WADC TECHNICAL REPORT 55-97

SOUNDPROOFING MATERIALS AND THE INSTALLATION THEREOF IN AIRCRAFT

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MARCH 1955

AIRCRAFT LABORATORY
CONTRACT No. AF 33(616)-2379
PROJECT No. 1370

[redacted]

USAF WRIGHT AIR DEVELOPMENT CENTER
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

Carpenter Litho & Prtg. Co., Springfield, O.
200 - 13 July 1955

FOREWORD

This report was prepared by A. J. Grafman of the Frank Mayer Engineering Company, Los Angeles, California, on Air Force Contract No. AF 33(616)-2379, Project No. 1370, "Aeroelasticity, Vibration Flutter," Task No. 13465, "Standardization of Soundproofing Blankets." The work was administered under the direction of the Dynamics Branch, Aircraft Laboratory, Wright Air Development Center, with Mr. R. F. Cook serving as project engineer.

The assistance of the many aircraft engineers whose frank opinions and counsel were obtained during the survey is gratefully acknowledged. Their number is too great to permit inclusion in this foreword.

USAF personnel at the bases visited contributed greatly to an understanding of the problems involved in maintenance of service aircraft; their patience during many hours of "check list" questioning is deeply appreciated.

The completion of this report within the contract period, despite delays due to material procurements, etc., would not have been possible without the unstinting personal efforts of Mr. Louis Jarmie, head of the Technical Publications section of the Frank Mayer Engineering Company.

We are deeply indebted to Messrs. W. E. Benke, Donald A. Floto and O. W. Sauter of the H. I. Thompson Fiber Glass Company for the many hours which they devoted to our personnel in the course of accumulation of data on materials, assembly methods and installation techniques, as well as for their advice and counsel.

ABSTRACT

Research was directed toward evaluating current materials and methods used in installation of soundproofing in military aircraft, toward the end of developing more suitable methods if possible. The work was performed by the Frank Mayer Engineering Company for the Dynamics Branch of the Wright Air Development Center's Aircraft Laboratory. Soundproofing installations on military aircraft currently produced by six West Coast airframe manufacturers were surveyed as to design, fabrication and installation. The survey was extended to four USAF bases to obtain service and maintenance data. An approved evaluation procedure was used to determine characteristics desirable for inclusion in optimum blanket development. Optimum blankets were designed, fabricated and installed on a large test panel, simulating an aircraft fuselage. The optimum blanket installation methods tested were evaluated. For optimum standarization, two blanket types, trimmed and plain, were recommended, together with procedures for installation. Deficiencies in current specifications were noted and suggestions made for their elimination.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

for Carl E. Reichert
D. D. McKEE
Colonel, USAF
Chief, Aircraft Laboratory
Directorate of Laboratories

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INTRODUCTION

The study reported upon herein was started in March 1954. The project was undertaken in order to evaluate methods of fabrication and installation of soundproofing blankets presently in use in military aircraft and to develope and evaluate more suitable methods if possible.

It was recognized that methods presently in use differed widely between various aircraft. It was also recognized that current specifications for such installations were not fully in agreement with accepted current practices.

The study was directed toward the end of determining a minimum number of suitable blankets and methods of installation for standard use in Air Force aircraft.

The following points were to be specifically studied and evaluated :

Ease of removal, reinstallation and replacement.

Ease of maintenance, including cleaning and degree of skilled labor required.

Acoustical efficiency, i.e., sealing of blanket to prevent direct air paths at joints.

Cost.

Durability, including effects of punching and striking the blanket by caro and passengers.

Appearance.

Simplicity of tools required for installation.

Economy in number of different items to be stocked.

Applicability to various blanket types (quilted, non-quilted, blankets with oil and fuel resistant trim and backing cloths, etc.

Universality of application of method to conditions encountered in different aircraft.

SECTION I

SURVEY OF SOUNDPROOFING BLANKET INSTALLATIONS

1.1 Objectives

1.1.1 Soundproofing blankets and their installation in military aircraft currently differ in many significant respects. The purpose of this survey was to reveal these differences and to determine those characteristics which result in better blankets and highest and most economical service life.

1.2 Scope

1.2.1 The investigation was intended to cover as many military types as possible in the most economical manner. Aircraft produced by six major West Coast airframe manufacturers were selected for inclusion in the survey.

1.2.2 Airframe manufacturers whose plants were visited on this survey include: Boeing Airplane Co., Seattle, Washington; Consolidated-Vultee Aircraft Corp., San Diego, California; Douglas Aircraft Co., Inc., Santa Monica and Long Beach, California; Lockheed Aircraft Corp., Burbank, California; Northrop Aircraft, Inc., Hawthorne, California; North American Aviation, Inc., Los Angeles, California.

1.2.3 Aircraft covered by the survey include the following:

B-47E	KC-97G	C-124C	T-29C	F-86
B-52	C-118A	YC-130	T-29D	F-89
B-52 Recon.	C-121A	C-131A		F-94C
RB-66	YC-121C			

1.2.4 USAF facilities were included in the survey in order to establish the service and maintenance characteristics of the soundproofing blanket installations in the aircraft surveyed.

1.2.5 USAF facilities visited were:

Hamilton AFB	Norton AFB
March AFB	Tinker AFB

1.3 Survey Methods

1.3.1 The initial installation phase of the survey was carried on by interviewing responsible engineers, inspecting blanket fabrication and installation work, and examination of engineering drawings. A check list (Survey Form No. 1) was prepared to facilitate procurement of uniform data. See Figure 1. Detailed examination of drawings necessary for the average installation was made possible by the loan of data from the various airframe manufacturers subsequent to initial examination during the survey visit. This procedure was necessary due to the amount of data involved and the time required for recording of materials, sizes, fastening details, etc.

1.3.2 The service and maintenance phase of the survey was accomplished by interviewing USAF personnel involved in maintenance activities, inspecting soundproofing installations which had been subjected to service conditions, inspecting fabrication and installation of replacement blankets. A check list (Survey Form No. 2) was prepared to facilitate procurement of uniform data. See Figure 2.

1.4 Survey Visits to Airframe Manufacturers

1.4.1 Installations surveyed differed widely between various manufacturers as well as between projects in the same plant. Typical structural details at soundproofed locations are shown in Figure 3. The amount of soundproofing installed varied from a complete absence of treatment (F-86 and F-89) to very comprehensive treatment, equivalent to that installed in aircraft destined for luxury-type commercial airliners.

1.4.2 It is obvious that the absence of soundproofing is the practical recognition, on the part of those responsible for the design of the aircraft, that no useful purpose could be served by the additional weight and cost of such soundproofing material. A fighter or trainer type aircraft, with a cockpit canopy, can hardly benefit from the few square feet of blanket which could possibly be installed.

1.4.3 In cargo-transport types, a very wide diversity of treatment was found. Discussions with design personnel revealed that installations for which they were responsible, varied with their knowledge of the problems involved and their ability to follow through on the principles of the treatment to be used. For example, an important detail such as the prevention of airborn noise by avoidance of gaps or passages was glossed over by some designers as impractical of achievement; whereas other designers were careful in this regard, and also made certain that their specifications were followed by inspecting actual installations and conferring with responsible foremen.

1.4.4 In the beginning of the survey, a supplier of soundproofing blankets stated that orders for various military aircraft seldom required adherence to Specification MIL-S-5659 (superseding AN-S-32a). The survey confirmed this information. The deviations from specification requirements, in most cases, were not necessarily harmful from an acoustical standpoint. However, when deviations involved the use of batts composed of coarser glass fibers, there arose the question of a decrease in acoustical efficiency of the installation. Substitution of coarser glass batts was no doubt prompted by savings in weight and in cost. At the time of specification theremay have been cost savings, but current prices seem to be about the same for either type.

1.4.5 Aircraft which were modifications or derivations from commercial types invariably departed from specification requirements, in that the trim cloth was not a part of the soundproofing blanket, but was separately installed after the installation of acoustical materials. Rigid panel board, as well as plastic sheeting, was found to be used in some cases in lieu of trim cloth. The substitution of hard paneling for trim cloth in radiant heating systems or for the alleged purpose of improved durability must result in the loss of the ability of the acoustical treatment to absorb any significant amount of the noise which finds its way into the cabin. It is understood that some development work is being done on a panel board composed principally of glass fibers, intended to provide some degree of absorptive capacity. It is believed that acoustic tests of this material are in progress.

1.4.6 Fastening means differed widely. See Figure 8. It was observed that several types were often used on one aircraft. In only one instance was the use of a "company-designed" fastener observed, and in that usage the fastener lacked the fundamental ability to retain the blanket. A more complete discussion of fasteners will be found in a subsequent portion of this section.

1.5 Materials and Blanket Fabrication

1.5.1 Specification MIL-S-5659 divides blanket materials into four categories. These categories will be utilized as the basis for discussion of materials used by various airframe manufacturers in preparing soundproofing blankets. A tabulation of these materials in various aircraft is given in Figure 4. There was a notable lack of uniformity in the description and specification of identical and similar materials on the various drawings examined. In the following paragraphs, these

