Load Carrying Vented Free Balloons

Material for these vehicles has been a special laminate by the G. T. Schjeldahl Company. The base fabric is a leno weave dacron scrim in a count approximately 12 x 4 which provides 6 x 4 openings per inch. Weight of this fabric is about .6 oz/sq yd. Mylar (generally 1/2 mil) is laminated to one side of the scrim by means of an adhesive which dries or sets without any troublesome residual tack. The composite commonly employed weighs less than 1-1/2 oz/sq yd.

There is ever increasing interest in carrying extremely heavy or valuable payloads on free balloons. A need exists for a material to be used in

TABLE II
GENERAL PHYSICAL PROPERTIES OF
"MYLAR" POLYESTER FILM

<u>Property</u>	<u>Value</u>	<u>Unit of Measure</u>	<u>Test Method</u>
Melting Point	250-255	°C	-
Density	1.39	gms./c.c.	Density Gradient Tube
Refractive Index	1.655	n _D 25	Abbe' Refractometer
Area Factor	20,000	sq.in./lb./mil	-
Tensile Strength	17,000-25,000	p.s.i.	Instron Tensile Tester
Tensile Modulus	450,000-600,000	p.s.i.	Instron Tensile Tester
Impact Strength	60 (1 mil)	Kg.-cm.	Falling Ball
Break Elongation	70-130 (1 mil)	%	Instron Tensile Tester
Tear Strength	15 (1 mil)	gms.	Cellophane Tear Tester
Flex Life, 0°F.	20,000 (1 mil)	cycles	Du Pont Yerkes Flex Tester
Bursting Strength	45 (1 mil)	lbs./sq.in.	Mullen
Bending Recovery (immediate)	43 (1 mil)	%	Recovery from 180° Bend
Bending Recovery (60 sec.)	51 (1 mil)	%	Recovery from 180° Bend
Thermal Coefficient of Linear Expansion	15 x 10 ⁻⁶	inches/inch/°F	70-120°F
Humidity Coefficient of Linear Expansion	11 x 10 ⁻⁶	inches/inch/% R.H.	20-92% R.H.
Coefficient of Thermal Conductivity	3.63 x 10 ⁻⁴	Cal/cm./sec/°C.	Cenco-Fitch Method
Oxygen Permeability	0.90 (1 mil)	g/100m ² /hr.	Modified General Foods Tester
Water-vapor Permeability, 39.5°C. 53 mm Hg. Vapor Pressure Difference	110 (1 mil)	g/100m ² /hr.	Du Pont Film Moisture Vapor Permeability Test
Moisture Absorption	Less than 0.5%	%	Water Immersion
Shrinkage (150°C.)	1.5-2	%	30 Minute Exposure
Fungus Resistance	Excellent	-	12 Months Soil Burial
Corrosive Effect on Copper	Negligible	-	-

NOTE: Data shown are average values and should not be used for specifications.

PROPERTIES OF PRESENTLY USED MATERIALS (continued)

balloons for such applications. As compared with polyethylene vehicles, these may be premium items because the applications are ones which either 1) because of the heavy load cannot be accomplished with polyethylene, or 2) involve payloads so delicate or expensive as to justify use of premium vehicles in order to obtain greater reliability. An annual production requirement of 200,000 sq yd per year is considered realistic.

An ideal material must be strong for its weight, high in tear resistance, low in absorption of radiant energy, relatively free of pinholes (though this is not as critical as with super pressure candidate materials), and capable of being sealed inexpensively in a manner that achieves a high percentage of material strength. Since for high altitude applications the balloon's own weight is very significant (often far greater than that of the load carried), a new material cannot hope to compete with the existing standard, even by incorporating the other desirable properties, if its weight per square yard is appreciably higher.

Desirable Features of Mylar/Dacron Scrim Laminate

High strength-to-weight ratio
Good tear resistance
Exists

Shortcomings of Mylar/Dacron Scrim Laminate

Sealable only by slow expensive adhesive process
Incorporates the pinhole difficulties associated with Mylar
Utilizes expensive components and a laminating process which also adds to cost
Absorbs more radiant energy, resulting in more superheat and ballast consumption than desirable.

SURVEY QUESTIONNAIRE (continued)

7. Heat

8. Thermoplastic adhesive

9. Liquid adhesive

Sealable (yes or no) _____ 10. Seal strength, lb/in-mil (unsupported), lb/in (supported) Peel _____ Shear _____ Strain rate, in/in-min _____ Test temperature, °C _____ Sealer or adhesive used _____ Temperature, pressure, dwell, etc. { _____ _____	_____ _____ _____ _____ _____ _____ _____ _____	_____ _____ _____ _____ _____ _____ _____ _____
--	--	--

11. Aging characteristics
 Do film properties change appreciably under normal storage conditions over a period of 1 yr _____, 3 yrs _____, 5 yrs _____? Which properties change? _____
 Storage conditions to be avoided _____

Any high altitude conditions (low pressure, low temperature, UV radiation, ozone concentration, etc.) likely to prove detrimental within 1 day _____, 1 week _____, 1 month _____?

12. Absorption of solar radiation (0.2 to 15 micron range)
 Submit plot of % transmission vs. wavelength as obtained from Beckman Spectrophotometers (models DK-2 and IR-4) or equal

13. Creep characteristics
 Submit strain vs. time curves (0-48 hr) for the following conditions
 (a) Constant load 50% of yield strength as determined by ASTM D 882-61 T
 (b) Temperatures, room and -60°C
 Creepocity _____% increase in strain per first 24 hrs (omit strain occurring in first minute after loading from calculations)

14. Weight of film _____ lb/sq ft

15. Construction of supported films and laminates

(a) Film
 Type (Mylar, etc.) _____
 Film thickness _____ mil Number of layers _____

(b) Supporting material Warp Fill

Yarn (nylon, etc.) _____
 Yarn type (high tenacity, etc.) _____
 Count (yarns/inch) _____
 Yarn denier _____
 Type weave (leno, etc.) _____
 Stabilizing material (Geon, etc.) _____
 Weight of supporting material _____ oz/sq yd

SURVEY QUESTIONNAIRE (continued)

(c) Composite

Means of combination - heat and pressure only _____,

Adhesive (identify) _____

Film applied - intact _____, or extrusion laminated _____

Weight of composite _____ oz/sq yd

16. Availability - Experimental _____ Production _____
Width - Present max. _____ in. Planned max. _____ in.
Thickness (mils) - Present max. _____ Planned max. _____ Present min _____
Planned min _____
Manufacturing tolerances - Thickness \pm _____ mil, Width \pm _____ in.
Form - Tube _____ or Sheet _____
17. Samples
Twenty pieces 8-1/2 x 11 are enclosed for report purposes _____.
Fifteen sq yd will be supplied on request for test comparison _____.
Seal samples will be supplied on request for test purposes _____.
18. Cost
Film \$ _____/lb for _____ mil (thinnest available)
\$ _____/lb for _____ mill (thickest available)
Supported film - \$ _____/sq yd

APPENDIX B

FIRMS SURVEYED WHICH ARE INCLUDED IN ALPHABETICAL
LIST TAKEN FROM MODERN PLASTICS ENCYCLOPEDIA

CATEGORIES FROM WHICH FIRMS
SURVEYED WERE SELECTED*

1. Biaxially-Oriented Film and Sheets
 2. Cast Film and Sheets
 3. Extruded or Calendered Sheets
 4. Extruded Film
 5. Film Laminates, Thermoplastic
 6. Coating of Component Parts
 7. Coating, Web
 8. Additional Firms Selected by Review of Entire Alphabetical List - Known to be Appropriate for Contact
- T Firms included in alphabetized Modern Plastics Encyclopedia list but selected on the basis of a spot check against categories of interest in Thomas Register.

