https://ntrs.nasa.gov/search.jsp?R=19720013269 2020-03-11T18:58:20+00:00Z

N72-20919

SD 72-SH-0005

FINAL REPORT ON STUDY OF LOW-COST FABRICATION OF ABLATIVE HEAT SHIELDS

31 March 1972

Contract NAS1-10708

Prepared by

L. B. Norwood

Space Division
North American Rockwell

SD 72-SH-0005

FINAL REPORT
ON
STUDY OF LOW-COST FABRICATION
OF
ABLATIVE HEAT SHIELDS

31 March 1972

Contract NAS1-10708

Prepared by

L. B. Norwood

Space Division
North American Rockwell

FOREWORD

This report is the final technical documentation of all work performed under Contract NAS1-10708 in accordance with Part IVD of the Statement of Work.

The program was conducted by the Production Engineering and Development Department at the Space Division of North American Rockwell Corporation, Downey, California, between May 1971 and March 1972.

This report documents the results of a team effort coordinated in close cooperation with Mr. Claud M. Pittman of the Langley Research Center, who was the Technical Representative for this contract. Mr. L. B. Norwood of NR-SD was the Program Manager.

CONTENTS

ILLUSTRATIONS

TABLES

SUMMARY

The major objectives of this program were accomplished in three tasks: (1) modification of the ablative material composition for ease of fabrication as well as thermal and mechanical performance; (2) scaled-up, simplified, manufacturing techniques which resulted in cost reductions; and (3) the identification of a significant design problem caused by the differential pressure buildup imposed on mechanically attached ablative heat shield panels during launch.

In Task 1, nineteen different compounds were formulated and fifty-seven 7.6 cm (3-inch), diameter ablation test models were fabricated and delivered to NASA-LRC for thermal performance testing. In addition, twenty-six 12.2 cm (6-inch) diameter air permeability test specimens were fabricated and twenty-two were tested, with and without coatings, for selecting the most permeable, easy to fabricate, combination to be further explored in Tasks 2 and 3.

The permeability test results of Task 1 showed that all noncoated specimens, irrespective of composition variations, exhibited similar air permeability characteristics. The average peak vacuum pressure differential was 3.7 kN/m^2 (0.53 psi). After coating, the peak differential increased to at least 14.4 kN/m^2 (2.09 psi) even with the most permeable coating (TBS 758 produced by the General Electric Company). A total of 22 specimens were tested before coating and 13 were tested after coating with four different silicone coating materials.

Upon completion of Task 1, the Langley Research Center selected the following compositions for Task 2:

Elastomer	25% (Sylgard 182)	25% (RTV602-SRC-04)
Phenolic microballoons	65%	50%
Glass bubbles	10%	15%
Nylon powder	0	10%

The selection of the 25/65/10 composition was based on the ease of manufacturing, and the selection of the 25/50/15/10 composition was based on plasma arc thermal efficiency tests (conducted at the Langley Research Center).

Three improved manufacturing techniques were demonstrated in Task 2: (1) large batch weighing and mixing of ablative compounds in a new 37.9 mm^3 (10-gallon) vertical helicone mixer; (2) bonding and curing of twelve core-to-facing subassemblies in a multiple heated press; and (3) two-at-a-time panel compaction, fill, and cure operations. The results of these new manufacturing techniques were an improvement in quality and a substantial cost reduction. The flat panel cost estimates for 100 units are now $58 per square foot and for 1000 units are $42 per square foot.

Four panels from Task 2 were mounted in a test fixture and subjected to a simulated shuttle orbiter launch pressure history. Five test runs were conducted in an environmental altitude chamber. The test data presented show that, without a surface coating, the panel was sufficiently permeable to prevent a significant differential pressure buildup. However; panels coated with the two most permeable coatings were damaged by the resultant pressure differentials of 10.3 - 18.6 kN/m^2 (1.5 to 2.7 $lb/in.^2$). Although localized doubler reinforcements and up to nine additional attach points were added, some localized damage still occurred at all attach points.

INTRODUCTION

The results of the previous program for low-cost ablative heat shields for space shuttles[1] have established some unique fabrication methods and have provided much valuable cost data. From this effort, areas of further processing refinements have been identified that provide a basis for reducing fabrication costs and establish a better base line for estimating costs of large quantities of panels. The lowest possible fabrication costs are very important because it is estimated that at least 60 percent of the ablative heat shields on the shuttle will have to be replaced after each space flight. Since thousands of square feet per vehicle are involved, panel costs are of major concern.

Whereas the original program entailed development of two ablative material systems of two densities each, the follow-on study is concerned only with improving the low-density elastomeric-type material (approximately 15 pounds per cubic foot). Based on previous results, panels with this type of ablative compound possess the best dimensional, warp-free characteristics, are comparatively easy to fabricate, and provide the lowest weight ablative heat shields.

After materials and fabrication processes have been selected and panels fabricated, the significance of the boost pressure differentials across the ablator panel is to be determined.

The study described in this report was divided into three tasks. The task objectives and rationale are as follows:

TASK OBJECTIVES

Task 1. Vary the composition of the ablative material, both in percentages of constituents and in the resins and fillers used, to achieve ease of fabrication while maintaining reliability and performance.

Task 2. After selection of the material composition, from test results of Task 1, fabricate twelve identical flat panels to establish a good base line for estimating costs.

---

[1] Final Report, Low-Cost Ablative Heat Shield for Space Shuttles, Contract NAS1-9943, NASA CR-11175

Task 3. Fabricate a pressure differential test fixture and install and test uncoated and coated flat panels from Task 2 to establish the significance of the pressure differentials which might occur during a simulated ascent pressure history.

TASK DEFINITION RATIONALE

Task 1. One difficulty previously encountered was the time-consuming mixing of the compound, which is one of the specific problems to be solved in this study. The difficulty can be overcome to a large degree by making minor composition modifications, using more recently improved materials in formulating the ablative compounds, and using larger mixing equipment to produce larger batches. These composition changes are to be evaluated for ease of fabrication and density control, and test specimens prepared for thermal performance testing at Langley Research Center by NASA personnel, before full-size flat panels are fabricated.

Another area of concern is whether pressure buildup during ascent of an actual vehicle would be of sufficient magnitude to present an attachment design problem. To study this potential problem, small 6-inch-diameter specimens are to be fabricated and qualitatively tested early in the program to select the best compositions and coatings from an air permeability standpoint.

Task 2. After obtaining the producibility, thermal efficiency, and venting capability test results, a final selection of composition is to be made by NASA/LRC personnel, and identical flat panels are to be fabricated to establish a better base line for cost estimating without sacrificing material performance or reliability.

Task 3. Following this effort, a full-size panel mounting fixture will be fabricated, and a number of previously fabricated panels with and without coatings are to be subjected to qualitative launch simulation pressure tests to evaluate the adequacy of the panel attachment spacing versus the differential pressure buildup which could occur depending on panel porosity. The logic for conducting these tests is that the panel configuration was selected to enhance replaceability and, therefore, is not bonded to the vehicle skin but is attached at discrete points. Thus, on an actual vehicle, there is a possibility of a differential pressure buildup across the panel during ascent, tending to force the panel away from the vehicle. This could impose severe design problems on the attachments. This problem is of considerable concern to designers of replaceable ablative heat shields for space shuttle. However, the problem may be alleviated

by proper selection of the ablative panel configuration. By using an ablative panel with a porous face sheet, relying on the inherent permeability of the ablation material, and judicious selection of any surface coating which may be required, it may be possible to fabricate a heat shield through which air can escape, thus preventing the differential pressure buildup. This theory is predicated on finding a surface coating which will allow the air to escape while still performing any required functions such as moisture sealing, temperature control, etc.

This Page Intentionally Left Blank

TASK 1: MATERIAL VARIATION STUDIES

This initial study was conducted to further investigate the feasibility of varying the composition of the ablation filler materials to increase the ease of fabrication, such as mixing, handling, density control, friability, etc., without adversely affecting quality, reliability and thermal performance. The following materials were studied:

1. Three other silicone resins—RTV 602, RTV 655, and 541-111 were selected to compare with Sylgard 182 used in the previous program.

2. Combinations of fillers—phenolic microballoons, Saran microspheres, glass bubbles, and nylon power in varying percentages were selected for evaluation.

3. Four ratios of resin to filler were selected (i.e., 15-percent resin, 85-percent filler, 20-percent resin, 80 percent filler; 25-percent resin, 75-percent filler; and 30-percent resin, 70-percent filler.

4. Two core primers were selected—DC 1203 silicone primer and SC 1008 phenolic primer.

Table 1 is a detailed list of materials used in the fabrication of the 7.6 cm (3-inch) diameter ablative test models and 15.2 cm (6-inch) diameter air permeability test specimens described later.

SPECIMEN MOLDS

One 7.6 cm (3-inch) diameter mold was available prior to start of contract for the fabrication of the ablative test models in compliance with Figure 1. This allowed fabrication to start immediately after contract go-ahead. Due to the relatively large quantity of specimens required, it was decided to make a four-cavity mold as shown in Figures 2 and 3. The two molds allowed the fabrication and delivery of all specimens to be accomplished at a satisfactory rate. The 15.2 cm (6-inch) diameter molds, shown in Figures 4 and 5, were made for fabrication of the air permeability vent specimens.

Table 1. Materials Evaluated

Material Type	Designation	Supplier
Facing prepreg	R 1714	Reliabond Corp.
Honeycomb core	HRP 3/8 - GF 12-3.2	Hexcel Corp.
Silicone elastomer	Sylgard 182	Dow Corning
	RTV 602	General Electric Co.
	RTV 655	General Electric Co.
	541-111	General Electric Co.
Core primers	1203	Dow Corning
	SC 1008	Monsanto
Fillers	Phenolic, microballoon, BJO-0930	Union Carbide
	Nylon, polypenco 66D	Polymer Corp
	Glass bubbles B-30B	3M
	Saran microspheres No. XD-7051.04	Dow Chemical
	Saran Powder No. 7052-02	Dow Chemical
Coatings	92-007 thermal control coating (white)	Dow Chemical
	92-009 dispersion coating (clear)	Dow Corning
	TBS-757 foam thermal barrier (white)	General Electric Co.
	TBS-758 thermal coating (white)	General Electric Co.

FILLER COMPOUND EVALUATION

Saran Microspheres No. XD-7051.04 and Saran Powder No. XD-7052.02

One of the efforts in Task 1 was to evaluate other types of filler material than were used in the previous contract (Contract NAS1-9943). The

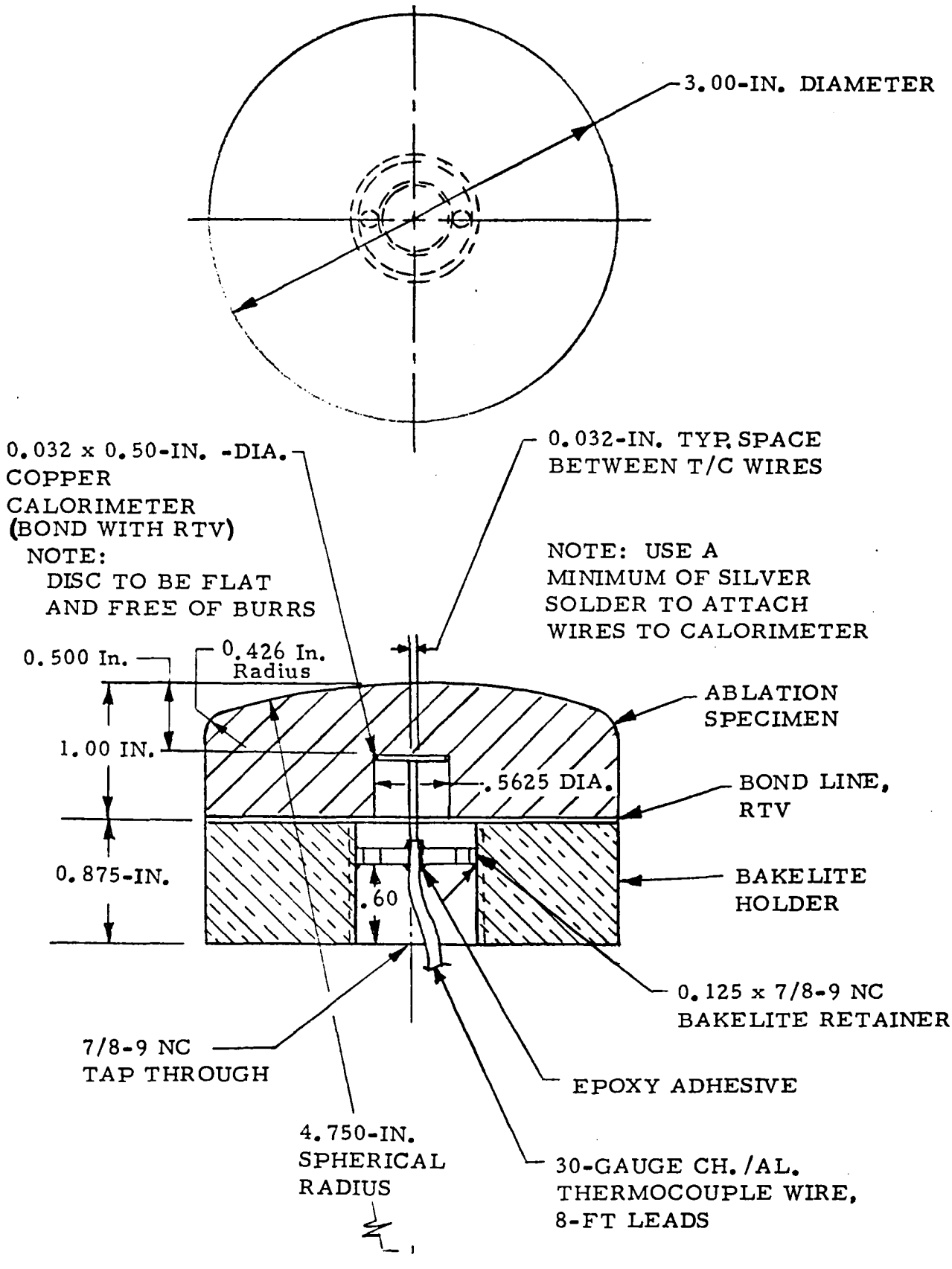


Figure 1. Plasma Arc Test Model

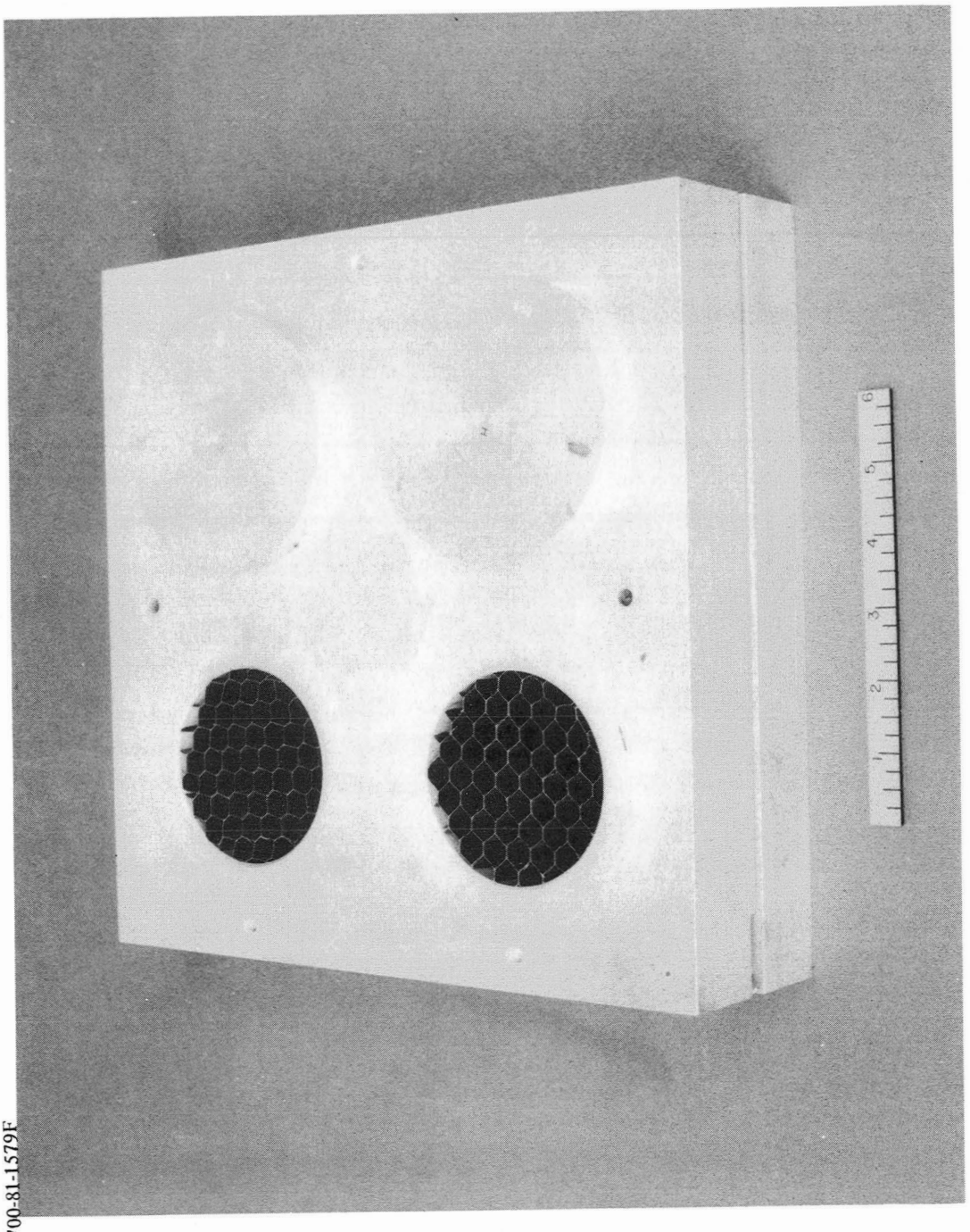
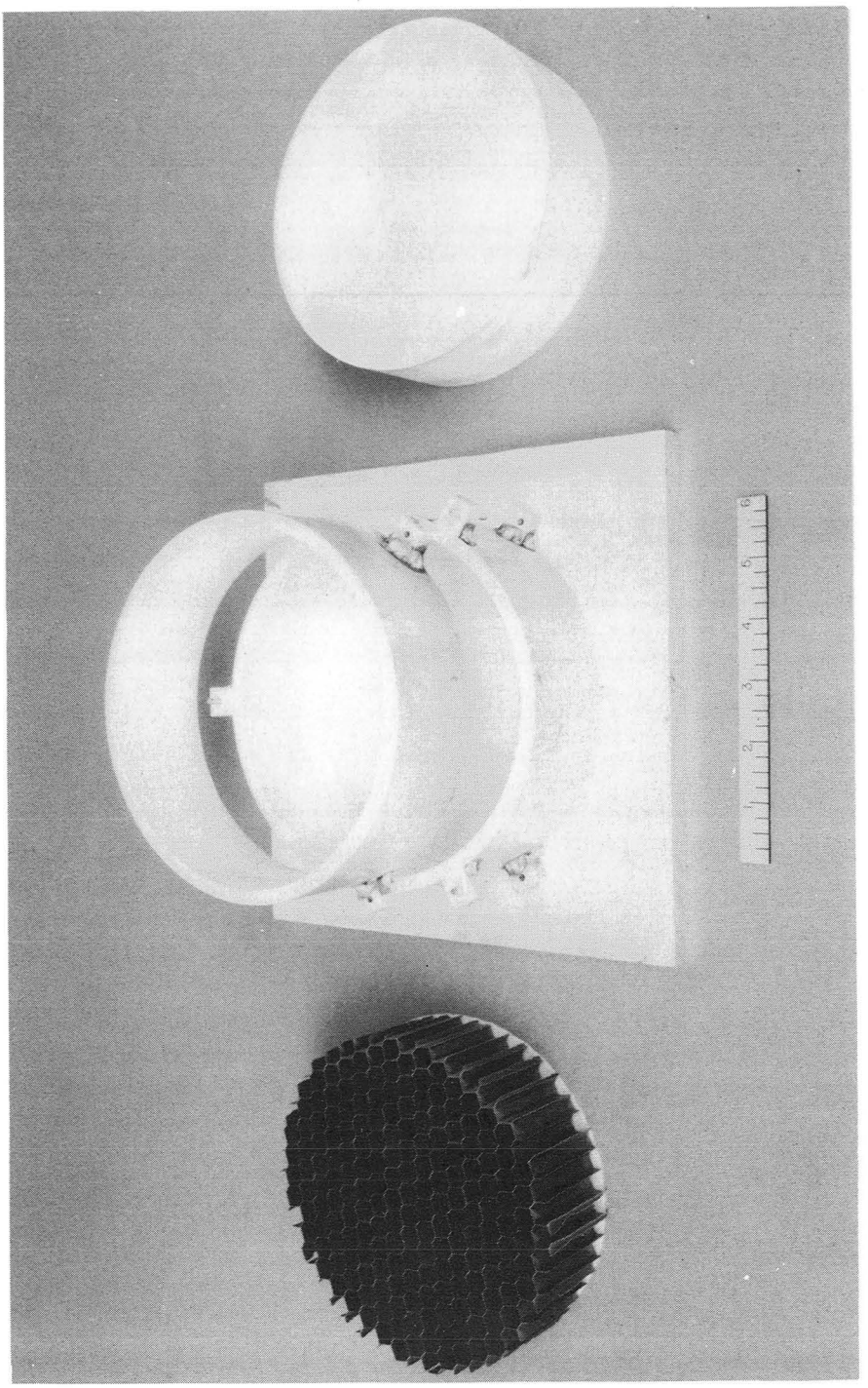


Figure 2. Mold for Plasma Arc Test Model, Core in Place

700-81-1579E

Figure 3. Mold for Plasma Arc Test Model, Model Removal



700-81-1579C

Figure 4. Mold for Vent Test Model With Prebonded Core and Face Sheet

700-81-1579D

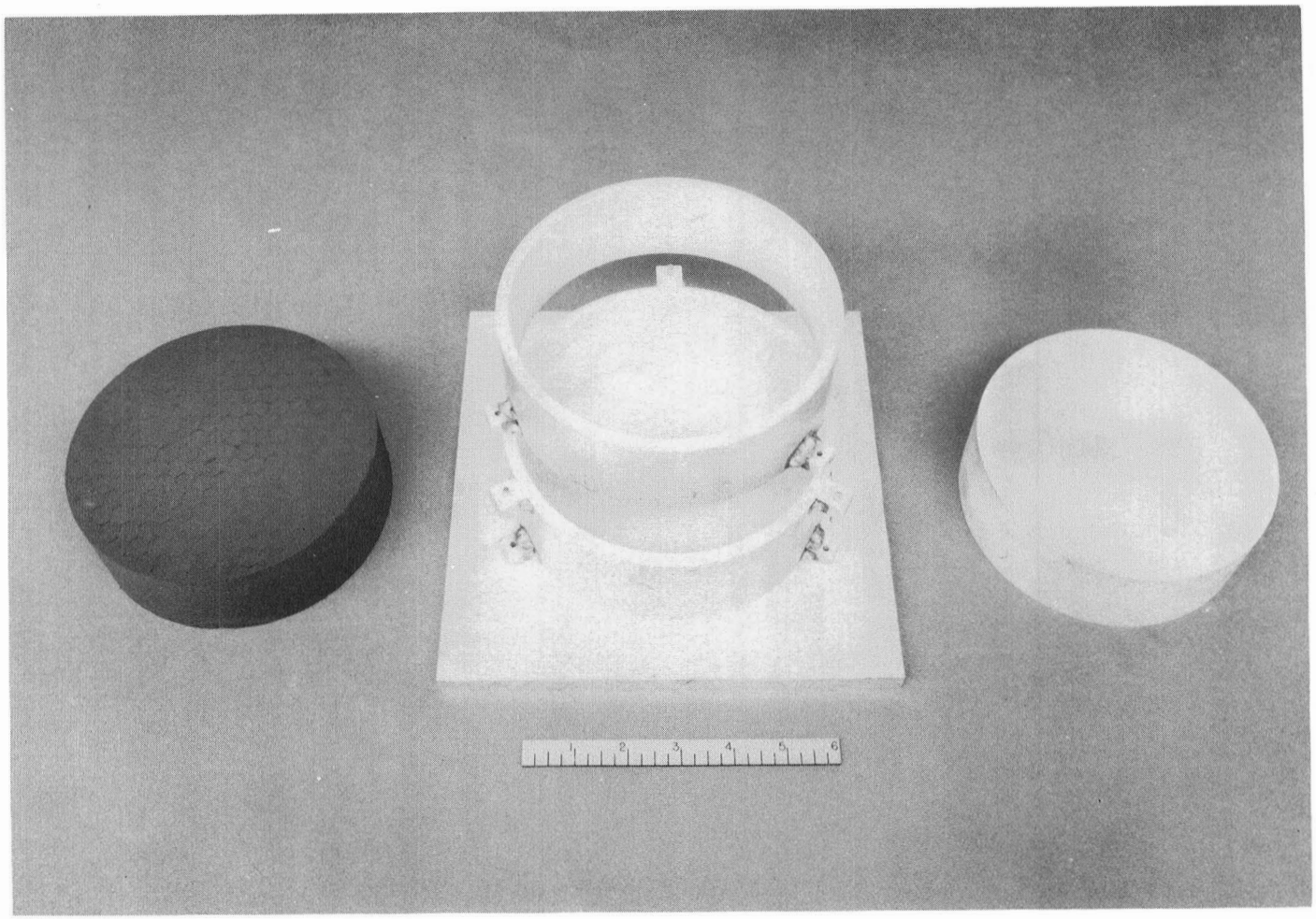


Figure 5. Mold for Vent Test Model With Completed Model Removed

Space Division
North American Rockwell

objective was to increase ease of fabrication while maintaining density control, reliability, and performance. A Saran filler material was obtained in two forms from Dow Chemical. One was in the form of microspheres while the other was a heat-foamable powder. All attempts to mix the Saran microspheres with Sylgard 182 resin met with failure. This was due to the extremely fine low density nature of the filler which caused a dust cloud even when hand mixing methods were used. The next attempts were made with the powder which was supposed to foam at a relatively low temperature (311K). The mixing was accomplished without difficulty, but it took several attempts at various cure temperatures before the material would foam. A cure cycle of 16 hours at 380 K (225 F) appeared to be the best when mixing the Dow Saran powder in Sylgard 182 resin. A low percentage produced a uniform mixture whereas a high percentage (20 percent) caused large irregular bubbles to form.

The next step was to scale up from the 7.6 cm (3-inch) diameter specimen size to the 15.2 cm (6-inch) diameter by 5.1 cm (2-inch) thick size planned for the air permeability vent tests. Several attempts were made where cure time was increased from 4 to 16 hours and the Saran powder was increased from 3.1 to 6.2 percent without success. The problem was that the foaming action was considerably less than previously found and this resulted in incomplete filling of the core cells. It was felt that cell wall drag was probably responsible for this result since core was not used previously. After the Langley Research Center was notified of the problem, it was mutually agreed to discontinue further tests with the Saran materials.

Glass Bubbles, B-30B

At the beginning of the contract NASA/LRC, recommended that glass microspheres in quantities of approximately 15 percent be introduced in place of a portion of the phenolic microballoons to improve the char stability. This was done, and mixing was accomplished with about the same ease as with all phenolic microballoons.

Nylon Powder, Polypenco 66D

Due to the favorable thermal test results at NASA/LRC when 10-percent nylon powder was added to the elastomeric compound, it was decided to substitute nylon powder for phenolic microballoons in some of the specimens. There was a noticeable increase in hand mixing time when one compound was mixed using three different fillers. This was 25-percent RTV 602 resin, 10-percent nylon powder, 15-percent glass bubbles, and 50-percent phenolic microballoons. Since the amount mixed was only 210 grams and was mixed by hand, it was felt that machine mixing could eliminate the need for a longer mixing time on large batches.

CORE PRIMER EVALUATION

Two core assemblies for the vent specimens were primed with a silicone primer DC 1203, filled with the 20-percent Sylgard 182, 80-percent microballoon compound, and cured. Others were primed with a phenolic primer SC 1008, which was air dried for 1 hour at room temperature.

After filling and curing, the two specimens were visually inspected upon removal from the molds and handled. Those primed with the SC 1008 obviously indicated a stronger bond between the filler and the core cell walls. The filler in exposed edge cells readily fell out when the DC 1203 was used. Therefore, all plasma arc specimens and vent specimens, except specimens 1 and 2 (reference Table 3) were primed with the phenolic SC 1008.

SILICONE RESIN EVALUATION

Sylgard 182

Since Sylgard 182 was used and evaluated in Contract NAS1-9943 (see Reference 1), this resin was used as a control in the fabrication of all Task 1 test specimens. In comparison with the other three resins evaluated, there was no discernable difference in ease of mixing or fabrication of specimens. This resin after catalyzing and mixing with fillers has an excellent pot life that is significantly greater than the RTV 602. The pot life, when stored in a freezer at 266 K (20 F), is at least 30 days, which would present a cost and schedule advantage for producing ablative panels in large quantities.

A resin cost comparison is shown in Table 2 which shows Sylgard 182 and RTV 602 to be lower in cost than RTV 655.

RTV 602

RTV 602 seemed, from a producibility viewpoint, to have similar characteristics to Sylgard 182 with the exception of pot life. Originally, the manufacturer's recommendation was to use 0.5 to 1.0 percent, by weight, of SRC-04 catalyst. Even with 0.5 percent catalyst, the mixed compound could be used only for approximately 8 hours.

After consulting with the Silicone Products Division of General Electric, the catalyst content was reduced to 0.25 percent. This resulted in a slightly improved pot life of approximately 12 hours.

Table 2. Silicone Resin Cost Comparison

Resin	Supplier	Cost/Min. Lot Size		
		10-Lb Lots ($ per lb)	55-Lb Lots ($ per lb)	495-Lb Lots ($ per lb)
Sylgard 182	Dow Corning	5.75	5.30	5.20
RTV 602	General Electric	5.80	5.40	5.25
RTV 655	General Electric	9.40	8.95	8.80
#541-111	General Electric	----	----	3.90

RTV 655

The RTV 655 resin, while being the most costly resin of the group, exhibited two advantages when mixed with the various fillers used in Task 1. RTV 655 had a better pot life than RTV 602, but probably not as good as Sylgard 182. It also produced the best binder adhesion characteristics of all resins evaluated. This resin produced the toughest surface of all specimens produced, which is probably due to the higher strength of the resin and better adhesion to the filler materials.

No. 541-111 (Experimental)

No. 541-111 is a low-cost experimental pigmented silicone potting compound evaluated primarily because of its attractive low price. After curing, however, the specimens were very fragile. It produced, by far, the poorest adherence to the filler materials of all resin systems. Since the plasma arc specimens could not be released from the molds completely intact, it was decided not to attempt to make vent test specimens using the 541-111 resis system.

FABRICATION OF PLASMA ARC TEST MODELS

Eighteen different combinations of silicone resins and filler materials were used in the fabrication of the plasma arc test specimens (Figure 1). Figures 2 and 3 show how the molds were used to produce the individual test specimens. Even though a four-cavity mold is shown, only three were used to produce the three identical specimens at a time. The various components required to produce the finished test models are shown in Figure 6. Figure 7 shows how the RTV 102 sealant was applied to seal the holes in the retainer as well as to bond the retainer to the holder. A total of 54 specimens

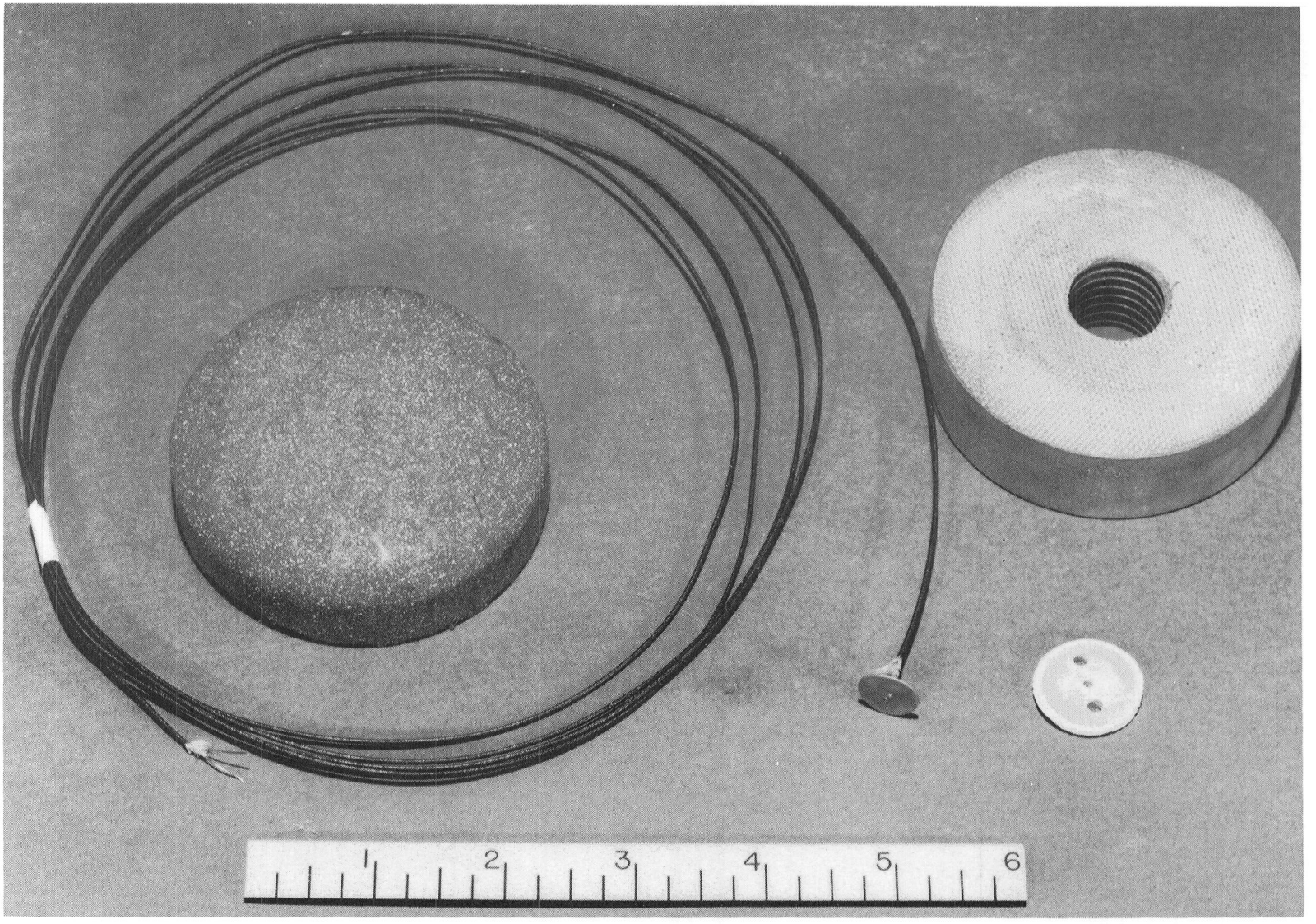
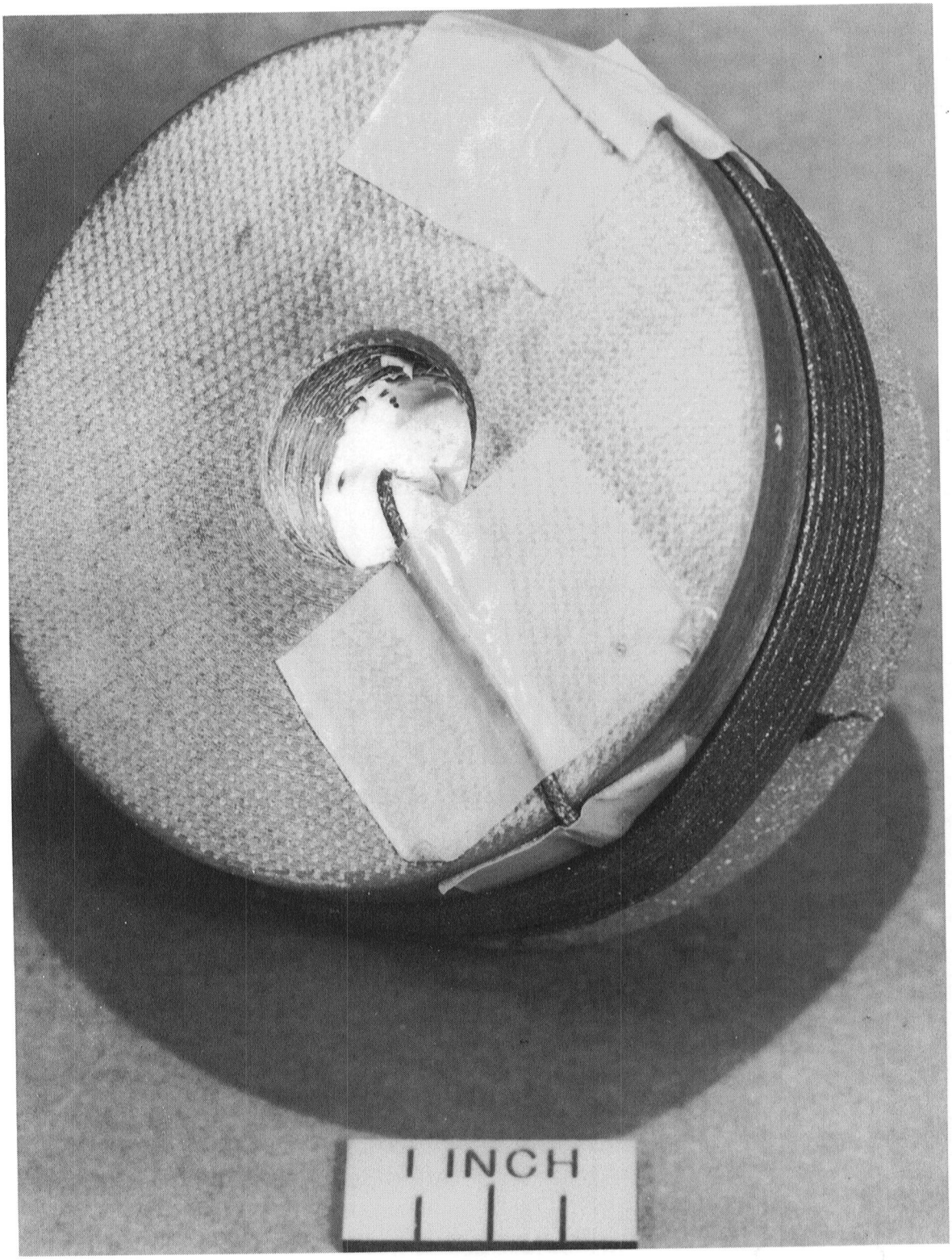


Figure 6. Calorimeter, Holder, and Ablation Specimen for Plasma Arc Test Model

Space Division
North American Rockwell



700-86-1023D

Figure 7. Plasma Arc Test Model Assembled Complete

were shipped to NASA/LRC, although over sixty specimens were made. It was decided not to ship those with poor surfaces caused by the very fragile nature of specimens made with 541-111 resin. All specimens were produced with hexagonal core, HRP 3/8 GF 12-3.2, primed with phenolic primer SC 1008, air dried 1 hour at room temperature, filled with compound, and cured for 16 hours at 394 K (250 F). Table 3 identifies the specimen numbers, composition, and density of those delivered test models.

All test specimens were delivered to NASA-LRC for plasma arc testing to determine thermal efficiency and char stability characteristics.

FABRICATION AND EVALUATION OF AIR PERMEABILITY VENT SPECIMENS

Fabrication of Specimens

The specimen size selected for the preliminary vent tests was 5 cm (2 in.) thick by 15.2 cm (6 inches) in diameter. The core and facing prepreg (listed previously) were bonded as a subassembly, filled with ablator, and cured according to procedures reported in Report NASA CR-111795. The typical core-facing subassembly, filling and curing molds, and a typical finished specimen are shown in Figures 4 and 5. A total of 26 specimens were fabricated in which eighteen different combinations of silicone resin and filler combinations were used. Four different resins were used—Dow Corning's Sylgard 182, General Electric's RTV 602, RTV 655, and experimental resin No. 541-111. The fillers ranged from all phenolic microballoons to combinations of nylon powder, glass bubbles, and phenolic microballoons.

Table 4 lists the various compounds formulated, the cure cycles used, specimen densities obtained, characteristics of the finished specimen, and pressure differential test results of all specimens tested.

Design and Fabrication of Air Permeability Vent Fixture

An inexpensive test fixture, shown in Figure 8, was designed and fabricated to test and evaluate the relative air permeability of the ablative test specimens noted previously. The fixture was made from 6061 aluminum alloy and was designed for the specimen to be supported and sealed in the center of the pipe with a leak-tight removable cap and base. This provides for an upper and lower air chamber. The lower chamber was connected to a vacuum pump so that it could be evacuated at a rate which would simulate an ascent pressure history.