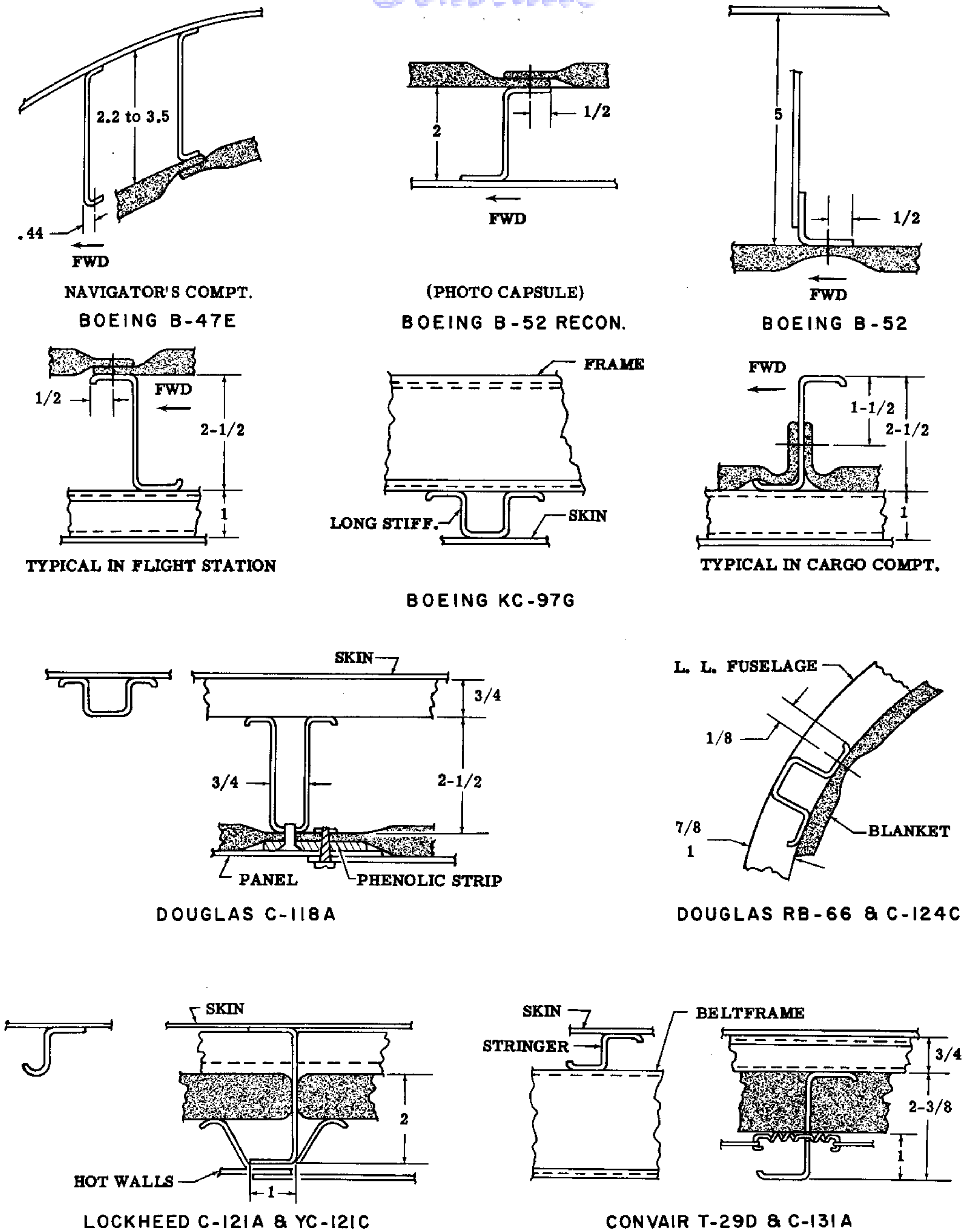

Figure 3. Typical Structural Details at Soundproofing Locations.

differences will be noted in order to draw attention to the need for greater uniformity in material specification.

1.5.2 Homogeneous sound-absorbing material-Specification MIL-B-5924, Type I and Type II batting is generally used. These materials are not referenced in Specifications MIL-S-5659 and MIL-S-6144. Following are some examples of engineering drawing notations:

"PF 105 (XAA-PF) Fiberglas batt, density - 0.6 lb/cu. ft." (Spec MIL-B-5924, Type I)

"PF 314 Fiberglas batt, density - 0.5 lb/cu. ft." (Spec MIL-B-5924, Type II)

"F-10A (or FAAJ) Fiberglas"

"K-311 Fiberglas batt" (No thickness specified on drawing.)

1.5.3 Impervious septum-Specification MIL-S-5659 gives the requirements for this blanket element. The material generally used is cotton muslin, with an aluminized coating on one side only. The coated side is usually faced outward, with the intention of achieving some thermal insulation value from the aluminized coating. Not all blanket assemblies included an impervious septum. It is possible that some designers intended the trim cloth to function as an impervious septum, although none of the engineers contacted during the survey expressed such an intention. The following are examples of impervious septum drawing callouts:

"119VA Cloth - Vinyl coated non-porous aluminum colored"

"#119 Vinyl coated fiberglas cloth septum - non-porous aluminum colored"

"Aluminum colored coated fabric - surface density 0.04 lbs/sq. ft."

"Impervious septum" (LAC 1-980)

"Vinyl coated cotton cloth septum"

"Aluminum vinyl resin treated cloth septum"

"Impervious aluminum vinyl coated cloth septum"

".001 thick Koroseal"

".00045 thick aluminum foil 2S0"

1.5.4 Backing material -This is intended to facilitate handling of the delicate blanket, and is indicated in Specification MIL-S-5659 as an optional "Fabric Envelope." In almost every installation surveyed, some form of backing material was used. The principal material used for this purpose at the present time is .0015 inch thick Cast Polyvinyl Film. The reasons for this wide usage are: relatively high strength, low unit weight, ease of handling, low cost and availability. This material has one draw back, a tendency to tear during stitching. This has influenced one project group (Lockheed XC-130A) to use a stronger but more expensive material.

As in the case of other materials, drawing callouts for cast polyvinyl film backing material differed widely in the engineering data examined. The following are illustrative examples of this lack of uniformity:

"K Film - .0015 vinyl chloride" (Boeing, Douglas)

".0015 Vinyl chloride film" (Douglas)

".0015 Koroseal" (Convair)

"Reynolon 10,000 TGL cast vinyl chloride film - .0015" (Boeing)

"Cast polyvinyl chloride - .0015 GA" (Boeing)

"Cast vinyl Koroseal - .0015" (Boeing)

"Plastic insulating film - MILF-6264" (Douglas)

"Vinyl copolymer film" (Douglas)

Other materials specified for the same purpose were:

"E-25 Plastiglas - vinyl coated fiberglas cloth"

"E-25 Plastiglas - green #245 vinyl coated fiberglas cloth"

"E-25 Plastiglas - aluminum color - vinyl coated fiberglas cloth"

"B-27 Resistrol (black) (Special formula fabric treatment to withstand oil penetration)"

"#108 Fiberglas cloth"

"#113 Fiberglas cloth"

"ECC-113 Impervious fiberglas cloth - both sides vinyl coated - color: Med. gray dull finish per ANA Bul 157c"

"ECC-11-119V Green vinyl coated fiberglas cloth (E-25 plastiglas - green #245 is equiv. cloth)"

"#A2598 Nylon cloth - $2\frac{1}{2}$ oz. - #512 gray ANA Bul #166"

"Vinylcoated silk - 1.2 oz."

"Vinyl coated glass fabric - 3.5 oz."

"Waterproof nylon coated fabric - color aluminum"

"Aluminumized vinyl coated cloth"

"Cheesecloth"

"3.5 oz. Plastic film"

"V8P5 Film - .0012"

".001 Aluminum foil"

".002 Aluminum foil 2S0"

1.5.5 Trim cloth-Specifications varied as widely as for other blanket materials. In reviewing the various materials listed in Figure 4, culled from drawings of the aircraft studied, it will be noted that the use of vinyl coated fibrous glass cloth predominates. The choice of such materials was generally predicated upon the fact that weight is almost invariably at a premium.

The trim cloth presents a ready target for weight reduction and the loss of utility resulting from the use of very lightweight material is easily ignored. Some of design engineers expressed their regret for the necessity of specifying, for weight-saving considerations, a material which required extreme caution in handling 1/. The material in question tears readily when folded tightly, as at a sewn edge, and it is therefor common practice to attempt to offset this deficiency by employing an edge binding tape. This practice does improve utility in that regard, but does not alleviate the inherent deficiency of the weak material used. A stronger trim cloth material 2/ used on several aircraft possesses many generally desirable properties, but it must be used with a porous coating. A non-porous coating would entail a considerable increase in weight. A fibrous glass cloth of somewhat different weave 3/ is used on a newer cargo-transport aircraft, the Lockheed YC-130A; the choice of this material was apparently predicated upon its relatively high strength-weight ratio in the coated condition. The tightness of the weave results in a nonporous coating with a relatively small weight expenditure for the vinyl coating.

1.5.6 Blanket Assembly-Specification MIL-S-5659, Paragraph E-1c, (2), recognizes the use of both sewing and cementing as a means of joining the several components of a blanket. Current practices include both edge stitching and edge cementing. The broad faying surfaces between blanket elements were either devoid of any means of preventing relative movement or were cemented, using a "cob-web" cementing technique which resulted in a rather uniform overall bonding without appreciable increase in weight. Airframe manufacturers avoided spot cementing, the reason generally being given was that such attachment was difficult to control and seldom produced a satisfactory bond. Quilted (overall stitched) blankets were generally avoided because of the almost universal recognition of the significant loss in acoustical efficiency which results from the compacting of the material due to the stitching. It is understood that the Santa Monica (California) Division of the Douglas Aircraft Company has made some progress in loose stitching, but that the amount of compaction is still rather great.

A noteworthy time-saving fabrication technique was observed at the Boeing Airplane Company trim shop, where ordinary hand staplers were used to secure turned edges of blankets prior to stitching; the unobtrusive wire staples were not subsequently removed, as would have been necessary if conventional pins had been used for this purpose.

1-6 Fastening Methods

1.6.1 Cementing-(Reference Fig. 8, Types A-1 to A-4 inc.)-Installations in which the trim cloth (or other interior surfacing) was not a part of the blanket, almost invariably utilized cement in the installation scheme, although cement seldom was the primary means of attachment. Cement was applied continuously along frame webs and in spot form along stringers or longerons. The small amount of material installed in the F-94C aircraft, which served more as cockpit padding than as acoustical treatment, was assembled and installed entirely using cementing techniques.

1/ Vinyl coated. Cloth is Owens-Corning Fiberglas Corporation Type ECC, Style 119, plain woven; uncoated weight is approx. 2.80 ounces per square yard.

2/ Vinyl coated. Cloth is Type ECC, Style 126, plain woven; uncoated weight is approx. 5.37 ounces per square yard.

3/ Vinyl coated. Cloth is Type ECC, Style 118, crushed satin weave; uncoated weight is approx. 4.06 ounces per square yard.