On the pages which follow, an alphabetical list of firms contacted with the initial "Survey Package" is presented. Firms are coded to identify category (categories) from which they were selected. Responses are also coded in accordance with the following list, and the response is further described in a few words. Addition of the letters AF after the response code indicates that the response followed the Air Force follow-up letter, rather than the initial inquiry.

In cases where a second "Survey Package" was sent, the response is described directly below the original response.

Code for Response Categories

1. Negative.
2. Negative, literature included to illustrate type of business done.
3. Custom operator, might be able to produce to specification, but no standard product.

*Distribution based on Modern Plastics Encyclopedia, 1963 issue, Sep't. 1962.

4. Decline to participate because lack data on product, as well as test equipment, funds to conduct tests, or both.
5. Literature forwarded with idea that we may find products suitable.
6. Sample forwarded with idea that we may find it suitable.
7. Sample and literature forwarded with idea that we may find suitable. Sketchy questionnaire included in some cases.
8. Positive, sample and questionnaire, fairly complete.

Firms Surveyed Which Are Included in Alphabetical
List Taken from Modern Plastics Encyclopedia

<u>Cate- gory</u>	<u>Firm</u>	<u>Date</u>	<u>Code**</u>	<u>Response</u>	<u>Action</u>
3, 6, 7	Abutco Plastics Industries, Inc				
6	Acadia Plastics, Inc.				
3	Ace Plastics Company	8/8/63	1(AF)	Do not produce film.	
7	Acro Chemical Products Corp.				
7	Adock Manufacturing Corp.	6/24/63	1	Custom converters of plastic film.	
3	Allegheny Plastics, Inc.				
4	Allied Chemical Corp., General Chemical Div.				
6	Allied Engineering & Pro- duction Corp.				
3, 4	Alma Plastics Company				
2	Alsynite Division, Reichhold Chemicals, Inc.	8/19/63	2(AF)	No questionnaire, but liter- ature indicates rigid panel work only.	
3, 6	American Agile Co., The, Sub. Nalge Co., Inc.				
5, 7	American Combining Corp.				
2	American Cyanamid Co., Building Products Div.	8/7/63	1(AF)	Division does not make plas- tic films.	

b
1
3

See page B-1.
See page B-1.

Category	Firm	Date	Code	Response	Action
3, 6	American Durafilm Co.	7/5/63	6	PYRE ML film sample made from PYRE ML liquid. Claim proper- ties similar to duPont H film. Questionnaire with no data but with a few comments.	
5	American Erka Corp., Brand-Rex Div.	6/11/63	1	Do not make film.	
2	American Kleer-Vu Plastics, Inc., Div. Kleer-Vu Indus- tries, Inc.	6/24/63	2	Offer to bid on program to develop seals for promising materials. Literature on sealers included.	
6	American PreS-Stix Tape Co.	8/14/63	M(AF)	Did not receive questionnaire.	S. P. sent 9/5/63
4	American Pyroxylin Corp.				
6, 7	American Rubberizing Co.				
3, 4, 6	American Sisalkraft Co., Div. St. Regis Paper Co.	6/20/63	1	No suitable products.	
7	American Vinyl Corp.				
2	Amplast, Inc.				
3	Amplex Manufacturing Co.				
3	Applied Research & De- velopment Corp.				
6	Arhonite Corp.	6/24/63	1	Do vinyl coating.	
3	Argo Plastic Products Co.				
6	Arkon Products	6/14/63	1	PVC foam only.	
5	Arksafe Packaging Service, D.V. Arkel Safety Bag Co.				

S. P. Surety Package

Cate- gory	Firm	Date	Code**	Response	Action
5	Armen, Inc.	8/5/63	5	Data sheets on Arvak and Kuvar, chlorotrifluoroethylene with specific gravities of 2.13 and 2.1, respectively.	
5, 7	Arvey Corporation	8/7/63	5(AF)	Exotic materials--fluorocarbons. Duplicates response to GMI 8/5/63.	
3, 5, 7	Associated Rubber & Plastic Corporation	6/21/63	1	No products.	
3	Atlas Mineral Products Co.	6/18/63	1	Mainly rigid materials.	
2, 3, 4	Auburn Plastic Engineering				
3, 7	Auburn Plastics, Inc.	6/17/63	1	Not in scope of production ability.	
1, 3, 4	Avisun Corporation	7/1/63	1	Unsupported polypropylene does not even come close to meeting cold brittle requirement, hence no data submitted.	
6, 7	Babco, Inc.				
2, 3, 4, 5, 7	Barr Corporation, The				
5	Barrier Plastics, Co.				
6	Bel - Art Products				
6, 7	Biggs, Carl H., Co., Inc.				
2, 3, 5	Blank, Arthur & Co., Inc.				
2, 3, 4	Blum, Paul, Co.				
3, 5	Bolta Products Div., The General Tire & Rubber Co.				
7	BoMyte Co., The				
7	Bortman Plastics Co.				

Cate- gory	Firm	Date	Code**	Response	Action
6, 7	Bricmar Manufacturing Co.				
1, 2, 3, 4, 5, 6	Cadillac Plastic & Chemical Co.				
7	Cahill, J. D., Co.				
3, 4	Campo Plastics Co., Div. Chicago Molded Products Corp.	7/12/63		Unable to supply a film. satisfac- tory for application.	
4, 5	Canton Containers, Inc.				
6, 7	Carlson Products Corp.				
3	Carmar Industries, Inc.	8/14/63	M(AF)	Do not have questionnaire on file.	Sent S. P. 9/5/63
4	Carolina Industrial Plastics Div., Essex Wire Corp.	6/28/63	2	Extrude flexible and rigid PVC. Literature included.	
5	Carroll, J. B., Co.	6/19/63	1	Rigid plastic sheet.	
2	Cast Optics Corp.				
2 4	Celanese Plastics Co., Div. Celanese Corp. of America	?	M	Returned questionnaire with only tensile and tear data on Celanex Polycarbonate.	Sent stream- lined S. P. and special letter 9/3/63
5	Chase Bag Co.	9/27/63	7****	Forwarded literature on Celanex and more complete questionnaire.	
7	Chemical Coatings and Engin- eering Co.				
1, 3, 4	Chemore Corp.				
3, 4, 6	Chemplast, Inc.				

This code used in composite.

Cate- gory*	Firm	Date	Code**	Response	Action
2	Chemtron Fiber Glass Co.				
7	Chicago Price Tag Mfg. Co.				
2, 3, 4, 5, 7	Clopay Corp.				
7	Coating Products, Inc.	8/13/63	M(AF)	Did not receive questionnaire.	Sent S. P. 9/5/63
1, 2, 3, 4	Colonial Kolonite Co.	7/26/63	1	Distributors, not producers.	
3	Colonial Plastics Mfg. Co.	8/8/63	1(AF)	Pipe extruders, not film.	
1	Commercial Plastics Co.				
2, 3, 4	Commercial Plastics & Sup- ply Corp.	6/12/63		Not in position to quote.	
6	Conforming Matrix Corp.				
3	Conneaut Rubber & Plastics Co.	6/20/63	1	Extrude vinyl sheet.	
4	Consolidated Thermoplastics Co., C. T. Film Div., Turex Plant	6/28/63	4	Do not have equipment to test per specs referenced in ques- tionnaire. Requested market potential to justify procure- ment of test equipment.	Form letter no. 2 sent 7/16/63 re- questing par- tial question- naire and sales data
4	Continental Can Co., Inc.	6/25/63	4	Make films and laminates which <u>might possibly qualify</u> . Too much <u>physical test work</u> needed to com- plete questionnaire. Would sup- ply samples for our examination and test, if requested.	Form letter no. 2 sent 7/16/63
4	Continental Extrusion Corp.				
3	Contour Extrusion Co., Inc.				