Table 3. Composition and Density of Plasma Arc Test Specimens

Specimen Numbers	Compound (Percent)	Formula Type	Average Density kg/m^3 (lb/ft^3)	Remarks
FTS A-1-1, FTS A-1-2, FTS A-1-3	20 80	RTV 655 Phenolic microballoons	247.3 (15.44)	Good surface adherence.
FTS A-2-1, FTS A-2-2, FTS A-2-3	20 80	RTV 602 Phenolic microballoons	248.3 (15.50)	Surface rubs off slightly.
FTS A-3-1, FTS A-3-2, FTS A-3-3	20 80	Sylgard 182 Phenolic microballoons	248.3 (15.50)	Surface rubs off slightly.
FTS A-4-1, FTS A-4-2, FTS A-4-3	20 80	GE 541-111 Phenolic microballoons	270.1 (16.86)	Extremely fragile. Surface powdery.
FTS B-1-1, FTS B-1-2, FTS B-1-3	15 10 75	RTV 602 Nylon Phenolic microballoons	261.7 (16.34)	Surface rubs off very easily. Fragile.
FTS B-2-1, FTS B-2-2, FTS B-2-3	15 10 75	RTV 655 Nylon Phenolic microballoons	270.1 (16.86)	Surface rubs off very easily. Fragile.
FTS B-3-1, FTS B-3-2, FTS B-3-3	15 10 75	Sylgard 182 Nylon Phenolic microballoons	275.0 (17.17)	Surface rubs off very easily. Fragile.
FTS C-1-1, FTS C-1-2, FTS C-1-3	20 15 65	RTV 602 Glass bubbles Phenolic microballoons	271.4 (16.94)	Surface condition same as 20/80.
FTS C-2-1, FTS C-2-2, FTS C-2-3	20 15 65	Sylgard 182 Glass bubbles Phenolic microballoons	267.2 (16.68)	Surface conditions same as 20/80.
FTS C-3-1, FTS C-3-2, FTS C-3-3	20 15 65	RTV 655 Glass bubbles Phenolic microballoons	276.6 (17.27)	Surface condition same as 20/80.
FTS D-1-1, FTS D-1-2, FTS D-1-3	20 10 70	RTV 602 Nylon microballoons	270.1 (16.86)	Surface condition same as 20/80.
FTS D-2-1, FTS D-2-2, FTS D-2-3	20 10 70	Sylgard 182 Nylon microballoons	263.7 (16.46)	Surface conditions same as 20/80.
FTS D-3-1, FTS D-3-2, FTS D-3-3	20 10 70	RTV 655 Nylon microballoons	272.0 (16.98)	Surface condition same as 20/80.
FTS E-1-1, FTS E-1-2, FTS E-1-3	30 70	RTV 602 Phenolic microballoons	266.7 (16.65)	Easier to mix. Very good surface.
FTS E-2-1, FTS E-2-2, FTS E-2-3	30 70	RTV 655 Phenolic microballoons	266.1 (16.61)	Easier to mix. Best surface of all.
FTS E-3-1, FTS E-3-2, FTS E-3-3	30 70	Sylgard 182 Phenolic microballoons	271.4 (16.94)	Easier to mix.
FTS F-1-1, FTS F-1-2, FTS F-1-3	25 15 10 50	RTV 602 Glass bubbles Nylon microballoons	270.1 (16.86)	Mixing was time-consuming. Surface condition same as 20/80.
FTS F-2-1, FTS F-2-2, FTS F-2-3	25 15 10 50	RTV 655 Glass bubbles Nylon Phenolic microballoons	238.7 (14.9)	Surface condition slightly improved over that of specimen group FTS F-1.
FTS G-1-1, FTS G-1-2 FTS G-1-3	25 65 10	Sylgard 182 Microballoons Glass bubbles	264.3 (16.5)	Easy to mix

Table 4. Evaluation of Air Permeability Vent Specimens (Uncoated)

Specimen No.	Compound Formula		Cure Cycle*	Density, gms/cm^3 (lb/ft^3)	Maximum Vacuum Differential, kN/m^2 (psi)	Maximum Vacuum Differential After Perforating Skin kN/m^2 (psi)	Time to Reach Maximum Differential (sec)	Remarks
	Percentage	Material Type						
1	20 80	Sylgard 182 Phenolic microballoons	Press cured 4 hr at 394 K	245.1 (15.30)	2.3 (0.34)	1.7 (0.25)	60	Good appearance*. Core primer DC1203.
2	32.3 3.1 64.6	Sylgard 182 Saran powder Phenolic microballoons	Oven cured 3 hr at 394 K 1 hr at 408 K	252.3 (15.75)	Not tested			Incomplete fill. Little foaming action. Core primer DC1203.
3	32.3 3.1 64.6	Sylgard 182 Saran powder Phenolic microballoons	Oven cured 16 hr at 394K	251.2 (15.68)	Not tested		60	Incomplete fill. Little foaming action. Core primer SC1008.
4	32.3 6.2 61.5	Sylgard 182 Saran powder Phenolic microballoons	Oven cured 16 hr at 394 K	257.4 (16.07)	8.5 (1.23)		60	Incomplete fill. Slight increase in foaming action.
5	20 80	Sylgard 182 Phenolic microballoons	Press cured 3-1/2 hr at 394 K	253.3 (15.81)	7.1 (1.032)	7.1 (1.032)	60	SC1008 primer partially sealed skin core. Filling difficult.
6	20 80	Sylgard 182 Phenolic microballoons	Press cured 3 hr at 394 K	262.5 (16.39)	6.8 (0.98)	5.1 (0.74)	60	Scrim added to absorb excess primer. Some sealing of skin. Good surface.
7	20 80	RTV 602 Phenolic microballoons	Oven cured 5 hr at 394 K	225.6 (14.08)	1.7 (0.25)	1.7 (0.25)	60	Incomplete fill.
8	20 80	RTV 655 Phenolic microballoons	Oven cured 16 hr at 394 K	256.4 (16.01)	2.7 (0.39)	2.7 (0.39)	60	Surface has better adherence than others with 20 percent resin.
9	30 70	Sylgard 182 Phenolic microballoons	Over cured 3 hr at 394 K 3 hr at 408 K	251.4 (15.69)	2.3 (0.34)	3.4 (0.49)	60	Good appearance.
10	30 70	RTV 655 Phenolic microballoons	Oven cured 16 hr at 394 K	253.3 (15.81)	5.1 (0.74)	2.0 (0.29)	60	Slight incomplete fill. Good surface.

*The cure cycle was varied in an attempt to reduce the cure time and press curing was used as a convenient optional method

Space Division
North American Rockwell

Table 4. Evaluation of Air Permeability Vent Specimens (Uncoated) (Cont)

Specimen No.	Compound Formula		Cure Cycle	Density, kg/m^3 (lb/ft^3)	Maximum Vacuum Differential kN/m^2 (psi)	Maximum Vacuum Differential After Perforating Skin, kN/m^2 (psi)	Time to Reach Maximum Differential (sec)	Remarks
	Percentage	Material Type						
11	30 70	RTV 602 Phenolic microballoons	Oven cured 16 hr at 394 K	269.7 (16.84)	3.4 (0.49)	3.0 (0.44)	50	Good appearance.
12	30 70	RTV 655 Phenolic microballoons	Oven cured 16 hr at 394 K	272.3 (17.00)	6.8 (0.98)	6.8 (0.98)	50	Very good surface adherence.
13	20 65 15	RTV 602 Phenolic microballoons Glass bubbles	Oven cured 16 hr at 394 K	252.9 (15.79)	2.0 (0.29)	1.7 (0.25)	60	Good appearance.
14	30 70	Sylgard 182 Phenolic microballoons	Oven cured 16 hr at 394K	269.7 (16.84)	Not tested (Same composition as specification 9)			Good appearance.
15	20 15 65	Sylgard 182 Glass bubbles Phenolic microballoons	Oven cured 16 hr at 394 K	253.3 (15.81)	2.3 (0.34)	1.4 (0.20)	60	Surface rubs off easily.
16	20 15 65	RTV 655 Glass bubbles Phenolic microballoons	Oven cured 16 hr at 394 K	253.6 (15.83)	3.0 (0.44)	2.7 (0.39)	50	Good surface adherence.
17	15 10 75	RTV 602 Nylon microballoons	Oven cured 16 hr at 394 K	252.5 (15.76)	3.4 (0.49)	3.4 (0.49)	60	Takes longer to mix. Surface rubs off very easily.
18	15 10 75	RTV 655 Nylon microballoons	Oven cured 6 hr at 394 K	257.1 (16.05)	5.7 (0.83)	5.7 (0.83)	20	Takes longer to mix. Surface rubs off very easily.
19	15 10 75	Sylgard 182 Nylon microballoons	Oven cured 16 hr at 394 K	251.2 (15.68)	3.4 (0.49)	3.4 (0.49)	30	Takes longer to mix Surface rubs off very easily.
20	20 10 70	RTV 602 Nylon microballoons	Oven cured 16 hr at 394 K	247.6 (15.46)	2.7 (0.39)	2.7 (0.39)	30	Good surface appearance.
21	20 10 70	Sylgard 182 Nylon microballoons	16 hr at 394 K	252.3 (15.75)	4.0 (0.58)	4.0 (0.58)	20	Good surface appearance.

Space Division
North American Rockwell

Table 4. Evaluation of Air Permeability Vent Specimens (Uncoated) (Cont)

Specimen No.	Compound Formula		Cure Cycle	Density kg/m^3 (lb/ft^3)	Maximum Vacuum Differential kN/m^2 (psi)	Maximum Vacuum Differential After Perforating Skin, kN/m^2 (psi)	Time to Reach Maximum Differential (sec)	Remarks
	Percentage	Material Type						
22	20 10 70	RTV 655 Nylon microballoons	Oven cured 16 hr at 394 K	251.7 (15.71)	3.0 (0.44)	3.0 (0.44)	30	Good surface adherence.
23	20 80	RTV 602 Phenolic microballoons	Oven cured 16 hr at 394 K	250.0 (15.61)	6.8 (0.98)	6.8 (0.98)	30	Good surface adherence.
24	25 15 10 50	RTV 602 Glass bubbles Nylon microballoons	Oven cured 16 hr at 394 K	261.5 (16.33)	Not tested			Incomplete fill. Skin removed. Longer mix time used.
25	25 15 10 50	RTV 602 Glass bubbles Nylon microballoons	Oven cured 16 hr at 394 K	263.5 (16.45)	3.7 (0.54)	3.7 (0.54)	30	Good fill and good surface. Longer mix time.
26	25 10 65	Sylgard 182 Glass bubbles Phenolic microballoons	Press cured 3-1/2 hr at 394 K		1.0(0.15)		50	

*Good appearance is visual evidence of a good non-powdery surface and a complete fill.

Space Division
North American Rockwell

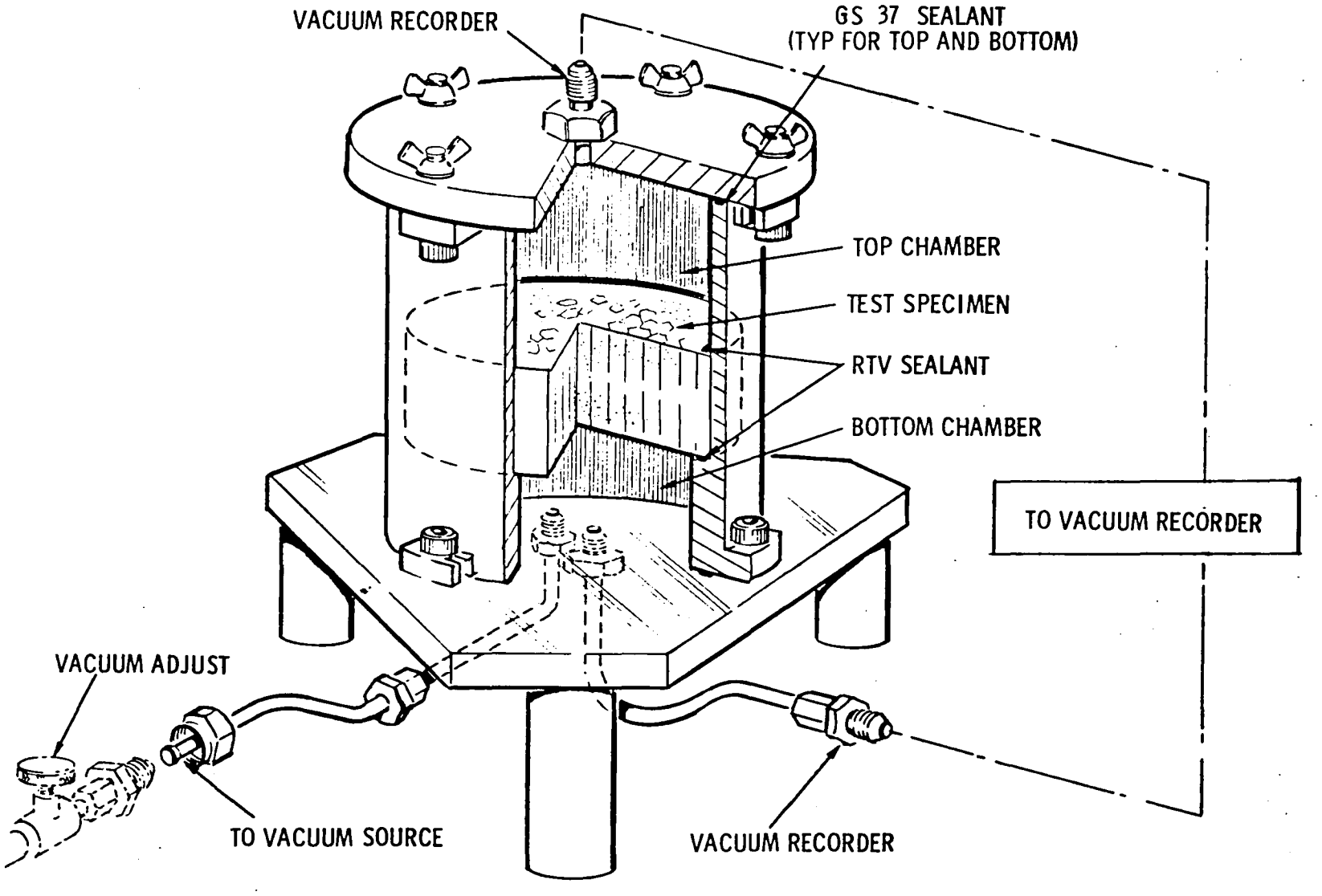


Figure 8. Test Fixture Design for 6-Inch-Diameter Vent Test Model

Pressure differential histories across the specimens were measured and recorded.

Test Setup and Procedure

The air permeability test setup is shown in Figure 9. The primary components consisted of a laboratory quality vacuum pump (not shown), the vent test fixture, a dual vacuum recorder, and a stop watch. Prior to testing the specimens, a leak check was made to verify the sealing method and that all connections were tight.

The assembly sequence and test procedure was as follows:

1. Each specimen was placed in the test fixture shown in Figures 8 and 10, sealed with RTV 102 sealant, and cured at room temperature for several hours until tack free.

2. The cylindrical section was attached to the base plate and top plate using GS-27 sealant to prevent air leakage.

3. One vacuum pump line was attached to a closed needle valve at the base and one vacuum recorder line connected to the base. The bottom chamber simulates the ambient atmospheric pressure during ascent.

4. The other dual recorder line was then attached to the upper plate to record the air vent rate.

5. After starting the vacuum pump, the needle valve was adjusted to achieve a vacuum rate of approximately 91.2 kN/m^2 (27 inches of mercury) in 1 minute. The stop watch was started at the same time.

6. At 10-second intervals, the graph paper was rotated slightly. Equilibrium usually occurred after 2 minutes when 97.9 kN/m^2 (29 inches of mercury) vacuum was reached.

7. The maximum differential pressure was then read from the dual recorder chart paper.

Air Permeability Vent Test Results

Uncoated Specimens

A total of twenty-two uncoated specimens were tested at least two times each, without and with facing perforations. The maximum pressure

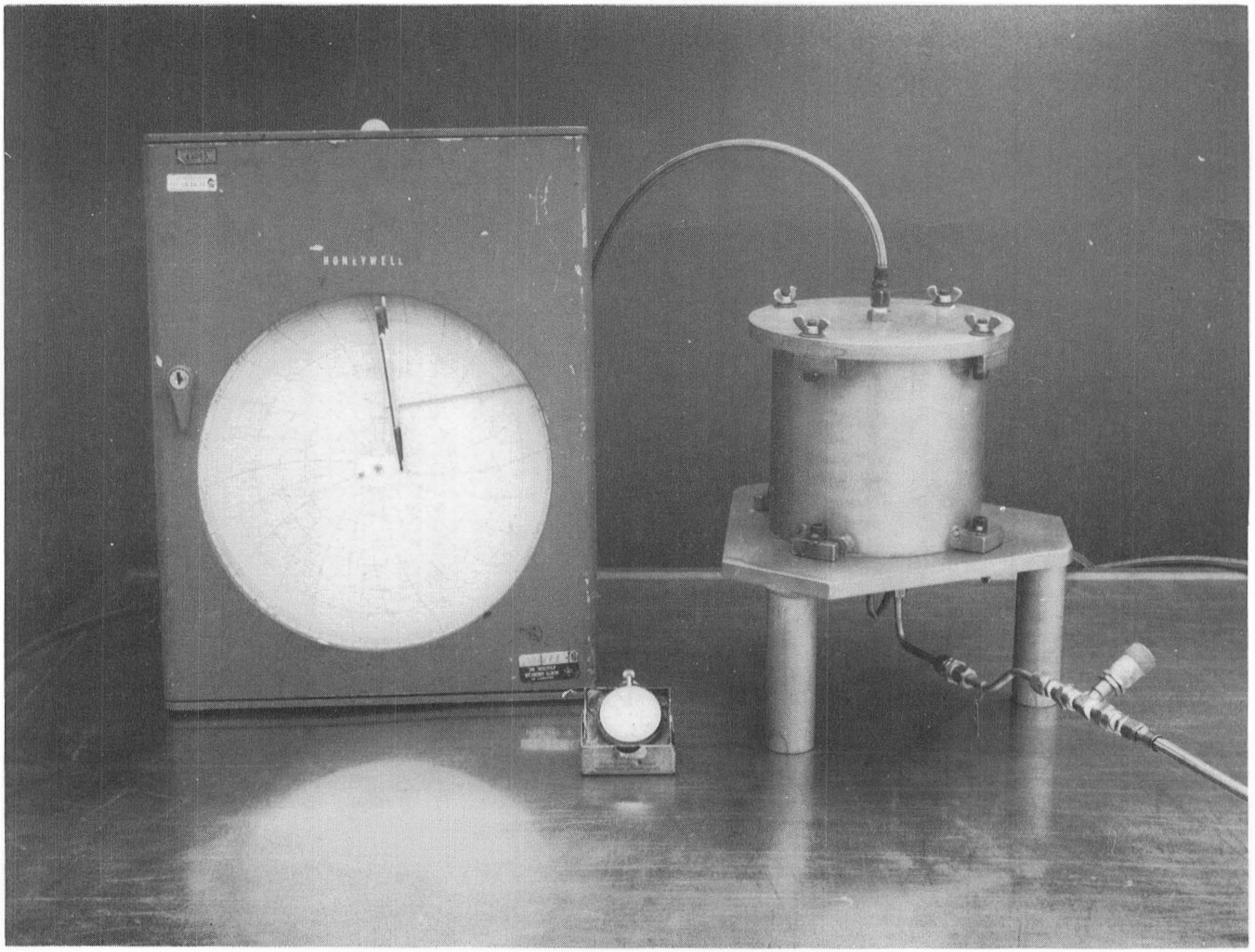


Figure 9. Six-Inch-Diameter Vent Test Model Test Setup

differentials obtained are reported in Table 3 for two specimen conditions. One test was on specimens as fabricated and the other was when the tests were repeated after adding a prick-punch perforated hole in each cell. (See Figure 10.) The perforations were added because it was suspected that the open weave facing might have been partially sealed by the primer. The perforations improved the permeability of about one third of the specimens, but the amount was not significant. There was no evidence to indicate that permeability was adversely affected due to increasing the resin content of the filler compound from 20 percent to 30 percent. The primary significance of the test results is that the highest pressure differential obtained was only 8.5 kN/m^2 (1.23 psi). This occurred on specimen 4, which was one of the specimens fabricated to evaluate the Saran foaming material. The lowest pressure differential was 1.0 kN/m^2 (0.15 psi) recorded on specimen 26. The average pressure differential was 3.9 kN/m^2 (0.57psi) for nonperforated specimens and 3.4 kN/m^2 (0.49 psi) for perforated specimens. In Figure 11, a plot of vacuum versus time is shown for the upper and lower chambers. The maximum difference occurred after approximately 60 seconds. This is the maximum pressure differential listed in Table 4. Also, shown on the figure is the ambient pressure history during ascent.

Coated Specimens

Nine previously tested specimens were selected to evaluate the influence of four different silicone coatings on reducing the permeability on three different ablative formulations. Each specimen was hand coated at random with one of the four coatings. Then, when it was found that the coating could be peeled after testing, the same specimen was recoated up to two additional times to reduce the number of variables influencing the test. The individual test results are shown in Table 5 and are summarized in Table 6. The coatings showing the most promise were the DC 92-009 and TBS 758. Even with these coatings the pressure differential was 3 to 7 times higher than the uncoated specimens. The lowest average differential pressure was 14.41 kN/m^2 (2.09 psi) for specimens coated with TBS 758. There was considerable scatter in the individual values. This scatter was due primarily to variations in coating thickness.

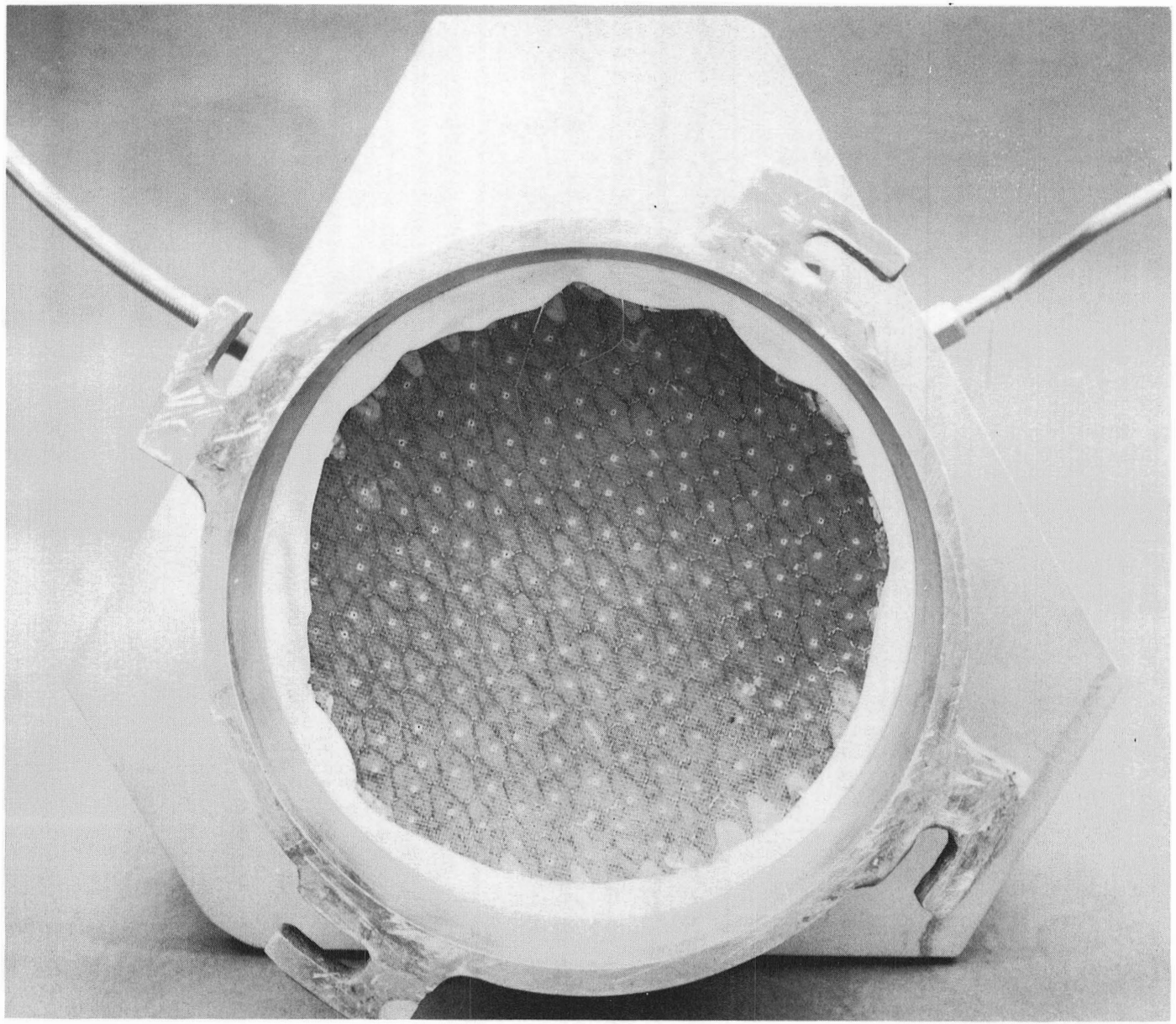


Figure 10. Perforated Air Permeability Specimen Sealed in Fixture

Space Division
North American Rockwell

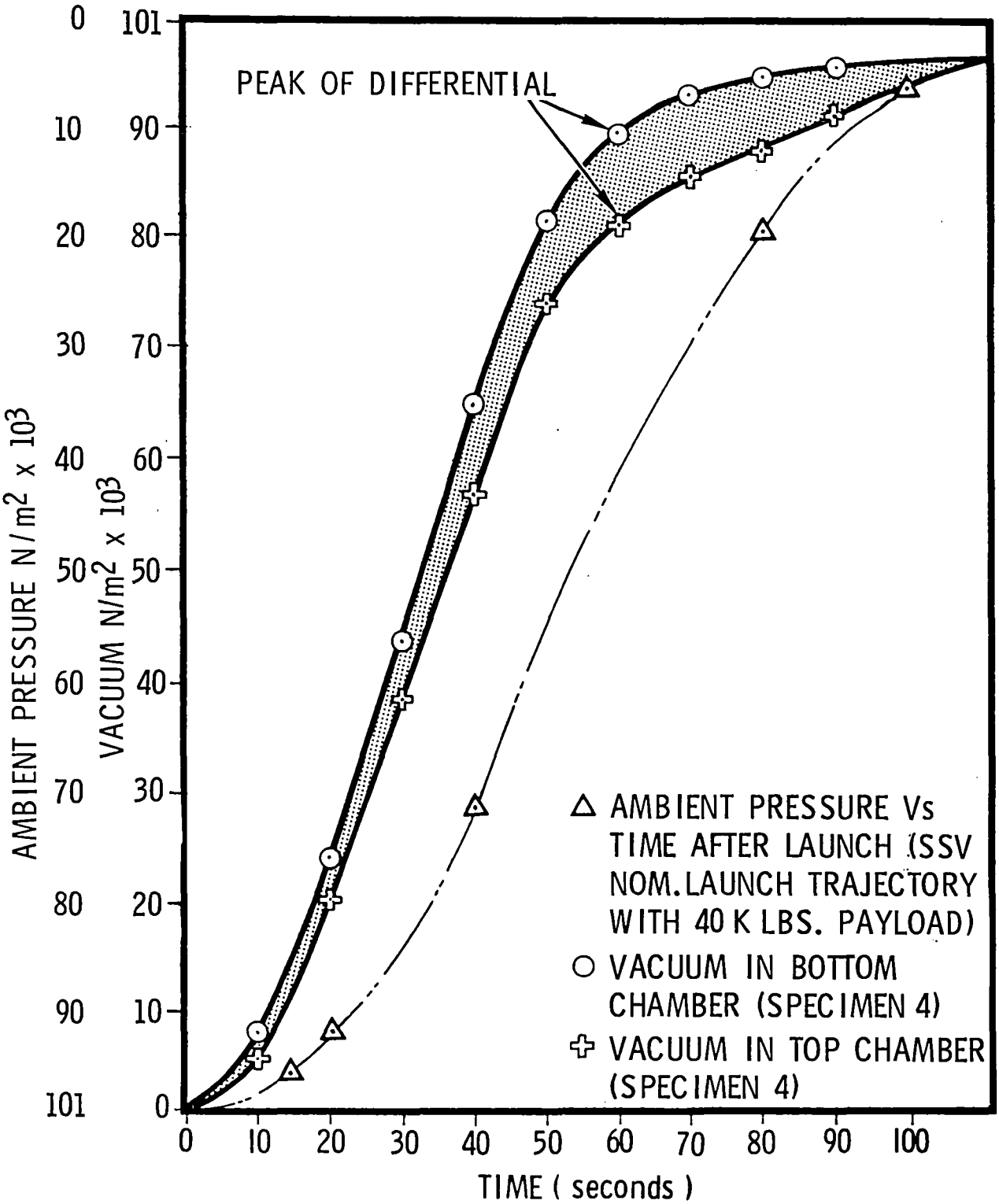


Figure 11. Typical Pressure Differential Curves Versus Time for 6-Inch-Diameter Vent Test Model

Table 5. Coated Specimen Permeability Evaluation

Specimen No.	Compound Type (See Table 4)	Coating		Maximum Vacuum Differential		Time to Reach Maximum Differential (sec)
		Type	Manufacturer	kN/m^2	(psi)	
5	20/80 (Sylgard 182)	TBS 757*	General Electric	66.534	(9.65)	40
5	20/80 (Sylgard 182)	DC92-007**	Dow Corning	95.217	(13.81)	40
5	20/80 (Sylgard 182)	TBS 757*	General Electric	65.500	(9.50)	50
6	20/80 (Sylgard 182)	TBS 758*	General Electric	12.480	(1.81)	30
8	20/80 (RTV 655)	DC92-009*	Dow Corning	16.892	(2.45)	30
9	30/70 (Sylgard 182)	TBS 757*	General Electric	23.649	(3.43)	30
9	30/70 (Sylgard 182)	DC92-007**	Dow Corning	87.770	(12.73)	40
10	30/70 (RTV 655)	TBS-758*	General Electric	24.683	(3.58)	30
11	30/70 (RTV 602)	TBS-758*	General Electric	6.067	(0.88)	30
13	20/65/15 (RTV 602)	DC92-009**	Dow Corning	9.101	(1.32)	20
15	20/65/15 (Sylgard182)	TBS-757*	General Electric	3.723	(0.54)	50
15	20/65/15 (Sylgard182)	DC92-007**	Dow Corning	88.460	(12.83)	60
16	20/65/15 (RTV 655)	DC92-009**	Dow Corning	20.960	(3.04)	40

*Cured at approximately 300 F for 15 minutes
**Cured at room temperature for 24 hours

Space Division
North American Rockwell

Table 6. Influence of Coating on Permeability

Coating	DC 92-007*	DC 92-009*	TBS 757**	TBS 758**
Maximum Vacuum Differential kN/m^2 (psi)	66.534 (9.65)	16.892 (2.45)	65.983 (9.57)***	12.480 (1.81)
	87.770 (12.73)	9.101 (1.32	23.649 (3.43)	24.683 (3.58)
	88.460 (12.83)	20.960 (3.04)	3.723 (0.54)	9.101 (1.32)
Average	90.459(13.12)	15.651 (2.27)	31.164 (4.52)	14.410 (2.09)

*Manufactured by the Dow Corning Co.
**Manufactured by the General Electric Co.
***Average of 2 tests

This Page Intentionally Left Blank

TASK 2: FULL-SIZE FLAT PANEL FABRICATION AND COST STUDY

In this task, several improved manufacturing techniques were explored to further reduce panel fabrication time and costs. The objective was to a obtain an accurate, valid baseline for cost estimating production quantities of 100 and 1000 units. It was felt that this could be best accomplished by fabricating a quantity (twelve) of identical flat panels utilizing many of the recommendations made in the previous contract (NAS1-9943, NASA CR-11175) as well as improvements realized in performing Task 1. In addition, some of these panels would also serve as full-size air permeability vent test specimens.

MATERIAL SELECTIONS

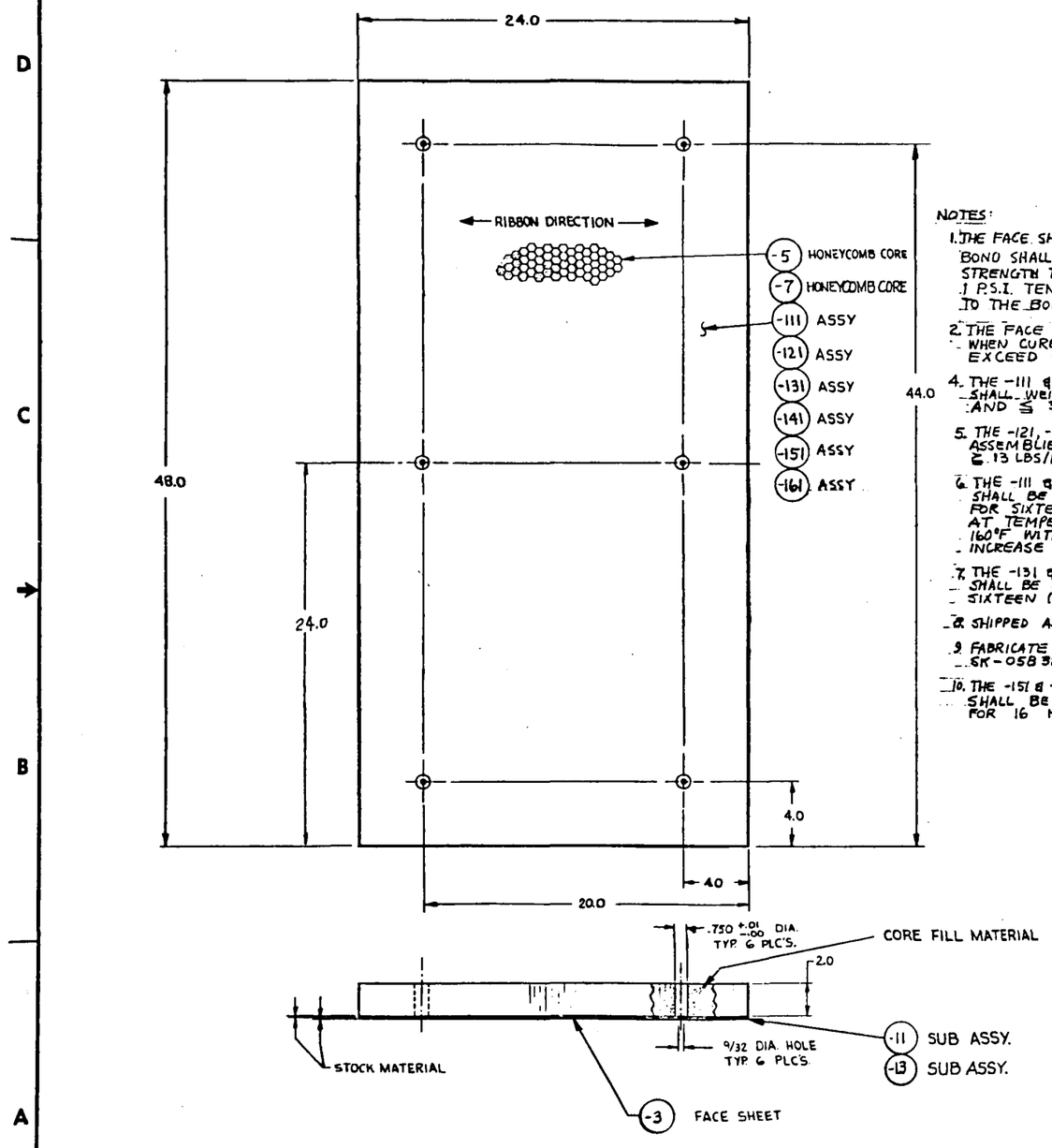
Upon completion of all thermal and vent tests in Task 1, a program review meeting was held at the Langley Research Center to discuss the results and agree on a selection of the ablative compound composition, core primer, catalyst for RTV602, and coatings. It was mutually agreed at this meeting to further evaluate the best two compositions by fabricating six panels each, in place of twelve panels made with only one composition. The full-size panels, including plugs, were to be fabricated to the configurations shown in Figures 12 and 13 from each of the ablator compound compositions identified below.

Material	SK058322-151	SK058322-161
Elastomer	25% (Sylgard 182)	25% (RTV602+SRC-04)
Phenolic microballoons	65%	50%
Glass bubbles	10%	15%
Nylon powder	0	10%

The selection of the composition for P/N SK058322-151 was based on the inherent ease of manufacturing and producibility characteristics, whereas that for SK058322-161 was based on the excellent plasma arc tests results conducted at the Langley Research Center. The arc test results showed that the composition with the nylon addition had the best combined char stability and thermal efficiency out of the 18 formulations tested. In addition, the air permeability test results from Task 1 indicated a satisfactory degree of permeability for these compositions.

This Page Intentionally Left Blank

Space Division
North American Rockwell



NOTES:

1. THE FACE SHEET TO HONEYCOMB BOND SHALL HAVE SUFFICIENT STRENGTH TO SUPPORT A 1 P.S.I. TENSILE LOAD NORMAL TO THE BONDLINE AT 300°F.
2. THE FACE SHEET MATERIAL WHEN CURED SHALL NOT EXCEED 0.18 LBS/FT^2.
4. THE -111 & -131 ASSEMBLIES SHALL WEIGH ≥ 25 LBS/FT^3 AND ≤ 30 LBS/FT^3.
5. THE -121, -141, -151 & -161 ASSEMBLIES SHALL WEIGH ≥ 13 LBS/FT^3 AND ≤ 17 LBS/FT^3.
6. THE -111 & -121 ASSEMBLIES SHALL BE CURED AT 250°F FOR SIXTEEN (16) HOURS OR AT TEMPERATURES DOWN TO 160°F WITH A PROPORTIONAL INCREASE IN CURE TIME.
7. THE -131 & -141 ASSEMBLIES SHALL BE CURED AT 300°F FOR SIXTEEN (16) HOURS.
8. SHIPPED AS A LOOSE ITEM.
9. FABRICATE PANEL PER SK-058324.
10. THE -151 & -161 ASSEMBLIES SHALL BE CURED AT 250°F FOR 16 HOURS.

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
6C, LM	C	ADDED -151 & -161 ASSEMBLIES		
5B		ADDED NOTE #10.		
5C		ADDED -151 & -161 TO NOTE #5	9-30-71	9-30-71
4A	D	CHG. QUAUT. -151 & -161 FROM 1 EA. TO 6 EA.	11-2-71	11-5-71
5B 1C	E	NOTE 10 REVISED: WAS CURE AT 180°F FOR 24 HRS. CURE AGENT 0063-85-1159 SPECIFIED FOR -161	11-10-72	

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
5C	A	REMOVED NOTE #3		
5C		REVISED NOTE #6		
5C		ADDED NOTE #9 PER E.O. M783929		
6A		REMOVED 2 PLIES ON F/D		
LM		REVISED WEIGHTS ON ELASTOMER, MICROBALLOONS, NYLON POWDER & PHENOLIC RESIN		
LM		ADDED RELIABOND R1714 FOR -3 FACE SHEET		
LM, 5 & 6	B	ADDED -7 CORE & -13 SUB ASSY.	7/14/71	

PARTS LIST

QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	CODE IDENT	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	MATERIAL	DATA: SPECIFICATIONS SIZES, NOTES, SUPPLIERS	ZONE
		3 lbs	1.8 lbs									GLASS BUBBLES	GLASS	3M CO. B-30B	
		6									SK058320-101	ABLATIVE PLUG			
			6								SK 058320-91	ABLATIVE PLUG			
		4 lbs										ELASTOMER	SILICONE	GENERAL ELECTRIC CO. RTV 602+0063-85-1159 CURE AGENT	
		1	1								-13	SUB ASSY			
								1			-7	HONEYCOMB CORE	PHENOLIC	HEXCEL HRP-3/8-GF12-3.2 2"x 26"= 50"	
				6							SK-058320-41	ABLATIVE PLUG			
					6						" " -31	↕			
						6					" " -21	↕			
							6				SK-058320-11	ABLATIVE PLUG			
				1	1	1	1				-11	SUB ASSY			
			4.6 lbs			4 lb.	24 lb.					ELASTOMER	SILICONE	DOW CORNING SYLGARD 182 + CURING AGENT	
		10 lbs	1.8 lbs	14 lb.		16 lb.	12 lb.					MICROBALLOONS	PHENOLIC	UNION CARBIDE BJO-0930	
		2 lbs		3 lb.	18 lb.							NYLON POWDER	NYLON	POLYMER CORP. POLYPENCO 66 D	
				3 lb.	18 lb.							PHENOLIC RESIN	PHENOLIC	UNION CARBIDE BRP-5549 B-STAGE	
									1		-5	HONEYCOMB CORE	PHENOLIC	HEXEL HRP-3/8-GF11-2.2 2"x 26"x 50"	
				1	1	1	1	1	1		-3	FACE SHEET	EPOXY PREPREG	RELIABOND R1714, 30Z. BOAT CLOTH, 26"x50" 1 PLY	
		-161	-151	-141	-131	-121	-111	-13	-11		SK-				

ITEM	QTY	NEXT ASSY	USED ON	END ITEM NO.	THRU
-161	6				
-151	6				
-13	12				
-141	1				
-131	1				
-121	1				
-111	1				
REQD PER END ITEM		APPLICATION		EFFECTIVITY	

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES.
TOLERANCES ON:
DECIMALS ANGLES
XX= ± .03
XXX= ± .010 ± 30'
HOLES NOTED "DRILL"

.013	THRU	.040	+.001 −.001
.041	THRU	.130	+.002 −.001
.131	THRU	.229	+.003 −.001
.230	THRU	.500	+.004 −.001
.501	THRU	.750	+.005 −.001
.751	THRU	1.000	+.007 −.001
1.001	THRU	2.000	+.010 −.001

DR BY	F.A. COLLINS	5-6-70
CHK BY		5-7-70
APPROVED BY		

SPACE DIVISION
NORTH AMERICAN ROCKWELL CORPORATION
12214 LAKEWOOD BOULEVARD • DOWNEY, CALIFORNIA 90241

ABLATIVE PANEL - FLAT

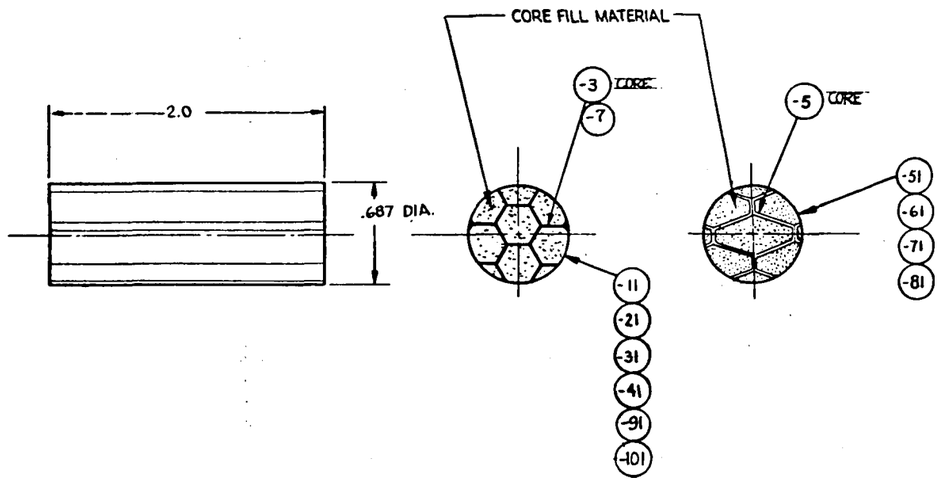
SIZE	CODE IDENT NO.	DRAWING NO.
D	03953	SK-058322

SCALE 4 SIZE — SHEET 1 OF 1

Figure 12. Flat Ablative Panel Design

Space Division
North American Rockwell

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
5B 3B 5B 6C	A	REMOVED NOTE #1 REVISED NOTE #4 ADDED NOTE #6 REVISED .687 DIA, WAS .750 +.00 -.01 & -5 H/C CORE CONFIGURATION PER E.O M783927		
5C LM 6A 6B	B	ADDED -91 & -101 ASSEMBLIES. ADDED NOTE #7 ADDED -91 & -101 TO NOTES 3 & 6	9-30-71 9-30-71	
6A 1B	C	NOTE #7 REVISED: WAS CURE AT 180°F FOR 24 HR CURE AGENT 0063-85-1159 SPECIFIED FOR -101	1-10-72	



NOTES:
1. THE -11, -31, -51 & -71 ASSEMBLIES SHALL WEIGH ≥ 25 LBS/FT³ AND ≤ 30 LBS/FT³.
2. THE -21, -41, -61, -81, -91 & -101 ASSEMBLIES SHALL WEIGH ≥ 13 LBS/FT³ AND ≤ 17 LBS/FT³.
4. THE -11, -21, -51 & -61 ASSEMBLIES SHALL BE CURED AT 250°F FOR SIXTEEN (16) HOURS OR AT TEMPERATURES DOWN TO 160°F WITH A PROPORTIONAL INCREASE IN CURE TIME.
5. THE -91, -41, -71 & -81 ASSEMBLIES SHALL BE CURED AT 300°F FOR SIXTEEN (16) HOURS.
6. FABRICATE THE -11, -21, -31, -41 -91 & -101 PER SK 058324, AND FABRICATE THE -51, -61, -71 & -81 PER SK 058326.
7. THE -91 & -101 ASSEMBLIES SHALL BE CURED AT 250°F FOR 16 HOURS.