AIRCRAFT	BLANKET LOCATION	SEP-ARATE TRIM	BLANKET ASSEMBLY (Refer to Figure 5) TRIM CLOTH	BATT.	SEPTUM	BATT.	BACKING	UNIT WT. LBS. PER SQ. FT.	FASTENING TYPE REFERENCE Fig. 8	ASSEMBLY METHOD Fig. 7
BOEING										
B-47E	Navigator's Compt. (STA 66-145)	-	1.9	2.1	-	-	1.11	.098	B1,B8,B9	(1)
B-52	STA 175.6 to 345.5, STA 1759.0 to 1852.5, Photo Capsule (Recon only)	-	1.18	2.1	-	2.1	1.41	.096	A1,B1,B9,B10,B20	(2)
B-52	Flight Station, Photo Capsule (Recon only)	-	1.19	2.1	-	2.1	1.41	.096	B1,B9,B10,B20	(2)
B-52	Lower Deck (STA 175.6 to 345.5)	-	1.1	2.1	-	2.1	1.41	.110	B1,B9,B10,B20	(2)
B-52	R. H. Lower Panels (STA 202.3 to 345.5)	-	1.2	2.1	-	2.1	1.41	.105est	B1,B9,B10,B20	(2)
B-52	Window - Eject Hatch, Sextant Opening	-	1.1	2.1	-	-	1.41	.085	B1,B9,B10,B20	(2)
KC-97G	Main Cabin (Lower Cabin Compt.)	-	1.1	2.1	-	2.1	1.41	.110	A1,B1,B9,B10,B11	(2)
KC-97G	Nose Section - Upper (Flight Station)	-	1.26	(2)2.1	1.31	(2)2.1	1.41	.155est	B1,B4,B9,B10,C1	(2)
KC-97G	Nose Section - Lower	-	1.27	2.1	-	2.1	1.27	.13est	B1,B9,B11	(2)
KC-97G	Boom Operator's Station	-	1.26	2.1	-	2.1	1.41	.105est	B1,B10	(2)
KC-97G	Lower Cabin Compartment Floor	-	-	2.1	-	-	-	.025	A1	-
CONVAIR										
T-29D	Cabin (Air Ducts & Door Flanges)	3.1	1.32	2.1	-	-	1.39	.041est	A1,C2	(3)
C-131A	Cabin (Rear Door & Area Adjacent)	3.1	1.39	2.1	-	2.1	1.39	.074est	A1,C2	(3)
C-131A	Flight Deck	3.1	1.39	(3)2.1	-	-	1.39	.099est	A1	(3)
C-131A	Cabin (Beltframe Flanges)	3.1	1.39	2.1	-	-	1.39	.037est	A1,C2	(3)
C-131A	Cabin (STA 419.2 to 744.0) Bailout Door	3.1	1.32	(3)2.1	(2)1.40	-	1.41	.114est	A1,C2	(3)
C-131A	Cabin (STA 109.0 to 419.2) Bailout Door	3.1	1.32	(4)2.1	(3)1.40	-	1.41	.149est	A1,C2	(3)
DOUGLAS										
RB-66	Crew's Compt., Pilots's Enclosure	-	1.6	2.1	1.13	2.1	1.41	1.38	B9	(2)
C-118A	Around Windows & Emergency Exits	-	1.30	(3)2.1	-	-	1.30	.137est	A1	(7)
C-118A	Heater Compartment Bulkheads	-	1.4	2.3	-	-	1.4	.145	A1,B15,C3	(4)
C-118A	Heater Compartment Bulkheads	-	1.4	2.1	-	-	1.4	.095	A1	(4)
C-118A	Lower Aft Cargo Compartment	-	1.10	2.3	-	-	1.10	.137	A4	(6)
C-118A	Lower Aft Cargo Compartment	-	-	2.8	-	-	-	.033	A4	(8)
C-118A	Lower Forward Cargo Compartment	-	-	2.8	-	-	-	.033	A4,B18	(8)
C-118A	Lower Aft Cargo Compartment	-	-	2.9	-	-	-	.104	B18	-
C-118A	Inverter Compartment & Radio Rack	-	1.10	2.10	1.34	2.10	1.8	.146	A1,C4	(6)
C-118A	Inverter Compartment & Radio Rack	-	1.10	2.10	-	2.1	1.8	.101	A1,C4	(5)
C-118A	Crew Compartment	*3.2	-	(2)2.1	1.35	2.1	-	.120est	A1,B15	(8)
C-118A	Main Cabin	**3.3	1.44	2.4	1.42	2.4	1.7,1.44	.1523	B17	(2)
C-118A	Main Cabin	**3.3	-	2.2	-	-	-	.050	B17	-
C-118A	Main Cabin	**3.3	1.4	2.12	-	2.12	1.4	.250	B17	(9)
C-118A	Fuselage	-	-	2.5	1.36	2.5	-	.129	A1	(2)

*Also 3.6 & 3.7 **Also 3.4 & 3.5

Figure 4 (Sheet 1 of 2). Composition of Soundproofing Blankets on Aircraft Surveyed.

AIRCRAFT	BLANKET LOCATION	SEP-ARATE TRIM	BLANKET ASSEMBLY (Refer to Figure 5) TRIM CLOTH	BATT.	SEPTUM	BATT.	BACKING	UNIT WT. LBS. PER SQ. FT.	FASTENING TYPE REFERENCE Fig. 8	ASSEMBLY METHOD REFERENCE Fig. 7
DOUGLAS										
C-118A	Fuselage	-	-	2.2	1.36	2.2	-	.145	A1	(2)
C-118A	Fuselage	-	1.28	2.5	-	-	1.41	.09	A1	(10)
C-118A	Fuselage	-	-	2.9	-	-	-	.104	A4	-
C-118A	Lower Fuselage, Aft	-	-	2.9	-	-	-	.104	A4	-
C-118A	Main Cargo Door	3.4	-	2.2	-	-	1.5	.085	A1	(2)
C-118A	Forward Cargo Door	3.2	-	2.2	-	-	1.5	.085	A1	(2)
C-118A	Forward Bulkhead	-	1.14	2.2	-	-	1.14	.120	A1,B12,B13	(6)or(10)
C-118A	Cockpit Ceiling	-	1.29	2.6	-	-	1.41	.109	B16	(10)
C-118A	Main Junction Box	-	1.3	2.11	-	-	1.3	.133	B18	(11)
C-124C	Flight Deck - Forward	-	1.15	2.1	1.12	2.1	1.41	.140	B9	(2)
C-124C	Flight Deck - Aft	-	1.16	2.1	1.12	2.1	1.43	.1395	B9	(2)
C-124C	Flight Deck - Aft	-	1.16	2.1	1.12	2.1	1.41	.140	B9	(2)
C-124C	Main Cabin	-	1.17	2.1	-	-	1.43	.0835	A1,B9	(2)
C-124C	Main Cabin	-	1.17	2.1	-	-	1.41	.084	A1,B9	(2)
C-124C	Main Cabin (Wainscoting Backing)	3.8	1.41	2.1	-	-	1.41	.055	B9	(2)
C-124C	Curtain Partition (STA 236.0)	-	1.20,1.41	2.1	-	-	1.20,1.41	.089est	-	(2)
LOCKHEED										
F-94C	Cockpit - Floor to Sill FS119.5 to FS103.0	-	1.24	2.1	1.33	2.1	1.32	.16	A1	(8)
F-94C	Cockpit - Floor to Sill FS119.5 to FS103.0	-	1.25	2.1	-	2.1	-	.083	A1	(8)
C-121A	Forward Compt.; Galley; Lavatory; Main Cabin	3.9	1.38	2.3	-	-	1.38	.099	A1	(2)
YC-121	Main Cabin	3.10	1.22	2.3	-	-	1.38	.099	A1	(2)
YC-130	Cargo Compt. (Wheel Wells & Sidewalls), Doors	-	1.23	2.2	-	-	1.21	.125	B2,B3,B4,B5	(2)
YC-130	Cargo Compt. (Alongside Plumbing Lines)	-	1.23	2.2	-	-	1.22	.131	B2,B3,B4,B5	(2)
YC-130	Cargo Compt. (Overhead)	-	1.22	2.2	-	-	1.21	.085	B2,B3,B4,B5	(2)
YC-130	Cargo Compt. (Between Fuselage & Curbs, etc.)	-	1.21	2.2	-	-	-	.062	B2,B3,B4,B5	(2)
YC-130	Nose Section (Bulkhead)	-	1.23	2.2	-	-	1.21	.124	A1	(2)
YC-130	Nose Section (Compt. & Press. Panels)	-	1.22	2.2	-	-	1.21	.082	A1	(2)

Figure 4 (Sheet 2 of 2). Composition of Soundproofing Blankets on Aircraft Surveyed.

ITEM NO.	DESCRIPTION	NOMINAL UNIT WT Lbs/Sq ft	COMM OR MIL SPEC	SOURCE REFER FIG. 6
1.1	#A14 Aluminum Vinyl Coated Cotton Fabric	.045	-	4
1.2	Duratrim Style No. H-24 Pattern No. 9, Color: Med. Gray #3615 per Spec TT-C-595	.04(est)	-	3
1.3	E-25 Plastiglas - Vinyl Coated Fiberglas Cloth	.035	-	4
1.4	E-25 Plastiglas - Green #245 Vinyl Coated Fiberglas Cloth	.035	-	4
1.5	E-25 Plastiglas - Aluminum Color Vinyl Coated Fiberglas Cloth	.035	-	4
1.6	Aeron #26 Nylon Cloth - Med. Gray Color #3615 per Spec TT-C-595	.042	-	4
1.7	B-27 Resistrol (Black) (Special Formula Fabric Treatment To Withstand Oil Penetration)	.045	-	4
1.8	#108 Fiberglas Cloth	.028	-	-
1.9	108VI - Both Sides Vinyl Coated - Color: Aluminum	.028	-	-
1.10	#113 Fiberglas Cloth	.031	-	-
1.11	ECC-113 Impervious Fiberglas Cloth - Both Sides Vinyl Coated - Color: Med. Gray Dull Finish per ANA Bul.157C	.045	-	-
1.12	119 VA Cloth - Vinyl Coated Non-porous Aluminum Color	.031	-	-
1.13	#119 Vinyl Coated Fiberglas Cloth Septum - Non-porous Aluminum Color	.031	-	-
1.14	ECC-11-119V Green Vinyl Coated Fiberglas Cloth (E-25 Plastiglas - Green #245 is Equiv. Cloth)	.035	-	4, 11 or 14
1.15	126 VP Cloth - Med. Green Color - Shade #612 Bul. 157 AN-L-21	.044	-	9
1.16	126 VP Cloth - Beige Gray Color - Plachere Color Directory Card #572	.044	-	9
1.17	126 VAP Cloth - Vinyl Coated Porous - Aluminum Color	.044	-	9
1.18	Flightex Fabric S/509 Vinyon - Non-porous Vinyon Coated Color: Light Gray #3635 per Spec TT-C-595	.031	-	5
1.19	Flightex Fabric S/509 Vinyon - Non-porous Vinyon Coated Color: Med. Gray #3615 per Spec TT-C-595	.031	-	5
1.20	#A2598 Nylon Cloth - $2\frac{1}{2}$ oz. #512 Gray ANA Bul. #166	.017	-	13
1.21	Vinyl Coated Silk - 1.2 oz.	.008	LAC 1-853	-
1.22	Vinyl Coated Glass Fabric - 3.5 oz.	.024	LAC 1-854	-
1.23	Vinyl Coated Glass Fabric - 8.5 oz.	.059	LAC 1-877	-
1.24	Vinyl Coated Glass Cloth Trim - Porous Weave	.05	LAC 1-857	-
1.25	Vinyl Coated Glass Cloth Trim	.035	LAC 1-859	-
1.26	Waterproof Nylon Coated Fabric - Color #612 Green	.04(est)	MIL-F-7719 Style I	-
1.27	Waterproof Nylon Coated Fabric - Color: Aluminum	.04(est)	MIL-F-7719 Style I	-
1.28	Vinyl Coated Cotton Cloth - Dark Green	.031(est)	-	-
1.29	Dark Green Vinyl Coated Cloth	.031(est)	-	-
1.30	Aluminumized Vinyl Coated Cloth	.031(est)	-	-
1.31	Aluminum Colored Coated Fabric	.04	-	-
1.32	Cheesecloth	.004	-	-
1.33	Impervious Septum	-	LAC 1-980	-
1.34	Vinyl Coated Cotton Septum	.04, .05	-	-
1.35	Aluminum Vinyl Resin Treated Cloth Septum	.045(est)	-	-
1.36	Impervious Aluminum Vinyl Coated Cloth Septum	.04, .05	-	-