Category	Firm	Date	Code	Response	Action
7	Cordo Chemical Corp.				
3	Corroplast, Inc., Sub. Lock Joint Pipe Co.				
3	Cortland Industries, Inc.				
1, 2, 3	Crystal-X Corp.				
3	Curry Arts Molding and Laminating Co.				
5, 7	Custom Coating & Laminating				
3	Custom Extruders, Inc.	8/8/63	1(AF)	Extruded vinyl profile shapes.	
3	Custom Extrusion, Inc.				
3, 4	Danielson Mfg. Co.				
8	Daubert Chemical Co.	6/12/63	12	Do not manufacture transfer films.	
3, 4	Davidson Products Co.				
3, 4	Davis, Joseph, Plastics Co.	6/19/63	1	Mfg. cellulose acetate, butyrate, propionate and biax oriented styrene sheet. Form response.	
3	Daylite Industries				
8	Dewey & Almy Chemical Div. W. R. Grace & Co.				
6	Dielectric Materials Co.				
2	Dimensional Plastics Corp.	8/13/63	1(AF)	Not in field.	
3	Diversified Industries, Inc.				
3	Dobackmun Div., The Dow Chemical Co.				
2, 3, 4	Dow Chemical Co.	8/27/63	M(AF)	No questionnaire located.	Sent S. P. 9/5/63
		10/21/63	4	Make biaxially oriented polypropylene. No exhaustive test data--could supply samples.	

Cate-
gory*

Firm

Date Code** Response Action

Dow Chemical Co. (cont'd)

2/12/64

Requested
data

Data on biaxially oriented
polypropylene.

5****

4,5

Dumais, Joseph F., Co.

2/20/64

2,3,
4,5

duPont de Nemours, E. I.
& Co., Inc.

7/1 and
7/5/63

5

Bulletins on Tedlar PVF and Tef-
lon FEP.

2,3,4

Dura Plastics of New York, Inc.

7(AF)

Partially completed questionnaire
on KODAR (polyester).

7

Electro Plastic Fabrics, Inc.

8/13/63

M(AF)

Did not receive questionnaire.

Sent S. P.
9/5/63

6
1,9

Electro-Technical Products
Div., Sun Chemical Corp.

9/20/63

1

No materials suitable to report.

3

Elloy Rubber Co.

3,4,5

Elm Coated Fabrics Co., Inc.

8/9/63

1(AF)

Calendered vinyl not up to Mylar,
Tedlar, nylon, etc. Form too
complex.

6

Engineered Plastics, Inc.

8/16/63

1(AF)

Do not manufacture film.

7

Eveready Plastics

Extrudaline, Inc.

7

Fabricon Products, Div., The
Eagle Picher Co.

8/21/63

1(AF)

Out of plastic film business.

7

Facile Corp., Sub. Sun Chem-
ical Corp.

7

Samples of 12 materials with data
generally limited to identification
of components in each laminate.
Most pertinent materials: #1137
bi-laminate of 1/2-mil Mylar A,
and #1147 Mylar (1/2 mil) lamin-
ated to 12 x 4 Dacron leno weave
scrim.

Cate- gory*	Firm	Date	Code**	Response	Action
6	Falls Hollow Staybolt Co.				
5, 6, 7	Farrington Texol Corp.				
7	Fassler, M. J., & Co., Inc.	8/8/63	1(AF)	Fabric coaters.	
8	Fasson Products	8/12/63	7(AF)	Enclosed samples of pressure-sensitive adhesive tape laminates.	
1, 3	Fields Plastics & Chemicals, Inc.				
3, 4	Firestone Plastics Co.	6/18/63	1	No commercial or R&D products suitable. Refer to duPont polyurethane film.	
7	Flexfirm Products				
2, 3, 4	Flex-O-Glass, Inc.				
8	Flightex Fabrics, Inc.				
3, 4	Fluoro Plastics, Inc.				
3, 4, 5, 6	Fluorocarbon Co., The	6/25/63	2	Teflon, Kel-F, and nylon. Not able to bid. Literature included.	
7	Foamade Industries	8/9/63	1(AF)	Do not make films.	
6	Fortin Plastics, Inc.				
4	Foster Grant Co., Inc.	6/21/63	M	Telephoned. Will send soon.	
1, 3, 4	Frank, J. P., Chemical & Plastic Corp.	7/30 and 9/6/63	8***	Fosta Stabilized Nylon XN662. This firm appears to have taken the program more seriously than any other. Evidence some special testing to obtain data, and several telephone calls.	
6	Futura, Inc.				

Cate- gory*	Firm	Date	Code**	Response	Action
2, 3, 4, 5, 7	Gelman, Herman A., Co.	6/22/63	4	Would like to be funded to obtain requested data. Reference to large military budget.	
8	General Electric Co., Chemical and Metallurgical Div.	6/21/63	8	Lexan polycarbonate film sample. Questionnaire: no data on cold flex, toughness, absorption of radiation, or creep.	
3	General Plastics Corp. (Marion, Ind.)	6/12/63	1	No suitable materials.	
5, 6	General Plastics Corp. (Bloomfield, N.J.)	6/14/63	1	Do not supply this type of film. Distributes Gencote, Teflon, Kel-F, Panton, Rokide.	
1	General Plastics Mfg. Co.				
3, 4	Gering Plastics Co., Dept. Monsanto Chemical Co.				
3	Gilman Bros. Co.				
6	Gits, J. A., Plastic Corp.				
2	Glasflex, Inc.				
7	Glassoloid Corp. of America	6/13/63	2	No. ID cards, etc. Included literature.	
7	Glastronics Div.				
5, 7	Gomar Mfg. Co., Inc.				
1, 3	Goodrich, B. F., Industrial Products Co., Aerospace Defense Prod.	7/24/63	1	Vinyl won't take cold. Estane V. C. not sufficiently tested to evaluate potential.	GMI letter explained that their answer crossed AF letter in mail. Brief questionnaire submitted with request for Estane data (not returned)
8	Goodyear Aircraft Corp.	8/27/63	4(AF)	Too costly to test for data required. To send catalogs. (Not received.)	