ITEM	QTY	NEXT ASSY	USED ON	END ITEM NO.	THRU
-101	6	SK058322-151			
-91	6				
-81	6				
-71	6				
-61	6				
-51	6				
-41	6				
-31	6				
-21	6				
-11	6				
REQD PER END ITEM		APPLICATION		EFFECTIVITY	

PARTS LIST

ZONE	QTY REQD -11	QTY REQD -21	QTY REQD -31	QTY REQD -41	QTY REQD -51	QTY REQD -61	QTY REQD -71	QTY REQD -81	QTY REQD -91	QTY REQD -101	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	MATERIAL	DATA: SPECIFICATIONS SIZES, NOTES, SUPPLIERS
	23 gr											ELASTOMER	SILICONE	GENERAL ELECTRIC CO. RTV 602 + 0063-85-1159 CURE AGENT
	14 gr	1 gr										GLASS BUBBLES		3M CO. B-30B
	1	1									-7	HONEYCOMB CORE	PHENOLIC	HEXEL HRP-3/8 GF12-3.2 1"x1"x2"
			1	1	1	1					-5	HONEYCOMB CORE	PHENOLIC	HEXEL HRP-OX-GF11-2.7 1"x1"x2"
							1	1	1	1	-3	HONEYCOMB CORE	PHENOLIC	HEXEL HRP-3/8-GF11-2.2 1"x1"x2"
		23 gr		1 gr.	11 gr.				1 gr.	11 gr.		ELASTOMER	SILICONE	DOW CORNING SYLGARD 182 + CURING AGENT
	45 gr	59 gr.	6 gr.		8 gr.	5 gr.	6 gr.		8 gr.	5 gr.		MICROBALLOONS	PHENOLIC	UNION CARBIDE BJO-0930
	1 gr		2 gr.	8 gr.			2 gr.	8 gr.				NYLON POWDER	NYLON	POLYMER CORP. POLYPENCO 66D
			2 gr.	8 gr.			2 gr.	8 gr.				PHENOLIC RESIN	PHENOLIC	UNION CARBIDE BRP-5549 B STAGE
	-11	-21	-31	-41	-51	-61	-71	-81	-91	-101	SK-			

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES.
TOLERANCES ON:
DECIMALS: XX= ± .03; XXX= ± .010; ANGLES ± 30'
HOLES NOTED "DRILL"
.013 THRU .040: +.001 −.001
.041 THRU .130: +.002 −.001
.131 THRU .229: +.003 −.001
.230 THRU .500: +.004 −.001
.501 THRU .750: +.005 −.001
.751 THRU 1.000: +.007 −.001
1.001 THRU 2.000: +.010 −.001

DR BY	F.A. COLLINS	5-7-70
CHK BY		5-7-70
APPROVED BY		

SPACE DIVISION
NORTH AMERICAN ROCKWELL CORPORATION
12214 LAKEWOOD BOULEVARD • DOWNEY, CALIFORNIA 90241

ABLATIVE PLUG

SIZE	CODE IDENT NO.	DRAWING NO.
D	03953	SK-058320

SCALE 2 = SIZE | SHEET 1 of 1

Figure 13. Ablative Plug Design

Other materials selected are as follows:

Material Type	Supplier Designation
Facing prepeg	R1714
Honeycomb core	HRP 3/8-GF12-3.2
Core primer	SC1008
Coatings	92-009 dispersion coating (clear) TBS-758 thermal coating (white)
Catalyst (for RTV602)	G. E. No. 0063-85-1159

The facing and core materials were selected based on the excellent results obtained in the previous contract, whereas the primer and coatings were selected based on the results of Task 1.

The special catalyst, No. 0063-85-1159, was selected based upon a study made to improve the pot life of the ablative compound using RTV602 (see SK058322-161). The results of the pot life study are shown in Table 7.

FABRICATION OF FILL AND CURE FIXTURES

The two fixtures available from the previous contract (NAS1-9943, NASA CR-11175) were refurbished for use in this program. The fixture design is shown in Figure 14.

The proposed third fixture, and a fourth nonscheduled fixture were fabricated. The latter fixture was procured for an in-house IR&D ablative program and has been utilized on this contract to demonstrate a more effective production rate capability in fabricating the twelve panels.

FABRICATION OF TWELVE FULL-SIZE PANELS (INCLUDING PLUGS)

Manufacturing Order Release (SK058320 and SK058322)

Manufacturing orders were released and cost centers established for accumulating manhours by operations for fabrication of plugs (SK058320-91, 101), subassemblies (SK058322-13) and panels complete (SK058322-151 and 161). The operations and sequence order are shown in Figure 15, and the manufacturing orders are given in Appendix A.

Table 7. Pot Life of RTV602 Catalyzed With Various Curing Agents

Curing Agent	Percentage	Approximate Time to Gel (hr)
General Electric SRC-04	1%	5
General Electric SRC-04	1/2 of 1%	8
General Electric SRC-04	1/4 of 1%	12
General Electric SRC-05	1/2 of 1%	1/2
General Electric SRC-05	1/4 of 1%	3
General Electric No. 0063-85-1159	1/4 of 1%	24
General Electric No. 0063-85-1160	1/4 of 1%	16

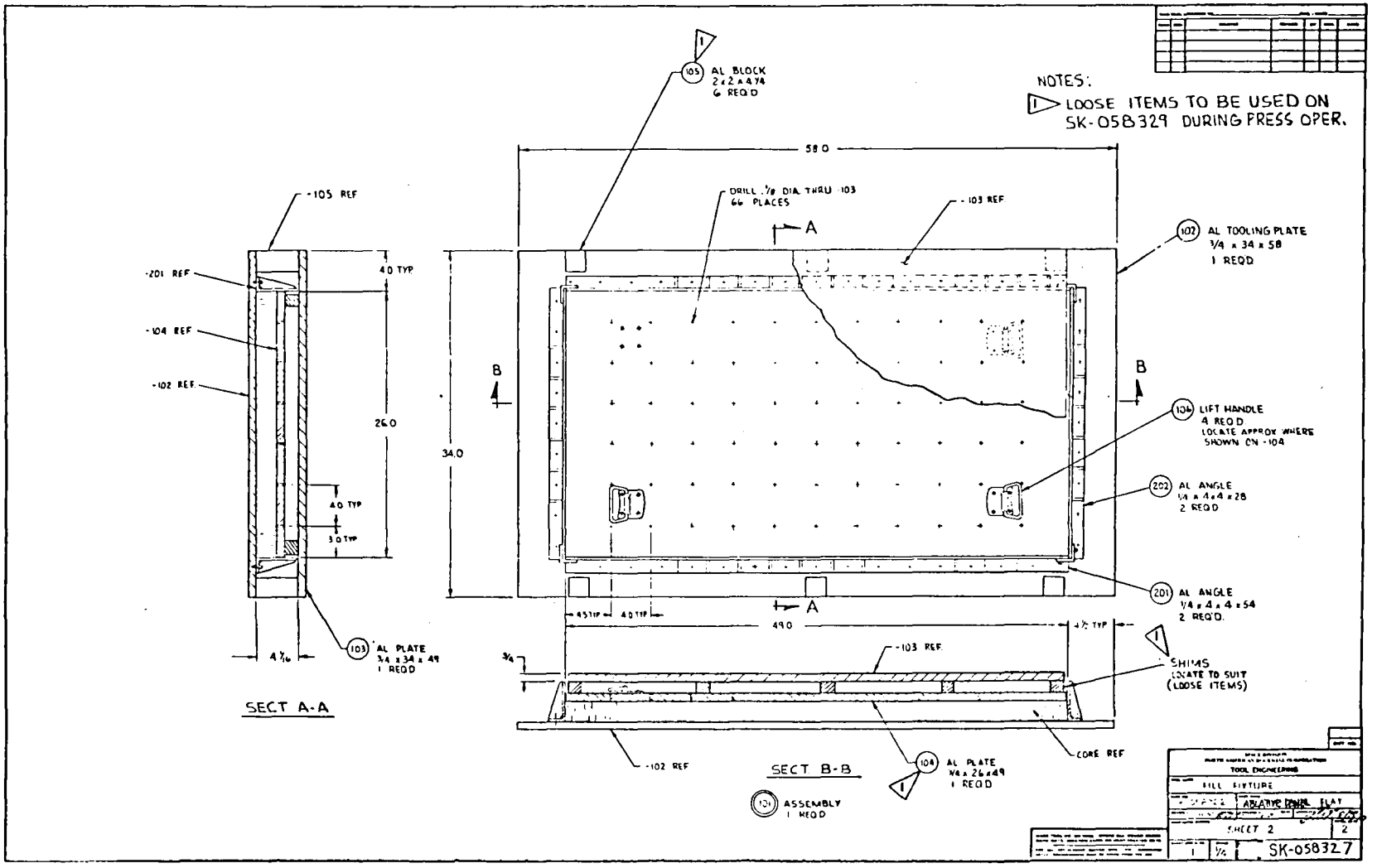


Figure 14. Combination Fill and Cure Fixture Detail Design

Space Division
North American Rockwell

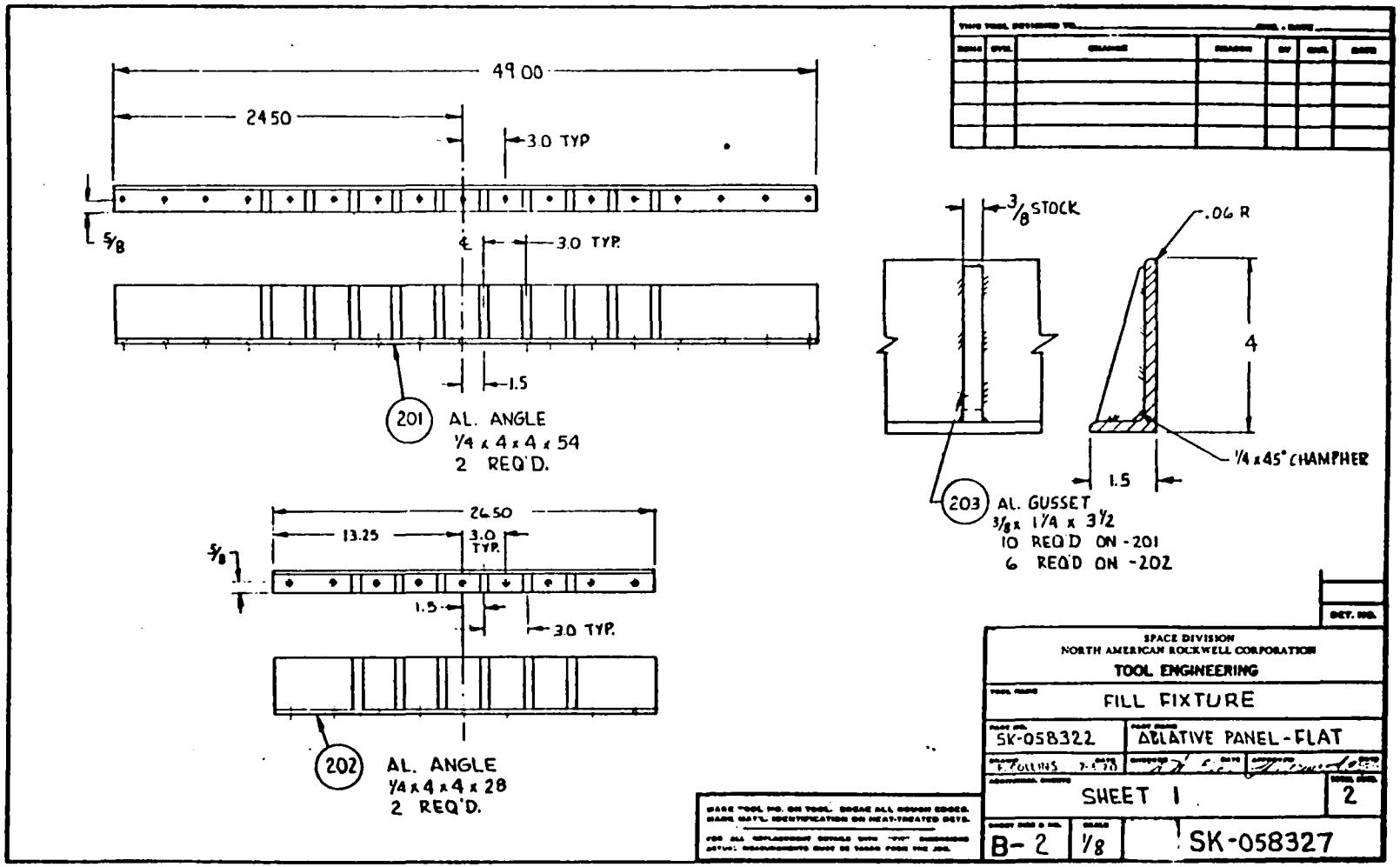
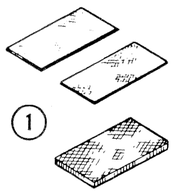


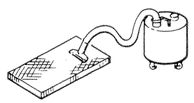
Figure 14. Combination Fill and Cure Fixture Detail Design (Cont)

Space Division
North American Rockwell

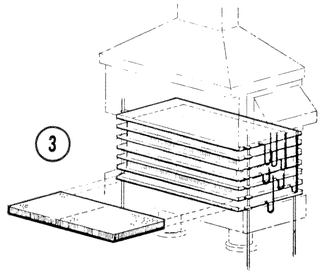
This Page Intentionally Left Blank



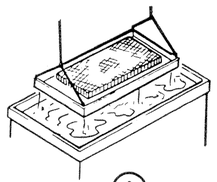
1 TRIM DETAILS



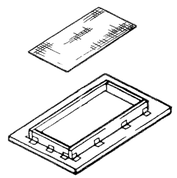
2 VACUUM CORE



3 MULTIPLE BOND CORE/FACING SUBASSEMBLIES

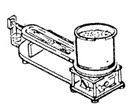


4 PRIME CORE

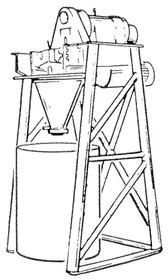


5 ADD SEPARATOR MATERIALS TO TOOL

6 PREMIX CATALYST IN RESIN

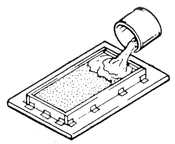


7 WEIGH FILLER MATERIALS

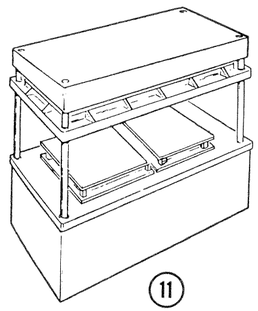


8 MIX ABLATIVE COMPOUND

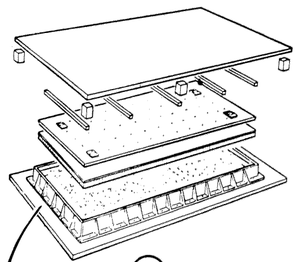
9 STORE IN FREEZER



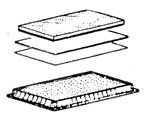
10 DISTRIBUTE COMPOUND IN TOOL



11 COMPACT COMPOUND (2 AT A TIME)

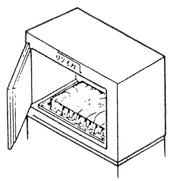


12 PRESS CORE/SKIN S/A INTO COMPOUND (2 AT A TIME)

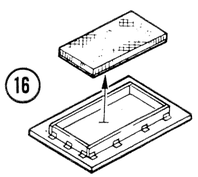


13 ADD SEPARATOR & CAUL PLATE

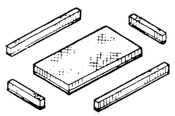
14 APPLY VACUUM BAG



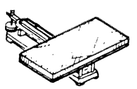
15 CURE IN OVEN



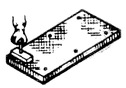
16 REMOVE FROM TOOL



17 TRIM EDGES



18 WEIGH PANEL



19 CUT HOLES

Figure 15. Fabrication Procedure for Ablative Flat Panels

Operation	Details
	SK-058322-151
	-3 Face Sheet
1	1. Remove prepreg material (Reliabond R1714) from the freezer.
	2. Cut one piece 26 by 200 inches with knife.
	-7 Honeycomb
1	1. Cut HRP-3/8-GF12-3.2 (honeycomb core) to size, 2" x 26" x 100".
2	2. Vacuum clean core and protective wrap.
	-13 Subassembly
3	1. Stack six successive assemblies in the press (1000-ton) with the following procedure for one subassembly. 1/8-inch aluminum caul plate, sheet of polyvinyl chloride, porous felted paper, honeycomb core, Reliabond 1714 prepreg, teflon cloth, porous felted paper, sheet of polyvinyl chloride, 1/8-inch aluminum caul plate.
	2. Close the press and set the pressure to apply 50 psi to the subassemblies, raise the temperature to 285 F, and hold for 1-1/2 hours.
	3. Open press and remove the six -13 Subassemblies.
	4. Cut the six subassemblies that are 2 by 26 by 100 inches into twelve -13 Subassemblies 2 by 26 by 50 inches.
	-151 Final Assembly
4	1. Position the -13 Subassembly (face sheet U) into the shop aid (pan) filled with SC 1008 and dip the core into the primer to within 1/8 inch of the face sheet.
	2. Raise -13 Subassembly from the primer (bath) and allow to drip dry for a minimum of 10 minutes (place on absorbent paper toweling).
	3. Allow the primer to cure at room temperature for a minimum of 1 hour.
	4. "B" stage cure the primer at 140 F for 30 minutes.
5	5. Add teflon sheet to the base and teflon tape to the side walls.
6	6. Premix Sylgard 182 with catalyst per manufacturer recommendations (10 parts by weight of resin, to one part per weight of catalyst) in a Hobart 5-gallon capacity mixer.
7	7. Weigh out the three ingredients of the ablative mixture/ i. e., silicone resin-Sylgard 182 (25 percent phenolic microballoons, BJO-0930 (65 percent) glass bubbles, B-30B (10 percent) For the amount required to fill a 2 by 26 by 50-inch panel.
8	8. Place the phenolic microballoons and glass bubbles in the mixer (vertical helicone, Atlantic Research Co. Model 10). Start in reverse at slow speed, 8 rpm. Change the direction to forward, increase speed to 16 rpm, and mix for 6 minutes. Reverse direction and mix for 6 minutes, change direction to forward and mix for 6 minutes, reverse direction and mix for 6 minutes.
	Empty mixture into a polyethelyne bag.
9	9. Store mixture in a freezer at 20 F until ready for use.
10	10. Fill the shop aid (fill fixture). With the mixture while screening through a 1/8-inch screen.
	11. Level off the mixture in the shop aid using a special straight edge.
11	12. Add teflon film to the top of mixture, and then add the 3/4-inch aluminum caul plate.
	13. Position two fill fixtures side-by-side in the press (Kard Inc. 150-ton 4 by 7-foot bed).
	14. Add the necessary spacers, bars, shims and stop blocks.
11	15. Close the press to precompress the mixture using 25 psi.
	16. Open the press and remove stop blocks, bars, caul plate, and teflon film, and check for accuracy of thickness (repress if required).
12	17. Position the -13 Subassembly face sheet on top of the precompressed mixture (stack three assemblies).
	18. Hand press the -13 Subassembly into the mixture.
	19. Add to the face sheet face, teflon film one sheet of porous felt paper, the 3/4-inch caul plate, and the necessary spacers, bars, and stop blocks.
	20. Close the press to compress the -13 Subassembly into the precompressed mixture within 2/10-inch or stop blocks.
	21. Open press to release any air entrapment.
	22. Close the press and apply 50 psi to bottom out to -13 Subassembly into the mixture.
	23. Open the press and remove the fixtures with filled assemblies.
13	24. Add one layer of Reliabond 1714 pressure material to the exposed face sheet. Also add one sheet of teflon film, one layer of porous felt paper, and the 3/4-inch caul plate.
14	25. Vacuum bag the complete assembly.
15	26. Cure the assembly in an air circulating oven at 240 F for 16 hours. Shut oven off and remove assembly after 2 hours.
16	27. Remove the filled assembly from the shop aid (fill fixture).
17	28. Visually check and cut off excess material around the periphery to 2 by 4-foot finished dimension.
18	29. Weigh completed panel and record.
19	30. Add the six 0.750-inch-diameter holes using a cutter.
	31. Final inspect, package, and ship.
	SK-058322-161
	1. Same as SK-058322-151
	-13 Subassembly
	1. Same as SK-058322-161
	-161 Final Assembly
	1. Same as SK-058322-161, except as listed below.
	(a) (Paragraph 6. Operation 6). Premix RTV 602 with catalyst (0.25% by weight of catalyst to 99.75% of resin) in a Hobard 5-gallon capacity mixer. Store the precatalized resin mixer at 20 F.
	(b) (Paragraph 7, Operation 7). Weigh out the four ingredients of the ablative mixture, i. e., silicone resin-RTV-602 (21%), phenolic microballoons - BJO-0930 (53%), glass bubbles, B-30B (15%), and nylon powder, polypenco 66D, (11%). For the amount required to fill a 2 by 26 by 50-inch panel.
	(c) (Paragraph 8, Operation 8). Place the phenolic microballoons, glass bubbles, and nylon powder in the mixer (Vertical Helicone, Atlantic Research Co. No. 10). Start in reverse at slow speed, add the RTV 602, and repeat the same as SK-058322-151.

Figure 15. Fabrication Procedure for Ablative Flat Panels (Cont)

Fabrication of Core to Facing Subassemblies (SK-058322-13)

All core to facing subassemblies using HRP 3/8-GF 12-3.2 core and Reliabond R1714 epoxy prepreg were fabricated in two days at General Veneer Manufacturing Company, Southgate, California. Six 0.66m x 2.54m (26- by 100-inch) panels were loaded and bonded in the press in one operation as shown in Figure 16. This multiple platen 1000-ton press is equipped with seven 1.27m x 2.54m (50- by 100-inch) heated platens. The press is capable of exerting 1,378,951 N/m^2 (200 psi) over the entire platen area. These platens can readily be identified in Figure 17 which shows the press in a closed condition while the cure cycle was initiated. The bonding pressure used was 344.7 kN/m^2 (50 psi) and the cure cycle was 414 K (285 F) for 90 minutes. After curing, the panels were removed from press as shown in Figures 18 and 19 and trimmed to the 0.66m x 1.24m (26 by 49 inch) size and readied for the priming operation.

This entire operation was a very fast, low cost, good quality method and is recommended for future production fabrication.

These subassemblies were dip-primed in a priming pan (see Figures 20 and 21) and filled with a 50-50 percent solution of SC1008 phenolic primer and butyl alcohol.

Compound Mixing

The required 22.7 kg (50-pound) batch mixing, based on the proprietary Rocketdyne technique, was evaluated and was not considered feasible because of the 24-hour drying time required after mixing. Some of the formulations tested to date will definitely polymerize during this period.

A Model 10CV, Atlantic Research Corporation, 10-gallon vertical helicone mixer (Figure 22), was procured early in the program and was used successfully to mix both compositions of the ablator filler compound. The maximum amount of filler that could be mixed at one time was approximately ten pounds, thus two batches were required per panel. The mixing procedure consisted of four, 6-minute, alternating forward and reverse cycles for a combined mixing time of 24 minutes. This mixing procedure produced mixes of uniform consistency and quality.

Filling and Curing of Full Size Panels (SK058322-151-161)

In all, thirteen full-size panels were filled and cured using the same basic techniques described in NAS1-9943, NASA CR111795. (See Figures 23 and 24). The first panel, SK058322-151, was a tool proofing (nontime studied) run to verify the tooling and the compaction and filling process. This proved

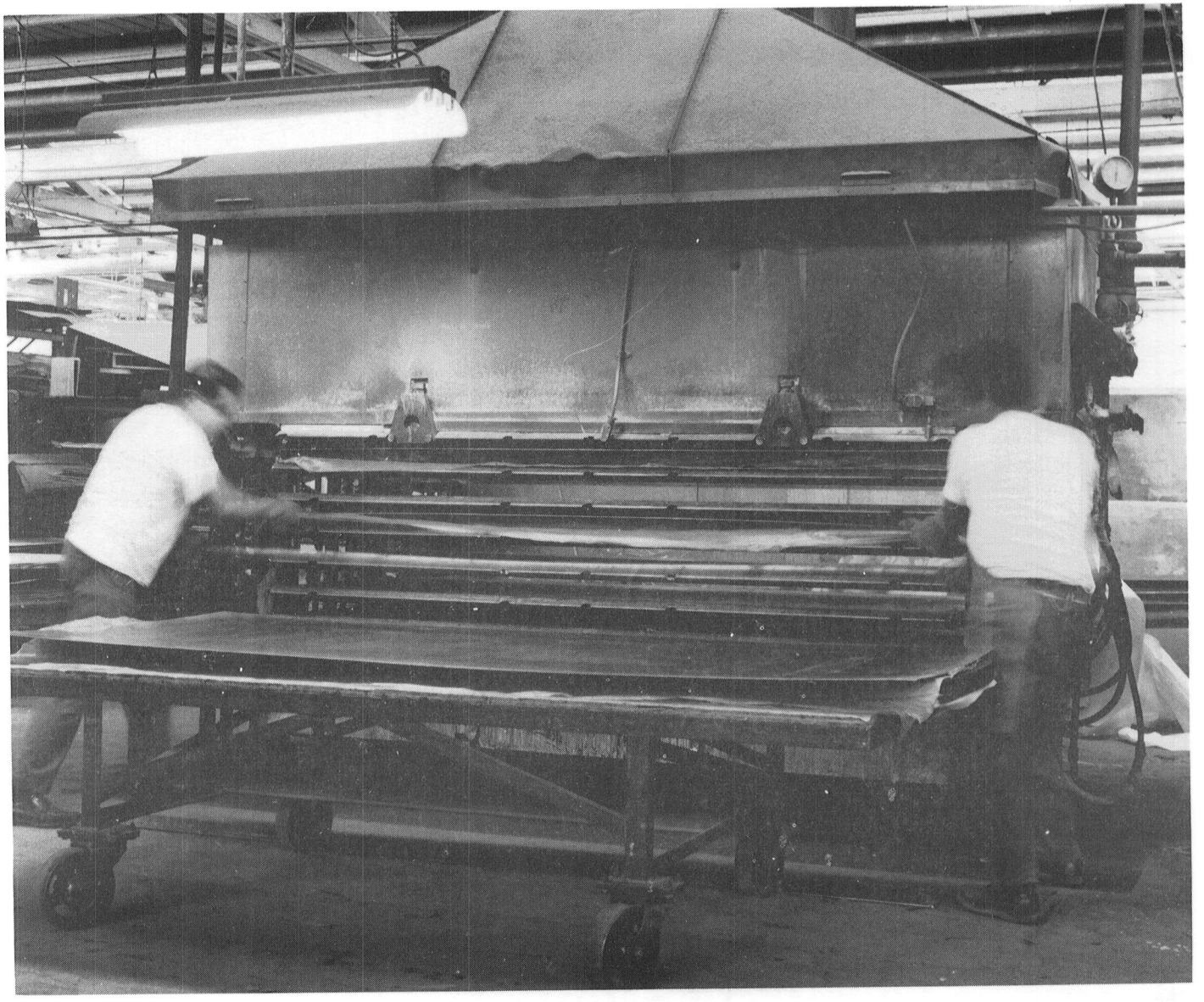


Figure 16. Loading of Multiple Platen Press for Bonding -3 Subassembly

Space Division
North American Rockwell

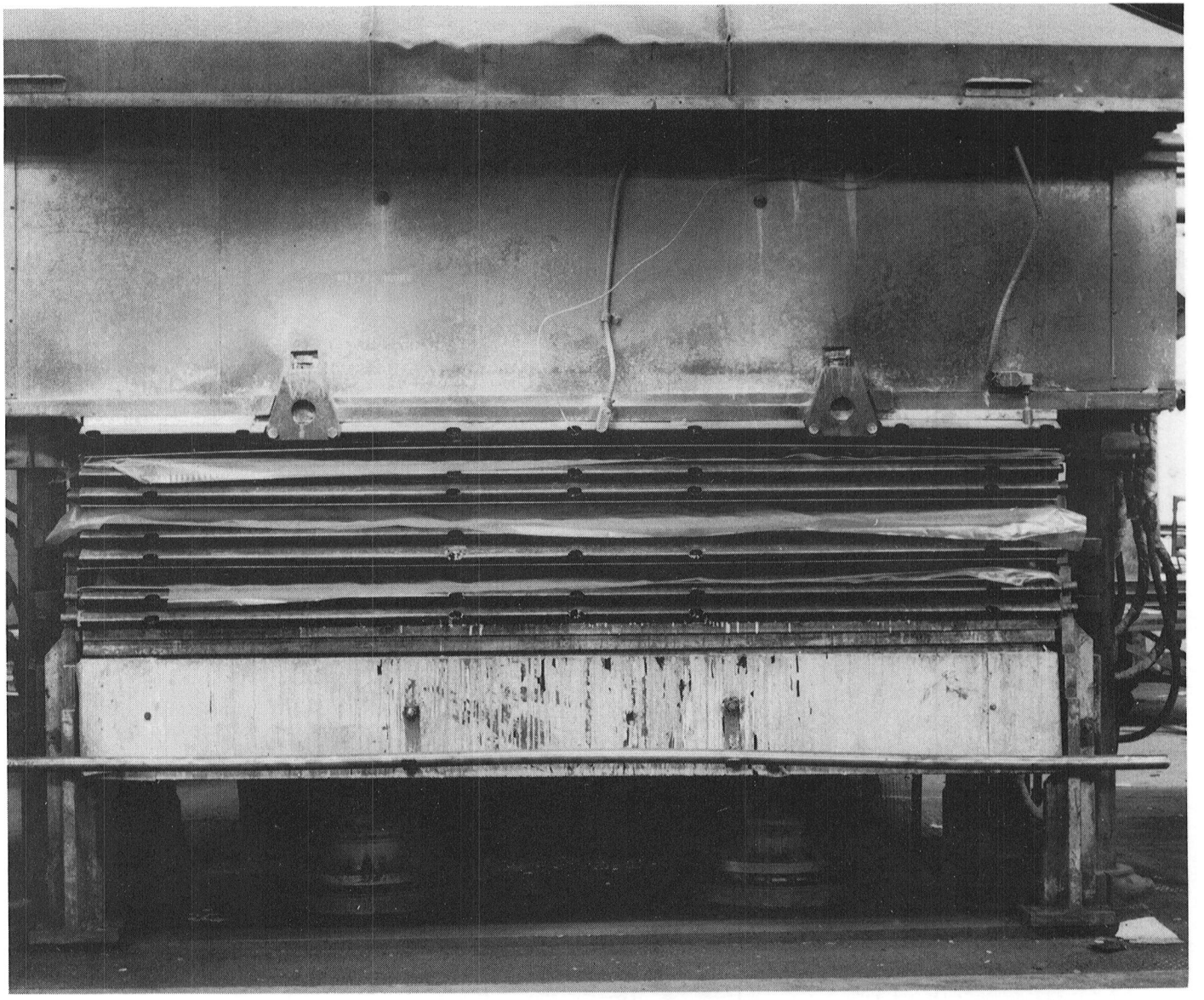


Figure 17. Multiple Curing of Subassembly Panels (Press Closed)

Space Division
North American Rockwell

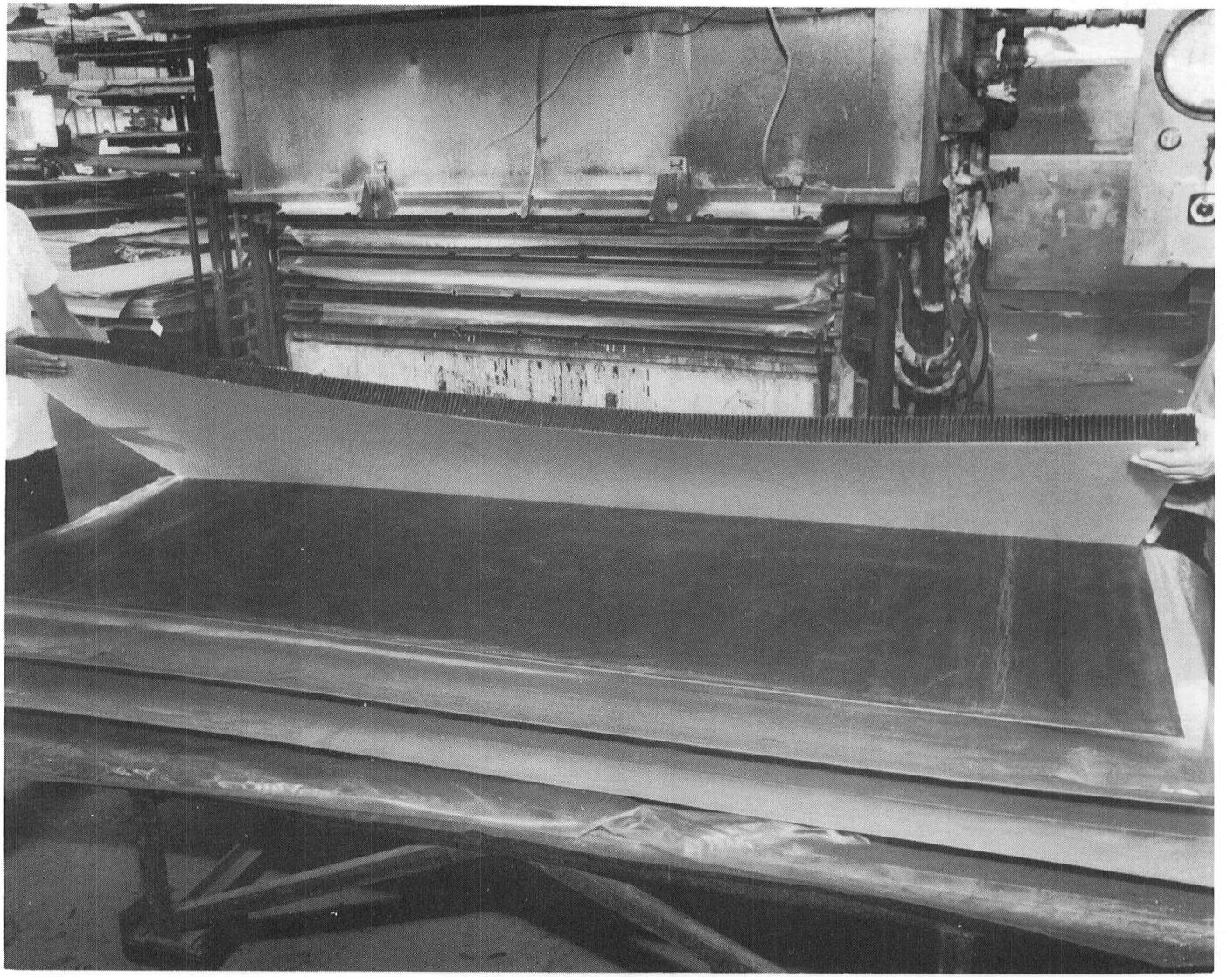


Figure 18. Subassembly Panels After Bond (One Panel Makes Two -13 Subassemblies)

Space Division
North American Rockwell

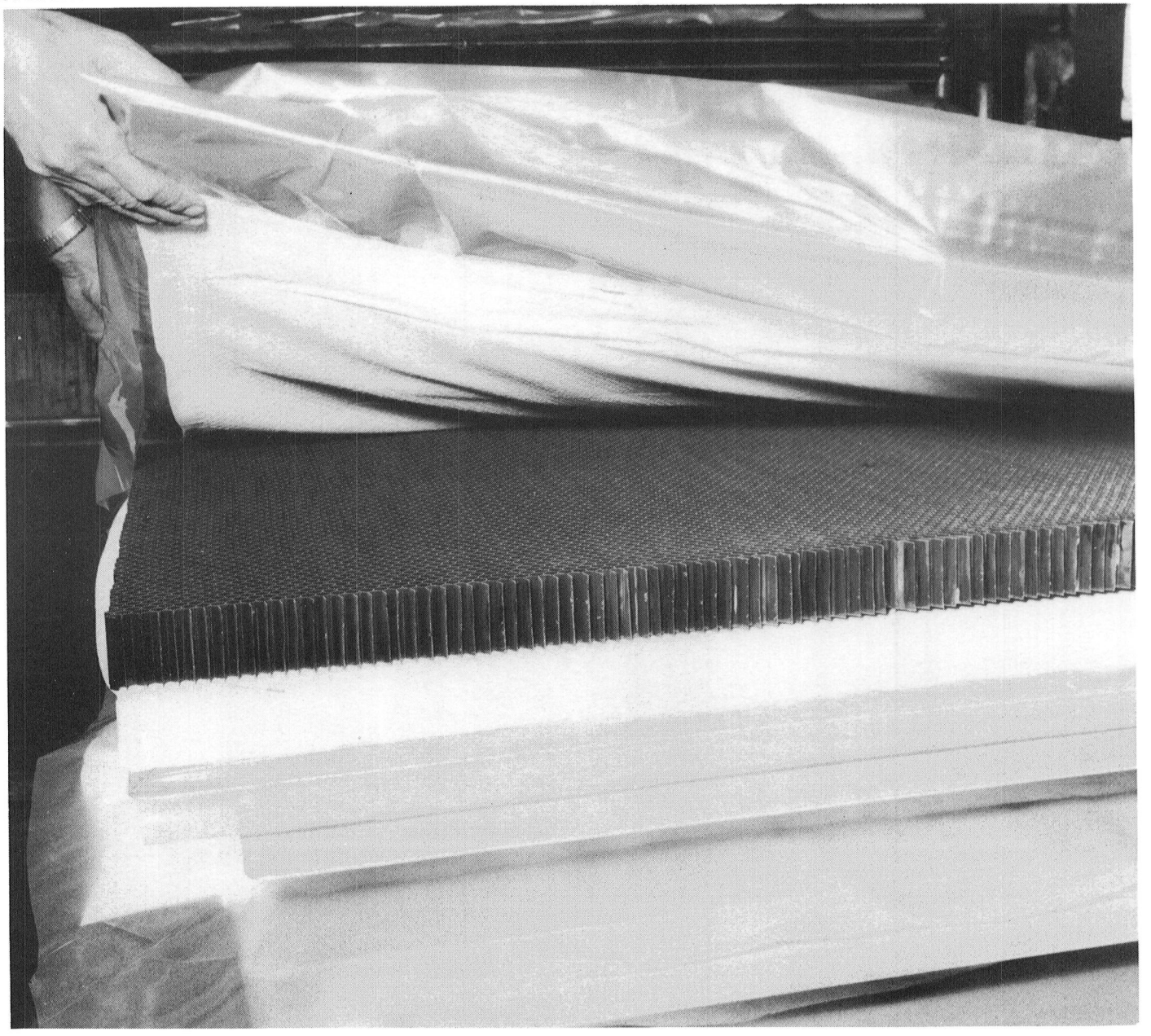


Figure 19. Closeup of -13 Subassembly After Bond Showing Porous Felt Paper and Teflon Cloth

Space Division
North American Rockwell

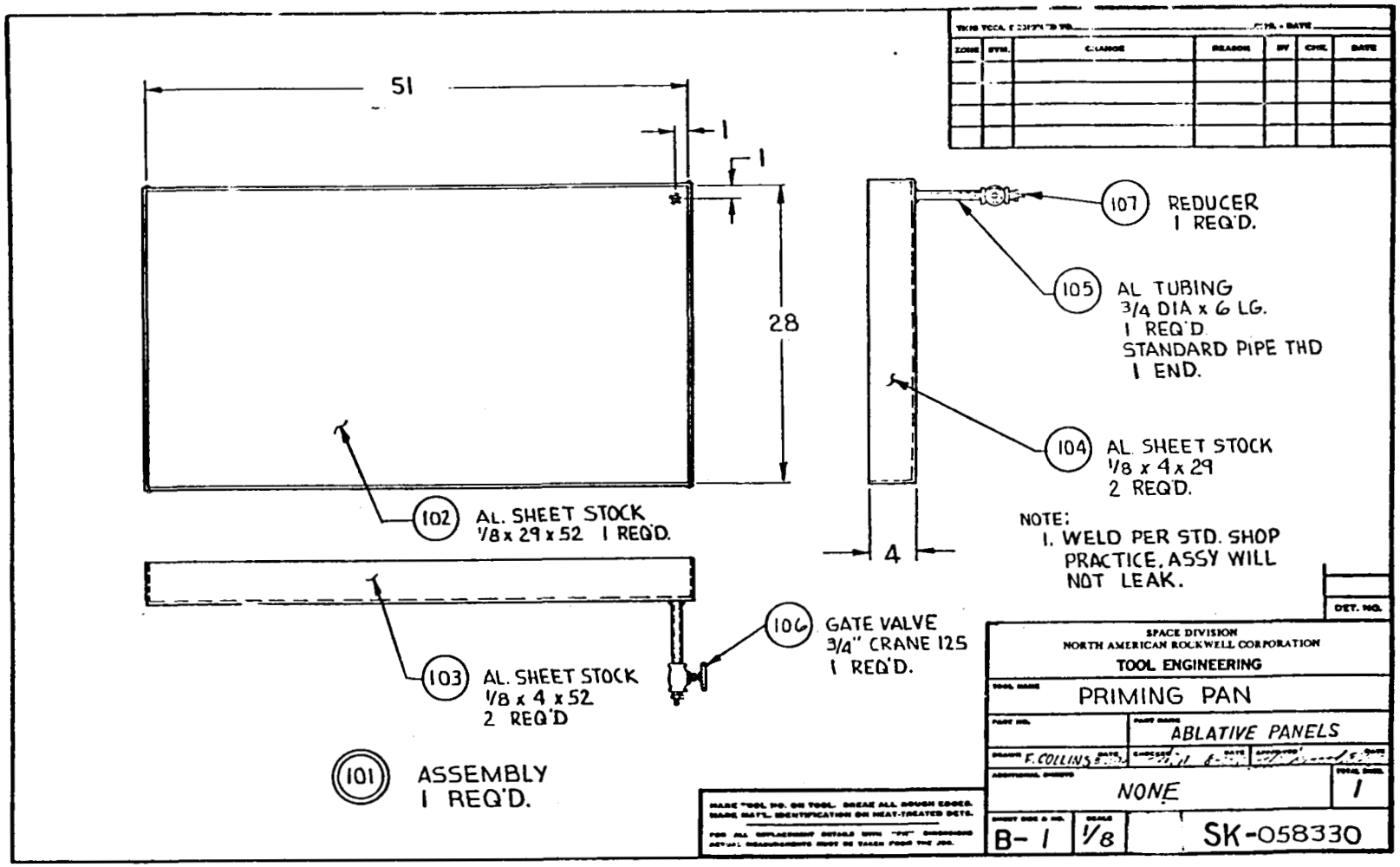
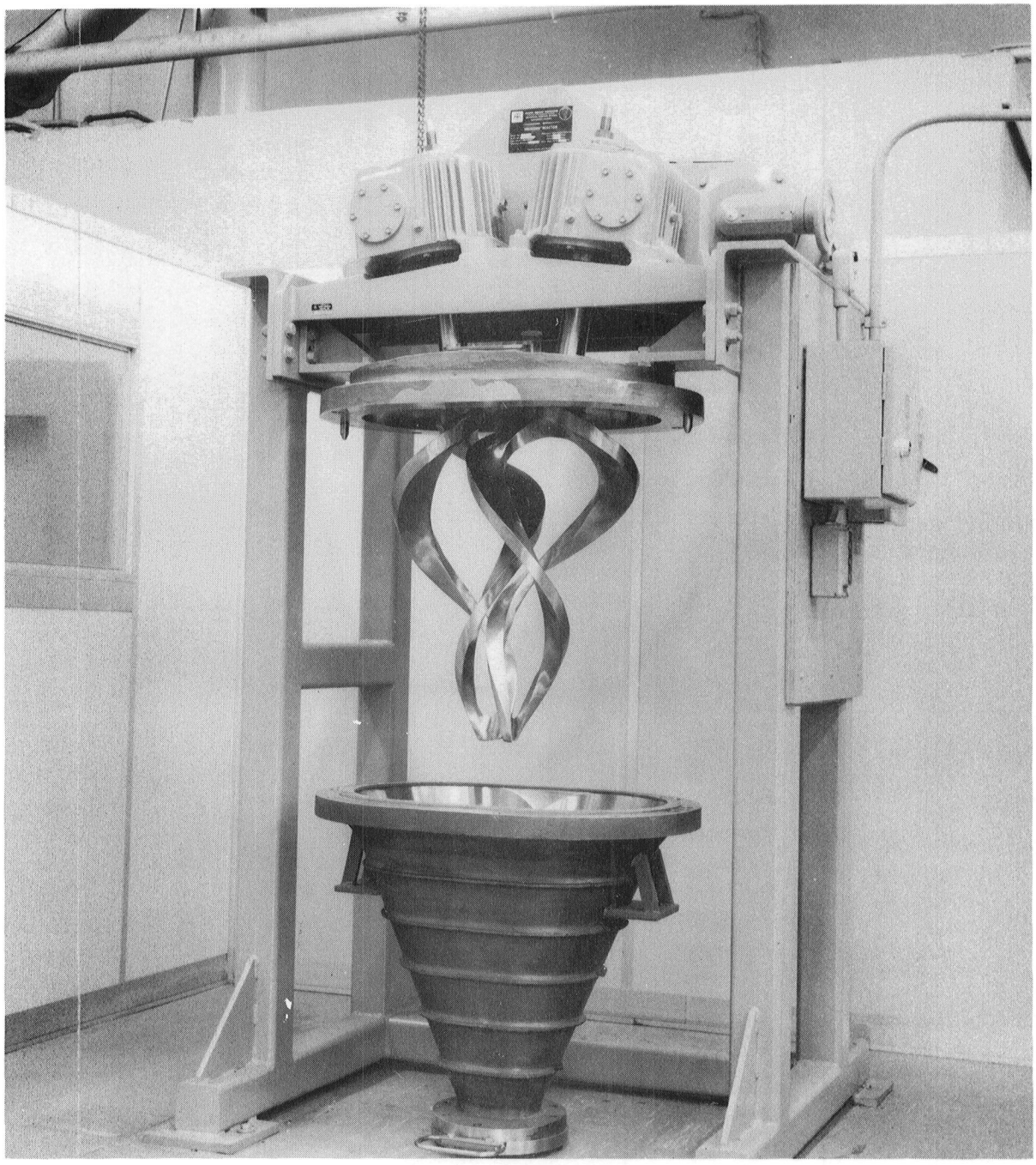