Figure 5 (Sheet 1 of 2). Soundproofing Blanket Materials.

ITEM NO.	DESCRIPTION	NOMINAL UNIT WT Lbs/Sq ft	COMM OR MIL SPEC	SOURCE REFER FIG. 6
1.37	Plastic Insulating Film	-	MIL-F-6264	1
1.38	3.5 oz. Plastic Film	.024	MIL-P-6264A	-
1.39	V8P5 Film - .0012" thick	.012(est)	-	8
1.40	.0010" thick Koroseal	.010	-	7
1.41	.0015" thick Cast Polyvinyl Chloride Film *See Appendix "A"	.015	MIL-F-6264	*
1.42	.00045" thick Aluminum Foil 2SO	.0073	-	10
1.43	.001" thick Aluminum Foil	.0145	-	-
1.44	.002" thick Aluminum Foil 2SO	.029	-	10
	INSULATION			
2.1	½" thick PF105 (XAA-PF) Fiberglas Batt., Density - 0.6 Lb/Cu Ft.	.025	MIL-B-5924 Type I	9
2.2	1" thick (Same as 2.1)	.050	(Same as 2.1)	9
2.3	1½" thick (Same as 2.1)	.075	(Same as 2.1)	9
2.4	½" thick PF314 Fiberglas Batt., Density 0.5 Lb/Cu Ft.	.021	MIL-B-5924 Type II	9
2.5	1" thick (Same as 2.4)	.042	(Same as 2.4)	9
2.6	1½" thick (Same as 2.4)	.063	(Same as 2.4)	9
2.7	B. C. Sound Deadener - .03" thick Sprayed	-	-	2
2.8	.00045" thk. Embossed Aluminum Foil, 2SO (5 Layers incl. 3 Crinkled between 2 Smooth)	.033	-	10
2.9	¼" Foamed Polyvinyl Chloride - Turquoise Color	.104	-	12
2.10	1" thick F-10-A Fiberglas or 1" thick FAAJ Fiberglas	.021	-	11or14
2.11	3" thick F-10-A Fiberglas or 3" thick FAAJ Fiberglas	.063	-	11or14
2.12	K-311 Fiberglas Batt.	.090	-	14
	TRIM MATERIALS			
3.1	Trim Fabric per Convair Spec ZF240-001 (Applied with Extruded Retaining Strips)	-	-	-
3.2	.032 Laminated Fiberglas Sheet	-	DOUGLAS DMS 10011	-
3.3	.040 Laminated Fiberglas Sheet	-	DMS 10011	-
3.4	.042 Laminated Fiberglas Sheet	-	DMS 10011	-
3.5	.064 Laminated Fiberglas Sheet	-	DMS 10011	-
3.6	-2 Fabric per Finish Specs	-	DOUGLAS	-
3.7	-4 Fabric per Finish Specs	-	DOUGLAS	-
3.8	Wainscoting per Douglas 5293489	-	-	-
3.9	Unknown - Lockheed	-	-	-
3.10	Unknown - Lockheed	-	-	-

*Appendix "A" - Item 1.41 - .0015" Cast Polyvinyl Chloride Film is shown as follows:

AIRCRAFT MANUFACTURER	DESCRIPTION	SOURCE-REF TO FIG. 6
BOEING, DOUGLAS	"K" Film - .0015 Vinyl Chloride	6
DOUGLAS	.0015 Vinyl Chloride Film	-
CONVAIR	.0015 Koroseal	7
BOEING	Reynolon 10,000 TGL Cast Vinyl Chloride Film - .0015	10
BOEING	Cast Polyvinyl Chloride - .0015 Ga	9
BOEING	Cast Vinyl Koroseal - .0015	7
DOUGLAS	Plastic Insulating Film - MIL-F-6264	1
DOUGLAS	Vinyl Copolymer Film	-

Figure 5 (Sheet 2 of 2). Soundproofing Blanket Materials.

NO.	NAME	ADDRESS
1	Bakelite Co.	1709 W. 8th St. Los Angeles, Calif.
2	Billings-Chapin Co.	Cleveland, Ohio
3	Duracote Corp.	Ravenna, Ohio
4	Flexfirm Products Co.	1200 Chico Ave. El Monte, Calif.
5	Flightex, Inc.	93 Worth St. New York, N. Y.
6	John Foster Co.	Santa Ana, Calif.
7	B. F. Goodrich Co.	Akron, Ohio
8	Owens-Corning Fiberglas Corp.	Toledo, Ohio
10	Reynolds Metal Co.	Louisville, Ky.
11	Seaman Products Co.	Burbank, Calif.
12	Sponge Rubber Products Co.	Shelton, Conn.
13	Stern & Stern Textiles Co.	819 Santee St. Los Angeles, Calif.
14	H. I. Thompson Fiberglas Co.	1733 Cordova St. Los Angeles, Calif.

Figure 6. Soundproofing Material Sources.

TYPE NO.	BLANKET ASSEMBLING METHODS
(1)	Cement Per BAC 5010 Type XXXIV - Spot Cement Blanket Together with .6 to .8 Dia. Circular Spots at 6" Squares
(2)	No Cementing or Other Method Called Out
(3)	Cement Layers with Methyl Ethyl Ketone or Other Suitable Plastic Resin Cement
(4)	The Face of Each Blanket Shall Contain a Grommet. The Face Cover Shall Not Be Cemented to the Fiberglas Batt. The Back Cover Shall Be Continuously Cemented to the Fiberglas Batt. per DPS 1.07 (Douglas)
(5)	Tufting Through Fiberglas Tape on 6" Squares
(6)	Quilting on 6" Squares
(7)	Parallel Stitching - 3 Rows
(8)	Cement Layers Together
(9)	1" Nominal - Quilted to $\frac{1}{4}$"
(10)	1 x 3 Diamond Quilting
(11)	Serpentine or Diamond Stitched 3" O.C.

Figure 7. Soundproofing Blanket Assembly Methods.