Cate- gory	Firm	Date	Code**	Response	Action
8, T	Goodyear Tire & Rubber Co. The General Offices				
3, 4	Goodyear Tire & Rubber Co., Films & Flooring Div.				
3, 5, 7	Gordon-Lacey Chemical Products Co., Inc.				
8	Grace, W. R., & Co., Cryovac Div.	10/29/63	M(AF) 6(AF)	Telecon of interest. Samples of Y film (polypropylene).	Litton wired for data 2/13/64
		2/13/63	7*** (AF)	Literature on Y film.	
3, 4, 5	Great Bay Chemicals & Plas- tics, Inc.				
7	Guardian Paper Co.				
2, 3, 4, 5, 6, 7	H & R Plastics Industries, Inc.				
4	Hall Mfg. Corp.				
3	Halogen Insulator & Seal Corp.	6/13/63	1	Do not make appropriate film.	
3	Hamilton Plastics, Inc.	6/10/63	1	Do not make film.	
6	Hanszen Plastics Co.				
4, 5	Harte & Co., Inc.				
1	Hercules Powder Co., Inc.				
3	Hermes Plastics, Inc.				
3, 5, 7	Hodgman Rubber Co.	8/8/63	1-4 (AF)	Fabric coaters. Too costly to test light fabrics for charac- teristics of interest in ballooning	
1, 2	Homelite Corp. The				

Cate- gory*	Firm	Date	Code	Response	Action
T	Hostachem Corp.	6/18/63	2	Films do not meet requirements. Literature included	
3, 4	Hyde, A L., Co.	8/8/63	2(AF)	Do not make suitable film. Bro- chure on molding.	
6	Hysol Corp.	6/24/63	1	Do not make plastic film.	
6	Industrial Coatings Co.				
1, 2, 3	Industrial Plastic Fabrica- tors, Inc.				
6, 7	International Coatings Co., Inc.	8/26/63	1(AF)	No laminated films. Do make high-temperature resistant ure- thane laminating adhesive.	
6	International Plastic Co.				
8	Jessall Plastics Div., The Electric Storage Battery Co.	8/9/63	1(AF)	Response from Stokes Molded Products (merged with Jessall)- Do not manufacture film.	
5, 7	Joanna Western Mills Co.				
3	Jodee Plastics, Inc.	6/17/63	2	Literature only. Tubing and shapes.	
3, 4	Kal Plastics, Inc.				
T	Kaufman Glass Co., Plas- tics Div.				
3	Kaye-Tex Mfg. Corp.	8/15/63	M(AF)	Have not received questionnaire. No suitable product.	S. P. sent 9/5/63
3, 4, 5	Kaykor Products Corp.	9/30/63	1		
7	Kehr Products Co.	6/21/63	1	No helpful materials. They for- warded survey package to another undisclosed firm.	
5, 7	Keller Products, Inc.				
3	Kendall Co., The, Polyken Div.				

Cate- gory	Firm	Date	Code	Response	Action
3, 4	Keystone Packaging Service, Inc.				
4	Koppers Co., Inc., Plastics Div.				
1, 4	Kordite Co.	6/27/63	1	Only candidate would be polyethylene. Unable to supply at present.	
3, 4	Koro Corp.				
6	L & P Tool Co.	8/22/63	1(AF)	Special PVC to customer requirements.	
6	Lakeside Plastics Corp.				
5, 7	Lamart Corp.	8/8/63	6(AF)	Sample of 1/4-mil Mylar on aluminum foil.	
4, 7	Lamex, Inc.	6/14/63	1	Nothing to report.	
1, 5	Laminations, Inc.				
1, 3, 4, 5, 7	Leathertone, Inc.	6/21/63	1	Press lamination only.	
6	Liberty Engineering & Mfg. Co.	6/19/63	1	Applications of M & T plastics.	
7	Low Paper Co				
4, 7	Ludlow Plastics Div., Ludlow Corp.				
3	Lus-Trus Corp.				
7	Mankato Paper Box Co.				
3	Marion General Plastics Co.				
7	Marmyre Co.				
3	Masland Duraleather Co., The				
1, 4, 5	Maynard Plastics Inc.				
4	Mehl Mfg. Co., Div. Sydney-Thomas Corp.	7/2/63	1	Unable to supply material requested.	
3, 4	Metallic Plastics Corp.				
5					

Cate- gory*	Firm	Date	Code**	Response	Action
4	Micron Plastics Corp.				
4, 5	Midwest Plastic Products Co.				
4	Minnesota Mining and Mfg. Co., Film Products Group	8/13/63	M(AF)	Telecon - send questionnaire.	S.P. sent 9/5/63
		9/16/63	7	Samples and sketchy questionnaires on Scotchpak polyester and heat sealable Scotchpak/nylon scrim #50441, Lot 84 which was included in G. T. Schjeldahl report on development of material for heavy load balloons.	
5	Minnesota Mining and Mfg. Co., Electrical Products Div.	8/13/63	M	Telecon - send questionnaire.	S.P. sent 9/5/63
3, 4, 5	Modern Industrial Plastics Div., Duriron Co., Inc.				
3	Moldings & Extrusions, Inc.	8/8/63	5(AF)	Tensitized nylon tape which might be of interest as load tape. (Moldex Molding & Extrusions)	
3	Monsanto Chemical Co., Plastics Div.	6/24/63	1	No product available.	
2, 6	Murray Products, Div., Fanner Mfg. Co.				
3, 6	Nalge Co., The, Inc.	6/20/63	1	Not in film business.	
T	Napco Plastics Co., Div. National Union Electric Corp.	8/15/63	2(AF)	Molders.	
3	National Vulcanized Fibre Co.				
4	Natvar Corp.				
6	New England Tape Co., Div. United-Carr Fastener Corp.				

Category	Firm	Date	Code**	Response	Action
3, 4	Nixon-Baldwin Chemicals, Inc.				
6	Nonweiler, A. P. Co.				
15	Norman Plastics, Inc.				
1, 2	Omni Plastics Corp.				
3	O'Sullivan Rubber Corp.	8/8/63	1(AF)	Convert resins to sheeting of ordinary commercial types.	
6	Parco Co.				
6	Pasley's Plastic Products, Inc.				
4	Permacel				
4	Phillips-Joanna Co.				
6	Plastics Arts Mfg. Co.				
3, 5	Plastic Converters, Inc.	6/27/63	1	No product to submit.	
6	Plastic Engineering & Sales Corp.				
7	Plastic Papers, Inc.				
3, 4	Plastic & Rubber Products Co.	8/13/63	2(AF)	Mold Teflon.	
2, 3	Plastic Stamping Corp				
7	Plastic Suppliers				
7	Plastic Suppliers & Mfgs.				
6, 7	Plastics Engineering of Hawaii, Inc.				
6	Plastics, Inc.	6/18/63	1	No processing of film.	
4	Plastic Form, Inc.				
2	Plast-Vue				
4	Plucose Mfg. Corp.	6/24/63	1	No suitable materials.	
4	Poly Plastic Products, Inc.				

Cate- gory	Firm	Date	Code	Response	Action
T	Polycast Corp, The	6/14/63	1	Cast methyl methacrylate only. Cannot assist.	
6	Polycote, Inc.				
3,4,6	Polymer Corp., The, Export- Polypenco, Inc.	6/20/63	2	TFE & nylon film only, would not warrant further investigation. Literature included.	
3,5,6	Polyplastex United, Inc.				
6	Precision Coating Co., Inc.				
2,4	Premier Plastic Mfg. Co., Inc.	6/21/63	1	Do not make plastic film.	
7	Printon Corp.				
3,4	Protective Lining Corp.				
6	Pyramid Industrial Finishing Corp.	6/25/63	1	Not manufacturers of plastic film.	
6	Pyramid Plastics, Inc.				
3	R. C. Can Co.				
1,3,5	Radiation Applications, Inc.				
1,3,5	Rand Rubber Co.				
4	Raritan Plastics Corp.				
3	Raybestos-Manhattan, Inc. Reinforced Plastics Dept.	7/29/63 8/12/63	1 M(AF)	No qualifying material. Sent negative reply to GMI 7/29/63 (crossed AF followup in mails).	
3,4	Reliance Plastic & Chemical Corp.				
3,4	Resinraft Plastics, Inc.				
3	Resistoflex Corp.				
1,2	Reynolds Metals Co.	8/14/63 9/17/63	M(AF)	Did not receive questionnaire. Manufacture PVC film by band- casting and extruding, and PVA by bandcasting. They do not qualify.	Sent S. P. 9/5/63