Figure 20. Priming Pan Detail Design

Space Division
North American Rockwell

Figure 21. Priming Pan

700-86-988E



700-86-1041

Figure 22. Atlantic Research Corp Mixer, Model 10CV

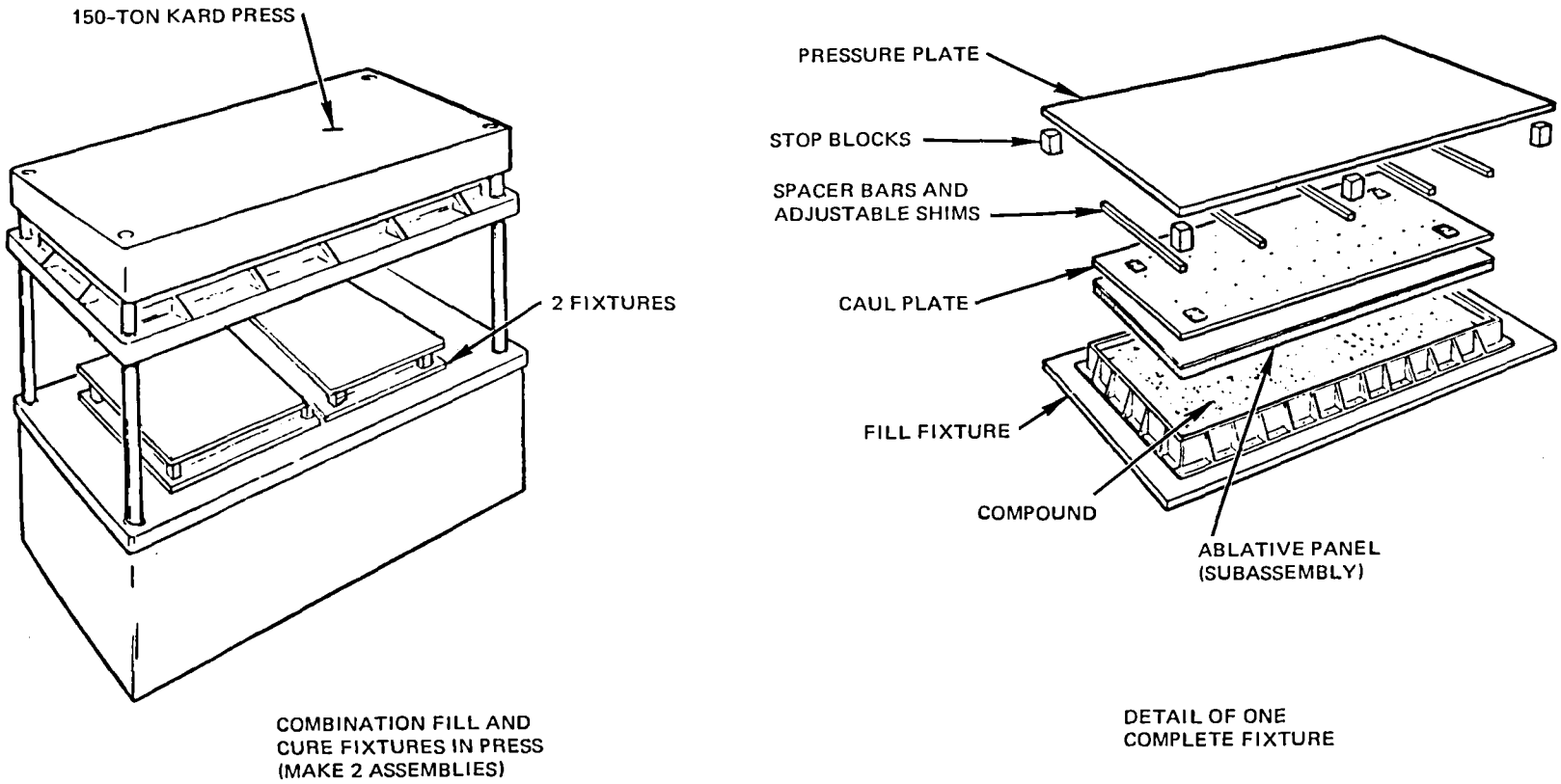


Figure 23. Detail Sketch of Fill and Cure Setup

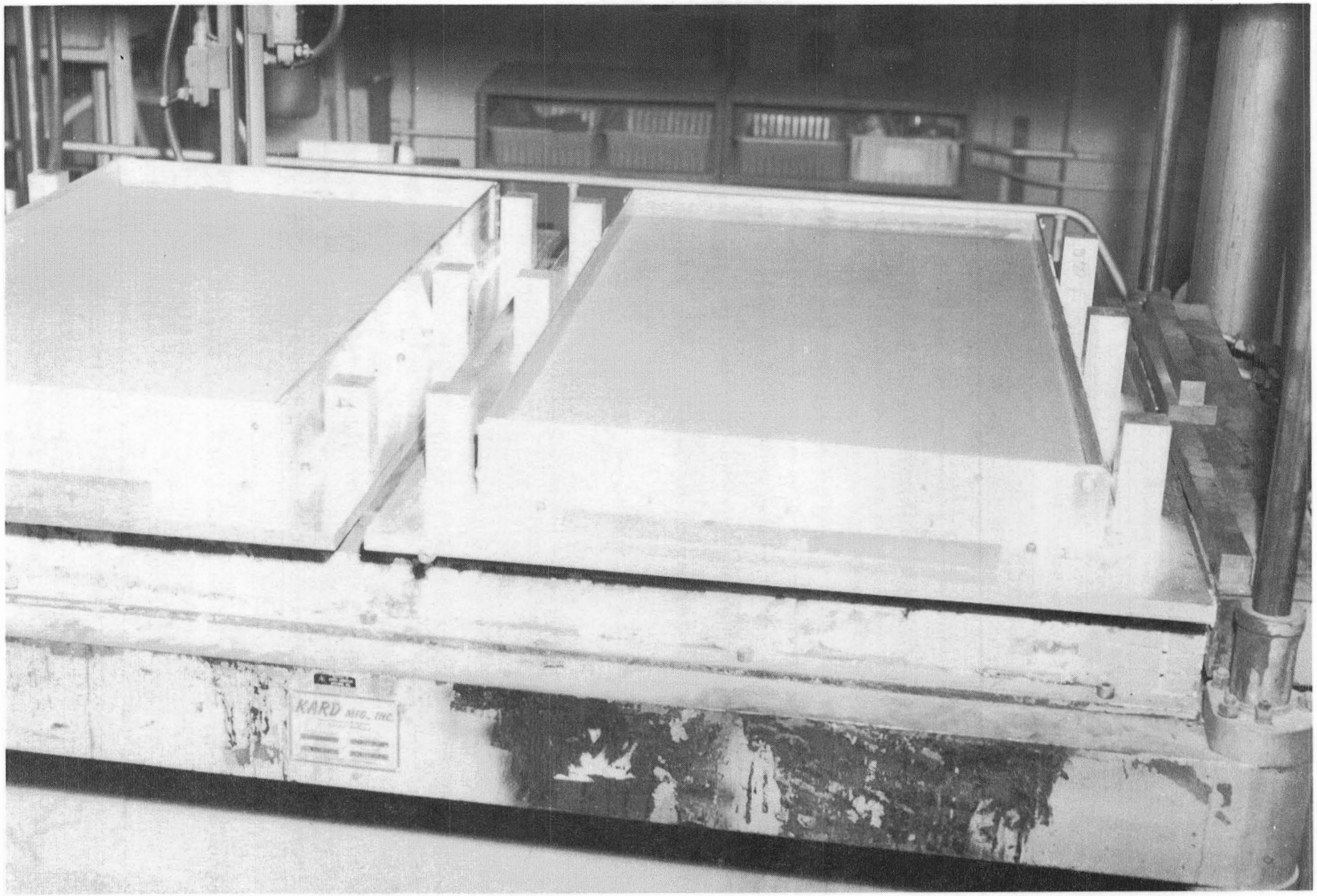


Figure 24. Precompacted Filler With Caul Plates Removed

Space Division
North American Rockwell

to be a wise decision since the ablative material did not completely cure and the panel was scrapped. An investigation was made as to the probable causes of the inhibited cure.

The investigation indicated that the Sylgard 182 resin was partially inhibited. Two changes were, therefore, made. One change was to increase the primer drying temperature from room temperature to 333 K (140 F). The time was reduced from 1 hour to 1/2 hour. The second change was to increase the curing temperature of the compound from 355 to 394 K (180 to 250 F) and reduced the cure time from 24 to 16 hours minimum at temperature. Thermocouples were added which indicated that the heatup time was approximately three hours. These changes completely eliminated the cure problem. The increase in cure temperature did not cause an increase in panel bowing. The maximum bow was found to be 0.45 cm (0.18 inch) and the panel could be easily held flat by hand.

All of the twelve required panels were compacted at and filled in the press, two at one time. This arrangement is shown in Figures 24, 25, and 26 and was found to be very satisfactory. By mixing the ablative compound ahead of time, four panels were compacted and filled in a one-shift operation.

Upon removal from the press, each panel was individually vacuum bagged and placed in an oven to cure at 394 K (250 F) for 16 hours.

Final Trimming, Hole Cutting, and Plug Cutting

After removal of the vacuum bags, the panels were trimmed to size using a conventional table saw with a fine-tooth blade. The holes were located with a 6.4mm (1/4-inch) thick Plexiglas template which also served as a guide for the manually operated tubular gasket cutter used for cutting the six 19mm (0.750-inch) diameter holes. A special bushing was then inserted and a 4mm (9/32-inch) diameter punch was inserted in the bushing. The six small holes were then punched out by hitting the punch with a ball-peen hammer. All plugs were cut from excess trimmings using a special 17.4mm (0.687-inch) inside-diameter gasket cutter. The plugs were readily pushed out of the hollow cutter. A typical completed panel with plugs is shown in Figure 27.

DIMENSIONAL AND DENSITY VARIATIONS

Before cutting the holes all panels were completely measured, weighed, checked with straight edges for warpage, and density calculations made. The data for each panel are presented in Table 8. It should be noted that the average thickness variation in the twelve panels was only 0.93mm (0.034 in.). The lengthwise bowing only occurred in the six SK058322-151 (Sylgard 182)

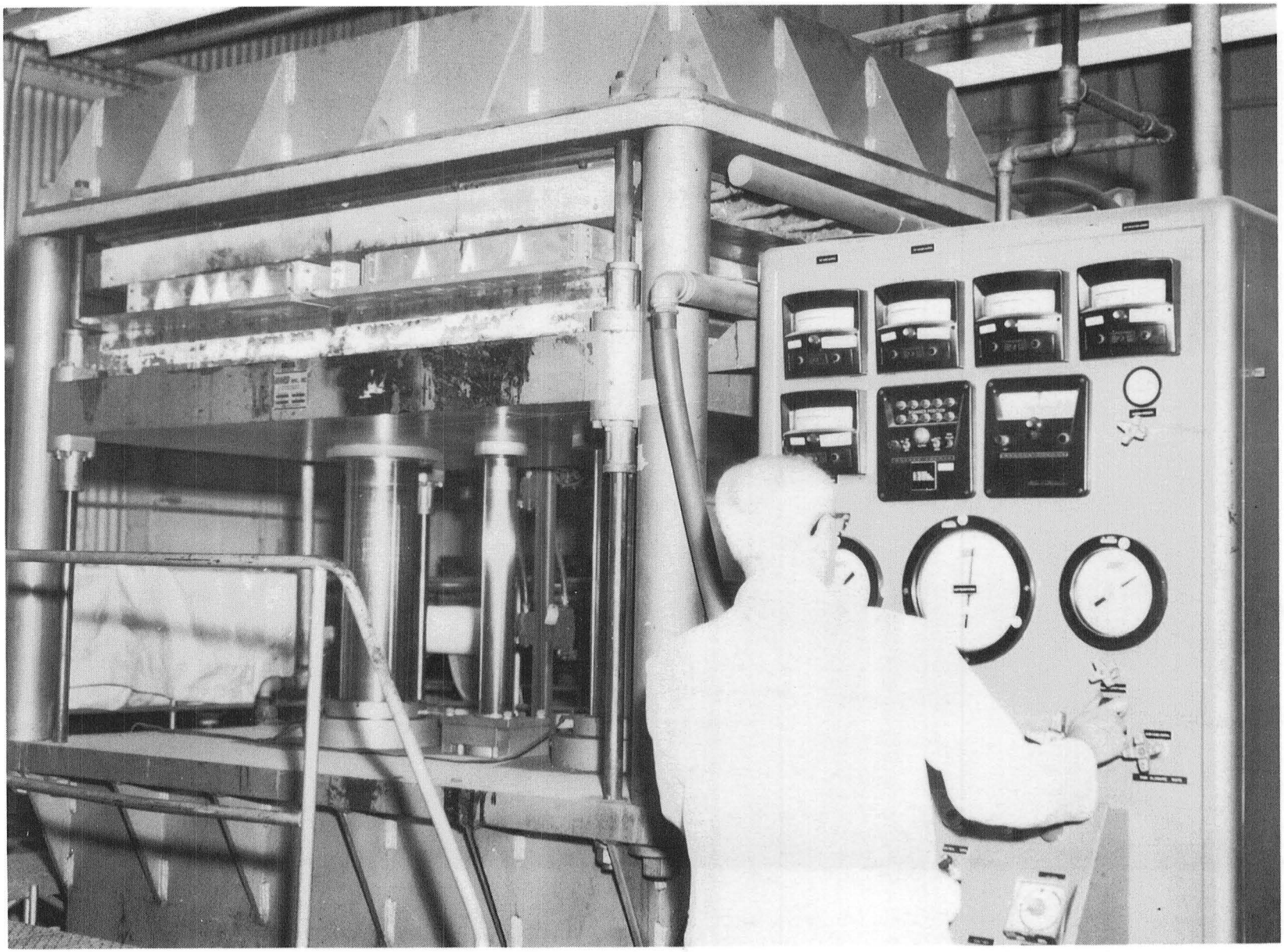


Figure 25. Press Closed During Filling of Inverted -13 Subassembly

Space Division
North American Rockwell

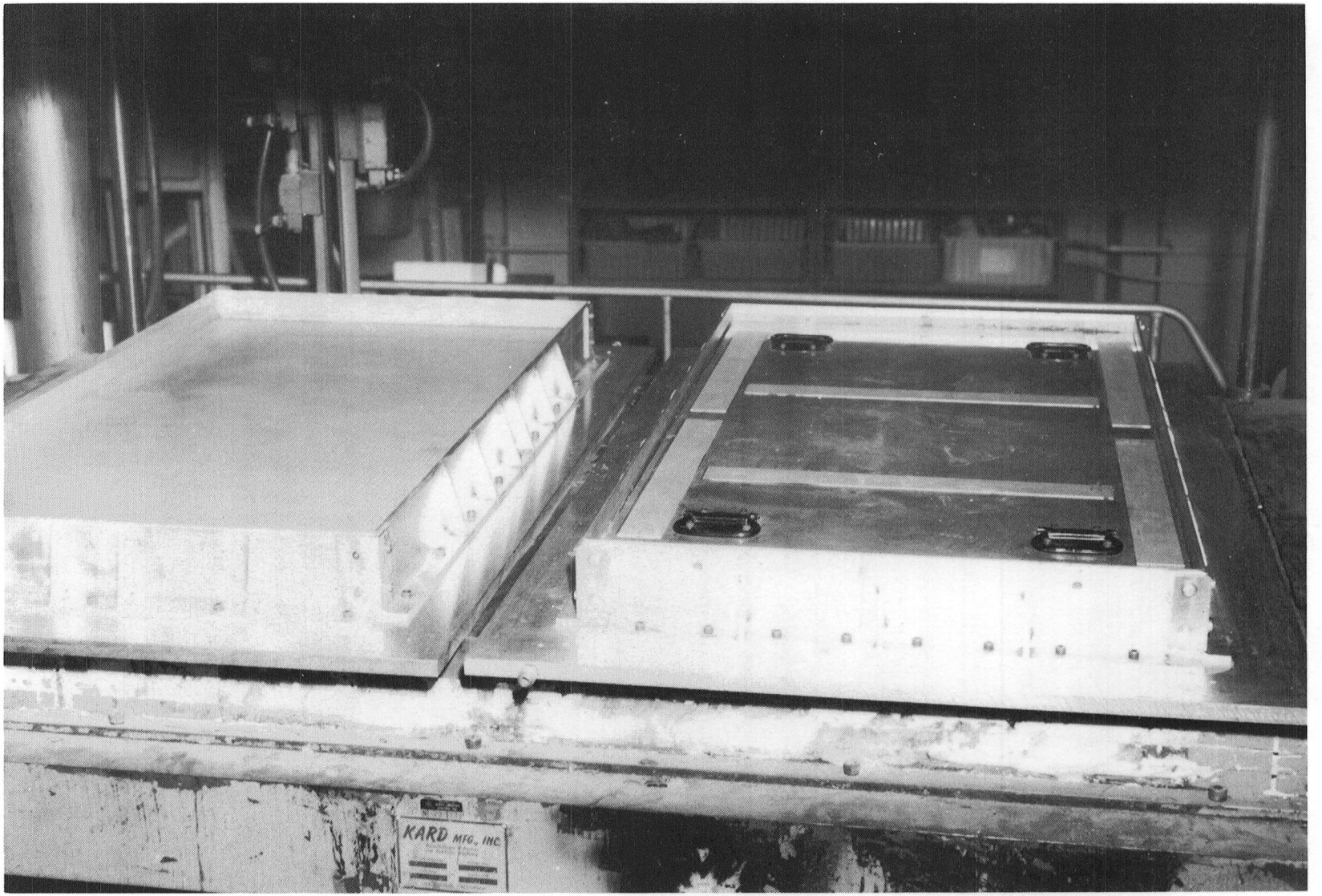


Figure 26. Open Press Showing Inverted -13 Subassembly Pressed Into Filler

Space Division
North American Rockwell

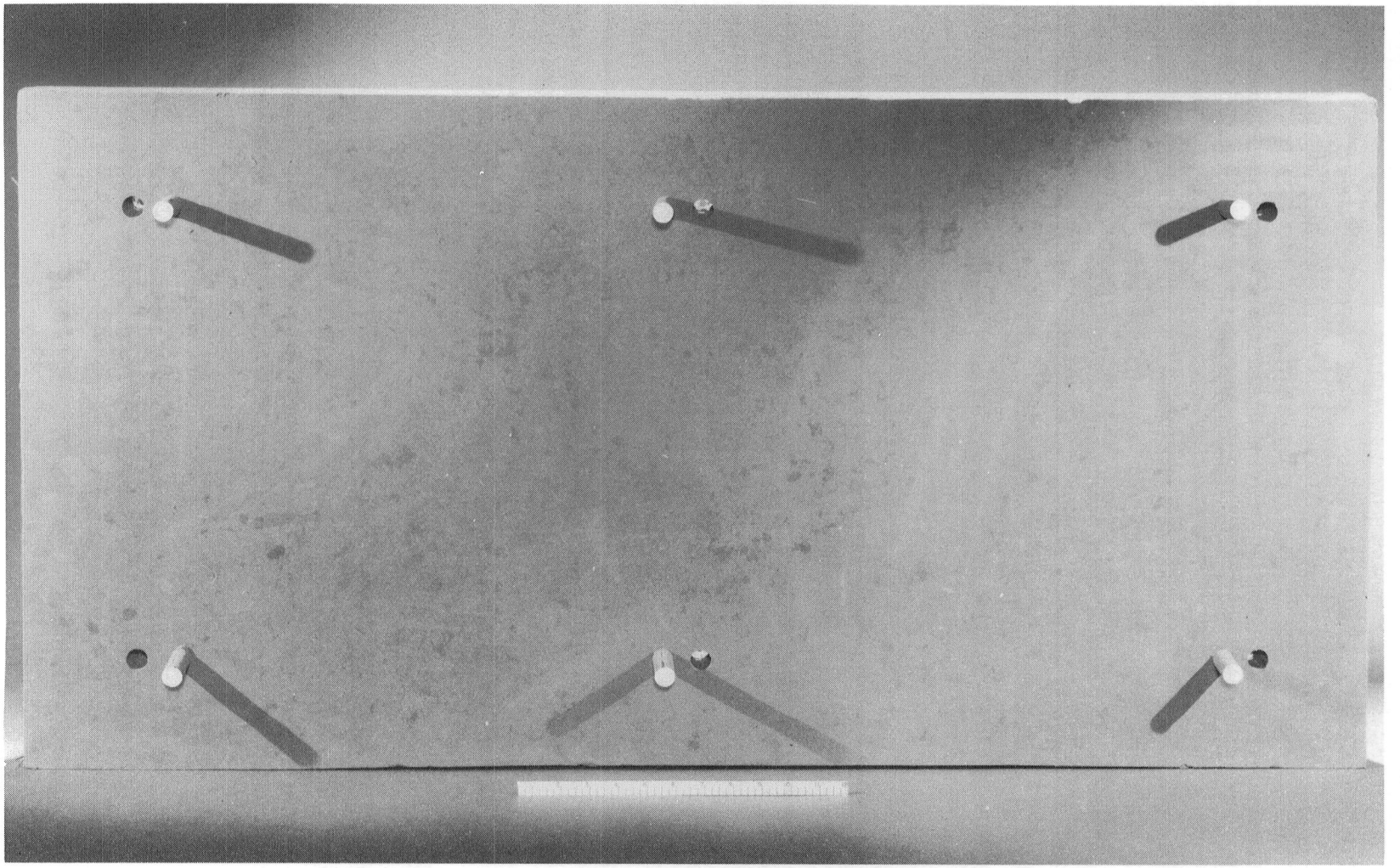


Figure 27. Typical Completed Panel Showing Attach Bolt Holes and Plugs

Space Division
North American Rockwell

panels. While the bowing of the SK058322-151 panels, was very slight, average of 2.96mm (0.116 inch), and could be held flat with slight hand pressure, it was interesting to note that the other SK058322-161 (RTV602) panels had sufficient flexibility to lie flat on the table.

The densities of the panels were closely maintained by accurate material weighing and thickness control. The average density for the six SK058322-151 panels was 245 kg/m^3 (15.28 lb/ft^3), whereas the average density for the six SK058322-161 panels was 271 kg/m^3 (16.86 lb/ft^3). This increase in density was done intentionally to improve the handling characteristics of the SK058322-161 panels. It is felt that the nylon powder in the SK058322-161 panels was responsible for the relative easy rubbing off of the ablator compound at a density around 240 kg/m^3 (15 lb/ft^3).

COST CONTROL AND ESTIMATING STUDY

Cost Control

The existing POLAR production control system was used in the fabrication of the twelve panels and seventy-two plugs required for this program. POLAR is an on-line mechanized system providing the required data base for utilization of standard values in planning, budgeting, cost, and schedule control. The system is based on engineered time standards. The part number standards file is a basic file of standard times for any operation required to produce any part or assembly. These standard times are applied to each detailed manufacturing order sequence. Personnel input their in-work and completions against these sequences on terminals located in their work area. The computer then collects and reports the earned standard hours, actual hours, and productivity by department, work center, and cost center. For scheduling purposes, Manufacturing is provided an on-line status of sequence completions and a measure of percent complete.

Cost Estimating Study

Fabrication Manhour Estimate Rationale

To estimate the cost of 1, 100, and 1000 panels, various cost analysis techniques were used. These costs were then compared with the costs of the SK 058322-121 panel fabricated on the previous contract, see Reference 1.

Task 2 of the contract required the fabrication of 12 details (SK 058322-13), 12 flat panel assemblies (SK 058322-151 and -161) and 72 plugs (SK 058320-91 and -101). Because the effort required to complete the 12 details and the 72 plugs took less than a day each, it was felt that this effort was not representative of the learning that should be experienced.

Table 8. Measurements and Density of Flat Panels

Panel No.	Average Thickness* centimeters	(inches)	Lengthwise Warpage millimeter	(inch)	Density kg/m^3	(lb/ft^3)
TYPE SK-058322-151						
1	5.182	(2.040)	1.37	(0.054)	249	(15.52)
2	5.222	(2.056)	1.36	(0.0535)	245	(15.27)
3	5.237	(2.062)	3.05	(0.120)	243	(15.16)
4	5.237	(2.062)	3.10	(0.122)	242	(15.10)
5	5.245	(2.065)	4.37	(0.172)	244	(15.23)
6	5.248	(2.066)	4.50	(0.177)	247	(15.39)
Average	5.228	(2.059)	2.96	(0.1164)	245	(15.28)
TYPE SK-058322-161						
7	5.161	(2.032)	None		272	(16.45)
8	5.197	(2.046)	None		270	(16.83)
9	5.169	(2.035)	None		271	(16.90)
10	5.161	(2.032)	None		276	(17.2)
11	5.182	(2.040)	None		268	(16.70)
12	5.232	(2.060)	None		266	(16.60)
Average	5.184	(2.041)	0		271	(16.86)

*A minimum of four measurements were made.

Space Division
North American Rockwell

The actual hours accumulated for the fabrication of the -151 and -161 flat panel assemblies, as shown in Tables 9 and 10, were subjected to a least square regressional analysis using the Wright Curve Theory programmed on the GE440 computer. The result: an 84.4-percent CRC with an extrapolated first unit cost of 45.6 hours. To this first unit assembly estimate, the average hours per unit for the details and the plugs were added, bringing the total first unit cost to 52.47 hours.

In certain specific sequential operations in Table 9, a greater number of hours will be noted for the -151 as compared with the -161. This was due to the normal learning process since the -151 panels were fabricated first. A review of the actual labor hours, recorded for every pair of panels fabricated, showed that there were no significant differences in the total hours required to produce the last four panels of either part number.

A program of 100 or 1000 units would be expected to have a steeper learning curve as a result of a higher production rate. Additionally, less than 1 percent of the operations time is expended on machine-paced activity. For these reasons, it was deemed appropriate to use an 80-percent CRC instead of the computer projected 84-percent CRC. The computer tabulations may be found in Appendix B.

On the basis of an 80-percent CRC, the estimates for fabrication of 100 and 1000 units are 1191 and 5677 hours, respectively.

Dimensional Tooling Estimate Rationale

Dimensional tooling estimates were based upon tooling experience on the development program and analysis of production contract requirements. The sustaining calculations for 100 units and 1000 units were based on a 106-percent sustaining slope.

Planning Estimate Rationale

Production Planning and Production Control operations are based upon the experience of North American Rockwell with previous programs. For the first unit, the historical experience of 12 percent of fabrication hours was used. The -121 estimates for 100 and 1000 units were established using a factor of 1/2 hour for each ticket in a lot of 99, and a factor of 1/4 hour for each ticket in a lot of 999. Planning and Production Control estimate for the -151 and -161 panels was reduced by 15 percent due to the reduction in the number of operations per ticket realized through the experience on the previous development program.

Table 9. Actual Labor Hours per Completed Panel

Sequence*	Operation	Actual Hours/Unit -121	-151	-161
1	Cut face sheets and check	3.0		
	Cut face sheets and core		1.0	1.0
2	Clean core	1.0	0.2	0.2
3	Assemble core, face sheets, bag and check	8.0		
3	Layup core and face sheets for shipment to vendor		0.2	0.2
	(Travel to and from vendor)		0.2	0.2
	Unpackage, assemble face sheet and core		0.6	0.6
3	Cure (standby)	1.0	0.5	0.5
3	Debag, check, package	2.0		
	Unpackage, check, repackage		0.9	0.9
5	Clean shop aid and apply release agent	3.0		
	Subtotal -11 subassembly	18.0		
	Subtotal -13 subassembly		3.6	3.6
4	Unpackage, prime, and dry core, repackage	4.0	2.5	2.3
6, 7, 8, 9	Mix and store materials	34.0	4.5	3.5
10	Clean fill fixture and apply release agent	5.0	6.0	3.0
10	Screen filler material into fixture	10.0		
10	Place material in fixture		2.5	2.0
11, 12	Compress material and compress core in material	12.0	9.0	8.0
13, 14	Add second face sheet, bag, and check vacuum	6.0	3.0	2.5
15	Oven cure	6.0	4.0	2.0
16	Debag, disassemble fixture, and check assembly	1.0	0.8	0.6
17	Trim excess	1.0	1.0	0.8
18	Weigh and check	1.0	0.6	0.5
19	Cut 6 holes	1.0	1.0	1.0
	Total assembly**	81.0	34.9	26.2
	SK 058320 plugs	2.0	2.8	1.3
	Package to ship	3.0	2.0	2.0

*See Figure 15 for sequence and operation details.
**Time to coat assembly is not included in totals.

Note: The hours shown are the time spent performing the actual operations. Delay hours, such as waiting for photographer, data recording, etc., have been eliminated. Refer to Reference 1 for hours and cost data on SK 058322-121.

Table 10. Low-Cost Ablative Panels
(Hours Summary)

Operation	1 Unit	100 Units	1000 Units
Fabrication			
SK058322-121	98	3477	13, 562
-151, -161	52	1191	5, 677
Production planning			
-121	12	60	262
-151, -161	10	51	223
Tool planning			
-121	10	20	25
-151, -161	10	20	25
Dimensional tooling			
-121	62	92	111
-151, -161	62	92	111
Inspection (12. 5%)			
-121	12. 5	466	1, 695
-151, -161	6. 5	149	710

Space Division
North American Rockwell

Material and Labor Cost Estimate

Material costs are estimated as shown in Table 11. It should be noted that a 20-percent loss and scrap factor has been included which could be reduced in large production operations.

A cost summary of both materials and labor for units of 1, 100, and 1000 is presented in Table 12. Table 12 also shows the costs from the previous program (Reference 1) are also given to show the total cost reduction accomplished on this program. A comparison shows that a 26 percent cost reduction was estimated for 1 unit, 48 percent for 100 units, and 31 percent for 1000 units.

Table 11. Fabricated Panels, Material Costs

Item	Costs
Panel Type (SK058322-121)	
1. HRP - 3/8 - GF11 - 2.2 (core)	$ 84.00
2. Reliabond R1714 prepreg (facing)	12.00
3. Elastomer (Sylgard 182)	22.00
4. Microballoons (BJO-0930)	32.00
5. Miscellaneous expendables	15.00
	$165.00 + 20%
	32.00
*See Reference 1	$197.00
Panel Type SK058322-151	
1. HRP - 3/8 - GF12 - 3.2 (core)	$ 84.00
2. Reliabond R1714 prepreg (facing)	12.00
3. Elastomer (Sylgard 182)	26.00
4. Microballoons (BJO-0930)	17.80
5. Glass bubbles (B-30B)	2.20
6. Miscellaneous expendables	15.00
	$157.00 + 20%
	31.00
	$188.00
Panel Type SK058322-161	
1. HRP - 3/8 - GF12 - 3.2 (core)	$ 84.00
2. Reliabond R1714 prepreg (facing)	12.00
3. Elastomer (RTV 602)	26.00
4. Microballoons (BJO-0930)	15.00
5. Glass bubbles (B-30B)	3.00
6. Nylon powder (Polypenco 66D)	8.00
7. Miscellaneous expendables	15.00
	$163.00 + 20%
	33.00
	$196.00

Table 12. Low-Cost Ablative Panels Cost Summary in Dollars

Description	Panel SK-058322-121*			Panel SK-058322-151, -161		
	1 Unit	100 Units	1000 Units	1 Unit	100 Units	1000 Units
Material**	197	19, 700	197, 000	188	18, 800	188, 000
Fabrication Hr x $13. 19	1, 293	45, 863	178, 883	686	15, 709	74, 880
Planning production Hr x $14. 13	170	848	3, 703	141	721	3, 151
Planning tool Hr x $14. 13	141	283	353	141	283	353
Dimensional tooling Hr x $13. 77	854	1, 267	1, 528	854	1, 267	1, 528
Inspection Hr x $13. 91	174	6, 482	23, 577	90	2, 073	9, 876
Subtotal	2, 829	74, 442	405, 043	2, 100	38, 853	277, 788
+ 20 per-cent other	566	14, 888	81, 009	420	7, 771	55, 558
Grand total	3, 395	89, 330	486, 052	2, 520	46, 624	333, 346
Cost per square foot	424	112	61	315	58	42

*Panel fabricated in previous contract NAS1-9943. See Reference 1.
**Reduction in material costs not indicated for 100 and 1000 units due to data reduction problems (i.e., variation in material lot sizes and cost break points).

This Page Intentionally Left Blank

TASK 3: AIR PERMEABILITY VENT TESTING OF FULL-SIZE PANELS

Of the twelve panels fabricated in Task 2, four were selected for air permeability vent tests to verify the pressure differentials established in Task 1 and, in particular, to determine the effects of the pressure on the low-density ablator panel and its attach points. Since the pressure differential magnitudes (loads) are to be established and no basic mechanical properties are available, no structural analysis was planned for this task. The influence of the two most permeable protective coatings selected in Task 1 were also to be further evaluated as to their effects on the panel's venting performance. The DC 92-009 clear dispersion coating and the white pigmented TBS-758 thermal coating were selected for their combined permeability and reported resistance to moisture, heat, and erosion.

TEST PROCEDURE

The Task 3 test program was planned to first test a full-size panel, without a coating, to the shuttle orbiter boost local pressure profile which is shown in Figure 28. If this panel was uneffected structurally, then the subsequent tests would be conducted on coated panels.

DESIGN AND FABRICATION OF TEST FIXTURE

The full-size air permeability test fixture (Drawing SK058322-151-T101, Figure 29) was designed for use in the Engineering Laboratories' 4-foot cube altitude chamber. The fixture was designed and fabricated with a 1.9 cm (3/4-inch) air space between the panel and the simulated structure. This was estimated to represent the worst attachment standoff distance condition that might be encountered for a mechanically attached ablator panel. The fixture was also fabricated with sufficient spacer bars to readily permit additional attach points to be added if necessary. Provisions were made to seal the panel around the periphery. The completed fixture, without panel, is shown in Figure 30.

LEAK TEST

Prior to conducting a launch profile test on specimen 1, a leak test of the test fixture, (SK-058322-151-T101) was performed. The test setup schematic is shown in Figure 31.