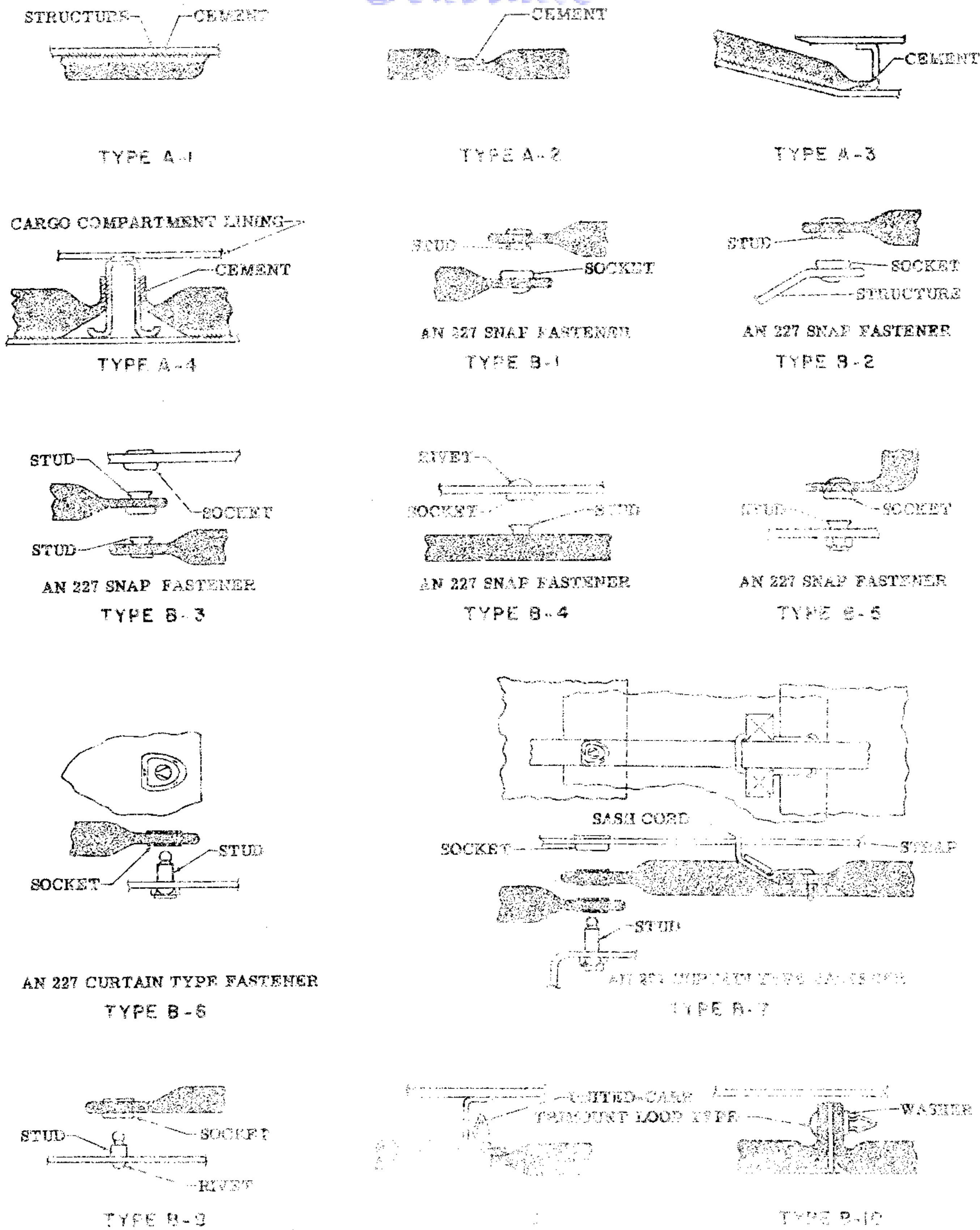

Figure 5 (Sheet [illegible]) [illegible] Types

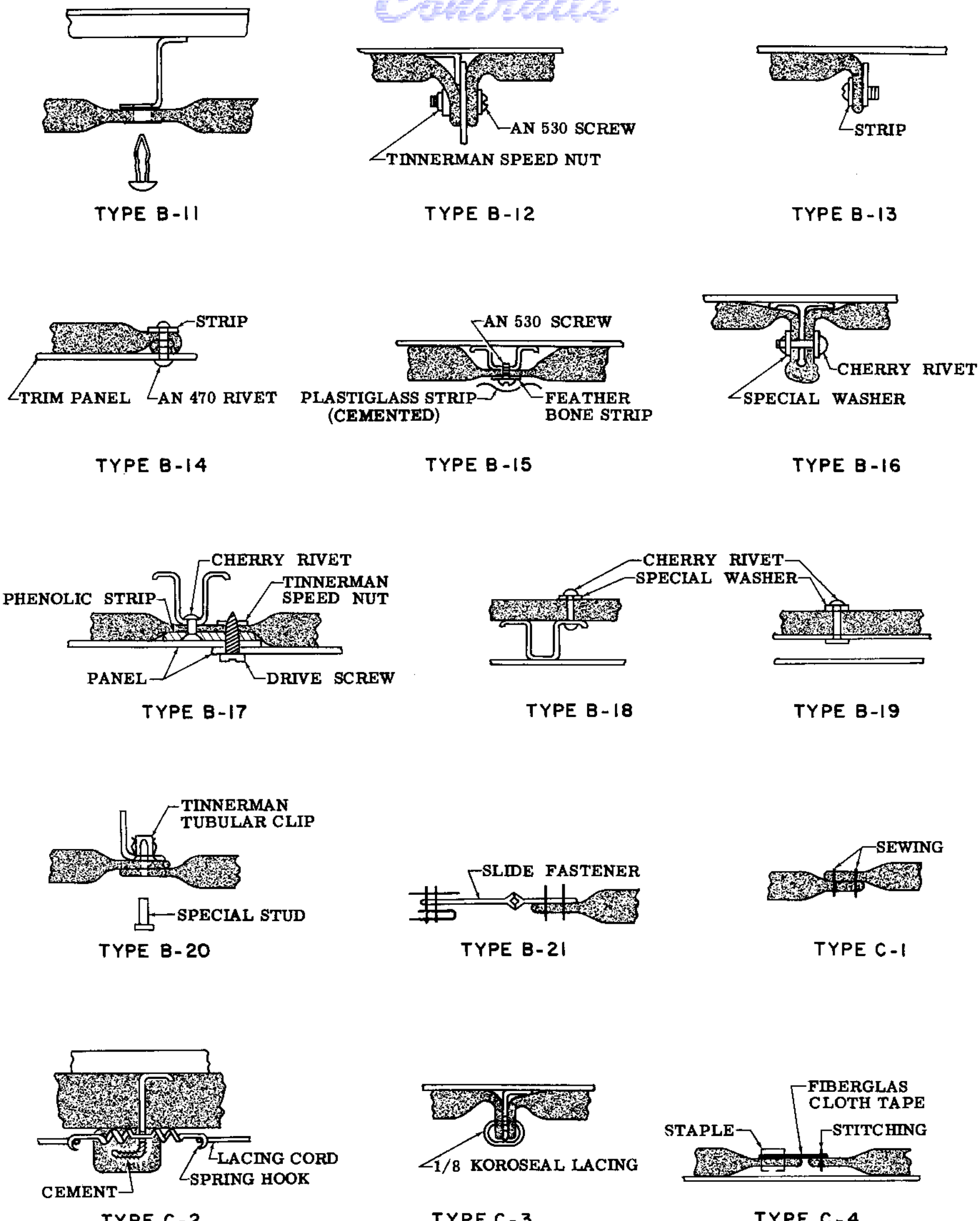

Figure 8 (Sheet 2 of 2). Soundproofing Blanket Fastening Types.

1.6.2 Lacing - (Reference Fig. 8, Type C-2) - This method was also employed where the trim cloth was not a part of the blanket. In general, with the lacing method, cord was stretched from frame to frame in a generally diagonal direction, with the cord being anchored at frame and stringer intersections by running the cord back of the frame, or anchored to ingenious tension springs fitted with hook-type ends; such springs were inserted into holes in the frame webs which were specially drilled for this purpose. The lacing method was found to be in general disfavor among designers, some of whom had used and discarded this method as being incompatible with requirements for installation of a military type blanket. Lacing along blanket edges was noted in one instance, where the structure was provided with a row of holes for this purpose. (Reference Fig. 8, Type C-3)

1.6.3 Riveting - (Reference Fig. 8 Types B-14, and B-16 to B-19 inc.) - Conventional rivets (AN470 type) were used in only one installation. This was for attachment of a blanket to an interior trim panel in one commercial type installation. Thermal considerations in the Douglas C-118A prompted the use of a non-metallic blanket retainer strip along interior flanges of the frames; this strip was fastened to the frame with blind rivets (Cherry or similar), and the interior trim was attached to a portion of the non-metallic strip which projected beyond the frame. Several other instances of use of blind rivets were observed. Most of these were for the simple purpose of providing a blind attachment to the supporting structure. One usage involved the wrapping of a blanket around a structural member and fastening same to the member with a blind type rivet, using special large diameter washers on both sides. In all cases, strips or large washers were used under the rivet heads.

1.6.4 Screws - Sheet metal screws (AN530 type) are utilized in some cases for blanket attachment. See Figure 8, Types B-12, B-13 and B-15. In some instances, the screws are threaded directly into structure, while in others the screws go through clearance holes in the structure and a nut plate (Tinnerman Speed-nut) is provided to retain the screw. Screws of this type are also utilized where the blanket must be held away from the interior trim in order to provide ventilation air passage space or to clear moving parts or cables; in such instances a blanket retainer strip is generally employed, extremely light "featherbone" strips have been used for this purpose in some of the installations. Ordinary machine screws were not used except in a few cases for attachment of parts to structure beneath the blanket.

1.6.5 Quick-fasteners - Fasteners falling in this broad category may be separated into four sub-classifications:

United-Carr Trimount Studs-Loop Type

AN 227 Snap and Curtain Fasteners

Plain "studs" or pins with tubular clips

AN 229 Interlocking Slide Fasteners

The first group is the so-called "Mae West" type of fastener and is the most commonly used. See Figure 8, Types B-9 to B-11 inc. Fasteners of this type are inserted through holes punched in the blanket and retained in simple holes in the structure by spring action. The use of a special washer permits this type of fastener to retain blankets on both sides of a structural member, and this possibility has been taken advantage of in several installations.

The second group is used where rapid blanket removal is desired or deemed necessary for inspection purposes. See Figure 8, Types B-1 to B-8 inc. In the curtain type fastener ("lift-the-dot") the studs are generally secured to the structure, and the blanket provided with the mating socket. In some cases, the mating part is placed on a blanket retaining cotton webbing tape and the holes in the blankets are reinforced by metal grommets (AN230). Snap fasteners constitute a more important part of this group and afford a means of rapid removability of blankets where a smooth surface, free from projections, is essential.

Plain pins were found in only one aircraft (B-52). See Figure 8, Type B-20. The pins resemble flat head rivets and are retained by formed tubular clips (Tinnerman) inserted in relatively large holes in the structure. This fastening system is presumably intended for permanent installation, but it is possible to remove the pins. The head diameter of the pins was so small that retention of the blankets observed was questionable. Increase of head diameter or addition of a suitable large diameter washer under the head would improve blanket retention.

Slide fasteners are found to a limited extent on various aircraft in locations within large blankets where local inspection openings are necessary. Considerable skill is required to install this type of fastener in a workmanlike manner. See Figure 8, Type B-21.

1.7 Miscellaneous Acoustical Treatment

1.7.1 Treatment other than in blanket form was provided in several aircraft for two reasons: one, environmental; and the other, acoustical.

1.7.2 Environmental conditions predicate other forms of treatment. One example is a highly absorbent blanket located near sources of leakage of inflammable fluid, creating an extreme fire hazard. Solutions encountered took two principal forms. Areas exposed to damage from personnel or cargo used a high strength, resilient foamed plastic (vinyl base). Protected locations were treated with a very fragile blanket made up of a number of layers of crumpled aluminum foil, tightly rolled together at the edges to minimize entry of fluid. The acoustical value of both of these materials was not ascertained and is believed to be rather insignificant, but both materials, furnish good thermal insulation. The foamed plastic material was also used for insulation of cargo doors, where the surface is subjected to extremely rough usage. On the same aircraft (C-118A) blankets near the aft end of the fuselage were found to be protected from moisture absorption by the addition of a waterproof fabric membrane. The source of moisture was alleged to be due to entry of water through fuselage skin joints, which subsequently flowed aft along downwardly sloping stringers.