Category	Firm	Date	Code	Response	Action
6, 7	Riegel Paper Corp.	8/13/63	M(AF)	Did not receive questionnaire.	S. P. sent 9/5/63
3, 7	Robinson Industries, Inc.	6/20/63	1	Not film producers--molders.	
7	Rochester Urethane Co., Inc.				
5	Rogers Associates, Inc.				
3	Rogers Corp.	8/27/63	1(AF)	No suitable material.	
1, 2	Rohm & Haas Co.	6/17/63	1	No films to meet requirement.	
3, 5, 7	Ross & Roberts, Inc.				
7	Ross/Waldron-Hartig, Divs. Midland-Ross Corp.	6/18/63	1	Machinery manufacturers.	
1, 3	Rotuba Extruders, Inc.	8/27/63	1(AF)	Do not manufacture film.	
3	Rowland Products, Inc.	6/27/63	1	Returned "Package" without comment.	
7	Royson's, Inc.	6/21/63	1	Do not fall in category.	
1, 3, 4, 5	Rubber Corp. of America				
3	Ryerson, Joseph T. & Son, Inc., Industrial Plastics Div.	6/19/63	1	No materials to meet requirements.	
6	Santay Eastern, Inc.				
2, 6	Schori Process Corp.				
1, 2, 3, 4, 5	Scranton Plastic Laminating Corp.				
3	Scelye Plastic-Fab, Inc.	6/10/63	1	No.	
3, 4	Seiberling Rubber Co., Plastics Div.	7/10/63	7	Samples polyurethane-nylon scrim and unsupported polyurethane. Sales literature and data. No ques- tionnaire.	

Cate- gory*	Firm	Date	Code**	Response	Action
3	Shamban, W. S. & Co.	6/27/63	4	Would cost them too much to supply information requested.	Form letter #2 7/16/63
3	Sheffield Plastics, Inc.	8/13/63	1(AF)	Extruders of rigid plastics.	
2	Sierracin Corp., The				
7	Smith, H. P. Paper Co.				
5	Synder Mfg. Co., Inc.	6/27/63	3	As custom laminators, could possibly produce to specification. Nothing on shelf to meet requirements. Refer to The Lamports Company. Literature enclosed.	Wrote to Lamports 9/11/63
4	Soo Valley Co.				
3,4, 5,7	Southern Plastics Co.				
1,3	Southwestern Plastics, Inc.				
6	Sparling Plastic Industries, Inc.	6/17/63	1	Out of their line.	
6	Spartek, Inc.				
4	Spencer Chemical Co.				
6	Spiratex Co., The	6/20/63	1	Extrude pipe, etc.	
5,7	Standard Insulation Co., Inc.				
3	Standard Pyroxoloid Corp.	6/14/63	1	No suitable materials.	
6	Steere Enterprises, Inc.				
7	Stowe-Woodward, Inc.				
3,5	Strauss, H. B., Corp.				
1	Swedlow, Inc.	8/13/63	M(AF)	Did not receive questionnaire.	S. P. sent 9/5/63
4	Swift & Co.	9/30/63	1	Utilize plastic but do not make it.	
7	Syuthon, Inc.	6/17/63	1	Flocking.	

Cate- gory	Firm	Date	Code**	Response	Action
6	Talimac Industries, Inc.				
6	Techform Laboratories, Inc.				
6	Technical Research Institute				
5	Texas Butadiene & Chemical Corp.		M(AF)	Moved. Left no forwarding address.	
4	Texas Plastics, Inc.				
4	Tex-Trude, Inc.				
T	Thielex Plastics, Corp., The	6/18/63	1	Profile extruders.	
T	Transilwrap Co.	6/13/63	1	Do not manufacture these materials.	
4	Trans-Poly Corp.				
3	Trend Mfg., Inc.				
6	Triangle Conduit & Cable Co.				
2, 3, 4	Union Carbide International Co., Div.				
3	Union Carbide Plastics Co., Div.	7/1/63	M	Forwarding letter to Technical Services Department for response.	
3, 4	United States Gasket Co., Plastics Div. of Garlock, Inc.				
8	U. S. Industrial Chemicals Co., Div National Distillers & Chemical Corp.	8/7/63	M(AF)	They referred to Film Products.	
2	U. S. Plastic & Chemical Corp.				
3	U. S. Rubber Co, Naugatuck Chemical Div.	8/8/63	M(AF)	Asked for copy of questionnaire.	S. P. sent 9/5/63
3	U. S. Rubber Co., Royalite Plastic Products	9/25/63	1	No materials to fit requirements.	

Category	Firm	Date	Code**	Response	Action
3	U. S. Stoneware Co., The	6/20/63	1	Do not manufacture plastic film. Bulletin on Tygon tubing.	
2,3	Urrite Plastics Fabricators	6/17/63	1	Custom fabricators of thermoplastics. Do not manufacture film.	
3,4	Visking Co., Div. Union Carbide Corp. (Chicago)	6/17/63	M	Plan to submit samples in 4 to 5 weeks.	6/26/63 letter requesting data in advance of samples, if possible
2,5	Wama Co., The				
7	Western Backing Corp.				
6	Western Plastic Products Div., Western Textile Products Co.				
B-21	Westinghouse Electric Corp., Micarta Div.	8/21/63	M(AF)	No questionnaire received.	S. P. sent 9/5/63
3,4	Westlake Plastics Co.	9/30/63	1	No candidate materials to report.	
		8/8/63	5(AF)	Literature on available materials such as GE Polycarbonate Lexan, Hercules Pro fax, duPont Delrin acetal resin TFE fiber, Celanese Celcon acetal copolymer.	
7	Woodall Industries, Inc.	6/21/63	1	Not interested.	

APPENDIX C

**FIRMS SURVEYED WHICH ARE NOT INCLUDED IN ALPHABETICAL
LIST TAKEN FROM MODERN PLASTICS ENCYCLOPEDIA**

Firms Surveyed Which Are Not Included in Alphabetical
List Taken from Modern Plastics Encyclopedia

Firm	Date	Code*	Response	Action
Acme Backing Corp.	8/22/63	M(AF)	No questionnaire received.	S. P. sent 9/5/63
Ametek, Inc. Filtration Fabrics Div.	9/9/63	3	Do not have standard materials available nor lab to make required tests.	
American Machine & Foundry	8/12/63	M(AF)	Asked for copy of questionnaire.	S. P. sent 9/5/63
Aquafilm Corp.	9/12/63	5	(Amflex Products Dept) Literature enclosed. Data not available. Teflon coatings.	
Bell Telephone Labs Western Electric Co.	6/14/63	5	Literature only. No reference to survey.	
Chase-Foster, Inc.	3/7/63	1(AF)	Suggest we contact Western Electric Co.	Form letter #2 sent 7/17/63
Chippewa Plastics Curwood Industries	6/21/63	4	Not in position to do all the testing required. Government programs not too attractive due to paper work, specs, inspection, etc.	
General Tire & Rubber Co., The, Pennsylvania Div.				

See page B-1.
S. P. - Survey Package.