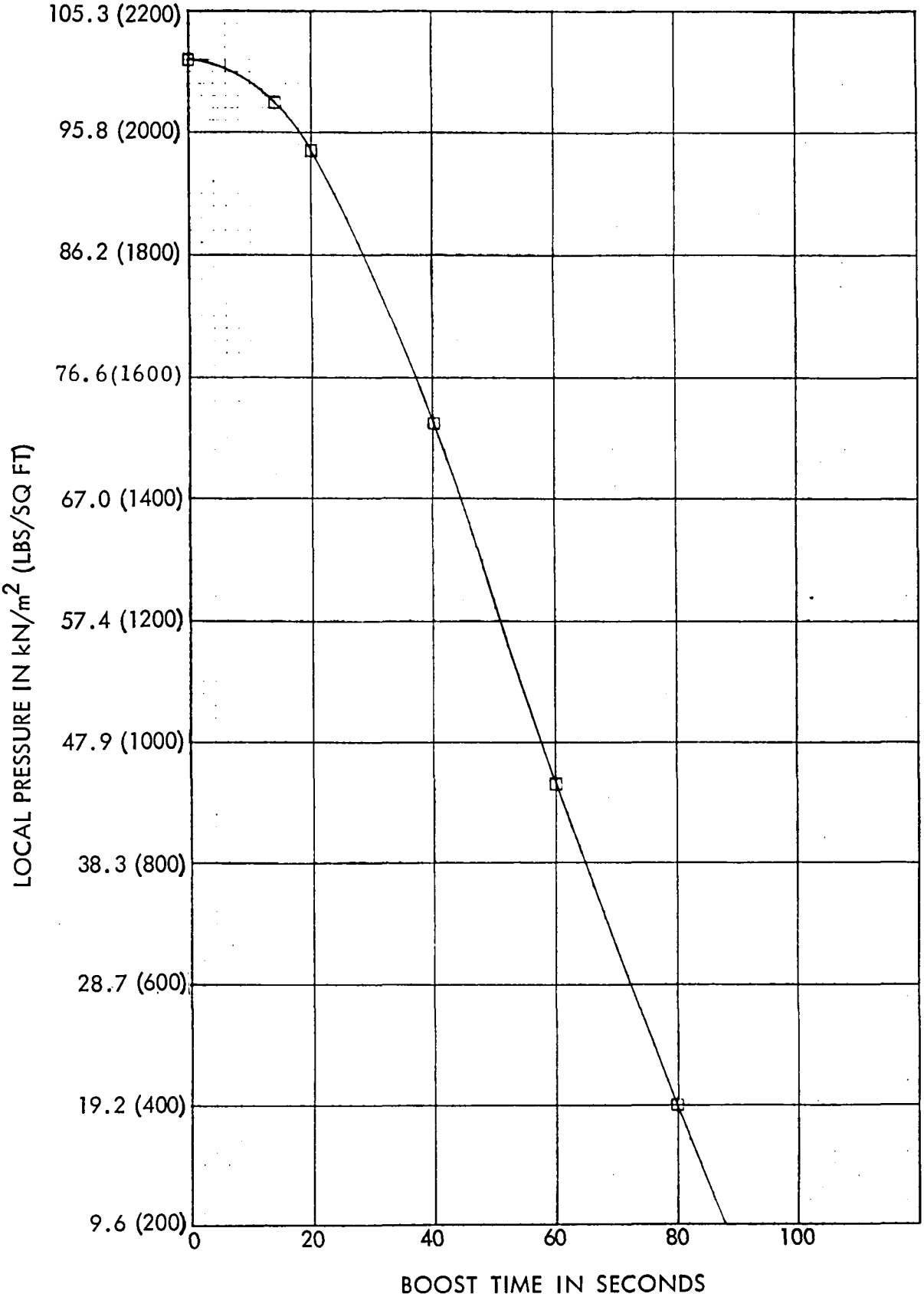


Figure 28. Orbiter Boost Local Pressure Profile

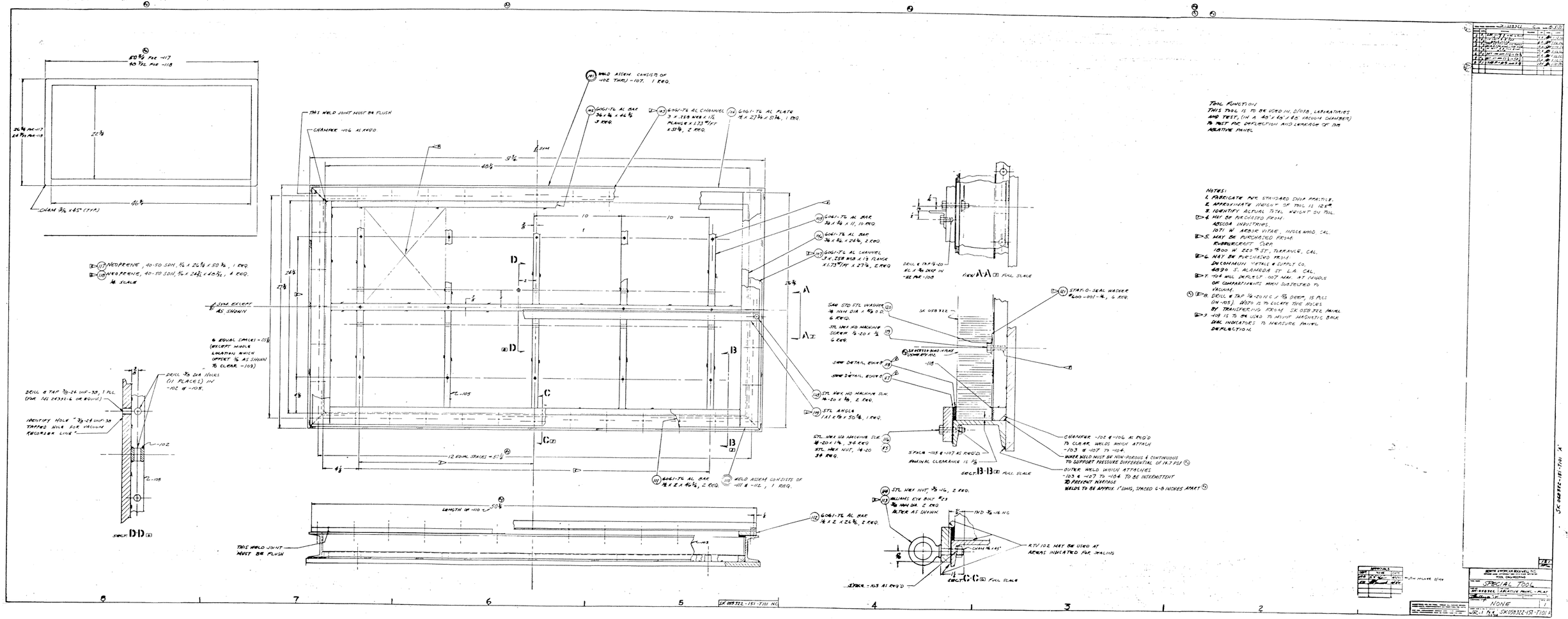


Figure 29. Full-Size Air Permeability Test Fixture Design

700-86-1055

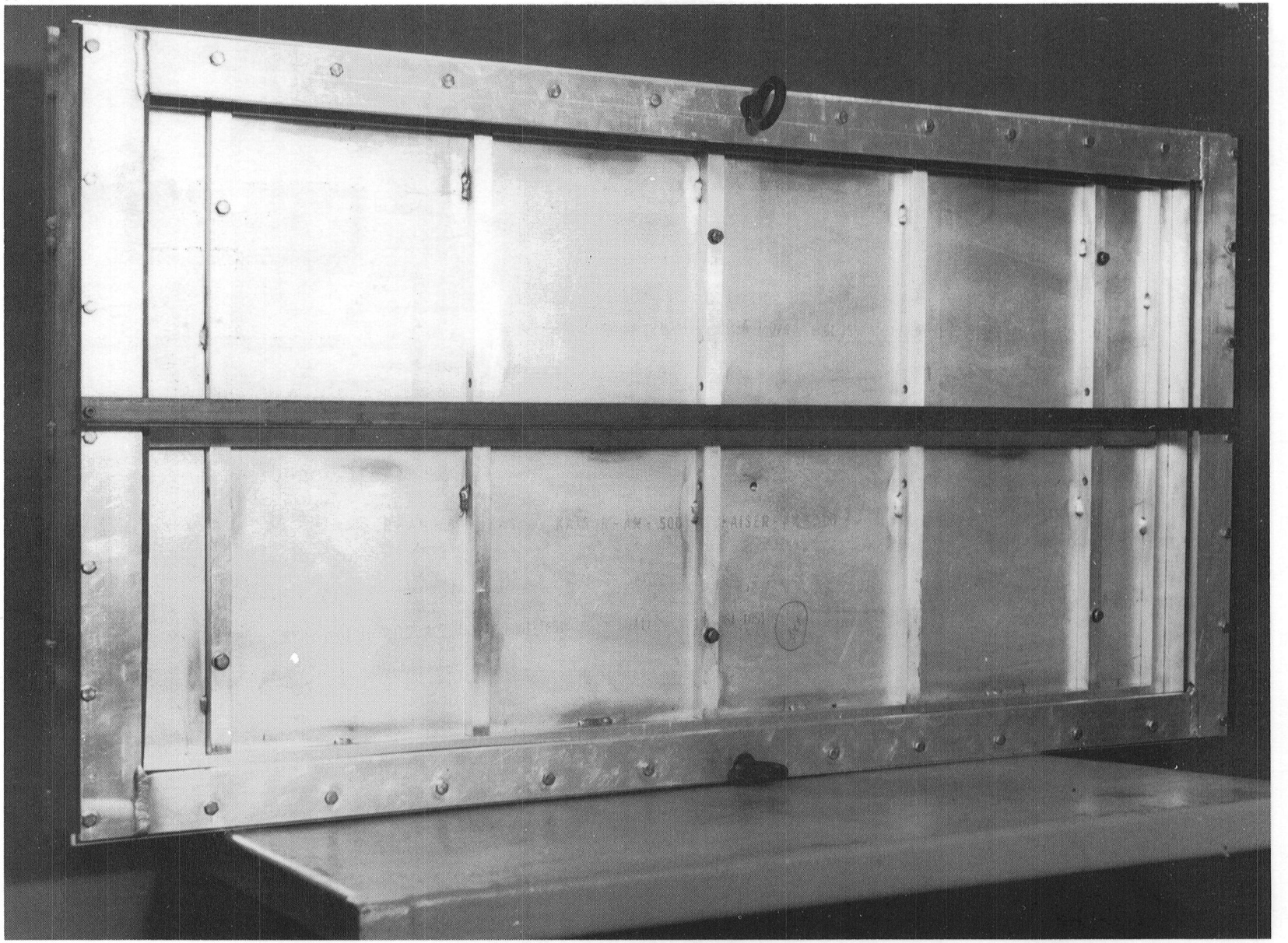


Figure 30. Completed Air Permeability Test Fixture

Space Division
North American Rockwell

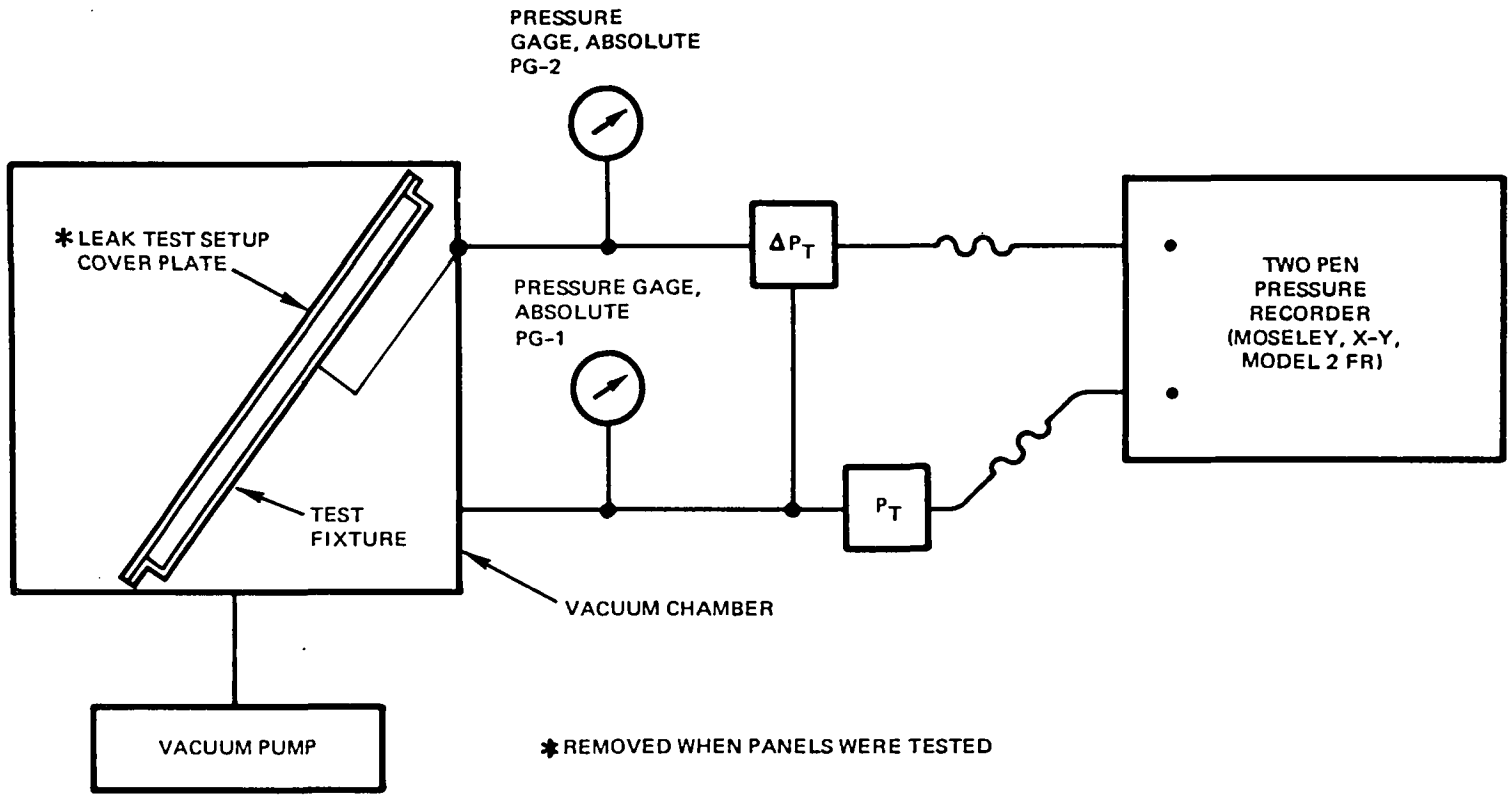


Figure 31. Typical Test Setup Schematic

Space Division
North American Rockwell

When the pressure in the chamber was reduced to 68.9 kN/m^2 (10 psia) and held for 4 minutes, the test fixture pressure dropped from 97.7 to 97.4 kN/m^2 (14.17 to 14.12 psia) indicating a leak rate of approximately 68.9 N/m^2 (0.01 psi) per minute. Since a pressure decrease of approximately 77.2 kN/m^2 (11.2 psi) per minute was planned for the vent tests, this leak rate was considered acceptable.

TEST RESULTS

Test Run 1

Specimen 1 (fabricated per SK-058322-161 without a coating) was installed in the test fixture with deflection dial indicators located as shown in Figure 32. The complete unit was then installed in the altitude chamber as shown in Figure 33 and subjected to a controlled decrease in chamber pressure simulating the launch profile. Chamber pressure and differential pressure across the panel versus time were measured and recorded throughout the test. Figure 34 shows that a maximum differential pressure of 1034 N/m^2 (0.15 psia) occurred 75 seconds after the start of the launch profile. A deflection of 0.25mm (0.010 inch) was observed visually and by motion picture coverage. Post-test examination of the ablative panel revealed no visible evidence of damage resulting from the test.

Test Run 2

The test fixture frame was removed from the specimen and a Dow-Corning 92-009 dispersion coating was applied to the exposed surface of the panel. After room temperature curing of the coating overnight, the frame was installed on the fixture as shown in Figure 35 and the test specimen was put back in the altitude chamber as before.

The specimen was subjected to the same launch profile pressure as for Test Run 1. Chamber pressure and differential pressure across the panel was recorded. Visual observations were made of the deflection gages during the test.

Test results shown in Figure 34, showed that a maximum ΔP of approximately 12.4 kN/m^2 (1.8 psia) occurred 59 seconds after start of launch profile. At about this time, a crack was observed just below the upper dial indicator. Maximum crack width was estimated to be 4.3mm (3/16 inch). Post-test examination revealed two additional cracks in the area of the lower dial indicator. The sketch in Figure 36 presents the dimsenional details of the cracks. Photographs of the affected areas are shown in Figures 37 and 38. Maximum deflection indicated by the dial indicators was 6.1mm (0.240 inch) as observed through the window.

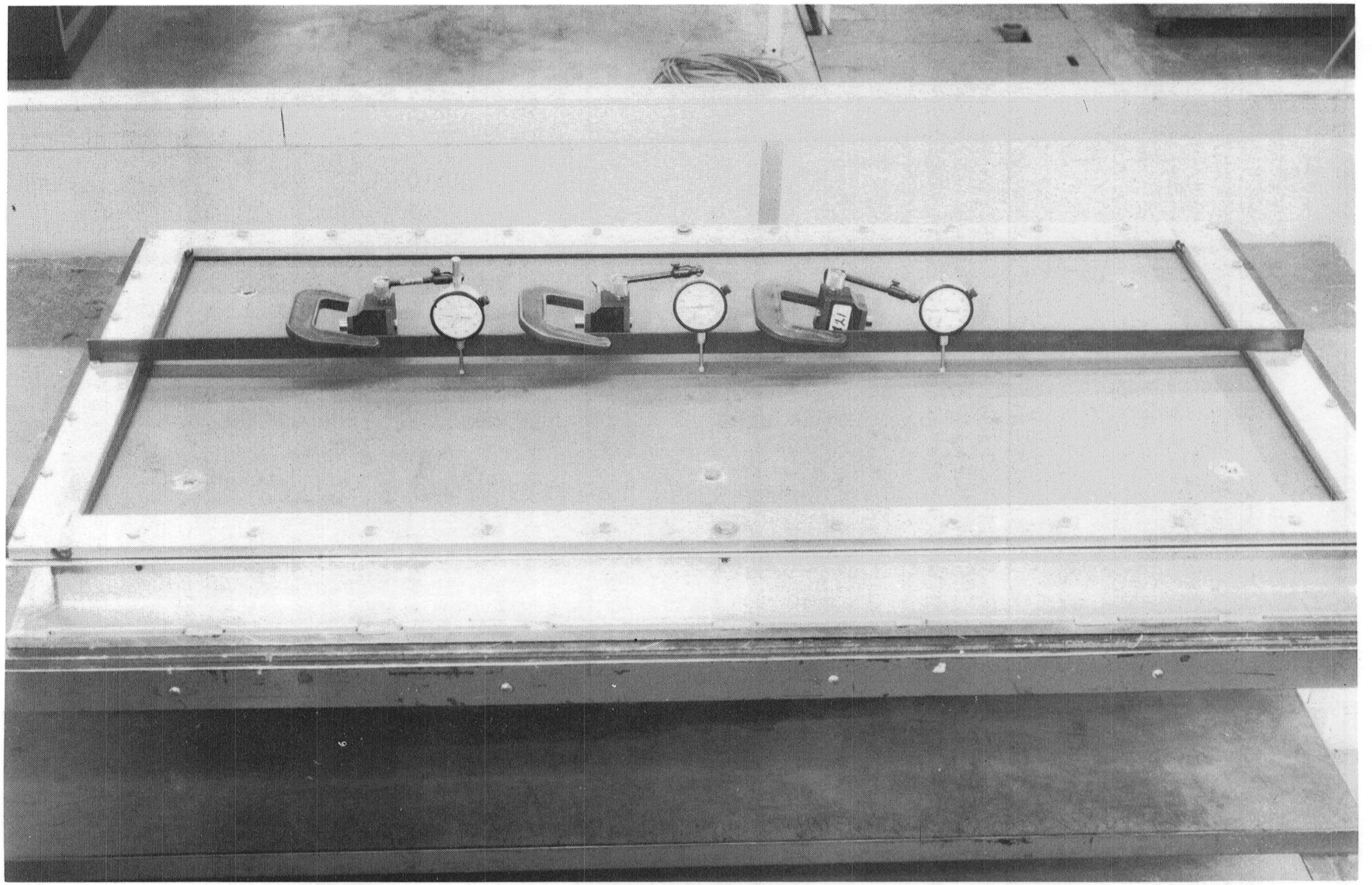


Figure 32. Specimen 1 Showing Ablative Panel Installed in Test Fixture With Dial Indicators Positioned

Space Division
North American Rockwell

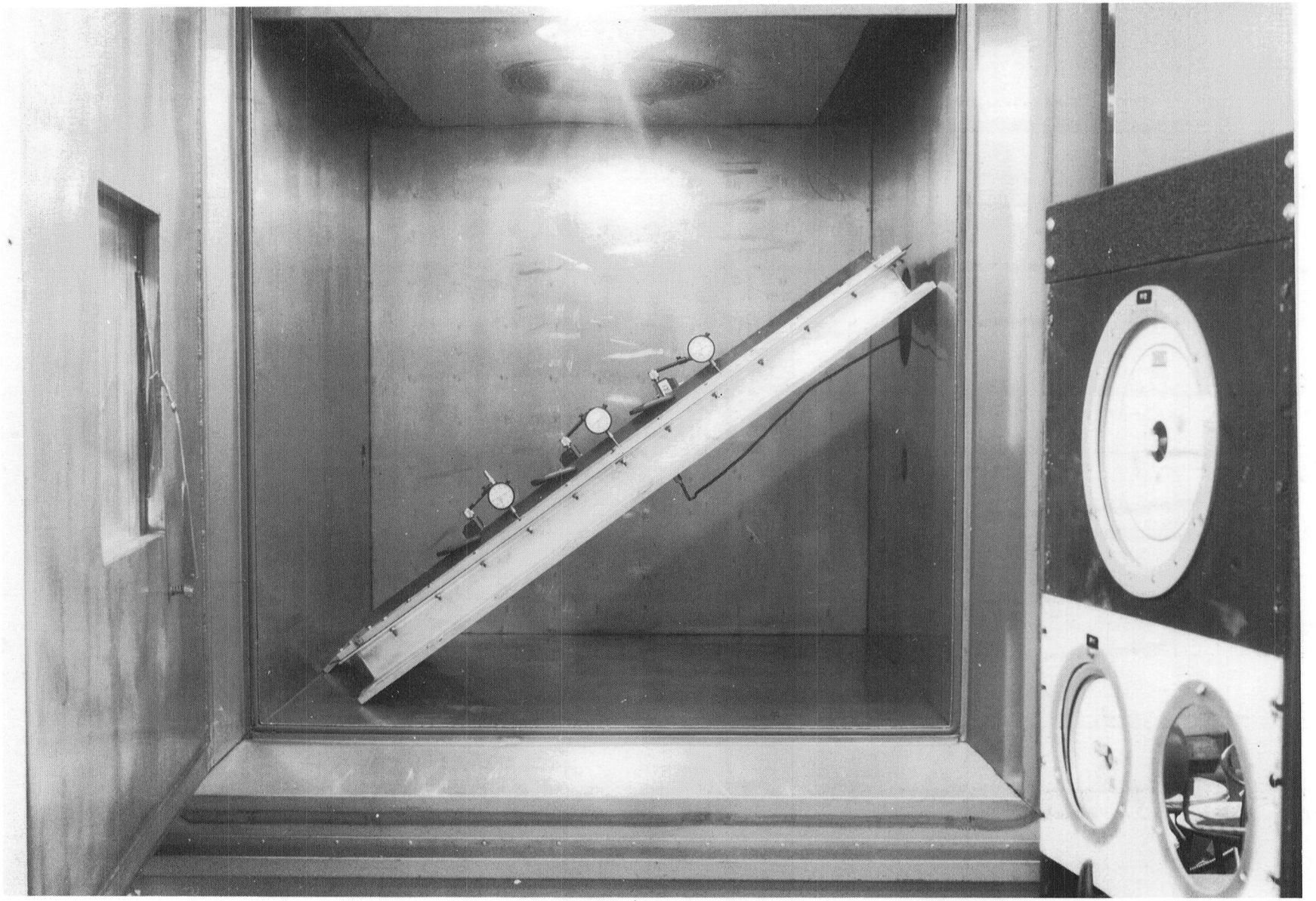


Figure 33. Specimen 1 in Test Fixture Installed in Altitude Chamber Ready for Test Run 1

Space Division
North American Rockwell

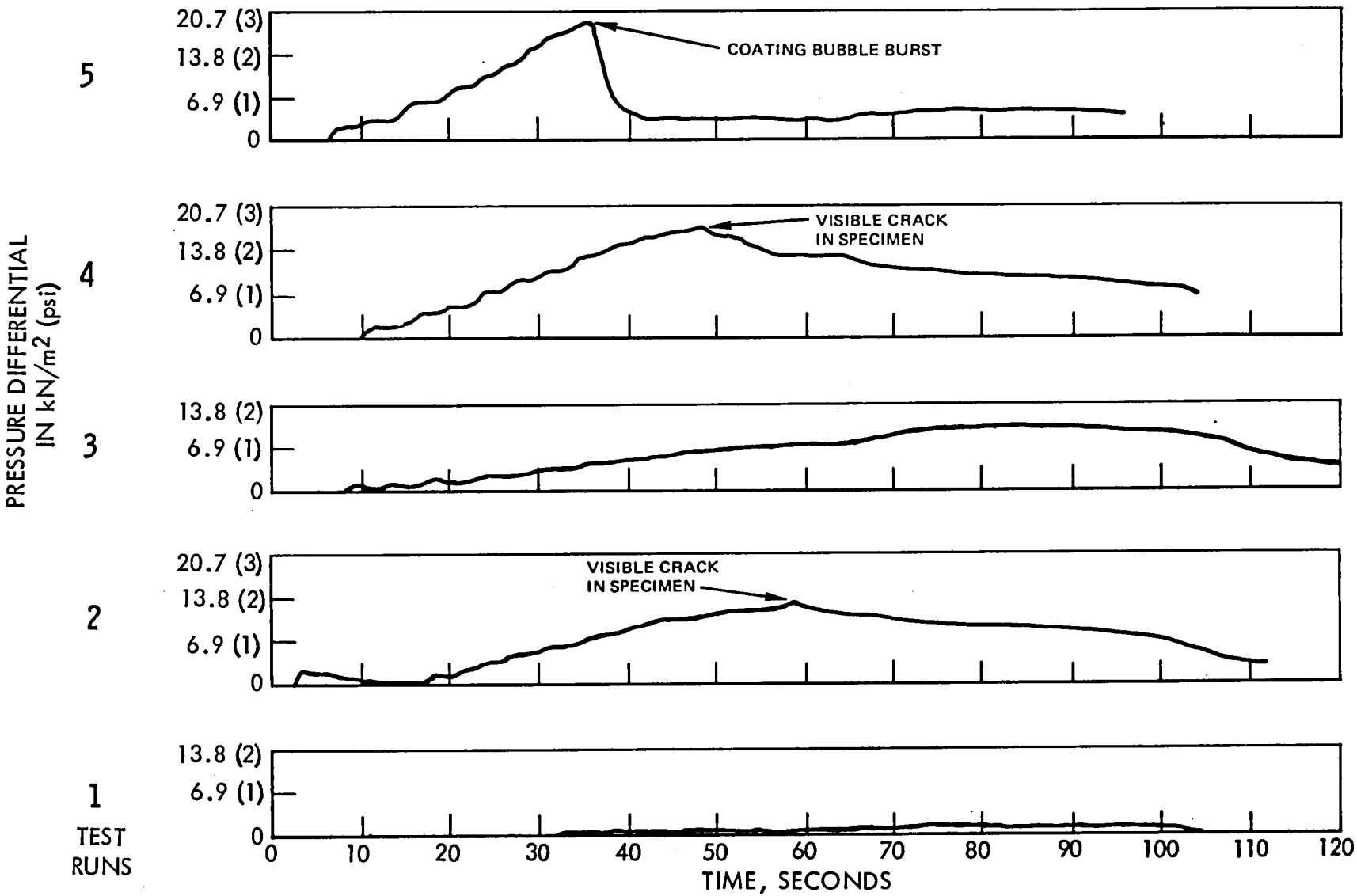


Figure 34. Air Permeability Vent Test Results - Pressure Differential Versus Time

Space Division
North American Rockwell

700-81-1680A

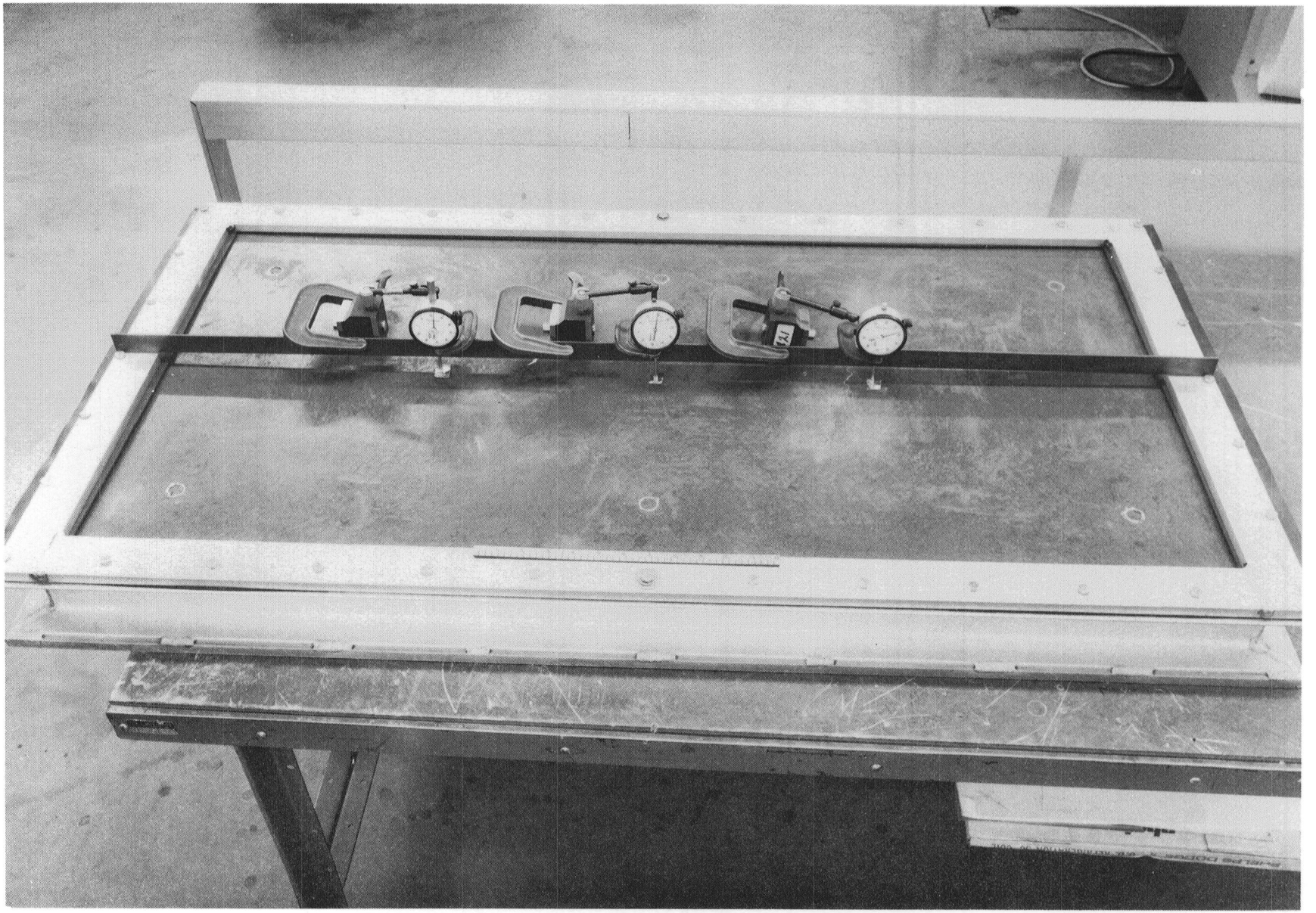
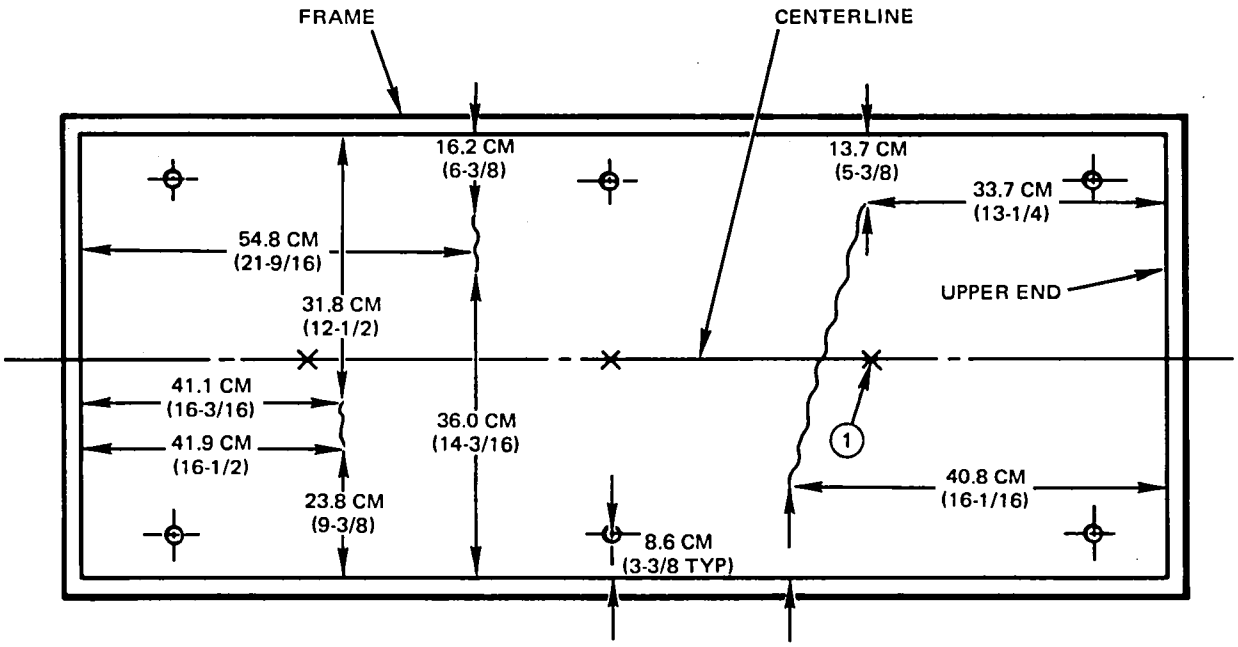


Figure 35. Specimen 1 Showing Coated Ablative Panel After Test Run 2

Space Division
North American Rockwell



SPECIMEN NO. 1 FOLLOWING RUN NO. 2
CRACK LOCATION DIMENSIONS
(6 BOLT SPECIMEN PATTERN)

(1) DIAL INDICATOR LOCATIONS 3 PLACES ON SPECIMEN CENTER LINE

Figure 36. Specimen 1 Crack Location Dimensions (6-Bolt Specimen Pattern)

700-81-1680B

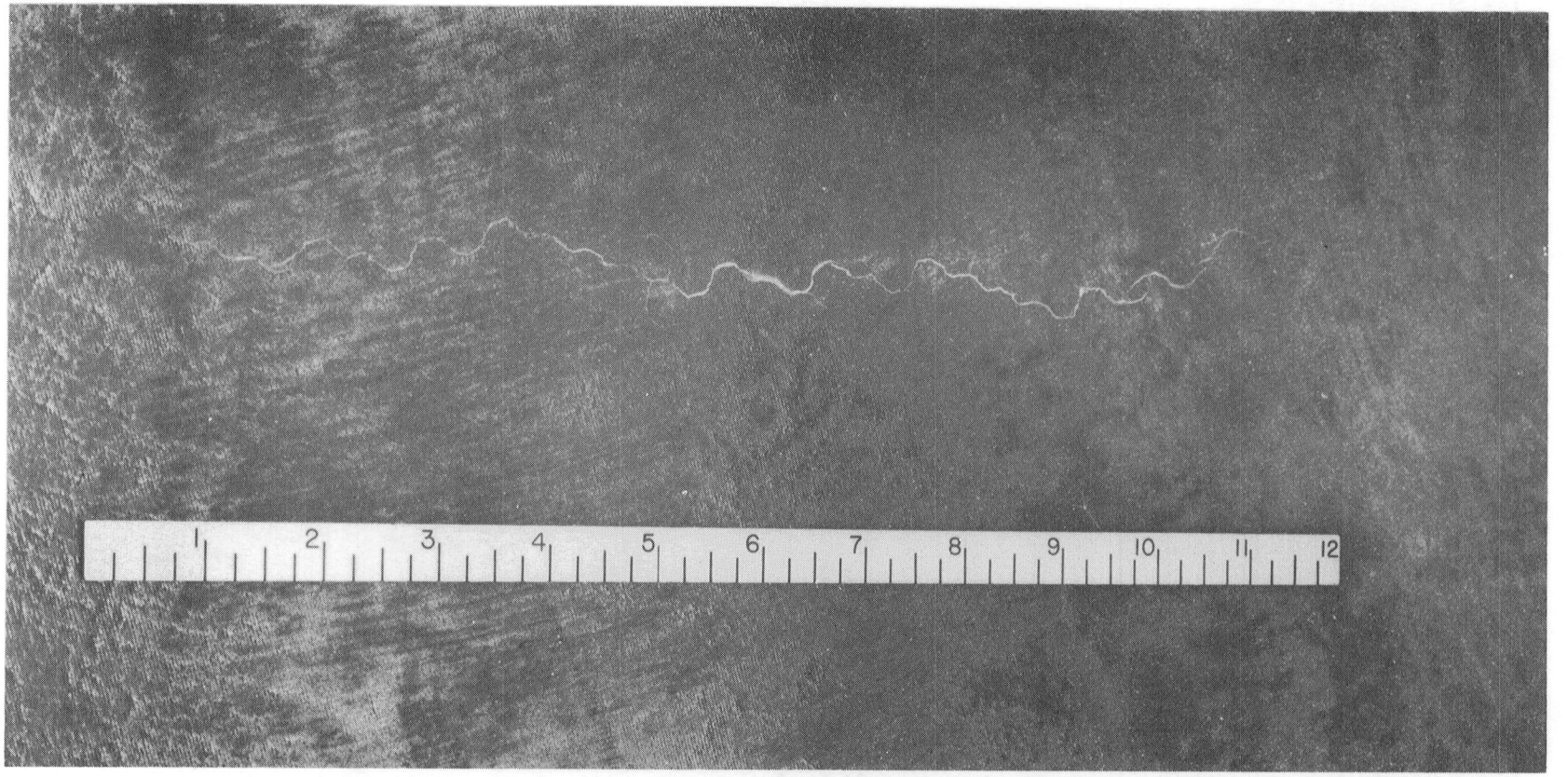


Figure 37. Closeup View of Longest Crack in Specimen 1 After Run 2

Space Division
North American Rockwell

700-81-1680C

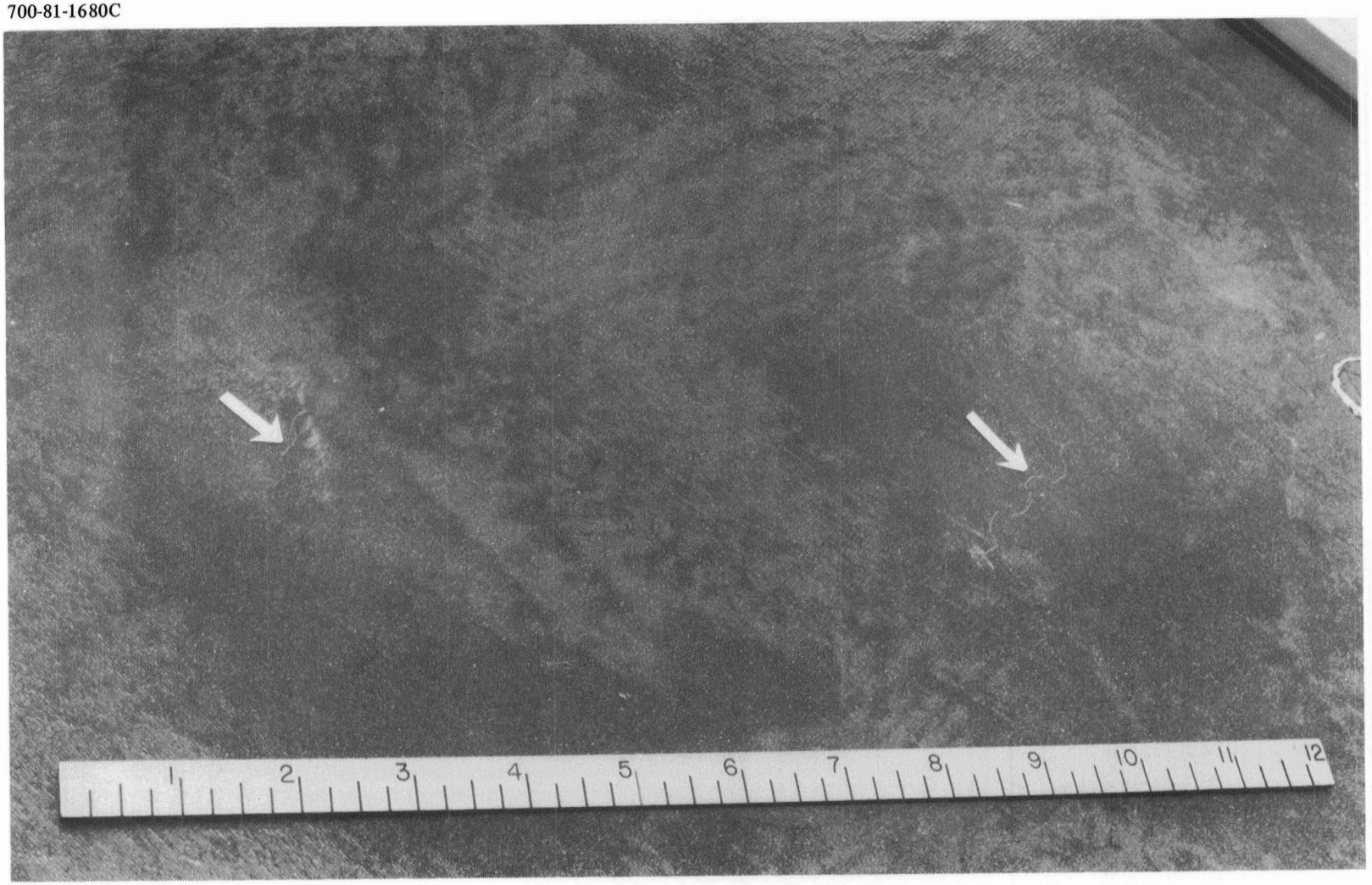


Figure 38. Detail View of Additional Cracks in Specimen 1 After Run 2

Space Division
North American Rockwell

The following deflections were shown by the dial indicators after the specimen was returned to ambient pressure:

Lower 0.06mm (0.0022 inch)
Center 0.07mm (0.0029 inch)
Upper 0.09mm (0.0037 inch)

After the specimen was removed from the fixture, localized evidence of delaminations between the face sheet and the core was visible around all attach points. The areas of delamination are shown in Figure 39.

Test Run 3

Because of the damage which occurred on the first panel, two additional attachment bolts were added along the center line of the second panel (See Figure 40) to reduce the excessive deflection and eliminate the cracking. Two ply, 7.6cm (3 inch) diameter doublers were also added. The ablative material and the dispersion coating were the same as used in specimen 1 during Run 2. The test specimen was then subjected to the same test conditions as previously described.

The results shown in Figure 34, showed that a maximum differential pressure of 10.3 kN/m^2 (1.5 psi) occurred approximately 83 seconds after test start and remained at that level until approximately 87 seconds after test start. Specimen deflection was 1.8mm (0.070 inch) in the center and 1.1mm (0.045 inch) midway between the added bolt and frame on the centerline (shown by the dial indicators positioned as shown on Figure 40). No visible evidence of cracking during the test or after the specimen was returned to ambient pressure.

The following deflections were shown by the dial indicators after the specimen was returned to lab ambient pressure:

Lower zero
Center 0.11mm (0.0045 inch)
Upper 0.01mm (0.0005 inch)

Upon removal of the panel specimen from the test fixture, there was evidence of localized separation of the glass fabric back facing from the core around seven of the eight bolt holes (Figure 41).

While the deflections were substantially reduced and the ablator cracking eliminated, there was still a need for reducing the load at each attach point. Therefore, it was planned that the next panel specimen be provided with seven additional attach points which would reduce the bolt spacing by one-half and redistribute the load.

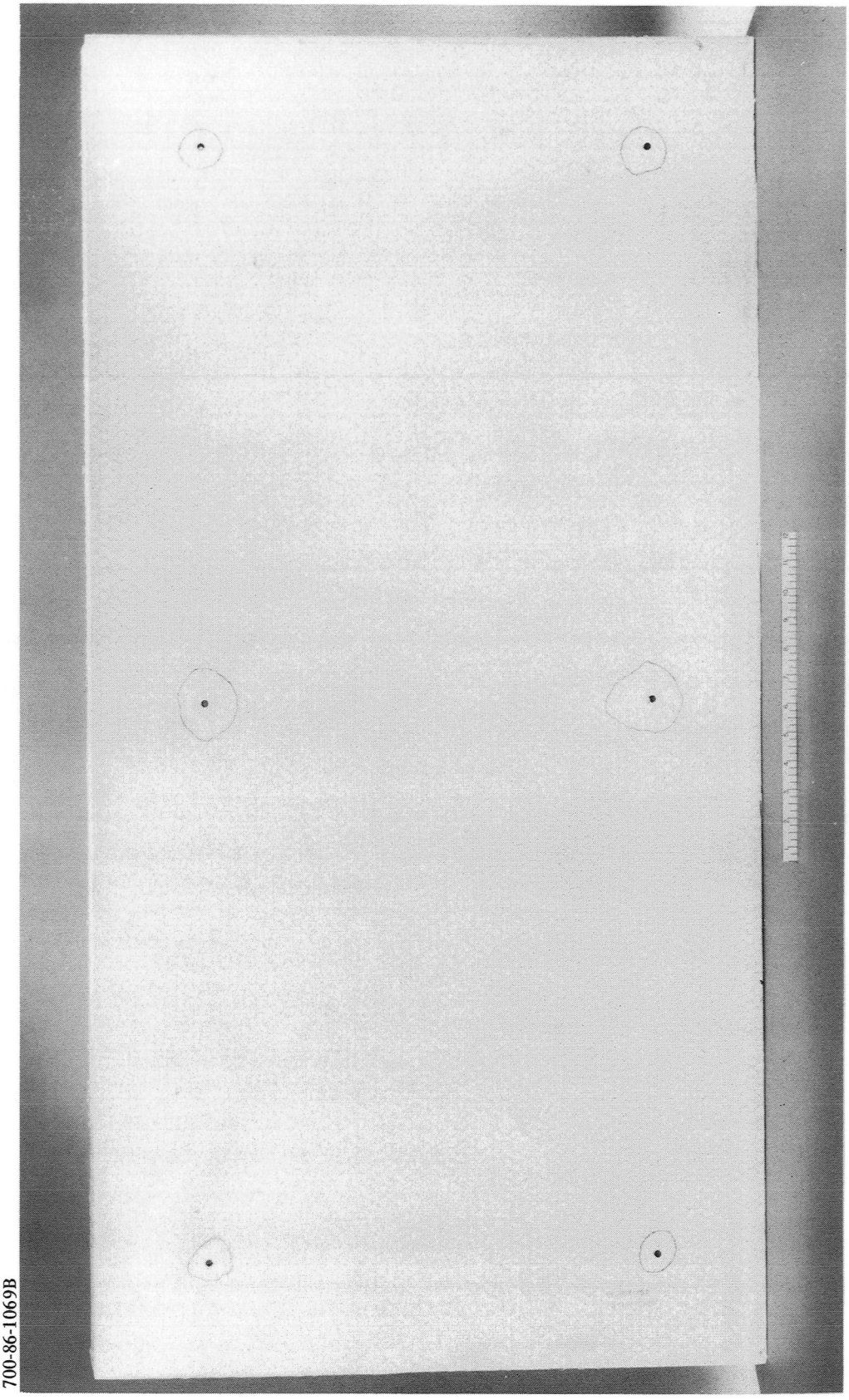


Figure 39. Back Face Delaminated Areas at Attach Points in Specimen 1

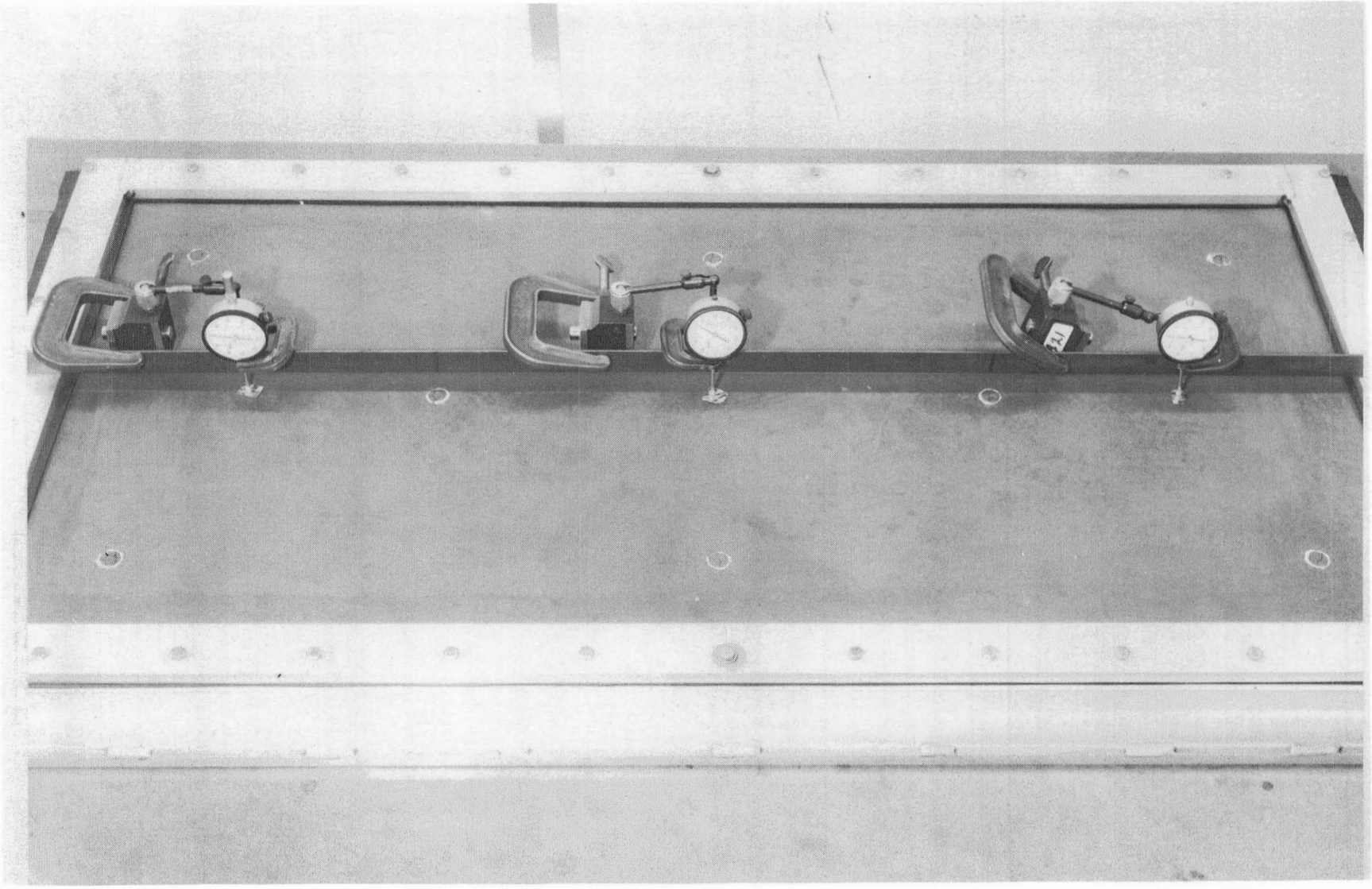


Figure 40. Specimen 2 Showing Two Additional Attach Points (8) With Dial Indicators Relocated

Space Division
North American Rockwell

700-86-1069D

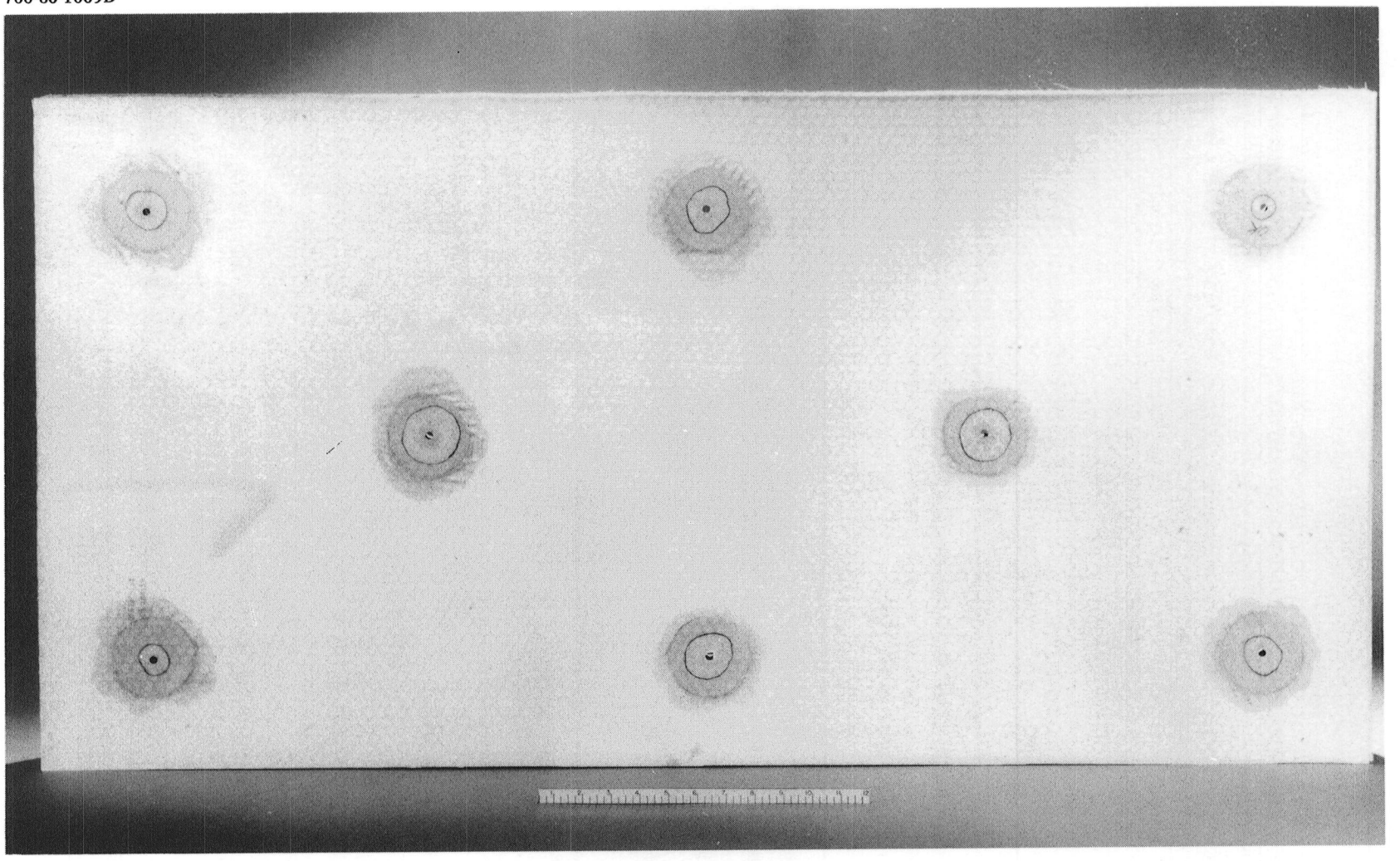


Figure 41. Back Face Delaminated Areas at Seven Attach Points in Specimen 2

Space Division
North American Rockwell

Test Run 4

The mounting bolt pattern of specimen 3 (SK-058322-161) was modified by adding 7 more attach points and doublers for a total of 15 attachments as shown in Figure 42. The dispersion coating on specimen 3 was the same as that used on panel specimens 1 and 2. Dial indicators were relocated as shown in Figure 42. Specimen 3 was then subjected to the same launch profile test conditions as previously described.