1.7.3 Special acoustical treatment was provided in some cases near the plane of rotation of the propellers, consisting of the application of sound-deadening material directly to the inside of the fuselage skin panels. Two types of sound-deadening material for this purpose were encountered: an adhesive material (B.C. (Billings-Chapin) sound deadener) sprayed on to a thickness of approximately 1/32 inch, and an adhesive backed aluminum foil (Minnesota Mining and Mfg. Co's P-12 Tape) applied in as many as six layers. Use of the sprayed material was discontinued in one case in favor of the foil, due to lack of control of the thickness (and weight) of the deadener application. The use of such materials was frowned upon by most designers with whom this matter was discussed. The general feeling was that where fuselage skins were sufficiently thick to withstand propeller-thrown ice, or where additional ice protection skin panels were provided, sound-deadening treatment was not necessary. (In one plant it was observed that a number of aircraft of one type were in process of modification, involving enlargement of ice protection panels and addition of fuselage frame members in the panel area.)

1.8 Service and Maintenance

1.8.1 All of the remarks under this heading are based upon observations made during survey visits to USAF bases, with the exception of one aircraft plant engaged in modifying some of their aircraft which had been in active military service. Installations on several older types, such as the C-47, C-54 and SA-16 aircraft, were observed and afforded a comparison with materials, installation techniques, etc. on newer types.

1.8.2 Cleaning - Vacuum cleaning and wiping with a damp cloth was found to be the usual method of cleaning interior trim. No formal methods are prescribed (by T.O. or other written procedure), and crew chiefs employ whatever method they deem effective. Oil soaked blanket areas are invariably removed and replaced. When less than half of a blanket is damaged, only that portion is cut away and replaced. Acoustically sound blanket were found to be replaced, in some cases, when the trim cloth was water-stained, but otherwise serviceable. The source of decision for such replacements was not ascertainable.

1.8.3 Repairs: Torn or badly scuffed and frayed areas are repaired until such time as the blanket appearance becomes rather unsightly. Locally torn areas are often repaired in place by cementing on a piece of matching trim cloth; general-purpose cement is usually used. In some instances this procedure was used near blanket edges where the trim cloth was torn at fastener attachment points. The majority of torn places requiring removal and repair occurred at attachment points where the trim cloth was subjected to maximum stress. Repairs at these locations usually involved sewing on a local patch of matching trim cloth; in some cases the original trim cloth was so weak that it was desireable to use patching material of stronger fabric. Where a number of attachment points had torn along one row, the repair material was added as a complete edging, producing a neater appearance to the repair. Scuffed and frayed areas were generally located near large access openings, such as cargo doors. An unexpected case of damage was in the area surrounding an emergency exit door which happened to give convenient access to the upper surface of the wing.

On cargo type aircraft the blanket areas adjacent to the floor were subject to considerable scuffing damage unless protected by a suitable hard faced material. One cargo aircraft on which such scuff strips were provided did not show damage adjacent to the protected areas, although trim cloth on a secondary access door was badly frayed and scuffed due to the absence of such protective treatment on the door. Aside from specific areas of damage previously mentioned, the greatest incidence of damage was observed in the side walls up to a height of about five feet above the floor, little damage being noted above that height.

The worst example of blanket damage due to absorption of hydraulic fluid was observed on the KC-97 aircraft, where, at the extreme forward portion of the refueling boom operator's station, the lower blankets became thoroughly soaked with oil. Examination of these blankets seemed to indicate that the oil entered through the needle holes resulting from the edge stitching, and that the stitched edge itself was sufficiently fluid tight, as were the covering materials.

1.8.4 Removal of blankets: When blankets are removed for repair purposes (or for other reasons, such as need for access for modification equipment) they are often torn at attachment points. The cause of this damage is attributable principally to the inherent weakness of the trim cloth, although some responsibility can be assigned to maintenance personnel. Foremen of fabric units sometimes had their own personnel remove blankets in order to avoid this additional damage. Man hour requirements for blanket removal did not appear to be excessive in any instance.

1.8.5 Replacement blankets: Spare blankets were not stocked for any of the aircraft surveyed. Inquiry among airframe manufacturers indicated that USAF spares provisioning teams considered blankets as items capable of fabrication in the field from raw stocked materials. Replacement blankets were made up by the fabric units at the bases visited. On older types quilted blanket material was generally used. The replacement material was an improvement where it replaced older quilted material composed of cotton trim cloth, kapok insulation and cheesecloth backing. Glass fiber batts and vinyl film were used in the replacement blankets, with a variety of trim materials and colors. It is to be noted that quilted blanket materials, regardless of color and trim variations, were carried in stock under the same number.

1.8.6 Replacement blanket materials: Glass fiber batts conforming to Specification MIL-B-5924, Type I were available at all bases as a stock listed material. None of the other materials originally used for blanket fabrication were available in this manner (except quilted blanket material required for replacement purposes on older types). Foremen of fabric units were hindered in their efforts to secure replacement materials by lack of information regarding the description and source of the original materials; in some cases the persistent efforts of foremen resulted in procurement of identical materials, stocked under "not listed" numbers. Inability to obtain exact replacement materials sometimes resulted in very costly substitutions. For example, at one base an expensive glass fiber cloth intended for electrical insulating purposes (commercial Type Class 21A) ECC-11-113, Federal Stock Number 7100-496000-171 was substituted for cheap polyvinyl film at a price differential of approximately $ 0.75 per yard, a substantial increase in weight and without achieving the moisture resistance afforded by the polyvinyl film.

Several foremen suggested that cemented type, assembled blanket materials be provided, similar to the 1/4 inch thick quilted blanket material stocked for older type aircraft (under Federal Stock Number 7100-490000-212, Class 21A). The opinion was expressed that the trim cloth materials currently used could be replaced by fewer types and colors.

1.8.7 Replacement blanket fabrication: The original blanket was found to be used as a template for cutting replacement blanket materials; notches, cutouts, grommets, and other special features of the original were carefully located from the damaged blanket. In no case was there any attempt or intention to alter or improve upon the original. Workmanship was found to be equal to that of the original, and man hours for fabrication of replacements did not in any case appear to be excessive, in spite of the handicap of working from a damaged article instead of a production template. Templates of more frequently replaced blankets were made by some fabric units.

On older types, those blankets which were taped and sewn into replacement panels were tailored to match the old blankets; in many aircraft much of the blanket material was fastened in place directly in the aircraft. Panels on SA-16 aircraft were somewhat different in that they were made up around a riveted frame of aluminum alloy strips to which snap fasteners were fastened for panel installation.

Taped or turned edges of replacement blankets were found to be made without benefit of sewing machines equipped with suitable attachments for this purpose, such as are found in airframe plant trim shops. Lack of this type of equipment results in an appreciable increase in blanket fabrication manhours. Fabric unit foremen were cognizant of the handicap under which they were operating, but lacked authority to procure the necessary equipment.

At one base it was found that special hand cream was used for protection against glass fibers. Precautions of this nature were not found at other bases, nor were they noted at airframe plants or at blanket fabricating establishments.

1.8.8 Reinstallation of blankets: Replacement blankets are generally installed by fabric unit personnel. In general, reinstallation activities are carefully coordinated with other overhaul and maintenance work in order to avoid the possibility of damage to replacement blankets. Reinstallation work is sometimes hampered by inability to obtain special fastener items which were lost following blanket removal. On the KC-97 aircraft blankets are located between frames and the edges of adjacent blankets are fastened to the frame webs with the same "Mae West" type fastener by utilizing a special washer; these washers are frequently lost and are not available from either base stock rooms or from local automotive trim shops.

On older types most of the replacement blankets were either cemented in place (on doors and partitions) or held in place with narrow aluminum alloy strips, screwed to fuselage frame flanges with sheet metal screws (AN530).

SECTION II

EVALUATION

2.1 Purpose

2.1.1 The purpose of evaluating the installations observed during the survey was to make it possible to readily recognize those characteristics which should be considered in the design of an optimum soundproofing blanket and installation system.

2.1.2 It was not the purpose of the survey to ferret out "flagrant examples", but to attempt to indicate, by evaluation, what system, technique of feature on any one aircraft was superior to those used on others.

2.2 Evaluation Technique

2.2.1 The various factors to be evaluated were separated into four basic groups: design; blankets and their fabrication; installation; and service. See Figure 25.

2.2.2 Merit values used in the Evaluation Form result from arbitrary weighting of blanket characteristics obtained in the survey.

2.2.2.1 The Merit Values used are all negative. Perfect blanket installation would have a zero rating, and a poor, heavy, expensive type would have a high negative score.

2.2.2.2 Values for undesirable characteristics of a non-recurrent nature are kept as low as was deemed consistent with the cost involved or the personnel skills required.

2.2.3 Design evaluation was kept as a separate item for several reasons: first, preparation of engineering data is a substantially non-recurrent item, and any "merit" value for design should not necessarily influence the evaluation of the physical aspects of the installation; second, one set of engineering data may cover a large number of different blankets and installation techniques, each of which must be separately evaluated. The merit values assigned for each factor are arbitrary and actually negative. They are, in fact, "demerits". Those factors which result in recurrent undesirable characteristics, such as high unit weight, high cost, poor acoustic qualities, etc., are reflected in higher values.

2.2.4 Blanket fabrication evaluation followed the same basic premises set down for evaluation of design, but values for the more undesirable features were made higher in accordance with their recurring nature. Blanket installation evaluation merit value assignment closely paralleled that for blanket fabrication.

2.2.5 Service and maintenance evaluation merit value assignments were high on those factors which reflected need for special skills, special tools, or high labor requirements, in recognition of their undesirability in a far-flung military establishment.

2.3 Evaluation Procedure

2.3.1 The engineering data provided by the various airframe manufacturers for the aircraft surveyed were first examined in detail and the variety and nature of the blankets and installation methods were noted in detail. See Figures 3 through 8. The drawings were later reviewed for evaluation purposes, making it possible to judge them on the basis of the completeness and usefulness of the data contained therein. The drawings studied are listed in Appendix I.

2.3.2 Weight data supplied by airframe manufacturers are to be found in Appendix I. These data are plotted in Figure 24.

2.3.3 Evaluation of fabrication, installation and service was based primarily upon information recorded during survey visits, supplemented by certain detail information obtained from the engineering data.

2.4 Evaluation Results

2.4.1 Design factors - Engineering data deficiencies brought to light by evaluation include:

Excessive use of "coded" assembly and installation drawings. Attempts to specify requirements for several similar aircraft models on one drawing almost invariable resulted in a presentation which required a high degree of skill in blueprint reading. In most cases photographic methods would provide similar drawings with small added expense, and would result in blueprints more easily understood in the shop.