Firm	Date	Code*	Response	Action
Gordon-Chapman Co.				
Griffolyn Co., Inc.	6/25/63	6	Eleven samples unidentified except for type number. No data on questionnaire. Construction can be varied by yarn weight, spacing, film weight and type. (Sent 9/11/63 at suggestion of Synder Mfg. Co.)	
Lamparts Co., The				
Marvellum Co.				
May Industries, Inc.	6/26/63	7	Sample 1 mil RILSAN (nylon 11) film. Sample film/aluminum foil laminate too. Sales data, but no questionnaire.	
Minnesota Mining & Mfg. Co., Irvington Division	7/15/63	1	No suitable products, suggest contact with Film Division (which had already been done). (This Survey Package submitted at request of a Division representative).	
National Poly Products, Inc.				
Noland Papers Co., Inc.	8/12/63	1(AF)	Do not make material, refer to Ludlow Paper Co. among others. (Previously contacted Ludlow Plastics Div., Ludlow Corp.)	
Poly-Tech Corp.				
RAP Industries, Inc.	8/13/63	M(AF)	Misplaced original questionnaire.	S. P. sent 9/5/63
	11/1/63	3, 4***	Make exotic structures (laminates) but requested data not available. Consider subcontract development.	

* This code used in composite.

Firm Date Code# Response Action

Reinhart Sabee Co.

Schjeldahl, G. T. Co.

7/5/63 8

Samples S-12 (Mylar on Dacron scrim), GT 21 1.5-mil Mylar Birlam, X154 (Mylar on Dacron cloth). Questionnaires included on all three, fairly complete on S-12, and sketchy on others.

Sea-Space Systems, Inc.

8/21/63 M(AF)

Will submit data on MERFAB to GMI. Samples may be taken from balloons previously supplied to AFCRL after test.

Requested data
2/12/64

Uni-Search Engineering Corp.

8/9/63 M

Will send data and samples in a week. Mylar adhesive basis for their work. Samples to include: 1/2-mil metalized Mylar/rip-stop nylon. No samples or data ever received.

Q 3

8/16/63 M(AF)

Essentially the same information as provided GMI 8/9/63.

Ethyli VisQueen Film Div.,
Ethyli Corp., Terre Haute, Ind.

7/18/63 7

Data sheets and samples on an experimental film (3 thicknesses).

8/9/63 M(AF)

Responses from Leventhal and Washburn cover Dr. Thor's input.

8/15/63 7

Data and samples of three films:
1971 (E-263-43A)
1972 (E-263-43B)
1973 (E-263-43C)

Latton letter 3/6/64 asking whether these materials could be delivered on production basis

Van Pak

Firm	Date	Code	Response	Action
Waldorf Paper Products Co.	6/18/63	1	No materials suitable to report.	
Headquarters Aeronautical Systems Div. Air Force Systems Command, USAF	8/14/63	5	Letter discussing properties of gelatin film in relation to possible use as balloon barrier material.	
Wright Patterson Air Force Base, Ohio Attn: Mr. Albert Olevitch, Chief Specialties and Materials Section Materials Application Division Air Force Materials Laboratories	9/9/63	5	Report on Gelatin Film.	

APPENDIX D

GENERAL MILLS DRAFT OF AIR FORCE FOLLOW-UP LETTER

TO: Suppliers of Plastic Film (unsupported, laminated and supported)

SUBJECT: Request for Product Information, Contract No. AF 19(628)-2944

Air Force Cambridge Research Laboratories have long been active in conduct of high altitude investigations in which balloons have served as the vehicle. As a result, they have become recognized authorities on most aspects of ballooning, being consulted by other government agencies and civilian scientists alike regarding balloon systems. Over the years, many research and development programs have been sponsored by the Laboratories with the principal objective of advancing the state of the balloon art in such areas as materials, design, and manufacturing techniques. The Laboratory is currently engaged in a survey of films (supported, laminated, and unsupported) for potential use in balloons. This work is being carried out under contract with General Mills, Inc., Aerospace Research Department. Several weeks ago, in an attempt to determine whether your firm has products which merit consideration for balloon use, General Mills submitted an explanatory letter and questionnaire. To date, your response has not been received.

Perhaps knowledge of one or more of the following facts will encourage your participation:

1. Copies of the survey report will be distributed to all balloon fabricators.
2. A copy will be available (upon request) to any firm which submits a complete questionnaire covering a material which meets the minimum requirements for consideration.
3. General Mills, as a balloon fabricator, is a user of materials of the type dealt with by the survey. They are neither engaged in nor equipped for production of plastic films, laminates, or supported films. They have no intention of engaging in such activities.
4. The market for balloon materials is appreciable. Polyethylene usage runs into hundreds of thousands (or in some cases millions) of pounds per year. A supported film of reasonable cost, utility and reliability would also find a worthwhile market.

Assuming that you produce materials fulfilling the minimum requirements, it is requested that you complete and return the questionnaire to GMI as soon as possible. Some firms have declined to complete the questionnaire on the grounds that too much testing would be required, particularly with equipment not available to them. If you have materials which satisfy stated requirements, we would prefer to receive a partially completed questionnaire than a negative response. Preference must naturally be shown to candidate materials supported by complete data. However, should we not receive complete data on ten materials which merit being considered for testing, the most promising of these materials not supported by complete data will be given attention. Should you have nothing suitable to report, it is requested that GMI be so notified. Your cooperation will be appreciated.

Very truly yours,

James F. Dwyer
Technical Project Monitor

APPENDIX E
AIR FORCE FOLLOW-UP LETTER

HEADQUARTERS
AIR FORCE CAMBRIDGE RESEARCH LABORATORIES
OFFICE OF AEROSPACE RESEARCH
UNITED STATES AIR FORCE
Laurence G. Hanscom Field Bedford, Massachusetts

Reply to

Attn of: CREB/J. Dwyer/3076

Subject: Survey Questionnaire, AF 19(628)-2944

To:

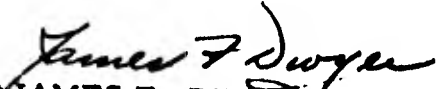
1. The Air Force Cambridge Research Laboratories has, for many years, been engaged in both plastic balloon development and the conduct of atmospheric research using balloon carriers. Extensive experience in this field has made us a prime source of information for other Government agencies, universities and private industries engaged in research and operations in the balloon field.
2. With the current emphasis on space and "near space", the demands being placed upon plastic balloons are fast exceeding the capabilities of proven balloon materials. In an effort to open new roles for balloons and to adapt the balloon to existing requirements exceeding the state of the art, this Laboratory has initiated a contract to evaluate, for balloon application, the most promising plastic films of both commercial and experimental status.
3. This contract was awarded on a competitive basis to General Mills, Incorporated, of St. Paul, Minnesota. To insure objectivity, no companies engaged in the production of plastic films or resins were solicited. In this way the Government can be assured that the selected films do not represent the contractor's product and that the contractor accrues no competitive advantage by virtue of the work performed. Accordingly, a survey questionnaire was prepared and distributed by our contractor. Response to date appears to be associated with two aspects of the stated "action desired", (1) the performance of tests and (2) the standardization of reporting units.

4. It was not intended that a burden be placed on the prospective film suppliers in order to qualify their products for inclusion in the test phase of the contract. Rather, it was hoped, that where sales budgets permitted, the suppliers could be encouraged to submit the more detailed information through which the selection process could be more discriminating. This has indeed been true in a number of cases. However, if in your case the desired effort is prohibitive, the submission of your commercial literature will still be of considerable value in achieving our goals.

5. Information which you may consider proprietary need not be furnished, but comment should be made where there might be reason to suspect that the omitted information is critical to the selection or elimination of the subject film.

6. We hope that you will support this important research program, not only because of its bearing on our national capabilities, but also because the results of this study will be made available both to you and to prospective processors of your products.