A maximum differential pressure of 17.2 kN/m^2 (2.5 psi) occurred as shown in Figure 34, 48.5 seconds after test start. A deflection in excess of 8.1mm (0.320 inch) was observed on the center dial indicator. Cracking of the material was observed at approximately the same time between the center bolt position and the second bolt from the upper end perpendicular to the specimen centerline. Post-test examination revealed a second crack approximately 5.1 cm (2 inches) long extending from the center bolt hole plug in a 60 degree angle from the specimen centerline. These cracks may be seen in Figure 43. The following dial indicator deflection readings were taken after the specimen returned to ambient pressure:

Lower 0.25mm (0.010 inch)
Center 0.74mm (0.029 inch)
Upper 0.33mm (0.013 inch)

Upon removal of this panel specimen from the test fixture, extensive delamination of the glass fabric backing was evident as shown in Figure 44. It was felt that the primary cause for the increased damage, compared to test run 3, was the 40 percent increase in pressure differential. Since some backface permeability had been restricted by the bonding of the fifteen doublers, this porosity blockage was considered to be the primary cause. It was therefore decided that perforations would be added for the next test run.

Test Run 5

Specimen 4 (SK-058322-151) had the same attachment 15 bolt pattern as specimen 3 and with a white silicone thermal coating instead of a dispersion coating (Figure 45). In addition the backfacing was perforated at all doubler locations using a No. 50 drill. The typical hole pattern is shown in Figure 46. The specimen was then subjected to the same launch profile test conditions as used before.

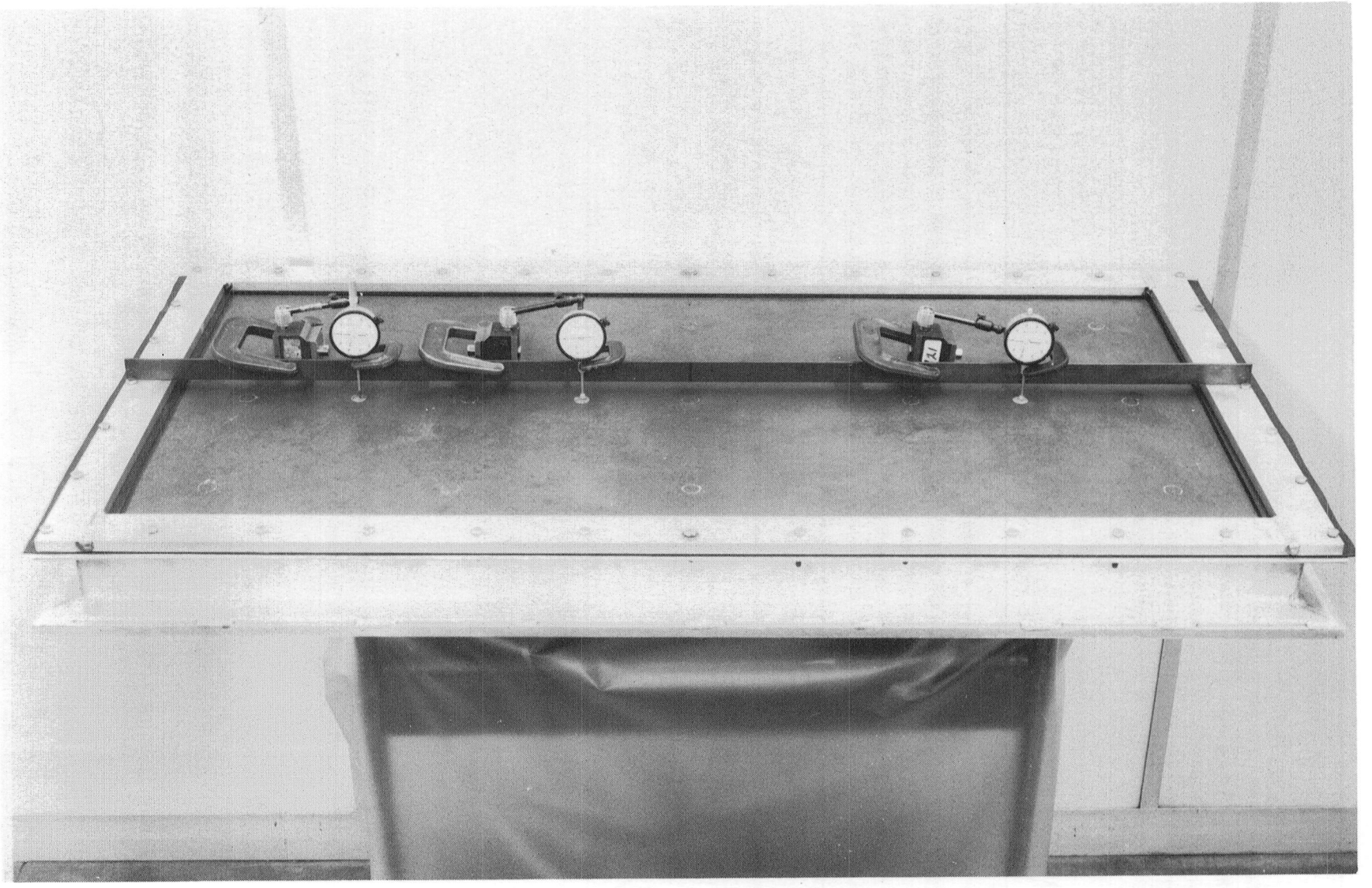


Figure 42. Specimen 3 Showing Nine Additional Attach Points (15)

Space Division
North American Rockwell

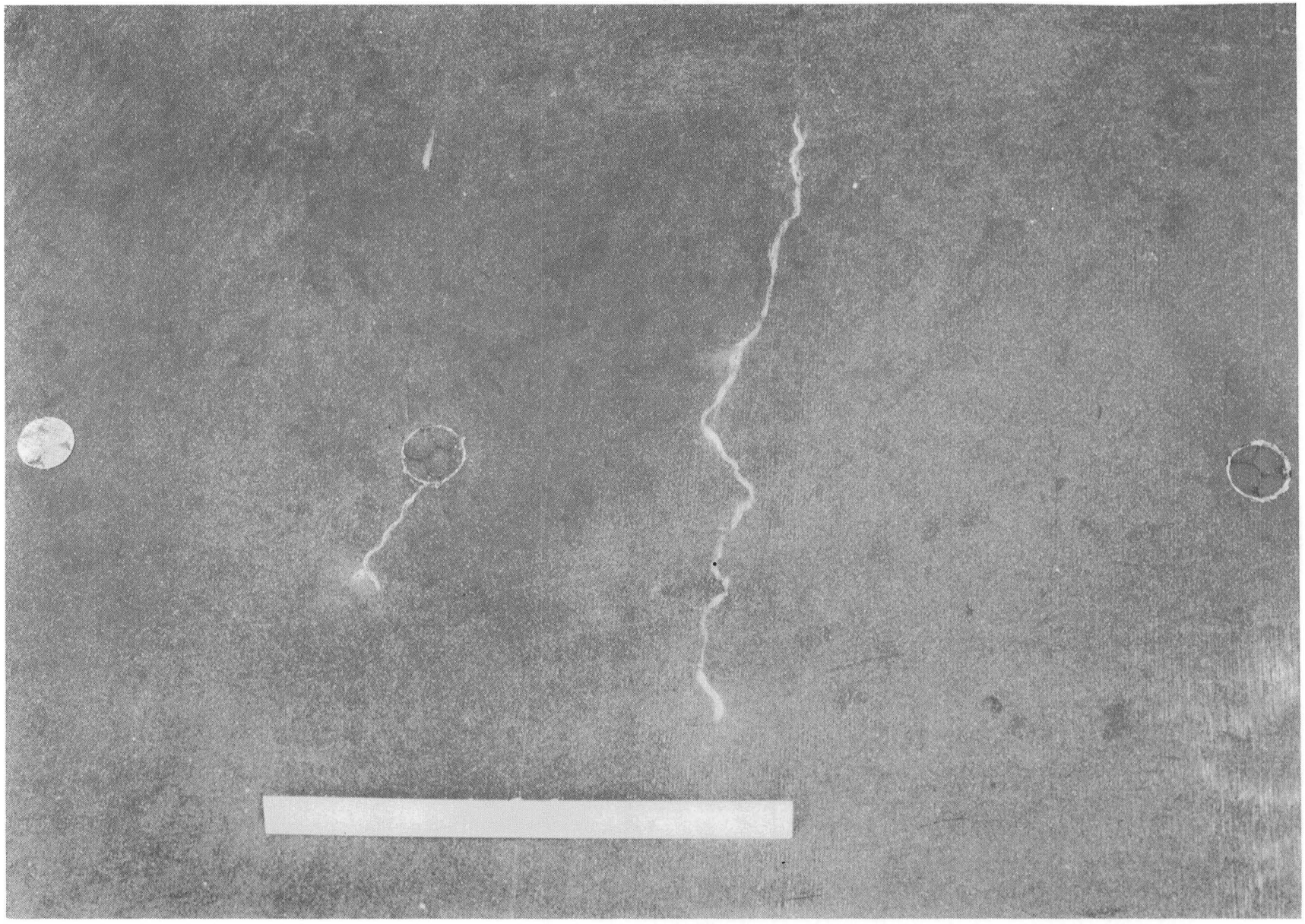


Figure 43. Detail View of Cracked Area in Specimen 3 After Run 4

Space Division
North American Rockwell

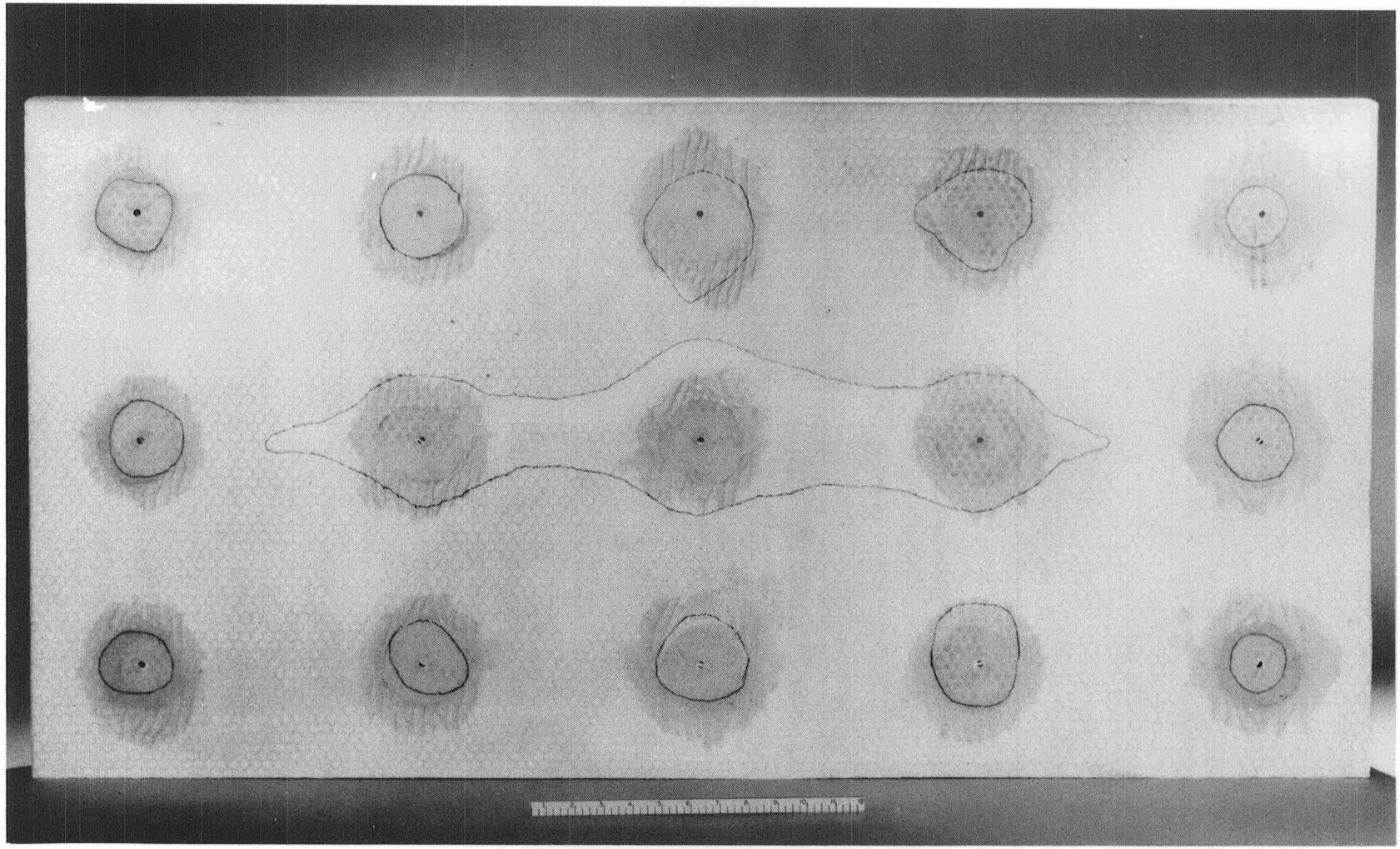


Figure 44. Extensive Delaminated Back Face Area in Specimen 3

700-81-1690A

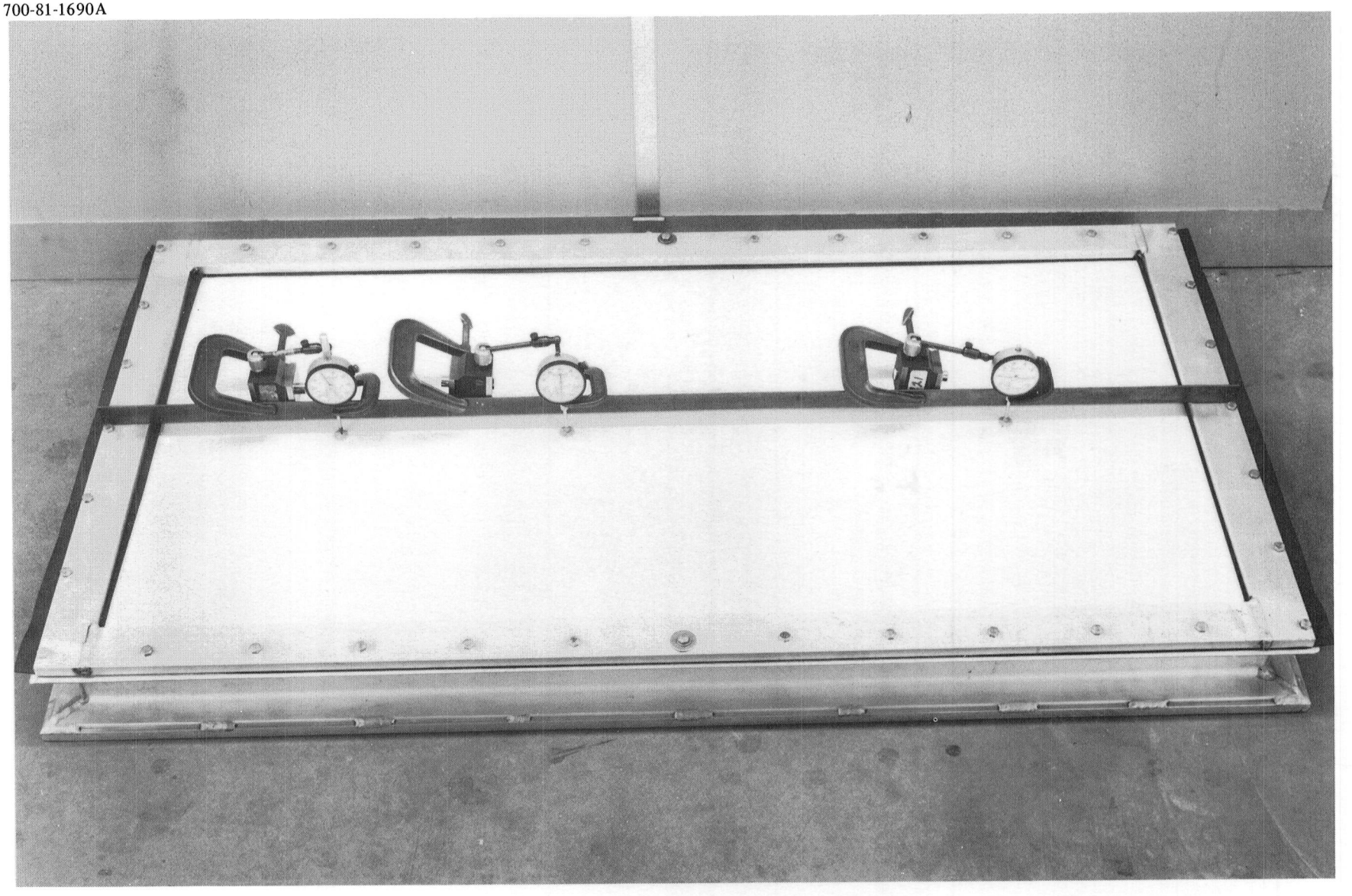


Figure 45. Specimen 4 With Thermal Coating Ready for Test Run 5

Space Division
North American Rockwell

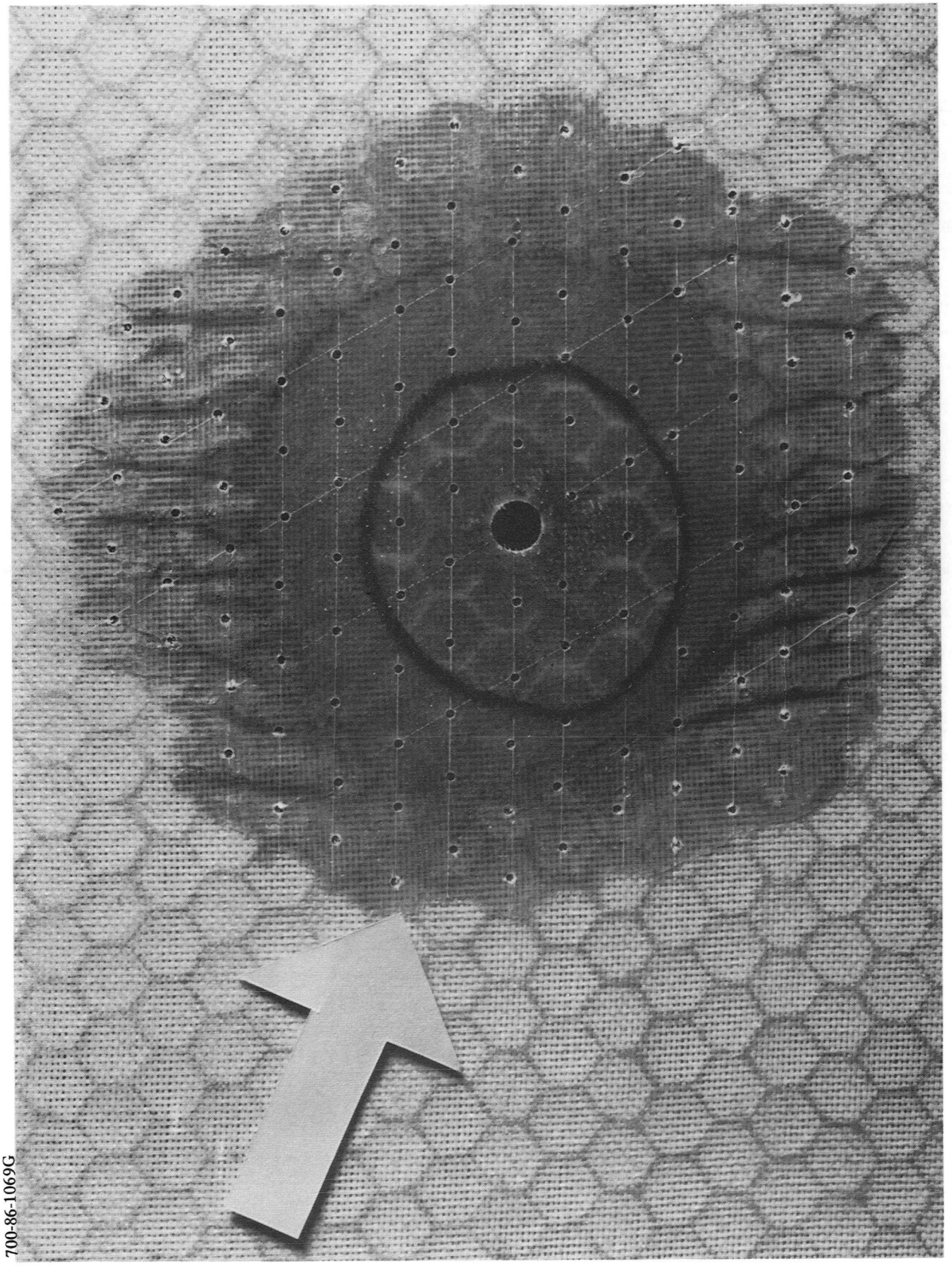


Figure 46. Perforation Pattern for all Attachment Areas in Specimen 4

A large bubble (coating separation) was observed in the upper forward corner of the panel during the test and the damage to the thermal coating was visible after the specimen was returned to ambient pressure (see Figure 47). The results, as shown in Figure 34, showed that a maximum pressure differential of 18.6 kN/m^2 (2.7 psi) occurred approximately 35 seconds after test start. A deflection in excess of 3.3mm (0.130 inch) was observed on the center dial indicator. A large bubble, approximately 25.4cm (10 inches) in diameter, was visible in the upper forward corner of the specimen. The indicated differential pressure decreased to 3.4 kN/m^2 (0.5 psi) when the bubble burst (approximately 35 seconds after test start). The following deflections were shown by the dial indicators after the specimen was returned to ambient pressure:

Lower 0.05mm (0.002 inch)
Center 0.19mm (0.0075 inch)
Upper zero

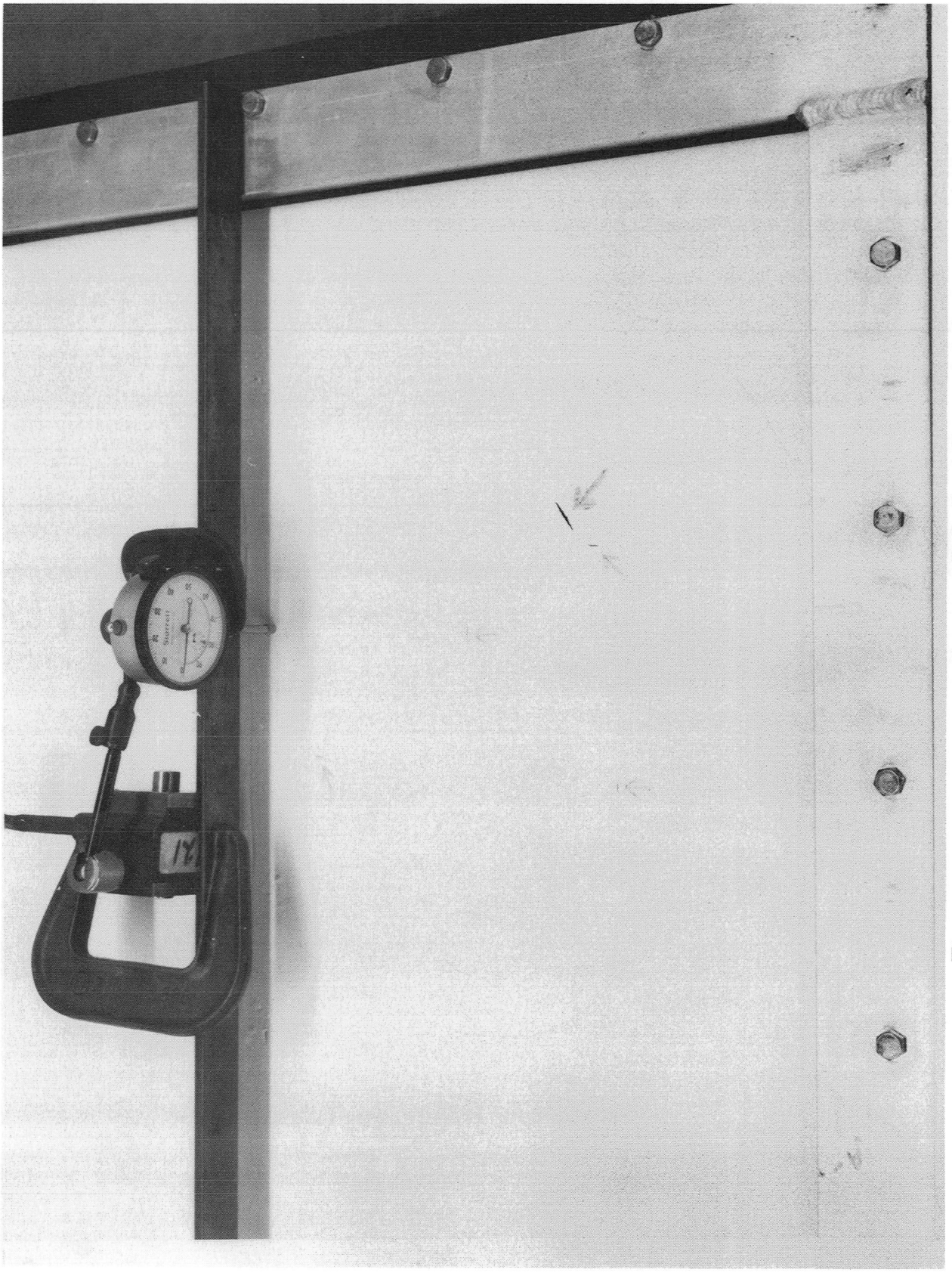
While the backside delamination was considerably reduced in area from the previous test, localized delamination was still present around all attach points as shown in Figure 48. Figure 49 shows a closeup view of the blistered coating area after the panel was removed from the test fixture.

Discussion of Results

It was felt that, within the scope of this contract, there would be no advantage in conducting additional full-scale tests with the existing panel design and available coatings.

A recap of the maximum pressure differentials and deflections are presented in Table 13.

It should be noted that a fairly good correlation exists between the maximum pressure differential results of the permeability tests of Task 1 and those of Task 3. It is estimated that the existing six-attach point panel design, coated with the clear dispersion coating, is capable of withstanding a maximum pressure differential of approximately 6.8 kN/m^2 (1 psi) without damage.



700-81-1690C

Figure 47. Specimen 4 Showing Detail of Damaged Area

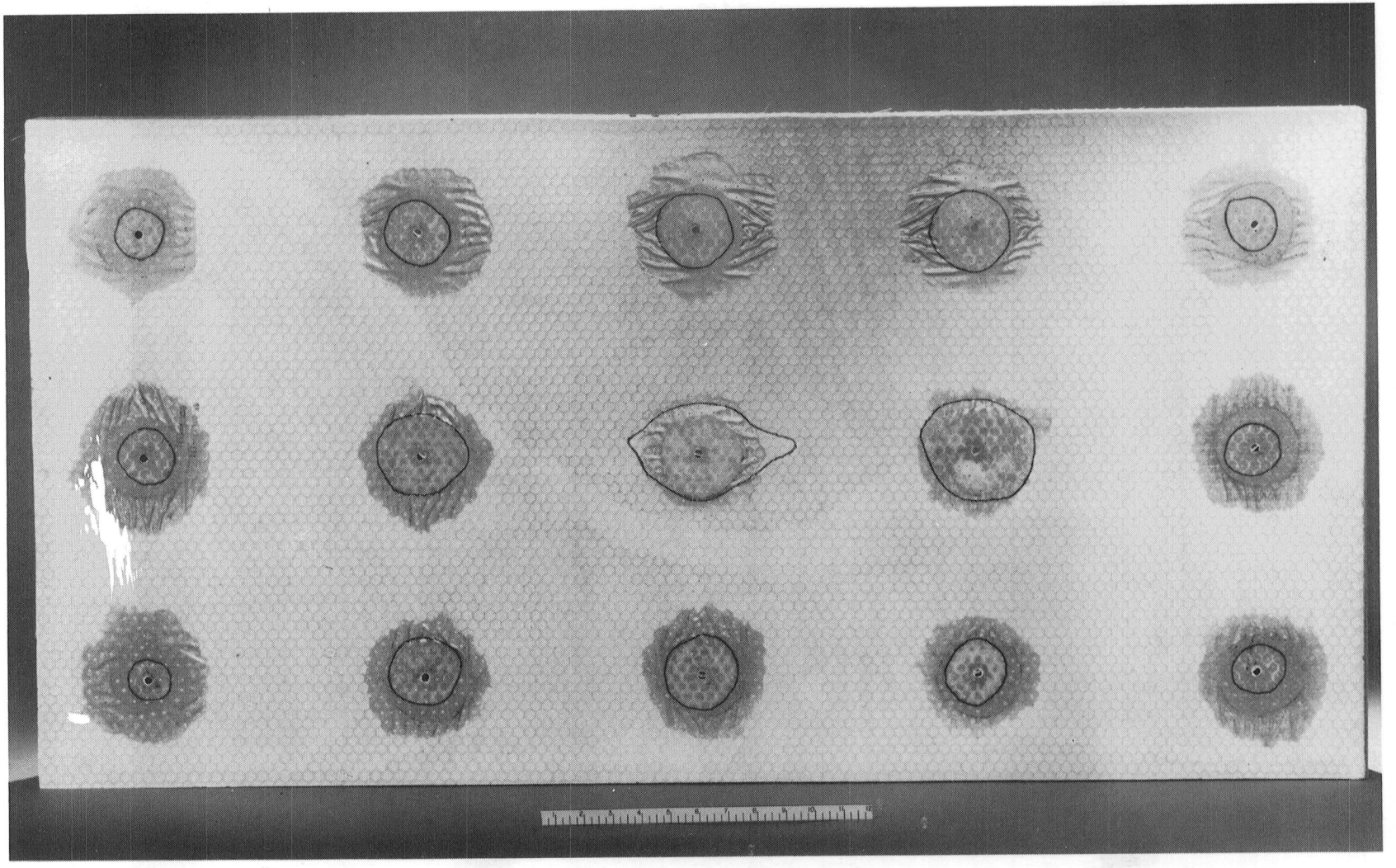


Figure 48. Back Face Delaminated Areas at Fifteen Attach Points in Specimen 4

Space Division
North American Rockwell

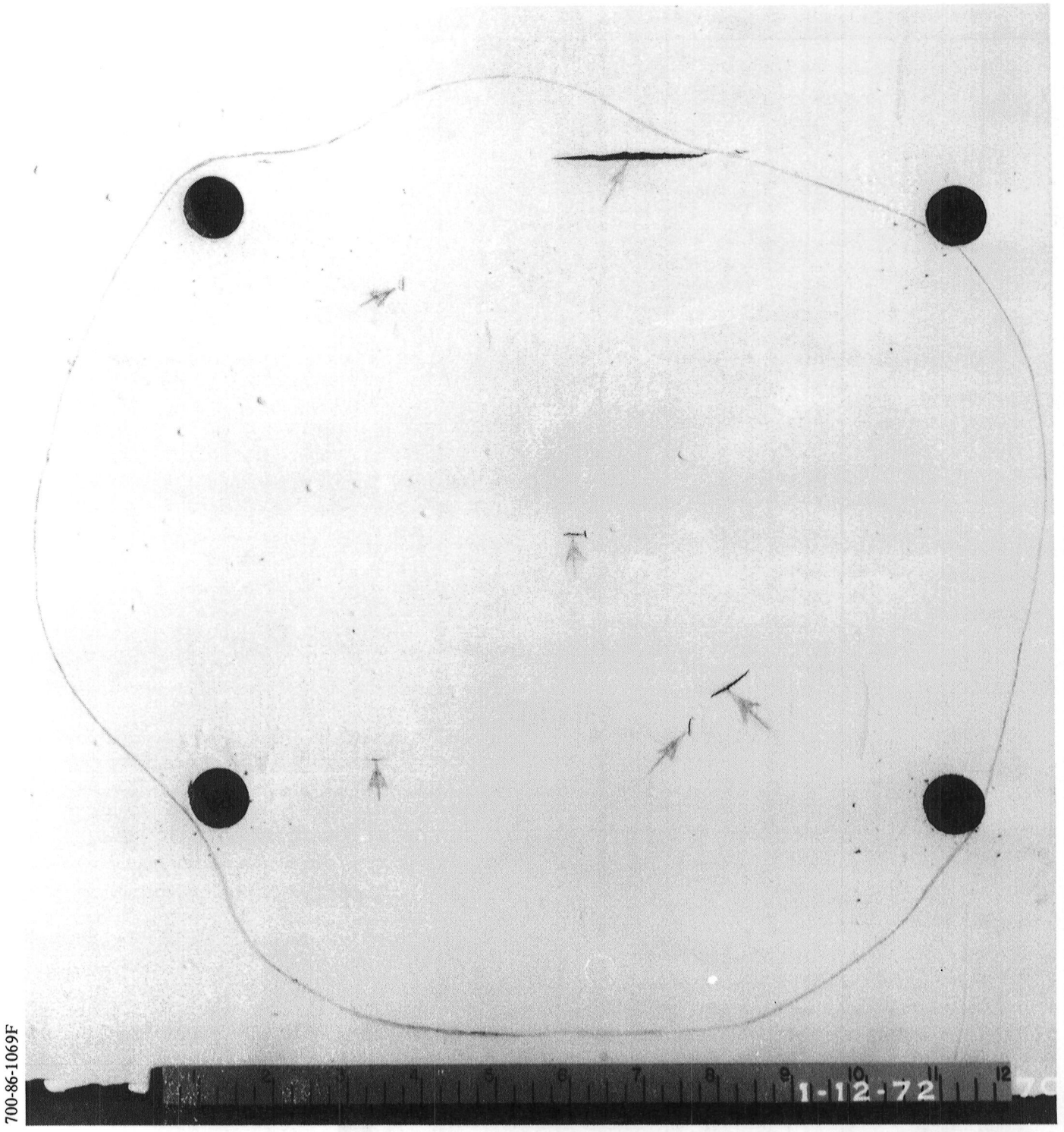


Figure 49. Closeup of Coating Separation Area in Specimen 4

Table 13. Maximum Indicated Differential Pressures and Deflections Versus Time

Test Run	Maximum Indicated ΔP		Maximum Observed Deflection		Time Maximum Indications (seconds from start)
	kN/m^2	(psi)	cm	(inches)	
1*	1.034	(0.15)		-	75
2	12.411	(1.8)	0.610	(0.240)	59
3	10.342	(1.5)	0.178	(0.070)	83
4	17.239	(2.5)	0.813	(0.320 + 1)	48.5
5	18.616	(2.7)	0.330	(0.130 + 1)	35

*Only panel specimen not coated.

This Page Intentionally Left Blank

PROBLEMS AND SOLUTIONS

Since most of the developmental problems and their solutions have been previously discussed in detail, a condensed recap of problems and their solutions is presented below:

Area	Problem	Solution
Materials and compounds	Specimens too fragile using 15 percent resin content.	Do not specify for ablative heat shield applications.
	RTV602 catalyzed with SCR04 or 05 has too short a pot life.	Use new catalyst GE No. 0063-85-1159
	Sylgard 182 resin had inhibited cure.	Completely dry core primed with SC1008 and cure panel at 394K (250F) for 16 hr.
	No. 541-111 resin had poor adhesion.	Eliminate from ablative applications.
Panel fabrication	Surface coatings difficult to apply uniformly thin to produce satisfactory permeability.	Consider development of thin film sheets to be layed up in the panel molding operations.
	The 240 kg/m^3 (15 lb/ft^3) density for the SK-058322-161 (RTV602) panels produced a more fragile compound than the SK-058322-151.	Increase compaction density to at least 264 kg/m^3 (16.5 lb/ft^3) to improve adhesion.

This Page Intentionally Left Blank

CONCLUSIONS AND RECOMMENDATIONS

TASK 1

Excellent progress was made in satisfying the objectives of this task. An evaluation of the fabrication characteristics of the plasma arc ablation models and the air permeability vent specimens has resulted in establishing the following specific conclusions:

1. The Saran foaming powder was inadequate in filling core cells completely.

2. The Monsanto SC 1008 primer provided the best bond between the ablation material and the core.

3. From an ease of compound mixing and overall quality viewpoint, the highest (30 percent) resin content specimens were superior. The average density of the specimens was 266 kg/m^3 (16.61 lbs/ft^3).

4. The 20 percent resin content specimens all exhibited qualities similar to that experienced in the previous contract (NAS1-9943). The average density of the specimens was 253 kg/m^3 (15.46 lb/ft^3).

5. All specimens made with 15 percent resin content were too fragile to be handled due to a lack of filler adhesion.

6. The RTV 655 was the most costly resin evaluated but produced the best quality specimens.

7. The Sylgard 182 resin produced the longest shelf life of all (uncured) ablator compounds.

8. The RTV 602 resin produced the shortest shelf life, using curing agent SRC-04, and is not recommended for full size panel fabrication without an improved curing agent.

9. The 541-111 resin produced a very fragile specimen, apparently due to a lack of adhesion.

The conclusions reached from analyzing the pressure differential test results were that all ablative compounds tested were very permeable and

should present little, if any, venting problems when uncoated. The average pressure differential on 20-percent resin specimens (uncoated) was essentially the same as for the 30 percent resin specimens. This leads one to conclude that there was no decrease in permeability due to a 50 percent increase in resin content. When coated, the two most permeable coatings caused an increase in pressure differentials of 3 to 7 times that of uncoated specimens. The coatings selected for further study were DC 92-009 and TBS-758.

Following an evaluation of the plasma are ablation test results conducted by NASA/LRC, ablator compound selections were made for the fabrication of the Task 2 panels. The conclusions reached were:

1. A 25 percent resin content was the best compromise between thermal efficiency and char cracking susceptibility.

2. A glass bubble content of 10 to 15 percent was sufficient to achieve char dimensional stability.

3. The RTV 602 resin with the 10 percent nylon powder addition provided the highest thermal efficiency.

Due to the difficulties in evaluating the effects of ablator material variables on cost and total performance using small specimens, it was decided that six full size panels would be made from each of the following two ablator compounds to further define fabrication and/or cost differences.

Material	SK-058322-151	SK-058322-161
Elastomer	25% (Sylgard 182)	25% (RTV 602)
Phenolic microballoons	65	50%
Glass bubbles	10%	15%
Nylon powder	0	10%

TASK 2

The following low-cost fabrication techniques and processes were developed which resulted in superior quality panels at a significant reduction in cost.

1. The multiple fabrication of the core to facing subassemblies using a seven heated platen press was very successful and is recommended as an excellent low cost fabrication technique.

2. The results of fabricating the first panel per drawing SK-058322-151 indicated that the SC 1008 primer, when reduced with 50-percent butyl alcohol, require a minimum of a 1/2-hour drying time of 60 C (140 F). It was also concluded that a 16-hour at 121 C (250 F) cure cycle is recommended over 24 hours at 82 C (180 F). It was found that the higher temperature cure was more reliable, less time consuming, and produced no perceptible increase in panel warpage.