Ambiguous, incomplete or incorrect description of materials on engineering drawings. Full utilization of the airframe manufacturer's extensive and competent engineering departments should result in a better product in this respect.

Vague indication of the manner in which the soundproofing material was to be installed.

2.4.2 Deviation from specifications. It was felt that no criticism was justified in the case of deviations which occurred on military aircraft which were actually variations of commercial types. One major deviation was in the treatment of trim material separate and distinct from the soundproofing blankets, principally in the main cabin areas; on Lockheed "Constellation" type aircraft the cabin lining or trim is part of a radiant heating system and a space must be provided just behind the lining for the passage of warmed air. The principal disadvantage of the commercial types of treatment mentioned is that tightly stretched trim material and hard panel cabin lining is much more readily subject to damage from personnel or cargo than the more loosely fitted military type blanket. From an acoustical standpoint the hard panel installations are quite undesirable since there is practically no absorption of cabin noise; perforated or somewhat porous panels might be used to improve this condition, and it is understood that some development work is being carried on with porous panel material.

Specification MIL-S-5659 calls for the use of a porous trim cloth and specifies a maximum value for flow resistance. However, no penalty was felt justified where a non-porous trim cloth was used since in cargo and bombardment type aircraft sufficient noise absorption is generally obtained from crew members, cushions, etc. This position is further regarded as sound since the aircraft were either considered satisfactory based on acceptance tests 1/ or, were accepted without such tests, by the procuring agency.

2.4.3 Blanket fabrication desideratum include maximum use of raw and partially finished materials and minimum need for precise tailoring of a multiplicity of differing blankets. The nearest approach was found in commercial aircraft type installations, where batts were taken from stock and cut to fit in the aircraft. Batts used differed widely: from one or more thicknesses assembled around an impervious septum cloth, to some with many thicknesses separated

1/ ref: Noise Level Measurements, par. 4.600, ARDCM 80-1.

by and covered with vinyl film material, assembled by cementing.

The almost complete absence of quilted blanket types in current installations is indicative of the recognition of the deleterious effect upon acoustical properties of the compaction resulting from the quilting process. Lightweight cementing techniques for assembly of blanket elements practically preclude the necessity for quilting except in very special cases, such as the large curtains at the forward end of the cargo compartment in the C-124 aircraft. Many large blankets have been fabricated without any cementing and seem to be satisfactory in service.

Edges of tailored blankets were almost invariably secured with one or two rows of stitching, for retention of blanket elements as well as for reinforcement against tearing at fastening points. No edge binding tape was used, except sometimes in the case of blankets with very light weight cloth trim. On older types, replacement blankets of quilted material tailored to fit, were edge taped to provide a neat installation. In a few instances edges of blankets intended for locations subject to fluid damage were sealed by cementing. The cement was brushed on, and the faying surfaces were joined by hand pressure. It is understood that blankets fabricated for naval aircraft at the El Segundo, Calif., plant of the Douglas Aircraft Co., Inc. are edge sealed in one operation on a heated platen type press, using special forms for each blanket configuration.

Blankets resistant to oil or water were either fabricated as noted above, using suitably resistant covering materials, or the problem was side-stepped by using thermal insulating materials, such as foamed vinyl sheeting or multi-layer wrinkled aluminum foil. In the latter case the installation was made below the floor of a lower baggage compartment and the overall acoustical efficiency of the installation was not apparently seriously affected. Edge sealed film covered batts as used in some commercial type installations, are inherently oil and water resistant.

2.4.4 Blanket installation is covered in the third portion of the Evaluation Form, although certain factors, depending upon the original installation are treated in the fourth portion, which deals with service experience. Greatest stress was laid on those factors dealing with the acoustical efficiency of the installation. High installation manhours were also considered undesirable, not only because of the attendant high cost, but because other work cannot be performed in the fuselage during the blanket installation period, generally resulting in a substantial lengthening of the assembly line.

Acoustical sealing, i.e., avoidance of passages for airborne noise, was seldom entirely satisfactory where tailored blankets were used. Batts stuffed between fuselage frames generally filled all voids. See Figure 9. In most cases where tailored blankets were deficient in this respect it appeared that engineering requirements did not stress the need for such tightness, since it would have been possible to tailor the blanket and fasten it in a manner which would have eliminated most openings.

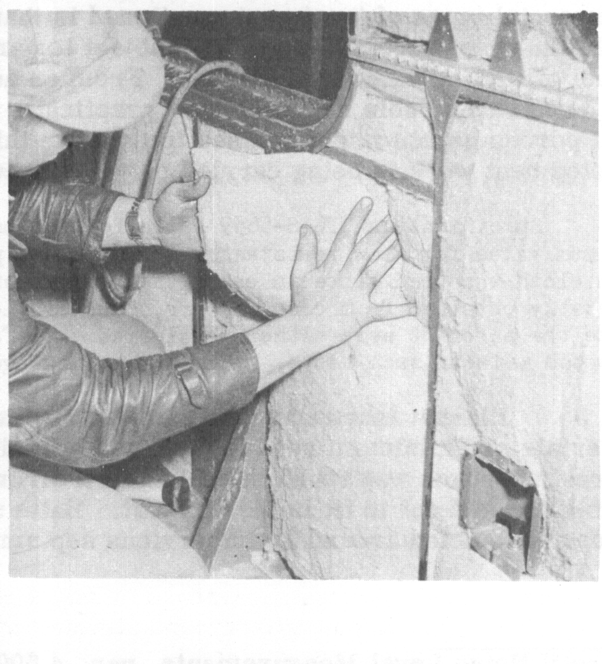

Figure 9. Installation of Batting Between Frames.

Little blanket damage was noted during installation. Where very light trim cloth was used some tears were noted, principally due to carelessness in pulling blankets over sharp corners. Enlargement of fastening holes was noted where the fasteners were provided with very small heads.

The use of cements for securing blankets in place was confined mainly to untrimmed blankets placed between fuselage frames. The application of the cement and the installation of the blankets was found to be simple and rapid, and no other fastening means was needed. Certain installations provided edge clamping strips, but these were mainly for trim attachment or to insure adequate space for hot air passage.

Untrimmed blankets were found to be secured in other less desirable ways. One consisted of diagonally laced cords, anchored to spring type hooks engaged in holes in frame webs. The anchorage required supplemental cemented type fastenings at many locations. Another device consisted of phenolic laminate strips attached to frame flanges with blind rivets requiring special tools and held to fuselage stringers with battens and sheet metal screws. Another method used very light weight battens made up of an assemblage of chicken feather quills.

The so-called "Mae West" type of fastener was found to be the most widely used means for blanket installation on the military aircraft surveyed. This type of fastener is light and inexpensive and requires no special tools to install. Preparation for the installation consists of a simple hole drilled into the supporting part.

Sheet metal screws are fairly widely used, but have the inherent disadvantage of possessing a small head diameter, which requires the use of large washers or batten strips in order to avoid local damage of the blanket as well as to provide proper retention.

Quick fasteners, of the several types covered by AN227 (Lift-the-dot, snap fasteners, etc.) are extensively used for removably securing inspection panels and the like. Snap fasteners are often chosen because their neat head appearance closely matches that of the "Mae West" type fastener. The Lift-the-dot type is useful where it is desirable to secure the edges of two blankets to the same fastener post; sometimes one of the two blankets is fitted with a metal grommet rather than a fastener element. The projecting posts of this type of fastener can present a hazard to personnel or equipment. These fasteners are extensively used on the YC-130A aircraft for attachment of blankets in the main cargo compartment. The installation system employed on this aircraft was found to be of a unique type, desirable from the standpoint of installation and removal, but not particularily desirable from an appearance standpoint on aircraft intended for transport use. The posts or studs used with these quick fasteners must be precisely installed in the aircraft, and the location of the mating portions of the fasteners which are mounted on the blankets must be carefully controlled in order to insure proper fit. For these reasons this type of installation is quite costly in manhours.

One type of fastening used on the B-52 aircraft, consisted of a small headed, rivet-like "Stud" (BAC-S21AA-75) which was engaged by a special formed sheet steel tubular clip snapped into a rather large hole in the supporting member. The head of the fastener was too small to properly retain the trim cloth, and the large hole required for the mating part appeared to be undesirable from a structural standpoint.

2.4.5 Blanket service experience evaluation - The factor of cleaning was found to be of minor importance. None of the installations presented any special problems in this regard. Vacuum cleaning or wiping with damp cloths were methods generally found satisfactory. Service personnel at several bases had attempted to use solvents of various kinds in the past, with unsatisfactory results. Grease or oil on blanket surfaces were readily removed from non-porous trim cloths, although no cleaning method was attempted when oil had managed to soak into the blanket batt material.

No special tools were used at any of the bases for blanket removal, although it appears that some form of tack lifter could profitably be used for removal of the "Mae West" fasteners.

With almost every type of fastening method it was found to be necessary to be rather careful when removing blankets, if tearing of trim cloth was to be avoided. Batts cemented between frames were almost invariably destroyed during removal, and considerable labor was involved in removing the blanket remnants which adhered to the structure at the cemented locations. The high labor cost mentioned here was not considered serious, in view of the fact that the trim material was more subject to damage and removal than the blanket. Former maintenance practices, which required the complete stripping of the airframe at periodic intervals, would have made such installations completely impractical, but in accordance with Technical Order 00-25-4, which covers IRAN (Inspect and Repair as Necessary) procedures, such removal is neither necessary nor desirable. No evidence was found of the occurence of structural damage due to blanket removal.

The frequency of damage to blankets was directly related to location and strength of trim cloth. Blankets were subject to damage at all fastening points, with the incidence of damage varying with the strength of the trim cloth, rather than the nature of the fastener. Tears in trim cloth were confined to the lower portion of the side walls, and were due to sharp corners or projections of cargo items, careless handling of tools by maintenance personnel, or sharp edges or protuberances on equipment carried by transported military personnel.

Some of the blankets which were replaced were repairable. Those blankets which were oil-soaked required replacement, as did those which were extensively torn; such blankets were relatively few in number. Repairable blankets which were replaced were those which had been repeatedly repaired, and whose appearance was consequently rather poor; under combat maintenance conditions such replacement would undoubtedly have been delayed. Manhour requirements for blanket replacement did not appear to be high at any of the bases surveyed.