7. In any case, your reply to the questionnaire, whether positive or negative, will be of value in programming the schedule of this effort.


JAMES F. DWYER

Task Scientist
Aerospace Instrumentation Laboratory

APPENDIX F

GENERAL MILLS FORM LETTER NO. 2

(for firms which declined to submit questionnaire
because of unavailability of data)



ELECTRONICS DIVISION • GENERAL MILLS, INC.

2222 WALNUT STREET • ST. PAUL 13, MINNESOTA • PHONE 781-6022

To:

Attention:

Subject: Survey of Potential Balloon Material
Contract AF 19(628)-2944

Reference 1: Request for Product Information 3 June 1963

Reference 2: Your Letter Dated

Gentlemen:

We wish to thank you for your response to reference 1, indicating your decision not to submit the questionnaire on balloon materials due to unavailability of certain requested data, and lack of test equipment or budgeted funds to obtain this information. We agree that for many (perhaps most) firms contacted, submitting requested information would represent a significant effort. We hoped that by supplying rather complete information on the program, those firms with real candidate materials would be motivated to make this effort.

Obviously the government should not fund a contractor to test indiscriminately all specimens submitted in quest of superior balloon materials. Hence, screening on the basis of data supplied by vendors is essential. You would also probably agree that it would be impossible to make a fair comparison of potential materials based on use of data sheets of the type distributed for sales purposes; owing to difference in test methods and conditions, as well as in the characteristics on which information is presented. We feel that even with standardization of test methods, reporting units, and characteristics considered, proper ranking of candidate materials will be difficult due to impracticality of assigning fair weight to various characteristics and to different degrees of excellence in each.

In the event that you have materials which meet the minimum requirements and which have no other obvious disqualifying features, it is suggested that you complete the questionnaire to the extent possible based on existing information, and submit it along with your standard sales data. While preference must be shown to materials supported by complete questionnaires, other materials will be considered, particularly if ten really promising materials are not found among those entitled to first consideration. We hope you will carefully reconsider your potential role in this program.

Very truly yours,

AEROSPACE RESEARCH DEPARTMENT

W. B. Parsons
Senior Engineer

APPENDIX G
DOUBLE POSTCARD SURVEY MATERIAL

Attention: W. B. Parsons

GENERAL MILLS, INC.
Electronics Division
Aerospace Research & Engineering Dept.
2295 Walnut Street
St. Paul 13, Minnesota

THIS SIDE OF CARD IS FOR ADDRESS



Suppliers of Plastic Film (supported, laminated & unsupported) Air Force Cambridge Research Center has engaged Aerospace Research Dept. of General Mills to contact suppliers and determine whether materials are available for balloon use which are better adapted to the application than those presently being used: polyethylene for normal use, Mylar for super pressure, and Mylar laminated to Dacron scrim for heavy load applications. Minimum requirements have been established as follows:

1. Cold brittleness temperature - not higher than -68°C.
2. Tensile strength, machine direction
 - a. Unsupported film and laminates > 2000 psi @ 20°C.
 - b. Supported films < 10 lbs/inch @ 20°C.
3. Weight per unit area - not more than 3 oz/yd²

Production potential - polyethylene seage for balloons runs into hundreds of thousands of pounds per year.

Please complete and return the attached card, whether or not you have materials which meet the minimum requirements.

Gentlemen:

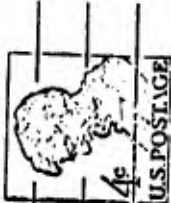
We have _____ (number, if none so state) products which meet the minimum requirements set forth on the attached card and merit consideration as potential balloon materials. Please send information on the survey program being conducted. We will supply data on candidate materials by completing questionnaires calling for information pertinent to their potential performance in balloons. We understand the General Mills' contract provides for testing the 10 materials judged most promising on the basis of information obtained by questionnaire.

Name of individual to whom information and questionnaires should be sent _____

Firm _____

Address _____

THIS SIDE OF CARD IS FOR ADDRESS



Chemold Company
Colorado Avenue at 20th
Santa Monica, California

APPENDIX H
RESPONSE TO DOUBLE POSTCARD SURVEY
(including list of all firms contacted)

Response to Double Post-Card Survey

Category	Firm	Date	Code	Response	Action
6	Honeycomb Co. of America, Inc.	9/9/63	1	No products meet min. requirements	
	Tee-Pak, Inc.				
	Malco Plastics, Inc.	8/12/63	1	No from Campco Plastics Co., Chicago Molded Products Corp. (assumed merged)	
	Central States Paper & Bag Co.	8/19/63	1	No products meet min. requirements	
	Madan Plastics				
	Kings Specialty Company	8/21/63		No products meet min. requirements	
	Hedemon Products, Inc.				
	Hartford Textile Corporation				
	General Tire & Rubber Co., Plastics Division	8/14/63	1	No products meet min. requirements	
	Plaskolite, Inc.				
	General Electric Co., Laminated Products Department	8/27/63	1	No products meet min. requirements	
	Federal Identification Co.				
	John L. Dore Company		M	Have 1 product which meets min. requirements	Sent S. P. 9/23/63 (no response)

Category	Type of Material	Thomas Register
3	plastic film (flexible)	pp. 5657-5659
6	plastic sheeting	pp. 5685-5688
9	plastics, transparent	pp. 5785-5786

See page B-1.
S. P. - Survey Package

Response to Double Post-Card Survey (continued)

Category	Firm	Date	Code	Response	Action	
3	Burcott Mills					
	Gilbert Plastics & Supply Co. Archer Rubber Company					
9	Research Molding & Film Co.	8/21/63	M	Have 2 products which meet requirements	Sent S. P. 8/29/63 (no response)	
	Olin Mathieson Chemical Corp.					
	G. C. Greene Corp.					
	Industrial Plastic Supply Div. Werner Manufacturing Co.					
	Keolyn Plastics, Inc.					
	The Frank Walter Organization Mono-Sol Corporation					
	Fawn Plastics Company, Inc. Deerfield Plastics Co., Inc.					
	Fabri-Kal Corporation Blue Water Plastics Co.					
	Booker & Wallestad Div. of Thermotech Industries, Inc.	8/14/63		1	No products meet min. requirements	
	Plastic Craft, Inc.	8/13/63		1	No products meet min. requirements	
	Regal Plastic Company Whalate Manufacturing Co.					
	Van Beck Industries Brurier Products Co., Inc.					

Response to Double Post-Card Survey (continued)

Category	Firm	Date	Code #	Response	Action
9	Springfield Fabricators, Inc. Plaxall, Inc.				
	Clutone Company				
	Robeco Chemicals, Inc.	8/12/63	1	No products meet min. requirements	
	Millington Mfg. Company				
	Charles W. Thomas, Inc.	8/14/63	1	No products meet min. requirements	

APPENDIX I

"STREAMLINED SURVEY PACKAGE" MATERIAL



ELECTRONICS DIVISION • GENERAL MILLS, INC.

2295 WALNUT STREET • ST. PAUL 13, MINNESOTA • PHONE 781-6022

To: Suppliers of Plastic Film (unsupported, laminated, and supported)

Subject: Request for Product Information

Gentlemen:

Air Force Cambridge Research Center has engaged the Aerospace Research Department of General Mills to conduct a program related to balloon materials. This effort is being carried out in the following sequence:

1. Obtain data on those characteristics of available materials which is pertinent to their potential performance in balloon applications. (See questionnaire attached)
2. Select the ten most promising materials on the basis of available data.
3. Test these materials to permit strict comparison with materials presently used. (Attributes tested will be generally those covered by questionnaire).