3. After conducting shelf life tests on the composition specified per SK-058322-161 using the new experimental catalysts 0063-85-1159 and 0063-85-1160, it was concluded that the improvement in shelf life, using curing agent 0063-85-1159 (1/4 of 1 percent), was sufficient for fabrication of full size panels.

4. The fabrication of the twelve panels using two fill and cure tools at one time in the press resulted in excellent quality panels with a 33-percent manhour reduction for the fill and cure operations.

The conclusions reached in the cost estimating study was that the cost data accumulation and analysis were superior and more accurate than used on the previous program. The combined advantages of improved manufacturing and cost analysis techniques resulted in significant cost reductions compared to the previous results on the SK-058322-121 panels. Comparative cost reduction estimates varied from 26 to 48 percent depending on quantity. With a total cost of $58 per square foot estimated for 100 panels and $42 per square foot estimated for 1000 panels, it is felt that the ablator panels fabricated in this contract can be produced at a very attractive price. It was further concluded that there were no significant fabrication or cost differences found between the SK-058322-151 and -161 panels.

TASK 3

After an inspection of each tested panel was made, it was concluded that the existing panel design without a coating successfully passed the simulated launch vent test without damage. Once a partially permeable coating was applied, however, the pressure differential of 10.3-18.6-kN/m^2 (1.5 to 2.7 lb/in^2) exceeded the panel strength and cracks resulted. Attachment area reinforcements and an increase in attach points were made but were insufficient to eliminate all panel damage.

It is, therefore, recommended that either (1) a thin honeycomb sandwich carrier panel be used to reinforce the ablator panel (2) a more permeable coating be developed or (3) a venting purge system be designed to reduce the pressure differential load on the ablator panel to less than 6.8 kN/m^2 (1 psi).

This Page Intentionally Left Blank

REFERENCES

1. Final Report, Low Cost Ablative Heat Shield for Space Shuttles. NASA CR-111795 (SD70-400) (20 Nov. 1970).

2. Study of Low-Cost Fabrication of Ablative Heat Shields. First Quarterly Technical Letter Progress Report, 30 April 1971 through 31 July 1971. Space Division, North American Rockwell Corporation, SD71-168 (Aug. 1971).

3. Study of Low-Cost Fabrication of Ablative Heat Shields. Second Quarterly Technical Letter Progress Report, 1 August 1971 through 31 October 1971. Space Division, North American Rockwell Corporation, SD71-348 (Nov. 1971).

APPENDIX A

MANUFACTURING ORDERS

MANUFACTURING ORDER

DIV. | PLAN DEPT. | PAGE C

PART NO. SK-058320-91

PART NAME ABLATIVE PLUG

PLANNED BY N. LEONE | TC 0 | 4. 225

NOTED A. B. C. D. E. F. G.

1. RC C | DATE ISSUED 10-15-71 | CONTRO NO. X 88329 | SPLIT | IW 7710 | C 7715

2. SC-SCN | SCHEDULE REF. PCD-71-SSC-05 | INITIAL STORES 070 | FINAL STORES 070

3. TYPE ORDER ROADER | WORK FOR XXX | IDENT. SERIAL NO.

ITEM/UNIT	ACCOUNT	ORDER NO.	SUB-ACCT.	NO. UNITS	LH N	PCS	RH
001-006	3001	03045	03010	6	36		

AUTHORIZATION TASK #2 | TOT THIS ORD. 6 | 36

SK-058322-151

QTY. PER UNIT/NA LH/N 6 | RH | MODEL ABLATIVE | INDEX NO. N I

THIS COPY USED ON | THIS PART EFF. ON

LAST MECH. INSP. CVR ☐ MOCK-UP ☐ NO. CHG. ☐ CHG LTR NO E.O. ☐ E.O. NO. DATE:

LINE	UNIT QTY. DEPT.	OPERATION / MATERIAL 1	2	DATE	MECH./LDM.	QTY. ACCEPTED LH/N	RH	DATE	INSP.	TOOL/CAT NO. E.O. DWG. REV	DEPTH OF CUT TOOL TYPE	SET-UP SPEED SEQ. NO.	RUN FEED HOURS	SCH MTC LINE
												10-7-71		
	6	PREP	MAKE FROM EXCESS ON SK058322-151											
	41-070													
	05	1	RECORD OCN NUMBER FROM MATERIAL									.030		(10)
	05	2	CUT TO SIZE (1X1X2)									.050	.010	(20)
	07	3	LATHE-FACE(1) END HOLD 2" DIM. (REMOVE FACE SHEET)									1.000	.250	(30)
			TURN .687 DIA.											
			REVERSE ENDS & FINISH TURN .687 DIA.											
	.33	4	IDENTIFY										.030	(40)
	97	5	PROTECT PER MAD 116-013 (PP5)										.004	(50)
	INSP	6												(60)
	41-070													

[redacted] | NO. OF PIECES RECEIVED | LH/N | RH | BY STOCKROOM NO. | CLERK'S SERIAL NO. | DATE

MANUFACTURING ORDER

DIV. | PLAN DEPT. | PAGE

PART NO. SK-058320-101

PART NAME ABLATIVE PLUG

PLANNED BY 10-6-71 N. LEONE | TC 0 | 4. 225

NOTED A. B. C. D. E. F. G.

1. RC C | DATE ISSUED 10-15-71 | CONTRC X 88330 | SPLIT | IW 3750 C 3755

2. SC-SCN | SCHEDULE REF. PCD-71-SSC-05 | INITIAL STORES 070 | FINAL STORES 070

3. | ITEM/UNIT | ACCOUNT | ORDER NO. | SUB-ACCT. | NO. UNITS | LH-N | (PLS) | RH

TYPE ORDER RoAOFR | 007-0012 | 3001 | 03045 | 03030 | 6 | 36

WORK FOR XXX

IDENT. SERIAL NO. | AUTHORIZATION TASK #2 | TCT THIS ORD

SK-058322-161

QTY. PER UNIT/NA LH/N 6 RH | MODEL ABLATIVE | INDEX NO.

THIS COPY USED ON | THIS PART EFF. ON

LAST MECH. INSP. CVR ☐ MOCK-UP ☐ NO. CHG. ☐ CHG LTR NO E.O. ☐ E.O. NO. DATE:

LINE	UNIT QTY. DEPT.	OPERATION 1	OPERATION 2	DATE	MECH./LDM.	QTY. ACCEPTED LH/N	QTY. ACCEPTED RH	MATERIAL DATE	MATERIAL INSP.	TOOL/CAT NO. E.O. DWG. RFV	DEPTH OF CUT TOOL TYPE	SET-UP SPEED SEQ. NO.	RUN FEED HOURS	SCN SPEC LINE
1.												16-271	PRS	
2.														
3.	6	REF	MAKE FROM EXCESS ON SK058322-161											
4.														
5.														
6.														
7.														
8.														
9.	41-070													
10.														
11.	05	1	RECORD OCN NUMBER FROM MATERIAL									.030		(10)
12.														
13.														
14.	05	2	CUT TO SIZE (1X1X2)									.050	.010	(20)
15.														
16.	07	3	LATHE - FACE(1) END HOLD 2" DIM.									1.600	.250	(30)
17.			(REMOVE FACE SHEET)											
18.														
19.			TURN .687 DIA.											
20.														
21.			REVERSE ENDS & FINISH											
22.			TURN .687 DIA.											
23.														
24.														
25.	.33	4	IDENTIFY										.030	(40)
26.														
27.														
28.	.97	5	PROTECT PER MAD 116-013 (PP5)										.004	(50)
29.														
30.														
31.	INSP'N	6												(60)
32.														
33.														
34.														
35.	41-070													
36.														
37.														
38.														
39.														
40.														
41.														
42.														
43.														

NO. OF PIECES RECEIVED | LH/N | RH | BY STOCKROOM NO. | CLERK'S SERIAL NO. | DATE

SK-058322-13

NR-A&SG MANUFACTURING ORDER

SET | BLUES | RC C | DATE ISSUED 7-16-71 | CONTROL No X 85376 | SPLIT | IW 3681 | C 3721

DIV. 41 | PLAN DEPT. 057 | PAGE 1 OF 2

PART NO. SK-058322-13

PART NAME ABLATIVE PANEL-FLAT (C)

SC-SCN SCHEDULE REF. POD-71-SSC-05 070 | INITIAL STORES 070 | FINAL STO

ITEM UNIT	ACCOUNT	ORDER NO.	SUB.-ACCT.	NO. UNITS	LH/N	(PLUS)
TASK 2	3001	05045	01010	6	6	

TYPE ORDER NO AOF-R | WORK FOR XXX | IDENT. SERIAL NO. | AUTHORIZATION EO M801026 | TOT THIS ORD 6 | 6

PLANNED BY 7-14-71 N. LEONE | TC 0 | 4. 225

NOTED A. B. C. D. E. F. G.

USED ON PART NO. / NEXT ASSY. SK058322-151 | SPLIT BY:

QTY. PER UNIT/NA LH/N 1 RH | MODEL ABLATIVE | INDEX NO. N I

THIS COPY USED ON | THIS PART EFF. ON

LAST MECH. INSP. CVR ☐ MOCK-UP ☐ NO. CHG. ☐ CHG LTR NO E.O. ☐ E.O. NO. DATE:

LINE	UNIT QTY. DEPT.	OPERATION 1	OPERATION 2	DATE	MECH / LDM.	QTY. ACCEPTED LH/N	QTY. ACCEPTED RH	MATERIAL DATE	MATERIAL INSP.	TOOL CAT NO. E.O. DWG. REV.	DEPTH OF CUT TOOL TYPE	SET-UP SPEED SEQ. NO.	RUN FEED HOURS	SCN MTC LINE
1.												7-15-71	HMI	
2.														
3.	1	B	26"X50" 1 PLY (REF-3)											
4.			EPOXY PREPREG, BOAT CLOTH											
5.			RELIABOND R174, 3 oz.											
6.			FOR C/N2											
7.														
8.														
9.	1	B	2"X26"X50" (REF-7)											
10.			HEXEL HRP-3/8-GF12-3.2											
11.			PHENOLIC HONEYCOMB CORE											
12.														
13.														
14.		X	FABRICATE PER PROCEDURE SK-058324											
15.														
16.	41-070													
17.														
18.	05	1	VERIFY MATERIAL HRP-3/2-3.2 MIL-C-8073A W/A									.476	.181	(10)
19.			POE 32N5A795A 1-231329											
20.			T 2.009											
21.	INSP	2												
22.														
23.		3	CUT PRE-PREG. MAT'L TO SIZE (REF-3)											
24.			CUT HONEYCOMB CORE TO SIZE (REF-7)											
25.			(NOTE: RIBBON DIRECTION)											
26.														
27.														
28.														
29.	28	4	CLEAN HONEYCOMB CORE PER MA0101-024										.073	(40)
30.														
31.														
32.														
33.														
34.														
35.	42	5	PREPARE SHOP AID FOR LAYUP									.070	.105	(50)
36.			ADD RAM 225 F CURE @ ROOM TEMP											
37.			FOR 4 HOUR											
38.	(C)													
39.			RECORD TIME											
40.														
41.														
42.														
43.														

[redacted] | NO. OF PIECES RECEIVED | LH/N | RH | BY STOCKROOM NO. | CLERK'S SERIAL NO. | DATE

NR-A&SG MANUFACTURING ORDER — SET — BLUES — PART NUMBER SK-058322-13

P/N SK-058322-13 | RC C | DATE ISSUED 7-16-71 | CONTROL No X 85376 | SPLIT | IW 36 | C 37

DIV 41 | PLAN DEPT 057 | PAGE 2 OF -

LAST MECH. INSP. CVR ☐ MOCK-UP ☐ NO. CHG. ☐ CHG LTR NO E.O. ☐ E.O. NO. DATE

LINE	UNIT QTY. DEPT.	OPERATION 1	OPERATION 2	DATE	MECH / LDM	QTY ACCEPTED LH RH	MATERIAL DATE	MATERIAL INSP.	TOOL CAT NO E.O. DWG. REV	DEPTH OF CUT TOOL TYPE	SET-UP SPEED SEQ. NO	RUN FEED HOURS	SCH MTC LINE
3		6	LAYUP (1) LAYER OF SEPARATOR (TX1040)										
7	42	7	LAYUP (1) LAYER OF EPOXY PRE-PREG. TO THE SEPARATOR & STRETCH TAUT (TAPE IN PLACE)									.077	70
12		8	POSITION HONEYCOMB TO EPOXY PRE-PREG. & TAPE IN PLACE										
16	33	9	IDENTIFY								.015	.004	90
19	97	10	PROTECT PER MA0116-013 (PP-28)								.113	.024	100
22	MFG. VERIFY	11											
24	066-99	12	PLACE IN PRESS CURE @ 300°F FOR 90 MINS. UNDER POSATIVE PRESSURE								.026	.100	120
			RECORD TIME ____ TEMP ____										
			RECORD PRESSURE ____										
34	INSP	13											130
37	33	13.1	INSP. IDENTITY, DIMENSIONAL & DAMAGE ONLY								.013	.002	131
40	INSP	14											140
44	41-070												
54			DRILL & TRIM TO SIZE ON N/A										

NR-A&LG MANUFACTURING ORDER

SET: Lou Core BLUES — PART NUMBER: SK-058322-13

REV: 41 | PLAN DEPT: 057 | PAGE 1 OF 2

PART NO.: SK-058322-13

PART NAME: ABLATIVE PANEL-FLAT

1. RC: C | DATE ISSUED: 7-16-71 | CONTR. NO: X 85377 | SPLIT | TW: 36 | C: 37

2. SC-S-N | SCHEDULE REF.: PCD-71-SSC-05 | INITIAL STORES: 070 | FINAL: 07

3. TYPE ORDER: NORMFR | WORK FOR: XXX | ITEM UNIT | ACCOUNT | ORDER NO. | SUB-ACCT. | NO. UNITS | LH/N | PCS
TASK 2 | 3001 | 03045 | 01020 | 6 | 6

PLANNED BY: N. LEONE 7-14-71 | TC: 0 | 4.: 225

IDENT. SERIAL NO. | AUTHORIZATION: ED. M801026 | TOT THIS ORD: 6 | 6

NOTED
A.
B.
C.
D.
E.
F.
G.

USED ON PART NO. / NEXT ASSY.: SK058322-151 | SPLIT BY:

QTY. PER UNIT: NA | LH/N: 1 | RH | MODEL: ABLATIVE | INDEX NO.: N I

THIS COPY USED ON | THIS PART EFF. ON

LAST MECH. INSP. CVR ☐ MOCK-UP ☐ NO. CHG. ☐ CHG LTR NO E.O. ☐ E.O. NO. | DATE:

SEQ	UNIT QTY. / DEPT.	OPERATION 1	OPERATION 2	DATE	MECH / LDM	QTY ACCEPTED LH N	QTY ACCEPTED RH	MATERIAL DATE	INSP.	TOOL CAT NO. / E.C. DWG. REV	DEPTH OF CUT / TOOL TYPE	SET-UP SPEED / SEQ. NO.	RUN FEED / HOURS	SCN MTC / LINE
1												7-15-71 MNI		
2														
3	1	B	26"X50" 1PLY (REF-3) EPOXY PREPREG, BOAT CLOTH SELLAPOX R1114, 39%. FOR G/N2											
4														
5														
6														
7														
8														
9	1	B	2"X26"X50" (REF.-7) HEXEL HRP-3/8-6F12-3.2 PHENOLIC HONEYCOMB CORE											
10														
11														
12														
13														
14		X	FABRICATE PER PROCEDURE SK-058324											
15														
16	41-070													
17														
18	05	1	VERIFY MATERIAL									476	.181	(10)
19														
20														
21	INSP	2												
22														
23		3	CUT PRE-PREG. MAT'L TO SIZE (REF-3)											
24			CUT HONEYCOMB CORE TO SIZE (REF-7)											
25			(NOTE: RIBBON DIRECTION)											
26														
27														
28														
29	28	4	CLEAN HONEYCOMB CORE PER MA0101-024										.073	(40)
30														
31														
32														
33														
34														
35	42	5	PREPARE SHOP AID FOR LAYUP ADD PAM 225 & CURE @ ROOM TEMP FOR (1) HOUR									.070	.105	(50)
36														
37	C													
38			KEPT'D TIME											
39														
40														
41														
42														
43														

NO. OF PIECES RECEIVED | LH/N | RH | BY STOCKROOM NO. | CLERK'S SERIAL NO. | DATE

NR-A&SG MANUFACTURING ORDER — SET — BLUES — PART NUMBER SK-058322-13

P/N SK-058322-13 | DIV. 41 | PLAN DEPT 057 | PAGE 2 OF - | RC C | DATE ISSUED 7-16-71 | CONTROL No X 85377 | SPLIT | IW 36 | C 37

LAST MECH. INSP. CVR ☐ MOCK-UP ☐ NO. CHG. ☐ CHG LTR NO E.O. ☐ E.O. NO. DATE

UNIT QTY. DEPT.	OPERATION 1	OPERATION 2	DATE	MECH / LDM	QTY ACCEPTED	MATERIAL DATE	INSP.	TOOL CAT NO E.O. DWG REV	DEPTH OF CUT TOOL TYPE	SET-UP SPEED SEQ NO	RUN FEED HOURS	SCN MTC LINE
	6	LAYUP (1) LAYER OF SEPARATOR (TX1040)										
43	7	LAYUP (1) LAYER OF EPOXY PRE-PREG. TO THE SEPARATOR & STRETCH TAUT (TAPE IN PLACE)									.077	70
	8	POSITION HONEYCOMB TO EPOXY PRE-PREG. & TAPE IN PLACE										
33	9	IDENTIFY								.015	.006	90
99	10	PROTECT PER MA0116-013 (PP-28)								.113	.024	100
MFG. VERIFY	11											
066-99	12	PLACE IN PRESS CURE @ 300°F FOR 90 MINS. UNDER POSITIVE PRESSURE								.026	.100	120
		RECORD TIME ____ TEMP ____										
		RECORD PRESSURE ____										
INSP	13											130
33	13.1	INSP. IDENTITY, DIMENSIONAL & DAMAGE ONLY								.013	.002	131
INSP	14											140
41-070												
		DRILL & TRIM TO SIZE ON N/A										

NR-A&SG MANUFACTURING ORDER

DIV. 41 | PLN DEPT. 057 | PAGE 1 OF 3

RC C | DATE ISSUED 10-15-71 | CONTROL L. X 88331 | SPLIT | IW 3737 | C 3739

PART NO. SK-058322-151

PART NAME ABLATIVE PANEL - FLAT

SC-SCN | SCHEDULE REF. PAD-71-SSC-05 | INITIAL STORES C70 | FINAL STORES 066-T

ITEM/UNIT	ACCOUNT	ORDER NO.	SUB-ACCT.	NO. UNITS	LH/N	RH (PCS)
001-002	3001	03045	02010	2	2	

TYPE ORDER ROAFR | WORK FOR XXX

PLANNED BY 10-6-71 M. LEONE | TC 0 | 4. 225

IDENT. SERIAL NO. | AUTHORIZATION TASK #2 | TOT THIS ORD. 2 | 2

NOTED A. B. C. D. E. F. G.

USED ON PART NO. / NEXT ASSY. | SPLIT BY:

QTY. PER UNIT/NA: LH/N 1 | RH | MODEL ABLATIVE | INDEX NO. N I

THIS COPY USED ON | THIS PART EFF. ON

LAST MECH. INSP. CVR ☐ MOCK-UP ☐ NO. CHG. ☐ CHG LTR NO E.O. ☐ E.O. NO. DATE:

NC	UNIT QTY. DEPT.	OPERATION 1	OPERATION 2	DATE	MECH/LDM	QTY. ACCEPTED LH/N	QTY. ACCEPTED RH	MATERIAL DATE	MATERIAL INSP.	TOOL/CAT NO. E.O. DWG. REV	DEPTH OF CUT TOOL TYPE	SET-UP SPEED SEQ. NO.	RUN FEED HOURS	SCN MTC LINE	FLO CON SCHED
													10-7-71		
	11.8 LBS.	R	PHENOLIC MICROBALLOONS UNION CARBIDE BJO-0930												
	4.6 LBS.	R	SILICONE ELASTOMER DOW CORNING SYLGARD 182 + CURING AGENT												
	1.8 LBS.	R	GLASS BUBBLES 3M CO. B-30B GLASS												
	1	C	SK-058322-13 SUB-ASSY												
	6	C	SK-058320-9/1 ABLATIVE PLUG *												
			* SHIP AS LOOSE ITEM												
		X	FABRICATE PER SK-058324												
	41-070														
	28	1	VERIFY MATL										030	10	
	MFG. VERIFY	2													
	47	3	PROTECT PER MAOING-013 (PP-7)									054	.007	30	
	VERIFY	4													

NO. OF PIECES RECEIVED | LH/N | RH | BY STOCKROOM NO. | CLERK'S SERIAL NO. | DATE

NR A&SG MANUFACTURING ORDER

P/N SK-058322-151 | RC C | DATE ISSUED 10-15-71 | CONTROL No. X 88331 | SPLIT | IW 3737 | C 3739
DIV. 41 | PLN DEPT 057 | PAGE 2 OF -
LAST MECH. INSP. C/R ☐ MOCK-UP ☐ NO. CHG. ☐ CHG LTR NO E.O. ☐ E.O. NO. DATE

NE	UNIT QTY. DEPT.	OPERATION 1.	2.	DATE	MECH / LDH	QTY. ACCEPTED LH N	RH	MATERIAL DATE	INSP.	TOOL CAT NO E O DWG. REV	DEPTH OF CUT TOOL TYPE	SET-UP SPEED SEQ NO.	RUN FEED HOURS	SCN MTC LINE	FLOW COOL SCHED
															225
	061-31	5	PRIME & CURE -13 SUB-ASSY PER SK-058324									1.246	.685	50
			RECORD TIME												
	33	6	IDENTIFY (TAG) MA0104-018										.030	60
	MFG. VERIFY	7													
	070-1(54	8	PREPARE FIXTURE FOR FILLING PER SK-058324									~~.491~~ .315	.629	80
	54	9	PREPARE -13 SUB-ASSY FOR POURING									.050	.250	90
	MFG. VERIFY	10													
	54	11	MIX FILLER MAT'L									~~1.174~~ 1.127	~~6.950~~ 1.750	110
	54	12	COMPACT MIXED FILLERS IN FILL TOOL									~~2.086~~ 1.127	~~1.179~~ .883	120
	54	13	PRESS -13 SUB-ASSY INTO MIXED MAT'L											130
	54	14	APPLY 2ND PLY OF R1714 PREPREG., SEPARATOR CLOTH, BLEEDER CLOTH & VACUUM BAG									.151	.856	140
	54	15	CURE RECORD CURE: START STOP TEMP										1.228	150
	55	16	TRIM TO SIZE									.063	.820	164
	33	17	IDENTIFY EXCESS AS SK-058322-151 & OCN NUMBER OF THIS MANUF. ORDER										.060	170

MANUFACTURING ORDER

P/N SK-058222-151 | RC C | DATE ISSUED 10-15-71 | CONTROL N: X 88331 | SPLIT | IW 3737 | C 3739

DIV. 41 | PLAN DEPT. 057 | PAGE 3 OF -

LAST MECH. INSP. CVR ☐ MOCK-UP ☐ NO. CHG. ☐ CHG LTR NO E.O. ☐ E.O. NO DATE

NE	UNIT QTY. DEPT.	OPERATION / MATERIAL 1.	2.	DATE	MECH./LDM.	QTY. ACCEPTED LH N	RH	DATE	INSP.	TOOL CAT NO. E.O. DWG. REV	DEPTH OF CUT TOOL TYPE	SET-UP SPEED SEQ. NO.	RUN FEED HOURS	SCN MTC LINE	FLOW COOL SCH.
1.		(													275
2.															
3.															
4.	MFG.VERIFY	18													
5.															
6.	55	19	PUNCH .750 +.01 -.00 DIA.(6) HOLES									.050	.406	190	
7.			BY USING COOKIE CUTTERS IN												
8.			ARBOR PRESS												
9.			(NOTE: .750 DIA. HOLES NOT												
10.			TO GO THRU FACE SHEETS)												
11.															
12.															
13.															
14.	55	20	USING COOKIE CUTTERS IN									.100	.300	200	
15.			ARBOR PRESS PUNCH 9/32 DIA.(6) HOLES												
16.															
17.															
18.															
19.	54	21	WEIGH COMPLETED ASSY									.100	.250	210	
20.															
21.			RECORD WEIGHT DENSITY												
22.															
23.															
24.															
25.	33	22	IDENTIFY										.030	220	
26.															
27.															
28.	28	23	ACCUMULATE SK-058320-91										.160	230	
29.			ABLATIVE PLUG(6) REQD												
30.															
31.															
32.															
33.	47	24	ASSEMBLE COMPLETE									.100	.250	240	
34.															
35.															
36.															
37.	MFG.VERIFY	25													
38.															
39.	97	26	PROTECT PER MA0116-013 (PP-17)									.500	1.00	360	
40.															
41.															
42.															
43.	INSP	27												270	
44.															
45.															
46.															
47.															
48.															
49.															
50.															
51.	41966-T														
52.		(													
53.															
54.															
55.															
56.															
57.															

NR-A&SG MANUFACTURING ORDER

DIV. 41 | PLAN DEPT. 057 | PAGE 1 OF 3

PART NO. SK-058322-151

PART NAME ABLATIVE PANEL - FLAT

PLANNED BY 10-6-71 N. LEONE | TC 0 | 4. 225

NOTED

RC C | DATE ISSUED 10-15-71 | CONTROL X 88332 | SPLIT | IW 3733 | C 3737

SC-SCH | SCHEDULE REF. POD-71-SSC-05 | INITIAL STORES 070 | FINAL STORES 066-7

ITEM. UNIT	ACCOUNT	ORDER NO.	SUB. ACCT.	NO. UNITS	LH N	(PCS) R
003-004	3001	03045	02020	2	2	

TYPE ORDER PO4OFR | WORK FOR XXX

IDENT. SERIAL NO. | AUTHORIZATION TASK #2 | TOT THIS ORD 2 | 2

USED ON PART NO. / NEXT ASSY. | SPLIT BY:

QTY. PER UNIT/NA LH/N 1 | RH | MODEL ABLATIVE | INDEX NO. N | I

THIS COPY USED ON | THIS PART EFF. ON

LAST MECH. INSP. CVR ☐ MOCK-UP ☐ NO. CHG. ☐ CHG LTR NO E.O. ☐ E.O. NO. | DATE:

NO.	UNIT QTY. DEPT.	OPERATION 1	OPERATION 2	DATE	MECH / LDM	QTY. ACCEPTED LH N	QTY. ACCEPTED RH	MATERIAL DATE	MATERIAL INSP.	TOOL/CAT NO. E.O. DWG. REV	DEPTH OF CUT TUOL TYPE	SET-UP SPEED SEQ. NO.	RUN FEED HOURS	SCH NTC LINE	FLOW COOL- SCHED
1.													10-7-71		
2.															
3.	11.8 LBS.	R	PHENOLIC MICROBALLOONS												
4.			UNION CARBIDE BJO-0930												
5.															
6.	4.6 LBS.	R	SILICONE ELASTOMER												
7.			DOW CORNING SYLGARD												
8.			182 + CURING AGENT												
9.															
10.	1.8 LBS.	R	GLASS BUBBLES												
11.			3M CO. B-30B GLASS												
12.															
13.															
14.	1	C	SK-058322-13 SUB-ASSY												
15.															
16.															
17.	6	C	SK-058320-91 ABLATIVE PLUG *												
18.															
19.															
20.			* SHIP AS LOOSE ITEM												
21.															
22.															
23.		X	FABRICATE PER SK-058324												
24.															
25.															
26.															
27.	41-070														
28.															
29.	28	1	VERIFY MATL										030	10	
30.															
31.															
32.															
33.	MFG. VERIFY	2													
34.															
35.	47	3	PROTECT PER MAPING-013 (PP-7)									054	.007	30	
36.															
37.															
38.	IC VERIFY	4													
39.															
40.															
41.															
42.															
43.															

[redacted] | NO. OF PIECES RECEIVED | LH/N | RH | BY STOCKROOM NO. | CLERK'S SERIAL NO. | DATE

MANUFACTURING ORDER — SK-058322-151

P/N SK-058322-151 | REV C | DATE ISSUED 10-15-71 | CONTROL L. X 88332 | SPLIT | IW 323 | C 323

DIV. 41 | PLAN DEPT 057 | PAGE 2 OF —

LAST MECH. INSP. CVR ☐ MOCK-UP ☐ NO. CHG. ☐ CHG LTR NO E.O. ☐ E.O. NO. DATE

UNIT QTY. DEPT.	OPERATION 1.	OPERATION 2. DATE	MECH / LDM.	QTY. ACCEPTED LH / RH	MATERIAL DATE	INSP.	TOOL CAT NO E.O. DWG REV	DEPTH OF CUT TOOL TYPE	SET-UP SPEED SEQ NO	RUN FEED HOURS	SCN MTC LINE
061-31	5	PRIME & CURE -13 SUB-ASSY PER SK-058324							1.246	.CE5	50
		RECORD TIME									
33	6	IDENTIFY (TAG) MA0104-018								.030	60
MFG. VERIFY	7										
070-1(54	8	PREPARE FIXTURE FOR FILLING PER SK-058324							315 .477	.629	80
54	9	PREPARE -13 SUB-ASSY FOR POURING							.050	.250	90
MFG. VERIFY	10										
54	11	MIX FILLER MAT'L							.774 1.179	1.4 1.450	110
54	12	COMPACT MIXED FILLERS IN FILL TOOL							1.45 2.086	1.47 1.779	120
54	13	PRESS -13 SUB-ASSY INTO MIXED MAT'L								1.10 .883	130
54	14	APPLY 2ND PLY OF R1714 PREPREG, SEPARATOR CLOTH, BLEEDER CLOTH & VACUUM BAG							.151	.856	140
54	15	CURE RECORD CURE: START STOP TEMP								1.228	152
55	16	TRIM TO SIZE							.063	.820	160
33	17	IDENTIFY EXCESS AS SK-058322-151 & OCN NUMBER OF THIS MANUF. ORDER								.060	170

NR-A&SG MANUFACTURING ORDER

P/N SK-058322-151 | RC C | DATE ISSUED 10-15-71 | CONTROL X 88332 | SPLIT | IW 223 | C 223

DIV. 41 | PLAN DEPT 057 | PAGE 3 OF -

LAST MECH. INSP. CVR ☐ MOCK-UP ☐ NO. CHG. ☐ CHG LTR NO E.O. ☐ E.O. NO. DATE

NC	UNIT QTY. DEPT.	OPERATION / MATERIAL 1.	2. DATE	MECH / LDM.	QTY. ACCEPTED LH N / RH	DATE	INSP.	TOOL / CAT NO. E.O. DWG. REV	DEPTH OF CUT / TOOL TYPE	SET-UP SPEED SEQ NO	RUN FEED HOURS	SCN MTC LINE
		(										
	MFG. VERIFY	18										
	55	19	PUNCH .750 +.01 -.00 DIA. (6) HOLES BY USING COOKIE CUTTERS IN ARBOR PRESS (NOTE: .750 DIA. HOLES NOT TO GO THRU FACE SHEETS)							.050	.406	(190)
	55	20	USING COOKIE CUTTERS IN ARBOR PRESS PUNCH 9/32 DIA. (6) HOLES							.100	.300	(200)
	54	21	WEIGH COMPLETED ASSY. RECORD WEIGHT DENSITY							.100	.250	(210)
	33	22	IDENTIFY								.030	(220)
	78	23	ACCUMULATE SK-058320-91 ABLATIVE PLUG (6) REQD								.160	(230)
	47	24	ASSEMBLE COMPLETE							.100	250	(240)
	MFG. VERIFY	25										
	97	26	PROTECT PER MA0116-013 (PR-17)							.250 ~~.500~~	1.000	(260)
	INSP	27										(270)
	41-066-T	(										

NR-A&SG MANUFACTURING ORDER

DIV 41 | PLAN DEPT. 057 | PAGE 1 OF 3

PART NO. SK-058322-151

PART NAME ABLATIVE PANEL - FLAT

PLANNED BY 10-6-71 N. LEONE | TC 0 | 4. 225

NOTED

SET SK-058322-151

1. RC C | DATE ISSUED 10-15-71 | CONTROL X 88333 | SPLIT | IW 373 | C 374

2. SC-SCN | SCHEDULE REF. POD-71-SSC-05 | INITIAL STORES 070 | FINAL ST. 066

3. TYPE ORDER ROUTER | WORK FOR XXX

ITEM/UNIT	ACCOUNT	ORDER NO.	SUB.-ACCT.	NO. UNITS	LH/N	(PCS)
005-006	3001	03045	02050	2	2	

IDENT. SERIAL NO. | AUTHORIZATION TASK #2 | TOT. THIS ORD. 2 | 2

USED ON PART NO. / NEXT ASSY. | SPLIT BY:

QTY. PER UNIT/NA: LH/N 1 | RH | MODEL ABLATIVE | INDEX NO. N I I

THIS COPY USED ON | THIS PART EFF. ON

LAST MECH. INSP. CVR ☐ MOCK-UP ☐ NO. CHG. ☐ CHG LTR NO E.O. ☐ E.O. NO. | DATE:

UNIT QTY. DEPT.	OPERATION 1	OPERATION 2	DATE	MECH./LDM.	QTY. ACCEPTED LH/N	QTY. ACCEPTED RH	MATERIAL DATE	MATERIAL INSP.	TOOL/CAT NO. E.O. DWG. REV.	DEPTH OF CUT TOOL TYPE	SET-UP SPEED SEQ. NO.	RUN FEED HOURS	SCN MTC LINE
												10-7-71	
11.8 LBS.	R	PHENOLIC MICROBALLOONS UNION CARBIDE BJO-0930											
4.6 LBS.	R	SILICONE ELASTOMER DOW CORNING SYLGARD 182 + CURING AGENT											
1.8 LBS.	R	GLASS BUBBLES 3M CO. B-30B GLASS											
1	C	SK-058322-13 SUB-ASSY											
6	C	SK-058320-9/1 ABLATIVE PLUG *											
		* SHIP AS LOOSE ITEM											
	X	FABRICATE PER SK-058324											
41-070													
28	1	VERIFY MATL										030	(10)
MFG. VERIFY	2												
47	3	PROTECT PER MA0116-013 (PP-7)										054 .007	(30)
VERIFY	4												

NO. OF PIECES RECEIVED | LH/N | RH | BY STOCKROOM NO. | CLERK'S SERIAL NO. | DATE

NR-ASSG MANUFACTURING ORDER

P.N. SK-058322-151 | DIV. 41 | PLAN DEPT. 057 | PAGE 2 OF - | RC C | DATE ISSUED 10-15-71 | CONTR X 88333 | SPLIT | IW 3739 | C 3742

LAST MECH. INSP. CVR ☐ MOCK-UP ☐ NO. CHG. ☐ CHG LTR NO E.O. ☐ E.O. NO. DATE

NC	UNIT QTY. DEPT.	OPERATION / MATERIAL 1.	2.	DATE	MECH/LDM.	QTY. ACCEPTED LH N	RH	DATE	INSP.	TOOL: CAT NO E.O. DWG. REV	DEPTH OF CUT / TOOL TYPE	SET-UP SPEED SEQ. NO	RUN FEED HOURS	SCN MTC LINE
		(												
	061-31	5	PRIME & CURE -13 SUB-ASSY PER SK-058324									1.246	.085	(50)
			RECORD TIME											
	33	6	IDENTIFY (TAG) MA0104-018										.030	(60)
	MFG. VERIFY	7												
	070-1(54	8	PREPARE FIXTURE FOR FILLING PER SK-058324									.315 ~~.477~~	.629	(80)
	54	9	PREPARE -13 SUB-ASSY FOR POURING									.050	.250	(90)
	MFG. VERIFY	10												
	54	11	MIX FILLER MAT'L									~~1.179~~	1.864 ~~1.950~~	(110)
	54	12	COMPACT MIXED FILLERS IN FILL TOOL									~~2.086~~	1.476 ~~1.179~~	(120)
	54	13	PRESS -13 SUB-ASSY INTO MIXED MAT'L										1.194 .887	(130)
	54	14	APPLY 2ND PLY OF R1714 PREPREG., SEPARATOR CLOTH, BLEEDER CLOTH & VACUUM BAG									.157	.856	(140)
	54	15	CURE RECORD CURE: START STOP TEMP										1.228	(152)
	55	16	TRIM TO SIZE									.063	.820	(164)
		(												
	33	17	IDENTIFY EXCESS AS SK-058322-151 & DCN NUMBER OF THIS MANUF. ORDER										.060	(170)

NR-A&SD MANUFACTURING ORDER — SK-058322-151

P/N SK-058322-151 | CIV. 41 | PLAN DEPT 057 | PAGE 3 OF –

RC C | DATE ISSUED 10-15-71 | CONTROL L. X 88333 | SPLIT | IW 373 | C 374

LAST MECH. INSP. CVR ☐ MOCK-UP ☐ NO. CHG. ☐ CHG LTR NO E.O. ☐ E.O. NO. | DATE

SC	UNIT QTY. DEPT.	OPERATION 1.	OPERATION 2.	DATE	MECH / LDM	QTY. ACCEPTED LH	QTY. ACCEPTED RH	MATERIAL DATE	INSP.	TOOL CAT NO. E.O.	DWG.	REV.	DEPTH OF CUT / TOOL TYPE	SET-UP SPEED SEQ NO	RUN FEED HOURS	SCN MTC LINE
	MFG. VERIFY	18														
	55	19	PUNCH .750 +.01 -.00 DIA. (6) HOLES BY USING COOKIE CUTTERS IN ARBOR PRESS (NOTE: .750 DIA. HOLES NOT TO GO THRU FACE SHEETS)											.050	.406	190
	55	20	USING COOKIE CUTTERS IN ARBOR PRESS PUNCH 9/32 DIA. (6) HOLES											.100	.300	200
	54	21	WEIGH COMPLETED ASSY											.100	.250	210
			RECORD WEIGHT DENSITY													
	33	22	IDENTIFY												.030	220
	28	23	ACCUMULATE SK-058320-91 ABLATIVE PLUG (6) REQD												.100	230
	47	24	ASSEMBLE COMPLETE											.100	.250	240
	MFG. VERIFY	25														
	97	26	PROTECT PER MA0116-013 (PR-17)											.500	1.000	260
	INSP	27														270
	41 966-T															

NR A&SG MANUFACTURING ORDER

DIV. 41 | PLAN DEPT. 057 | PAGE 1 OF 3

1. RC C | DATE ISSUED 10-15-71 | CONTROL X 88334 | SPLIT | IW 374 | C 374

PART NO. SK-058322-161

2. SC-SCN | SCHEDULE REF. POD-71-SSC-05 | INITIAL STORES 070 | FINAL ST 066

PART NAME ABLATIVE PANEL - FLAT (1)

3.

TYPE ORDER	ITEM/UNIT	ACCOUNT	ORDER NO.	SUB-ACCT.	NO. UNITS	LH/N	(PCS)
FOROFR	007-008	3001	03045	02030	2	2	

PLANNED BY 10-6-71 N. LEONE | TC 0 | 4. 225

WORK FOR XXX

IDENT. SERIAL NO. | AUTHORIZATION TASK #2 | TOT THIS ORD 2 | 2

NOTED
A.
B.
C.
D.
E.
F.
G.

USED ON PART NO. / NEXT ASSY. | SPLIT BY:

QTY. PER UNIT/NA: LH/N 1 | RH | MODEL ABLATIVE | INDEX NO. N I

THIS COPY USED ON | THIS PART EFF. ON

LAST MECH. INSP. CVR ☐ MOCK-UP ☐ NO. CHG. ☐ CHG LTR NO E.O. ☐ E.O. NO. DATE:

NC	UNIT QTY. DEPT.	OPERATION 1	OPERATION 2	DATE	MECH/LDM	QTY. ACCEPTED LH/N	QTY. ACCEPTED RH	MATERIAL DATE	MATERIAL INSP.	TOOL/CAT NO. E.O. DWG. REV.	DEPTH OF CUT TOOL TYPE	SET-UP SPEED SEQ. NO.	RUN FEED HOURS	SCN MTC LINE
1.														
2.														
3.	2 LBS.	R	NYLON POWDER											
4.			POLYMER CORP. POLYPENCO 66D NYLON											
5.														
6.	10 LBS.	R	PHENOLIC MICROBALLOONS											
7.			UNION CARBIDE BJO-0930											
8.														
9.	4 LBS.	R	SILICONE ELASTOMER											
10.			RTV602 + SPL. CURING AGENT*											
11.			GENERAL ELECTRIC CO.											
12.														
13.	LBS.	R	GLASS BUBBLES											
14.			3M Co. B-30B GLASS											
15.														
16.														
17.	1	C	SK-058322-13 SUB-ASSY											
18.	6	C	SK-058320-191 ABLATIVE PLUG *											
19.														
20.														
21.														
22.			* SHIP AS LOOSE ITEM											
23.														
24.														
25.		X	FABRICATE PER SK-058324											
26.														
27.														
28.														
29.														
30.	41-070													
31.														
32.	28	1	VERIFY MATL										030	(10)
33.														
34.														
35.														
36.	MFG. VERIFY	2												
37.														
38.	(97	3	PROTECT PER MA0116-013 (PP-7)									.054	.07	(30)
39.														
40.														
41.	MFG. VERIFY	4												
42.														
43.														