Before concerning yourself with the questionnaire you will benefit by this background:

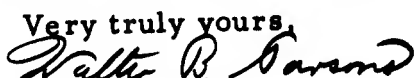
Minimum requirements for candidate materials:

1. Cold brittleness temperature - not higher than -68°C .
2. Tensile strength, machine direction
 - a. Unsupported film and laminates - greater than 2000 psi @ 20°C .
 - b. Supported films - greater than 10 lbs/inch @ 20°C .
3. Weight per unit area - not more than 3 oz/yd².

Types of balloons involved, presently used materials, and comments:

1. Vented, high altitude polyethylene balloons. The market - hundreds of thousands of pounds per year. Polyethylene is low in cost, readily sealable, and uniformly high in quality. Greater strength for given weight, and even lower cold brittle point desired.
2. Super pressure balloons provide unballasted long duration flights at constant altitude, since volume doesn't change with temperature. Mylar is used for high strength to weight ratio and low absorption of solar energy. It is used as a two ply laminate to counteract proneness to develop pin holes upon handling, although rather costly in this form. Mylar is low in tear resistance and the adhesive seal required, though strong in shear, is weak in peel. The market should grow rapidly, particularly if a more suitable material is found.
3. Vented heavy load balloons are presently fabricated of Mylar, adhesive laminated one side to 6 x 4 Dacron scrim. The 1-1/2 oz/yd² composite is marketed by GT Schjeldahl Co. as S-12. It offers a high strength to weight ratio and excellent tear resistance. The pin hole formation and sealing disadvantages are inherent with Mylar, and more solar energy is absorbed than desirable. If the cost of such balloons could be lowered modestly and reliability increased somewhat, a market of 200,000 yd²/year would appear conservative.

If your material(s) fulfill the minimum requirements above, kindly provide as much of the information requested on the attached questionnaire as possible. We ask your cooperation in returning the questionnaire even if you have no materials suitable to report.

Very truly yours,

Walter B. Parsons

SURVEY QUESTIONNAIRE

(Please return in attached envelope within 2 weeks following receipt)

(Return even though you have no materials suitable to report)

Individual Responding _____

Firm _____

Address _____

Product Identification _____

Thickness of film for which data reported below applies - _____ mil.

(Interest confined to material potentially available at 3 oz/sq yd or less)

1. Cold brittleness temperature (must be -68°C or less) - _____ $^{\circ}\text{C}$.

Method: ASTM D 1790-60T _____ or other (specify) _____

	<u>Unsupported Film</u>		<u>Supported Film</u>	
	Machine Direction	Transverse Direction	Warp Direction	Fill Direction
2. a Ultimate strength	psi	psi	lb/in	lb/in
2. b Ultimate elongation	%	%	%	%
3. a Yield strength	psi	psi	lb/in	lb/in
3. b Elongation at yield	%	%	%	%

Method: ASTM D 882-61T

Other (specify strain rate, sample size) _____

4. Tear strength _____ lb _____ lb _____ lb _____ lb

ASTM D 1004-61 Graves _____, or ASTM D 1922-61T Elmendorf _____
or other _____

5. Cold flex characteristics

Test Method _____ Value _____

Comments _____

6. Toughness

ASTM D 1709-59T, Impact failure weight _____ g, or _____ in-lb

Other Method _____ Value _____

7. Heat

8. Thermoplastic
adhesive

9. Liquid Adhesive

Sealable (yes or no) _____

10. Seal strength, lb/in-mil (unsupported), lb/in. (supported)

Peel _____

Shear _____

Strain rate, in/in-min _____

Test temperature, $^{\circ}\text{C}$ _____

Sealer or adhesive used _____

APPENDIX J
RESPONSE TO STREAMLINED SURVEY PACKAGE
(including list of all firms contacted)

Response to Streamlined Survey Package

Category	Firm	Date	Code	Response	Action
6	Chemold Company L. J. Segil Company General Tire & Rubber Co., Industrial Products Division Webster Industries, Inc. Air Cruisers Division Transeal, Ltd. Oppenheimer Corporation Elm Coated Fabrics Company	8/20/63	1	Make unsupported vinyl film which is not suitable in their opinion	
	Weblon, Inc. Cincinnati Industries, Inc. Allied Resinous Products, Inc.	8/26/63	1	Polyolefin products, but minimum thickness 10 mil	
	Duracote Corporation McNeff Industries	8/28/63	1	No material to report	
?	Portage Plastics Company B. L. Bowman	8/21/63	1	Do not have materials (this response could not be identified to any of the firms surveyed, hence represents merger, referral, or use of personal rather than firm name)	

Category	Type of Material	Thomas Register
3	plastic film (flexible)	pp. 5657-5659
6	plastic sheeting	pp. 5685-5688
9	plastics, transparent	pp. 5785-5786
Code - See page B-1.		

Response to Streamlined Survey Package (continued)

Category	Firm	Date	Code	Response	Action
3	Industrial Plastics Corporation Plymouth Rubber Company, Inc. National Transparent Plastics Div. Fibre Converters, Inc. Film Div.	8/21/63	1	Make cellulose, not plastic film	
9	Chester Packaging Products Div. Fremont Rubber Company Div. Pacific Waxed Paper Company Franklin Fibre-Lamitex Corp. Johnson Glass & Plastic Corp. Peoria Plastic Company Hyaline Plastics Corporation Universal Plastics & Engineering Gregstrom Corporation Garzel Plastic Industries, Inc. MacDonald Manufacturing Co. V. W. Busch Manufacturing Co. Aroplax Corporation				
	Schaper Manufacturing Co., Inc.	8/20/63	1		Do not manufacture plastic film
	Emeloid Company, Inc. (sub of Addressograph Multigraph Corp.) Grewe-Plastics Hydrawlik Company Colvin-Fredman Company Dural Fabricators Corporation				

Response to Streamlined Survey Package (continued)

Category	Date	Code**	Response	Action
9	American Plastics Corporation Reeves Plastics, Inc. Tico Plastics, Inc. Penn Arts Manufacturing, Inc. Milwaukee Plastics, Inc.			

APPENDIX K

GENERAL MILLS FORM LETTER NO. 3

(for firms indicating, in response to Air Force Follow-Up,
the unavailability of initial Survey Package)



ELECTRONICS DIVISION • GENERAL MILLS, INC.

2208 WALNUT STREET • ST. PAUL 13, MINNESOTA • PHONE 781-8022

Attention:

Subject: Survey of Potential Balloon Materials

References: 1) Survey package dated June 3, 1963,
distributed by General Mills
2) Recent Air Force Cambridge Research
Laboratories follow-up letter
3) Your response to Reference (2)

Gentlemen:

General Mills, Inc. is conducting the subject survey under sponsorship by Air Force Cambridge Research Laboratories and in accordance with the terms of Contract AF 19(628)-2944. In performance of this program, reference (1) was distributed. When response to the questionnaire included therewith did not meet expectations, the sponsoring agency assisted by distribution of reference (2) to those original recipients who had not responded.

It is definitely recognized that many of the addressees are large companies and that a follow-up would not necessarily reach the recipient of the original "Survey Package". We are pleased to have received your response to reference (2) and to enclose herewith, for your convenience, an additional copy of the survey package. We will certainly appreciate your assistance in this program as rendered by consideration of this material and submission of the completed questionnaire, assuming that you have one or more candidate materials. In any event, return of the questionnaire is desired and will be appreciated.

Very truly yours,

Aerospace Research Dept.

Walter B. Parsons

Enc. Survey Package