NO. OF PIECES RECEIVED | LH/N | RH | BY STOCKROOM NO. | CLERK'S SERIAL NO. | DATE

NR A&SD MANUFACTURING ORDER — SK-058322-161

P/N SK-058322-161 | C | DATE ISSUED 10-15-71 | CONTRO NO X 88334 | SPLIT | IW 374 | C 374

DIV. 41 | PLAN DEPT 057 | PAGE 2 OF -

LAST MECH. INSP. CVR ☐ MOCK-UP ☐ NO. CHG. ☐ CHG LTR NO E.O. ☐ E.O. NO. DATE

LINE	UNIT QTY. DEPT.	OPERATION 1.	OPERATION 2. DATE	MECH / LDH	QTY. ACCEPTED LH N	QTY. ACCEPTED RH	MATERIAL DATE	MATERIAL INSP.	TOOL CAT NO E.O. DWG. REV	DEPTH OF CUT TOOL TYPE	SET-UP SPEED SEQ. NO.	RUN FEED HOURS	SCN MTC LINE
1													
2													
3	061-31	5	PRIME & CURE -13 SUB-ASSY								1.246	.085	50
4			PER SK-058324										
5													
6			RECORD TIME										
7													
8													
9													
10	33	6	IDENTIFY (TAG) MAQ104-018									.020	60
11													
12													
13													
14	MFG. VERIFY	7											
15													
16	070-1(54	8	PREPARE FIXTURE FOR FILLING								.477	.629	80
17			PER SK-058324										
18													
19													
20													
21	54	9	PREPARE -13 SUB-ASSY								.050	.250	90
22			FOR POURING										
23													
24													
25	MFG. VERIFY	10											
26											.7~~~	1.6~~	
27	54	11	MIX FILLER MAT'L								~~1.179~~	~~1.950~~	110
28													
29											1.45~	1.47~	
30	54	12	COMPACT MIXED FILLERS IN FILL TOOL								~~2.086~~	~~1.479~~	120
31													
32													
33												1.1~~	
34	54	13	PRESS -13 SUB-ASSY INTO MIXED MAT'L									~~.883~~	130
35													
36													
37													
38	54	14	APPLY 2ND PLY OF R1714 PREPREG,								.151	.856	140
39			SEPARATOR CLOTH, BLEEDER CLOTH										
40			& VACUUM BAG										
41													
42													
43													
44	54	15	CURE									1.228	150
45			RECORD CURE:										
46			START STOP TEMP										
47													
48													
49													
50	55	16	TRIM TO SIZE								.063	.820	160
51													
52													
53													
54	33	17	IDENTIFY EXCESS GS SK-058322-161									060	170
55			& OCN NUMBER OF THIS MANUF. ORDER										
56													

NR-A&SG MANUFACTURING ORDER — PART NUMBER SK-058322-161

P/N SK-058322-161 | DATE ISSUED 10-15-71 | CONTRO Y 88334 | SPLIT | IW 374 | C 374

DIV. 41 | PLAN DEPT 057 | PAGE 3 OF —

LAST MECH. INSP. CVR ☐ MOCK-UP ☐ NO. CHG. ☐ CHG LTR NO E.O. ☐ E.O. NO. DATE

UNIT QTY. DEPT.	1.	2. DATE	OPERATION / MECH / LDM	QTY ACCEPTED LH	QTY ACCEPTED RH	MATERIAL DATE	INSP.	TOOL CAT NO E.O. DWG. REV	DEPTH OF CUT TOOL TYPE	SET-UP SPEED SEQ NO	RUN FEED HOURS	SCN MTC LINE
												28
MFG. VERIFY	18											
55	19	PUNCH .750 +.00 -.06 DIA. (6) HOLES BY USING COOKIE CUTTERS IN ARBOR PRESS (NOTE: .750 DIA. HOLES NOT TO GO THRU FACE SHEETS)								.050	.406	190
55	20	USING COOKIE CUTTERS IN ARBOR PRESS PUNCH 9/32 DIA. (6) HOLES								.100	.300	200
54	21	WEIGH COMPLETED ASSY. RECORD WEIGHT ____ DENSITY ____								.100	.250	210
33	22	IDENTIFY									.030	220
28	23	ACCUMULATE SK-058329-101 ABLATIVE PLUG (6) REQ'D									.100	230
47	24	ASSEMBLE COMPLETE								.100	.250	240
MFG. VERIFY	25											
97	26	PROTECT PER MA0116-013 (PP-17)								.500	1.000	260
INSP 98	27											270
41 [illegible] 6-T												

NR-A&SG MANUFACTURING ORDER

SK-058322-161

DIV. 41 | PLAN DEPT. 057 | PAGE 1 OF 3

PART NO. SK-058322-161

PART NAME ABLATIVE PANEL - FLAT

PLANNED BY 10-6-71 N. LEONE | TC 0 | 4. 225

NOTED

RC C | DATE ISSUED 10-15-71 | CONTRO: N: X 88335 | SPLIT | (W) 374 | C 374

2. | SC-SCN | SCHEDULE REF. POD-71-SSC-05 | INITIAL STORES 070 | FINAL ST 066

3. | ITEM/UNIT | ACCOUNT | ORDER NO. | SUB.-ACCT. | NO. UNITS | LH N (PCS)

TYPE ORDER RONOFR | 009-010 | 3001 | 03045 | 02040 | 2 | 2

WORK FOR XXX

IDENT. SERIAL NO. | AUTHORIZATION TASK #2 | TOT MFG ORD | 2 | 2

USED ON PART NO. / NEXT ASSY. | SPLIT BY:

QTY. PER UNIT/NA LH/N 1 RH | MODEL ABLATIVE | INDEX NO. N I

THIS COPY USED ON | THIS PART EFF. ON

LAST MECH. INSP. CVR ☐ MOCK-UP ☐ NO. CHG. ☐ CHG LTR NO E.O. ☐ E.O. NO. DATE:

INC	UNIT QTY. DEPT.	OPERATION / MATERIAL 1	2	DATE	MECH./LDM.	QTY. ACCEPTED LH/N	RH	DATE	INSP.	TOOL/CAT NO. E.O. DWG. REV	DEPTH OF CUT TOOL TYPE	SET-UP SPEED SEQ. NO.	RUN FEED HOURS	SCN MTC LINE
1.														
2.														
3.	2 LBS.	R			NYLON POWDER									
4.					POLYMER CORP. POLYPENCO 66D NYLON									
5.														
6.	10 LBS.	R			PHENOLIC MICROBALLOONS									
7.					UNION CARBIDE BJO-0930									
8.														
9.	4 LBS.	R			SILICONE ELASTOMER									
10.					RTV602 + SPL. CURING AGENT*									
11.					GENERAL ELECTRIC CO.									
12.														
13.	LBS.	R			GLASS BUBBLES									
14.					3M Co. B-30R GLASS									
15.														
16.														
17.	1	C			SK-058322-13 SUB-ASSY									
18.														
19.	6	C			SK-058320-191 ABLATIVE PLUG									
20.														
21.														
22.														
23.					* SHIP AS LOOSE ITEM									
24.														
25.														
26.		X			FABRICATE PER SK-058324									
27.														
28.														
29.														
30.	41-070													
31.														
32.	28	1			VERIFY MAT'L								030	(10)
33.														
34.														
35.														
36.	MFG. VERIFY	2												
37.														
38.	97	3			PROTECT PER MA0116-013 (PP-7)							.054	.007	(30)
39.														
40.														
41.	MFG. VERIFY	4												
42.														
43.														

NO. OF PIECES RECEIVED | LH/N | RH | BY STOCKROOM NO. | CLERK'S SERIAL NO. | DATE

NH-AP.SG MANUFACTURING ORDER — PART NUMBER SK-058322-161

P/N SK-058322-161 | RC C | DATE ISSUED 10-15-71 | CONTROL NO. X 88335 | SPLIT | IW 3741 | C 3747

DIV 41 | PLAN DEPT 057 | PAGE 2 OF

LAST MECH. INSP. CVR ☐ MOCK-UP ☐ NO CHG ☐ CHG LTR NO E.O. ☐ E.O. NO DATE

UNIT QTY. DEPT.	OPERATION 1.	2. DATE MECH	QTY ACCEPTED SN RM	MATERIAL DATE	INSP.	TOOL CAT NO. E.O. DWG REV	DEPTH OF CUT TOOL TYPE	SET-UP SPEED SEQ NO	RUN FEED HOURS	SCN MTC LINE
061-31	5	PRIME & CURE -13 SUB-ASSY PER SK-058324						1.246	.085	(50)
		RECORD TIME								
33	6	IDENTIFY (TAG) MAQ104-018							.030	(60)
MFG. VERIFY	7									
070-1(54	8	PREPARE FIXTURE FOR FILLING PER SK-058324						.315 ~~.447~~	.629	(80)
54	9	PREPARE -13 SUB-ASSY FOR POURING						.050	.250	(90)
MFG. VERIFY	10									
54	11	MIX FILLER MAT'L						~~1.179~~	1.950 ~~1.450~~	(110)
54	12	COMPACT MIXED FILLERS IN FILL TOOL						1.4 ~~2.086~~	1.41. ~~1.179~~	(120)
54	13	PRESS -13 SUB-ASSY INTO MIXED MAT'L							1.192 .883	(130)
54	14	APPLY 2ND PLY OF R1714 PREPREG, SEPARATOR CLOTH, BLEEDER CLOTH & VACUUM BAG						.151	.856	(140)
54	15	CURE RECORD CURE: START STOP TEMP							1.228	(150)
55	16	TRIM TO SIZE						.063	.820	(160)
33	17	IDENTIFY EXCESS GS SK-058322-161 & OCN NUMBER OF THIS MANUF. ORDER							060	(170)

[redacted] MANUFACTURING ORDER SK-058322-161

P/N SK-058322-161 | DIV. 41 | PLAN DEPT 057 | PAGE 3 OF –

RC C | DATE ISSUED 10-15-71 | CONTROL No. X 88335 | SPLIT | IW 374 | C 374

LAST MECH. INSP. CVR ☐ MOCK-UP ☐ NO. CHG. ☐ CHG LTR NO E.O. ☐ E.O. NO. DATE

NC	UNIT QTY. DEPT.	OPERATION 1.	OPERATION 2.	DATE	MECH./LDM.	QTY ACCEPTED LH	QTY ACCEPTED RH	MATERIAL DATE	INSP.	TOOL/CAT NO. E.O. DWG. REV	DEPTH OF CUT TOOL TYPE	SET-UP SPEED SEQ NO	RUN FEED HOURS	SCN MTC LINE
		(												2.
	MFG. VERIFY	18												
	55	19	PUNCH .750 +.00 -.01 DIA. (6) HOLES BY USING COOKIE CUTTERS IN ARBOR PRESS (NOTE: .750 DIA. HOLES NOT TO GO THRU FACE SHEETS)									.650	.406	190
	55	20	USING COOKIE CUTTERS IN ARBOR PRESS PUNCH 9/32 DIA. (6) HOLES									.100	.300	200
	54	21	WEIGH COMPLETED ASSY									.100	.250	210
			RECORD WEIGHT _____ DENSITY _____											
	33	22	IDENTIFY										.030	220
	28	23	ACCUMULATE SK-058329-101 ABLATIVE PLUG (6) REQ'D										.100	230
	47	24	ASSEMBLE COMPLETE									.100	.250	240
	MFG. VERIFY	25												
	97	26	PROTECT PER MA0116-013 (PP-17)									500	Leco	260
	INSP 98	27												270
	41 '66-T													

[redacted]

NR-A&SG MANUFACTURING ORDER

DIV. 41 | PLAN DEPT. 057 | PAGE 1 OF 3

PART NO. SK-058322-161

PART NAME ABLATIVE PANEL - FLAT

PLANNED BY N. LEONE | TC 0 | 4. 225

NOTED

SET | BLUES | PROD. NUMBER SK-058322-161

RC C | DATE ISSUED 10-15-71 | CONTROL N. X 88336 | SPLIT | IW 3747 | C 3750

2. | SC-SCN | SCHEDULE REF. POD-71-SSC-05 | INITIAL STORES 070 | FINAL STORES 066-T

3. | TYPE ORDER FOROFR | WORK FOR XXX | ITEM/UNIT 011-012 | ACCOUNT 3001 | ORDER NO. 03045 | SUB-ACCT. 02060 | NO. UNITS 2 | LH/N 2 | (PCS) RH

IDENT. SERIAL NO. | AUTHORIZATION THSK #2 | TOT THIS ORD. 2 | 2

USED ON PART NO. / NEXT ASSY. | SPLIT BY:

QTY. PER UNIT/NA LH/N 1 | RH | MODEL ABLATIVE | INDEX NO. N I

THIS COPY USED ON | THIS PART EFF. ON

LAST MECH. INSP. CVR ☐ MOCK-UP ☐ NO. CHG. ☐ CHG LTR NO E.O. ☐ E.O. NO. | DATE:

NO.	UNIT QTY. DEPT.	1	2	DATE	MECH / LDM.	OPERATION / MATERIAL QTY. ACCEPTED LH N	RH	DATE	INSP.	TOOL/CAT NO. E.O. DWG. REV.	DEPTH OF CUT TOOL TYPE	SET-UP SPEED SEQ. NO.	RUN FEED HOURS	SCH MTC LINE	FLOW COOL? SCHED
1.															
2.															
3.	2 LBS.	R	NYLON POWDER												
4.			POLYMER CORP. POLYPENCO 66D NYLON												
5.															
6.	10 LBS.	R	PHENOLIC MICROBALLOONS												
7.			UNION CARBIDE E-10-0950												
8.															
9.	4 LBS.	R	SILICONE ELASTOMER												
10.			RTV602 + SPL. CURING AGENT#												
11.			GENERAL ELECTRIC CO.												
12.															
13.	LBS.	R	GLASS BUBBLES												
14.			3M CO. B-30B GLASS												
15.															
16.															
17.	1	C	SK-058322-13 SUB-ASSY												
18.															
19.	6	C	SK-058320-191 ABLATIVE PLUG *												
20.															
21.															
22.			* SHIP AS LOOSE ITEM												
23.															
24.		X	FABRICATE PER SK-058324												
25.															
26.															
27.															
28.	41-070														
29.															
30.	28	1	VERIFY MAT'L										030	10	
31.															
32.															
33.															
34.	MFG. VERIFY	2													
35.															
36.	97	3	PROTECT PER MA0116-013 (PP-7)									.054	.007	30	
37.															
38.															
39.	MFG. VERIFY	4													
40.															
41.															

NO. OF PIECES RECEIVED | LH/N | RH | BY STOCKROOM NO. | CLERK'S SERIAL NO. | DATE

NR-A&SR MANUFACTURING ORDER — SK-058322-161-1

P/N SK-058322-161 | DIV 41 | PLAN DEPT 057 | PAGE 2 OF - | RC 0 | DATE ISSUED 10-15-71 | CONTROL NO No X 88336 | SPLIT | IW 3741 | C 3750

LAST MECH. INSP. CVR ☐ MOCK-UP ☐ NO. CHG ☐ CHG LTR NO E.O. ☐ E.O. NO DATE

UNIT QTY. DEPT.	1.	2. DATE	OPERATION / MECH / LDM	QTY ACCEPTED LH N RH	MATERIAL DATE	INSP.	TOOL CAT NO E.O. DWG REV	DEPTH OF CUT TOOL TYPE	SET-UP SPEED SEQ NO	RUN FEED HOURS	SCN MTC LINE	FLOW COOL SCHD
												225
061-31	5		PRIME & CURE -13 SUB-ASSY PER SK-058324						1.246	.085	50	
			RECORD TIME									
33	6		IDENTIFY (TAG) MAQ104-018							.030	60	
MFG. VERIFY	7											
070-1(54	8		PREPARE FIXTURE FOR FILLING PER SK-058324						.315 ~~.447~~	.629	80	
54	9		PREPARE -13 SUB-ASSY FOR POURING						.050	.250	90	
MFG. VERIFY	10											
54	11		MIX FILLER MAT'L						.796 ~~1.179~~	1.950	110	
54	12		COMPACT MIXED FILLERS IN FILL TOOL						1.[illegible] 2.096	1.476 ~~1.479~~	120	
54	13		PRESS -13 SUB-ASSY INTO MIXED MAT'L							1.1[illegible] ~~.663~~	130	
54	14		APPLY 2ND PLY OF R1714 PREPREG, SEPARATOR CLOTH, BLEEDER CLOTH & VACUUM BAG						.151	.856	140	
54	15		CURE RECORD CURE: START STOP TEMP							1.228	150	
55	16		TRIM TO SIZE						.063	.820	160	
33	17		IDENTIFY EXCESS GS SK-058322-161 & OCN NUMBER OF THIS MANUF ORDER							.060	170	

NR-ASSR MANUFACTURING ORDER

P/N SK-058322-161 | DIV. 41 | PLAN DEPT 057 | PAGE 3 OF - | RC 0 | DATE ISSUED 10-15-71 | CONTROL NO. No X 88336 | SPLIT | IW 374 | C 375

LAST MECH. INSP. CVR ☐ MOCK-UP ☐ NO. CHG. ☐ CHG LTR NO E.O. ☐ E.O. NO. DATE

NE	UNIT QTY. DEPT.	1.	2.	DATE	MECH / LDM	OPERATION / MATERIAL QTY. ACCEPTED LH RH	DATE	INSP.	TOOL / CAT NO. E.O. DWG. REV	DEPTH OF CUT / TOOL TYPE	SET-UP SPEED SEQ. NO	RUN FEED HOURS	SCN MTC LINE	FL CO SCH
1.														225
2.														
3.														
4.	MFG. VERIFY	18												
5.														
6.	55	19	PUNCH .750 +.010 -.000 DIA. (G) HOLES								.050	.406	(190)	
7.			BY USING COOKIE CUTTERS IN											
8.			ARBOR PRESS											
9.			(NOTE: .750 DIA. HOLES NOT											
10.			TO GO THRU FACE SHEETS)											
11.														
12.														
13.														
14.	55	20	USING COOKIE CUTTERS IN								.100	.300	(200)	
15.			ARBOR PRESS PUNCH 9/32 DIA. (G) HOLES											
16.														
17.														
18.														
19.	54	21	WEIGH COMPLETED ASSY								.100	.250	(210)	
20.														
21.			RECORD WEIGHT _____ DENSITY _____											
22.														
23.														
24.														
25.	33	22	IDENTIFY									.030	(220)	
26.														
27.														
28.	28	23	ACCUMULATE SK-058320-101									.100	(230)	
29.			ABLATIVE PLUG (6) REQ'D											
30.														
31.														
32.														
33.	47	24	ASSEMBLE COMPLETE								.100	.250	(240)	
34.														
35.														
36.	MFG. VERIFY	25												
37.														
38.	97	26	PROTECT PER MA0116-013 (PP-17)								500	1.000	(260)	
39.														
40.														
41.	INSP 98	27											(270)	
42.														
43.														
44.														
45.														
46.														
47.	41 766-5													
48.														
49.														
50.														
51.														

APPENDIX B

COMPUTER COST ANALYSIS DATA

```
PSC1 I              X08323          00001       99999
X08323      09 3770 0001  03045 03010      1.374     C   00036
   10 RECORD MATL. IDENT               070    00005    0.030 41 3701 070      00470 00005 00000 3001           0.0    0.0  0000 1 3751
 1.0    0.030  1.0    0.000    F F       A
   20 CUT TO SIZE                      070    00005    0.410 41 3701 070      00470 00005 00000 3001           0.0    0.0  0000 1 3751
 1.0    0.050  1.0    0.310    F F       A
   30 LATHE                            070    00007   10.000 41 3701 070      00470 00007 00000 3001           0.0    0.0  0000 1 3751
 1.0    1.000  1.0    0.250    F F       A
   40 IDENT                            070    00033    1.000 41 3701 070      00470 00233 00000 3001           0.0    0.0  0000 1 3751
 0.0    0.000  1.0    0.030    F F       A
   50 PROTECT                          070    00007    0.144 41 3701 070      00470 00007 00000 3001           0.0    0.0  0000 1 3751
 1.0    0.000  1.0    0.034    F F       A
   60 INSP.                            017    00008    0.000 41 3701 070      00470 00008 00000 3001           0.0    0.0  0000 1 0000
 0.0    0.000  0.0    0.000    F 0       A
X08323     .....
```


Space Division
North American Rockwell

```
PSCI I              X88330      0000 3   99999
X88330      99 3778 3001  03045 03030      1.374     0    00030
   10 RECORD MATL. IDENT                    070    00005    0.030 41 3791 070     00470 00005 00000 3001        0.0     0.0    0000 1 0000
 1.0    0.030  1.0    0.000    F F            A
   20 CUT TO SIZE                           070    00005    0.010 41 3791 070     00470 00005 00000 3001        0.0     0.0    0000 1 0000
 1.0    0.050  1.0    0.010    F F            A
   30 LATHE                                 070    00007   10.000 41 3791 070     00470 00007 00000 3001        0.0     0.0    0000 1 0000
 1.0    1.000  1.0    0.250    F F            A
   40 IDENT                                 070    00033    1.030 41 3791 070     00470 00033 00000 3001        0.0     0.0    0000 1 0000
 0.0    0.000  1.0    0.030    F F            A
   50 PROTECT                               070    00037    3.144 41 3791 070     00470 00037 00000 3001        0.0     0.0    0000 1 0000
 0.0    0.000  1.0    0.004    F F            A
   60 INSP.                                 047    00038    3.000 41 3791 070     00470 00038 00000 3001        0.0     0.0    0000 1 0000
 0.0    0.000  0.0    0.000    F Q            A
X88330      .....
```


Space Division
North American Rockwell

```
PSCI 1-             X88331        00001       99999
X88331      99 3776 3001  03045 02010    15.550   21    00002
 10 VERIFY MATL                   070    00028   0.060 41 3791 070   00470 00028 00000 3001     0.0    0.0   0000 1 0000
 0.0   0.000  1.0    0.030   F F      A
   30 PROTECT                     071    00097   0.032 41 3791 070   00470 00097 00000 3001     0.0    0.0   0000 1 0000
 1.0   0.054  1.0    0.007   F F      A
   50 PRIME & CURE                051    00031   1.810 41 3791 070   00470 00031 00000 3001     0.0    0.0   0000 1 0000
 1.0   1.240  1.0    0.035   F F      A
  [illegible] IDENT.              051    00033   [illegible] 41 3791 070   00470 00033 00000 3001     0.0    0.0   0000 1 0000
 0.0   0.000  1.0    0.030   F F      A
  [illegible] PREP TOOL           070    00054   1.[illegible] 41 3791 070   00470 00054 00000 3001     0.0    0.0   0000 1 0000
 1.0   [illegible].315  1.0    0.020   F F      A
  [illegible] TRIM -13 FOR POTTING  070  [illegible]   [illegible] 41 3791 070   00470 00054 00000 3001     0.0    0.0   0000 1 0000
 1.0   0.050  1.0    0.250   F F      A
  110 MIX FILLER                  070    00054   [illegible] 41 3791 070   [illegible]     0.0    0.0   0000 1 0000
 1.0   [illegible].700  1.0    1.204   F F      A
  120 COMPACT MIX                 070    00054   4.332 41 3791 070   00470 00054 00000 3001     0.0    0.0   0000 1 0000
 1.0   2.4[illegible]  1.0    1.478   F F      A
  130 PRESS                       070    00054   2.528 41 3791 070   00470 00054 00000 3001     0.0    0.0   0000 1 0000
 0.0   0.000  1.0    1.154   F F      A
  140 APPLY 2ND PLY               070    00054   1.605 41 3791 070   00470 00054 00000 3001     0.0    0.0   0000 1 0000
 1.0   [illegible].151  1.0    0.850   F F      A
  150 CURE                        070    00054   2.454 41 3791 070   00470 00054 00000 3001     0.0    0.0   0000 1 0000
 0.0   0.900  1.0    1.228   F F      A
  160 TRIM TO SIZE                070    00055   1.795 41 3791 070   00470 00055 00000 3001     0.0    0.0   0000 1 3751
 1.0   0.063  1.0    0.820   F F      A
  170 IDENT                       070    00033   0.190 41 3791 070   00470 00033 00000 3001     0.0    0.0   0000 1 3751
 0.0   0.000  1.0    0.000   F F      A
  180 PUNCH & TRIM                070    00055   0.802 41 3791 070   00470 00055 00000 3001     0.0    0.0   0000 1 3751
 1.0   0.050  1.0    0.406   F F      A
  200 CUT                         070    00055   0.7[illegible] 41 3791 070   00470 00055 00000 3001     0.0    0.0   0000 1 3751
 1.0   0.190  1.0    0.300   F F      A
  210 WEIGH ASSY.                 070    00054   0.000 41 3791 070   00470 00054 00000 3001     0.0    0.0   0000 1 3751
 1.0   [illegible].100  1.0    0.250   F F      A
  220 IDENT                       070    00033   0.060 41 3791 070   00470 00033 00000 3001     0.0    0.0   0000 1 3751
 0.0   0.000  1.0    0.030   F F      A
  230 ACOUST PLUG                 070    00028   0.200 41 3791 070   00470 00028 00000 3001     0.0    0.0   0000 1 3751
 0.0   0.000  1.0    0.100   F F      A
  240 ASSEM COMP.                 070    00047   0.000 41 3791 070   00470 00047 00000 3001     0.0    0.0   0000 1 3751
 1.0   0.100  1.0    0.250   F A
  260 PROTECT                     070    00037   2.250 41 3791 070   00470 00037 00000 3001     0.0    0.0   0000 1 3755
 1.0   [illegible].255  1.0    1.000   F F      A
  270 INSP                        047    00000   [illegible] 41 3791 070   00470 00000 00000 3001     0.0    0.0   0000 1 3755
 0.0   0.000  0.0    0.000   F Q      A
X88331      .....
```

B-3

SD 72-SH-0005

Space Division
North American Rockwell

```
PSCI I          X88332      00001   00000
X88332      3 4 3778 3001  03045 02020    15.550   21   00002
   10 VERIFY M/TL                          070    00023   0.000 41 3701 070    00470 00023 00000 3001      0.0      0.0   0000 1 3751
 0.0   0.000  1.0   0.000   F F             A
   30 PROTECT                              071    00037   0.000 41 3701 070    00470 00037 00000 3001      0.0      0.0   0000 1 0000
 1.0   0.054  1.0   0.007   F F             A
   50 PRIME & CURE                         001    00031   1.415 41 3701 070    00470 00031 00000 3001      0.0      0.0   0000 1 3751
 1.0   1.240  1.0   0.085   F F             A
   60 IDENT                                001    00033   0.000 41 3701 070    00470 00033 00000 3001      0.0      0.0   0000 1 3751
 0.0   0.000  1.0   0.000   F F             A
   65 PREP TOOL                            070    00054   1.575 41 3701 070    00470 00054 00000 3001      0.0      0.0   0000 1 3751
 1.0   0.510  1.0   0.320   F F             A
   70 PREP -25 FOR POURING                 070    00054   0.550 41 3701 070    00470 00054 00000 3001      0.0      0.0   0000 1 3751
 1.0   0.350  1.0   0.250   F F             A
  110 MIX FILLER                           070    00054   4.334 41 3701 070    00470 00054 00000 3001      0.0      0.0   0000 1 0000
 1.0   0.700  1.0   1.364   F F             A
  120 COMPACT MIX                          070    00054   4.352 41 3701 070    00470 00054 00000 3001      0.0      0.0   0000 1 3751
 1.0   1.400  1.0   1.470   F F             A
  130 PRESS                                070    00054   2.366 41 3701 070    00470 00054 00000 3001      0.0      0.0   0000 1 3751
 0.0   0.000  1.0   1.134   F F             A
  140 APPLY 2ND. PLY                       070    00054   1.865 41 3701 070    00470 00054 00000 3001      0.0      0.0   0000 1 3751
 1.0   0.151  1.0   0.855   F F             A
  150 CURE                                 070    00054   2.456 41 3701 070    00470 00054 00000 3001      0.0      0.0   0000 1 0000
 0.0   0.000  1.0   1.228   F F             A
  160 TRIM TO SIZE                         070    00055   1.703 41 3701 070    00470 00055 00000 3001      0.0      0.0   0000 1 3751
 1.0   0.363  1.0   0.820   F F             A
  170 IDENT                                070    00033   0.140 41 3701 070    00470 00033 00000 3001      0.0      0.0   0000 1 3751
 0.0   0.000  1.0   0.000   F F             A
  180 PUNCH & TRIM                         070    00055   0.332 41 3701 070    00470 00055 00000 3001      0.0      0.0   0000 1 3751
 1.0   0.050  1.0   0.496   F F             A
  200 CUT                                  070    00055   0.700 41 3701 070    00470 00055 00000 3001      0.0      0.0   0000 1 3751
 1.0   0.100  1.0   0.300   F F             A
  210 WEIGH ASSY.                          070    00054   0.300 41 3701 070    00470 00054 00000 3001      0.0      0.0   0000 1 3751
 1.0   0.100  1.0   0.250   F F             A
  220 IDENT                                070    00033   0.000 41 3701 070    00470 00033 00000 3001      0.0      0.0   0000 1 3751
 0.0   0.000  1.0   0.000   F F             A
  230 ACCUM PLUG                           070    00028   0.450 41 3701 070    00470 00028 00000 3001      0.0      0.0   0000 1 3751
 0.0   0.000  1.0   0.100   F F             A
  240 ASSEM COMP.                          070    00047   0.000 41 3701 070    00470 00047 00000 3001      0.0      0.0   0000 1 3751
 1.0   0.100  1.0   0.250   F A             A
  250 PROTECT                              070    00037   2.450 41 3701 070    00470 00037 00000 3001      0.0      0.0   0000 1 3755
 1.0   0.250  1.0   1.000   F F             A
  270 INSP                                 047    00038   0.400 41 3701 070    00470 00038 00000 3001      0.0      0.0   0000 1 3755
 0.0   0.000  0.0   0.000   F Q             A
X88332      .....
```


Space Division
North American Rockwell

```
PSCI I                X88333          00001     99999
X88333      00 3778 3001  03045 02050    15.550   21   00002
   10 VERIFY MATL                      070  00028  0.060 41 3791 070   00470 00028 00000 3001    0.0    0.0  0000 1 3751
 0.0   0.000  1.0   0.030   F F         A
   30 PROTECT                          071  00007  0.060 41 3791 070   00470 00007 00000 3001    0.0    0.0  0000 1 3751
 1.0   0.054  1.0   0.007   F F         A
   50 PRIME & CURE                     031  00031  1.410 41 3791 070   00470 00031 00000 3001    0.0    0.0  0000 1 3751
 1.0   1.240  1.0   0.035   F F         A
   60 IDENT                            061  00033  0.000 41 3791 070   00470 00033 00000 3001    0.0    0.0  0000 1 3751
 0.0   0.000  1.0   0.030   F F         A
   80 PREP TOOL                        070  00054  1.570 41 3791 070   00470 00054 00000 3001    0.0    0.0  0000 1 3751
 1.0   0.315  1.0   0.020   F F         A
   90 DRILL -15 FOR MOUNTING           070  00054  0.000 41 3791 070   00470 00054 00000 3001    0.0    0.0  0000 1 3751
 1.0   0.359  1.0   0.250   F F         A
  110 MIX FILLER                       070  00054  4.554 41 3791 07-   -470 00054 00000 3001    0.0    0.0  0000 1 3751
 1.0   0.786  1.0   1.804   F F         A
  120 COMPACT MIX                      070  00054  0.000 41 3791 070   00470 00054 00000 3001    0.0    0.0  0000 1 3751
 1.0   1.400  1.0   1.470   F F         A
  130 PRESS                            070  00054  2.500 41 3791 070   00470 00054 00000 3001    0.0    0.0  0000 1 3751
 0.0   0.000  1.0   1.134   F F         A
  140 APPLY 2ND. PLY                   070  00054  1.000 41 3791 070   00470 00054 00000 3001    0.0    0.0  0000 1 3751
 1.0   2.151  1.0   0.858   F F         A
  150 CUT                              070  00054  2.450 41 3791 070   00470 00054 00000 3001    0.0    0.0  0000 1 3751
 0.0   0.000  1.0   1.220   F F         A
  160 TRIM TO SIZE                     070  00055  1.780 41 3791 070   00470 00055 00000 3001    0.0    0.0  0000 1 3751
 1.0   0.003  1.0   0.830   F F         A
  170 IDENT                            070  00033  0.120 41 3791 070   00470 00033 00000 3001    0.0    0.0  0000 1 3751
 0.0   0.000  1.0   0.000   F F         A
  190 TRIM & SEAL                      070  00055  0.000 41 3791 070   00470 00055 00000 3001    0.0    0.0  0000 1 3751
 1.0   0.050  1.0   0.400   F F         A
  200 CUT                              070  00055  0.700 41 3791 070   00470 00055 00000 3001    0.0    0.0  0000 1 3751
 1.0   0.100  1.0   0.300   F F         A
  210 WEIGH ASSY.                      070  00054  0.000 41 3791 070   00470 00054 00000 3001    0.0    0.0  0000 1 3751
 1.0   0.100  1.0   0.250   F F         A
  220 IDENT                            070  00033  0.000 41 3791 070   00470 00033 00000 3001    0.0    0.0  0000 1 3751
 0.0   0.000  1.0   0.050   F F         A
  230 ACCUM FILE                       070  00028  0.200 41 3791 070   00470 00028 00000 3001    0.0    0.0  0000 1 3751
 0.0   0.000  1.0   0.100   F F         A
  240 ASSEM COMP.                      070  00047  0.000 41 3791 070   00470 00047 00000 3001    0.0    0.0  0000 1 3751
 1.0   0.1..  1.0   0.250   F A         A
  250 PROTECT                          070  00007  2.250 41 3791 070   00470 00007 00000 3001    0.0    0.0  0000 1 0000
 1.0   0.250  1.0   1.000   F F         A
  270 INSP                             047  00038  0.000 41 3791 07-   00470 00038 00000 3001    0.0    0.0  0000 1 0000
 0.0   0.000  0.0   0.000   F Q         A
X88333      .....
```


Space Division
North American Rockwell

```
PSCI I                    X88334          00001      99999
X88334      88 3703 3001  03045 02035    15.810   21   00002
   10 VERIFY MATL                                070   00028   0.050 41 3701 070   00470 00028 00000 3001      0.0     0.0  0000 1 0000
 0.0   0.000  1.0   0.030   F F                    A
   30 PROTECT                                    071   00097   0.000 41 3701 070   00470 00097 00000 3001      0.0     0.0  0000 1 0000
 1.0   0.054  1.0   0.007   F F                    A
   50 PRIME & CURE                               081   00031   1.410 41 3701 070   00470 00031 00000 3001      0.0     0.0  0000 1 0000
 1.0   1.240  1.0   0.005   F F                    A
   60 IDENT                                      081   00033   0.000 41 3701 070   00470 00033 00000 3001      0.0     0.0  0000 1 0000
 0.0   0.000  1.0   0.030   F F                    A
   80 PREP TOOL                                  070   00054   1.570 41 3701 070   00470 00054 00000 3001      0.0     0.0  0000 1 0000
 1.0   0.315  1.0   0.020   F F                    A
   90 PREP FOR POURING                           070   00054   0.550 41 3701 070   00470 00054 00000 3001      0.0     0.0  0000 1 0000
 1.0   0.050  1.0   0.250   F F                    A
  110 MIX FILLER MATL                            070   00054   4.000 41 3701 070   00470 00054 00000 3001      0.0     0.0  0000 1 0000
 1.0   0.700  1.0   1.950   F F                    A
  120 COMPACT MATL                               070   00054   4.350 41 3701 070   00470 00054 00000 3001      0.0     0.0  0000 1 0000
 1.0   1.400  1.0   1.470   F F                    A
  130 PRESS                                      070   00054   2.300 41 3701 070   00470 00054 00000 3001      0.0     0.0  0000 1 0000
 0.0   0.000  1.0   1.100   F F                    A
  140 APPLY FLY                                  070   00054   1.000 41 3701 070   00470 00054 00000 3001      0.0     0.0  0000 1 0000
 1.0   0.151  1.0   0.050   F F                    A
  150 CURE                                       070   00054   0.450 41 3701 070   00470 00054 00000 3001      0.0     0.0  0000 1 0000
 1.0   1.000  1.0   1.240   F F                    A
  160 TRIM                                       070   00055   1.700 41 3701 070   00470 00055 00000 3001      0.0     0.0  0000 1 0000
 1.0   0.000  1.0   0.040   F F                    A
  170 IDENT                                      070   00033   0.120 41 3701 070   00470 00033 00000 3001      0.0     0.0  0000 1 0000
 0.0   0.000  1.0   0.030   F F                    A
  190 PURGE & TRIM                               070   00055   0.382 41 3701 070   00470 00055 00000 3001      0.0     0.0  0000 1 0000
 1.0   0.050  1.0   0.400   F F                    A
  200 CUT                                        070   00055   0.700 41 3701 070   00470 00055 00000 3001      0.0     0.0  0000 1 0000
 1.0   0.100  1.0   0.300   F F                    A
  210 WEIGH                                      070   00054   0.000 41 3701 070   00470 00054 00000 3001      0.0     0.0  0000 1 0000
 1.0   0.100  1.0   0.250   F F                    A
  220 IDENT                                      070   00033   0.000 41 3701 070   00470 00033 00000 3001      0.0     0.0  0000 1 0000
 0.0   0.000  1.0   0.030   F F                    A
  230 ACCUM PLUG                                 070   00028   0.200 41 3701 070   00470 00028 00000 3001      0.0     0.0  0000 1 0000
 0.0   0.000  1.0   0.100   F F                    A
  240 ASSEL COMP                                 070   00047   0.000 41 3701 070   00470 00047 00000 3001      0.0     0.0  0000 1 0000
 1.0   0.100  1.0   0.250   F A                    A
  260 PROTECT                                    070   00097   0.250 41 3701 070   00470 00097 00000 3001      0.0     0.0  0000 1 0000
 1.0   0.250  1.0   1.000   F F                    A
  270 INSP                                       047   00098   0.000 41 3701 070   00470 00098 00000 3001      0.0     0.0  0000 1 0000
 0.0   0.000  0.0   0.000   F G                    A
X88334
```


Space Division
North American Rockwell

```
PSCI I              X88335      00001   00000
X88335       00 3778 3001  03045 02040     15.316    21   00002
   10 VERIFY MATL                          070    00028   0.050 41 3731 070    00470 00028 00000 3001        0.0     0.0  0000 1 0000
 0.0   0.000  1.0   0.030   F F      A
   30 PROTECT                              071    00037   0.068 41 3731 070    00470 00037 00000 3001        0.0     0.0  0000 1 0000
 1.0   0.054  1.0   0.007   F F      A
   50 PRIME & CURE                         061    00031   1.418 41 3731 070    00470 00031 00000 3001        0.0     0.0  0000 1 0000
 1.0   1.240  1.0   0.086   F F      A
   60 IDENT                                061    00033   0.030 41 3731 070    00470 00033 00000 3001        0.0     0.0  0000 1 0000
 0.0   0.000  1.0   0.030   F F      A
   80 PREP TOOL                            070    00054   1.373 41 3731 070    00470 00054 00000 3001        0.0     0.0  0000 1 0000
 1.0   0.515  1.0   0.029   F F      A
   90 PREP FOR POURING                     070    00054   0.350 41 3731 070    00470 00054 00000 3001        0.0     0.0  0000 1 0000
 1.0   0.000  1.0   0.250   F F      A
  110 MIX FILLER MTL                       070    00054   4.080 41 3731 070    00470 00054 00000 3001        0.0     0.0  0000 1 0000
 1.0   0.785  1.0   1.050   F F      A
  120 COMPACT MATL                         070    00054   4.352 41 3731 070    00470 00054 00000 3001        0.0     0.0  0000 1 0000
 1.0   1.400  1.0   1.470   F F      A
  130 PRESS                                070    00054   2.581 41 3731 070    00470 00054 00000 3001        0.0     0.0  0000 1 0000
 0.0   0.000  1.0   1.104   F F      A
  140 APPLY PLY                            070    00054   1.303 41 3731 070    00470 00054 00000 3001        0.0     0.0  0000 1 0000
 1.0   0.151  1.0   0.833   F F      A
  150 CURE                                 070    00054   2.456 41 3731 070    00470 00054 00000 3001        0.0     0.0  0000 1 0000
 0.0   0.000  1.0   1.223   F F      A
  160 TRIM                                 070    00055   1.705 41 3731 070    00470 00055 00000 3001        0.0     0.0  0000 1 0000
 1.0   0.000  1.0   0.020   F F      A
  170 IDENT                                070    00033   0.120 41 3731 070    00470 00033 00000 3001        0.0     0.0  0000 1 0000
 0.0   0.000  1.0   0.000   F F      A
  190 PUNCH & TRIM                         070    00055   0.802 41 3731 070    00470 00055 00000 3001        0.0     0.0  0000 1 0000
 1.0   0.050  1.0   0.406   F F      A
  200 CUT                                  070    00055   0.730 41 3731 070    00470 00055 00000 3001        0.0     0.0  0000 1 0000
 1.0   0.100  1.0   0.300   F F      A
  210 Metal                                070    00054   0.000 41 3731 070    00470 00054 00000 3001        0.0     0.0  0000 1 0000
 1.0   0.100  1.0   0.250   F F      A
  220 IDENT                                070    00033   0.060 41 3731 070    00470 00033 00000 3001        0.0     0.0  0000 1 0000
 0.0   0.000  1.0   0.030   F F      A
  230 ACCUM PLUG                           070    00028   0.200 41 3731 070    00470 00028 00000 3001        0.0     0.0  0000 1 0000
 0.0   0.000  1.0   0.100   F F      A
  240 ASSEM COMP                           070    00047   0.000 41 3731 070    00470 00047 00000 3001        0.0     0.0  0000 1 0000
 1.0   0.100  1.0   0.250   F A      A
  260 PROTECT                              070    00037   2.250 41 3731 070    00470 00037 00000 3001        0.0     0.0  0000 1 0000
 1.0   0.250  1.0   1.000   F F      A
  270 INSP                                 047    00001   0.000 41 3731 070    00470 00056 00000 3001        0.0     0.0  0000 1 0000
 0.0   0.000  1.0   0.000   F Q      A
X88335       .....
```


Space Division
North American Rockwell

```
PSCI 1              X83336      00001    99999
X83336        00 3770 3001  03045 02000      15.016    21    00002
  10 VERIFY MATL                          070      00028    0.000 41 3701 070    00470 00028 00000 3001     0.0     0.0  0000 1 0000
 0.0   0.000  1.0    0.030    F F             A
  30 PROTECT                              071      00037    0.063 41 3701 070    00470 00037 00000 3001     0.0     0.0  0000 1 0000
 1.0   0.054  1.0    0.007    F F             A
  50 PRIME & CURE                         061      00031    1.416 41 3701 070    00470 00031 00000 3001     0.0     0.0  0000 1 0000
 1.0   1.246  1.0    0.085    F F             A
  60 IDENT                                061      00033    0.060 41 3701 070    00470 00033 00000 3001     0.0     0.0  0000 1 0000
 0.0   0.000  1.0    0.030    F F             A
  80 PREP TOOL                            070      00054    1.575 41 3701 070    00470 00054 00000 3001     0.0     0.0  0000 1 0000
 1.0   0.315  1.0    0.029    F F             A
  90 PREP FOR POURING                     070      00054    0.550 41 3701 070    00470 00054 00000 3001     0.0     0.0  0000 1 0000
 1.0   0.050  1.0    0.250    F F             A
 110 MIX FILLER MATL                      070      00054    4.580 41 3701 070    00470 00054 00000 3001     0.0     0.0  0000 1 0000
 1.0   0.736  1.0    1.950    F F             A
 120 COMPACT MATL                         070      00054    4.552 41 3701 070    00470 00054 00000 3001     0.0     0.0  0000 1 0000
 1.0   1.400  1.0    1.476    F F             A
 130 PRESS                                070      00054    2.338 41 3701 070    00470 00054 00000 3001     0.0     0.0  0000 1 0000
 0.0   0.000  1.0    1.104    F F             A
 140 APPLY PLY                            070      00054    1.865 41 3701 070    00470 00054 00000 3001     0.0     0.0  0000 1 0000
 1.0   0.151  1.0    0.856    F F             A
 150 CURE                                 070      00054    2.456 41 3701 070    00470 00054 00000 3001     0.0     0.0  0000 1 0000
 0.0   0.000  1.0    1.246    F F             A
 160 TRIM                                 070      00055    1.703 41 3701 070    00470 00055 00000 3001     0.0     0.0  0000 1 0000
 1.0   0.063  1.0    0.820    F F             A
 170 IDENT                                070      00033    0.120 41 3701 070    00470 00033 00000 3001     0.0     0.0  0000 1 0000
 0.0   0.000  1.0    0.060    F F             A
 190 PUNCH & TRIM                         070      00055    0.862 41 3701 070    00470 00055 00000 3001     0.0     0.0  0000 1 0000
 1.0   0.050  1.0    0.400    F F             A
 200 CUT                                  070      00055    0.700 41 3701 070    00470 00055 00000 3001     0.0     0.0  0000 1 0000
 1.0   0.100  1.0    0.300    F F             A
 210 WEIGH                                070      00054    0.600 41 3701 070    00470 00054 00000 3001     0.0     0.0  0000 1 0000
 1.0   0.100  1.0    0.250    F F             A
 220 IDENT                                070      00033    0.060 41 3701 070    00470 00033 00000 3001     0.0     0.0  0000 1 0000
 0.0   0.000  1.0    0.030    F F             A
 230 ACCUM PLUG                           070      00028    0.200 41 3701 070    00470 00028 00000 3001     0.0     0.0  0000 1 0000
 0.0   0.000  1.0    0.100    F F             A
 240 ASSEM COMP                           070      00047    0.500 41 3701 070    00470 00047 00000 3001     0.0     0.0  0000 1 0000
 1.0   0.130  1.0    0.250    F A             A
 260 PROTECT                              070      00037    2.250 41 3701 070    00470 00037 00000 3001     0.0     0.0  0000 1 0000
 1.0   0.250  1.0    1.000    F F             A
 270 INSP                                 047      00038    0.300 41 3701 070    00470 00038 00000 3001     0.0     0.0  0000 1 0000
 0.0   0.000  0.0    0.000    F Q             A
X83336      .....
```


Space Division
North American Rockwell