No difficulty was observed in making repairs. Most of the small torn areas were repaired in place by cementing on a patch of similar material. Ordinary adhesive tape was often used to make temporary repairs. General purpose cement and some kind of patching cloth was always available.

Fasteners for reinstallation were no problem as long as they were fixed to the structure and to the blankets. Some of the original fasteners, if loose pieces, were lost and required replacement; AN screws, etc. presented no replacement problem, but any special items, such as special washers for "Mae West" fasteners, were very difficult to replace.

Materials for fabrication of replacement blankets presented a serious problem at all the bases visited. The wide variety of trim cloth materials and colors used on various aircraft, coupled with the fact that none of these materials were readily identifiable, aggravated the material procurement problem. Glass fiber batting was available at all bases as a stocked item. Cast polyvinyl film material was found to be lacking at one base and an expensive substitution was utilized.

The widespread use of tailored blankets necessitated the use of skilled trim shop personnel for fabrication of replacement blankets. Foremen of fabric units indicated that at least three years of experience was a prerequisite for assignment to such work. Replacement blanket manhours could be appreciably reduced by use of special type sewing machines, capable of stitching and turning edges at the same time. In general, fabrication time for replacement blankets did not appear to be excessive and compared reasonably well with work performed at airframe plants.

SECTION III

OPTIMUM BLANKETS AND INSTALLATION METHODS

3.1 General Considerations

3.1.1 Review of the aircraft surveyed indicated that installation requirements for optimum blankets should recognize commercial types, in addition to following Specification MIL-S-6144.

2.1.2 Structural differences between aircraft surveyed were of a minor order, insofar as they affected blanket installation. Such differences were in fuselage frame depths, flange widths, stringer heights, cross-sections, and spacing.

3.1.3 Optimum blanket types should be suitable for areas exposed to damage from personnel and cargo as well as areas not so exposed; they should also be suitably resistant to moisture, oil and fuel.

3.1.4 Optimum blanket types should be capable of direct installation into aircraft without prior preparation in the form of tailoring, except in very special cases, such as inspection panels and the like.

3.1.5 Optimum blanket installations should not depend upon special tools, techniques or fasteners.

3.2 Blanket Materials

3.2.1 Homogeneous sound-absorbing material as called for in Specifications MIL-S-5659 and MIL-S-6144, is currently acceptable in the form of glass fiber batting generally conforming to Specification MIL-B-5924A. Specification MIL-S-5659 requires a minimum total thickness of two inches of batting. On the aircraft surveyed a relatively small amount of material differed from this thickness. A lesser thickness which would be satisfactory from an acoustical standpoint would be contrary to specification requirements. However, it is questionable if the difference in weight and cost per aircraft would offset the savings in procurement and stocking costs afforded by a uniform thickness of blanket. Batts of the same thickness could be utilized to provide additional acoustical treatment at such locations as tests may indicate the need for same. Of the six types of batting covered by Specification MIL-B-5924A, only Type I is considered desirable for use in optimum blankets. The cost of Type I material is currently comparable to that of types composed of coarser fibers, and its slightly higher weight is more than offset by its greater acoustical efficacy.

3.2.2 Backing material, in the form of a vinyl film per Specification MIL-P-6264A, is currently used in most blankets. This is believed to be the most suitable material currently available for this purpose 1/, and is considered to be desirable for use in optimum blankets. Where a

1/ A newly developed film material, designated "Mylar" by the E. I. DuPont Co., Wilmington, Del., appears to be superior to the vinyl film in most properties. This film will also be available with a vacuum deposited aluminum coating of some thermal insulation value. A sample of this film was obtained and used in an alternate inspection panel blanket on the optimum installation. It was found that the material was entirely satisfactory from a handling and fabrication standpoint. Edge stitching showed no signs of tearing, and there were no indications of tear-out at snap fastener installation points. Until this material becomes commercially available in quantity and its cost firmly established, consideration for use in this connection must be deferred.

blanket without trim cloth is indicated, the blanket should be covered on both sides with this vinyl film. It is to be noted that Specifications MIL-S-5659 and MIL-S-6144 refer only to fabric envelope material as an optional part of the blanket.

3.2.3 Impervious septum material, intended solely for attenuation in certain sound frequencies, may be of any moisture and flame resistant material having a surface density of from 0.05 to 0.08 pounds per square foot and an air flow resistance of not less than 21,000 grams/sq. cm./sec., according to Specification MIL-S-5659. None of the impervious septum materials surveyed conformed to this requirement. Several materials closely approached the minimum weight requirement. These materials were vinyl coated cotton cloth, having a weight of approximately 0.045 pounds per square foot. It is believed that such vinyl coated cotton cloth materials are satisfactory for use in optimum blankets. It is not felt that the color of the vinyl coating is important, other than as an indication of the presence of the coating. However aluminized coatings are of some value in increasing overall thermal insulation properties.

3.2.4 Porous trim cloth, with a surface density of not more than 0.04 pounds per square foot, is required by Specification MIL-S-5659. Many of the aircraft surveyed had blankets with non-porous trim cloth, some of the aircraft had hard panel cabin linings and the only significant usage of a porous trim cloth was of a material about ten percent heavier than the maximum specified. The latter material was a coarsely woven fibrous glass cloth, vinyl coated; this material (126 glass cloth) has a high strength, according to the manufacturer's published data, but the rather open weave apparently lowers its resistance to local damage at fastenings, etc. No attempt was made to determine if the material conformed to the maximum air flow resistance of 42 grams/ sq. cm./second; required by Specification MIL-S-5659, but it is doubtful, from visual inspection that the flow resistance of this material is as low as that required.

It is obvious that some compromise must be made between trim cloth desideratum and what can be achieved in practice. Since moisture, oil and fuel resistance is quite desirable, and since sources of such contamination are widespread in modern military aircraft, it would appear that consideration should be given to the use of such resistant material throughout the soundproofing installation. Furthermore, current practices indicate that material of this type is widely used, and that the acoustical properties of these installations are not seriously impaired by their use. It would therefore appear that such (non-porous) materials should be given consideration for use on optimum blankets.

Examination of various trim cloth materials used on installations surveyed disclosed that one type of closely woven fibrous glass cloth, vinyl coated, possessed relatively high strength without being excessively heavy (although exceeding maximum weight permitted by specification). It was found that this material had been selected for use on the Lockheed YC-130 aircraft after careful consideration of the properties of the various materials available for this purpose. It is believed that this material (118 glass cloth) is satisfactory for use as trim cloth on optimum blankets for locations subject to damage by personnel and cargo. This material will be used on Type X blankets.

The material described in the previous paragraph is stronger than necessary for blankets covering in locations not subject to damage. A review of available materials disclosed that a light weight, relatively strong material was available, also of closely woven fibrous glass cloth, vinyl coated. Evaluation of such light weight materials had indicated that they were subject to damage at fastening points, and unqualified acceptance of this material for use on optimum blankets for locations not subject to damage by personnel and cargo could not be made. In spite of this, blankets covered with this material (108 glass cloth) were made up and installed on a test panel in order to check possible deficiencies. Blankets using this material will be designated as Type Y.

3.3 Blanket Fabrication

3.3.1 Assembly of blanket materials by currently used cob-web type cementing procedure appears to be most suitable for optimum blankets.

3.3.2 Optimum Blanket Types X and Y - See Figure 10. - In keeping with the objective of minimizing the large variety of tailored blankets, a study of installation requirements disclosed that blanket material with one finished end and one finished edge could be utilized for practically every type of installation. Details of assembly and construction are given in Figure 13.

3.3.3 Optimum Blanket Type Z - See Figures 11 and 12. - This optimum blanket type is considered desirable, in recognition of the need for a semi-finished blanket for areas requiring additional treatment, as well as for areas where trim cloth is not necessary. This type is identical with the Type X blanket except for the substitution of vinyl film for the trim cloth. Edges of Type Z blankets would not be finished.

3.3.4 Inspection panel blankets, and other blankets which must be tailored to suit specific locations may be fabricated from the Type X blanket material by simply finishing the edges to the required size and shape. Snap type fasteners or curtain type fasteners, either of which are stocked AN hardware items, may be located in the specific positions required to match the inspection opening and supporting structure. It is neither intended or desirable that inspection panels be fastened to unsupported edges of adjacent fixed blankets.

It is recognized that in a few cases the film backing may not be sufficiently rugged to withstand local environmental conditions. As an example, on certain aircraft, heavy rope for emergency use is kept in shallow pockets behind removal blanket panels; the abrasion of such rope would quickly destroy the film backing, consequently a canvas duck or similar material is desirable at this location. Inspection panel blankets for such locations may be made up utilizing the Type X material with the protective backing material placed over the film backing.

3.4 Blanket Installation

3.4.1 The procedures proposed herein for installation of optimum blankets are not unique; neither are they identical with any observed on the installations surveyed. The proposed procedures are recommended after consideration of the shortcomings observed in current practices.

3.4.2 Horizontal method - See Figure 14. - This procedure consists of stretching the blanket horizontally starting with the lowest blanket, fastening one end at a frame and progressively attaching the blanket to the frame flanges. At the end of the first blanket, the second blanket is overlapped at the nearest frame, with its finished edge exposed and installation of the remainder of the blanket would proceed as for the first blanket. Fastening to frame flanges would be by means of Loop Type Trimount Stud ("Mae West") fasteners, spaced from five to six inches on centers, in one-fourth inch diameter holes drilled before installation. The second row of blankets would be installed with the finished edge overlapping the upper edge of the first row by approximately two inches. Succeeding rows would be installed in the same manner. Type Y material, if used, would be installed in upper or protected areas only.

3.4.3 Vertical method - See Figure 15. - This procedure consists of fastening the finished (long) edge to the first (vertical) frame, leaving the unfinished edge overlap the second frame. The second blanket would be fastened to the flange of the second frame, over the edge of the first blanket. Successive blankets would be installed in the same manner. Fasteners and spacing would be the same as for the horizontal method. Depending upon cabin size, etc., blankets may either be continuous up and around from floor to floor, or run from floor to racks, ducts, rails or inspection openings. Blankets would be cut to length and fastened in any suitable manner to available supporting members. Trimmed ends would be folded over and secured by hand stapling to simplify handling and avoid fraying.

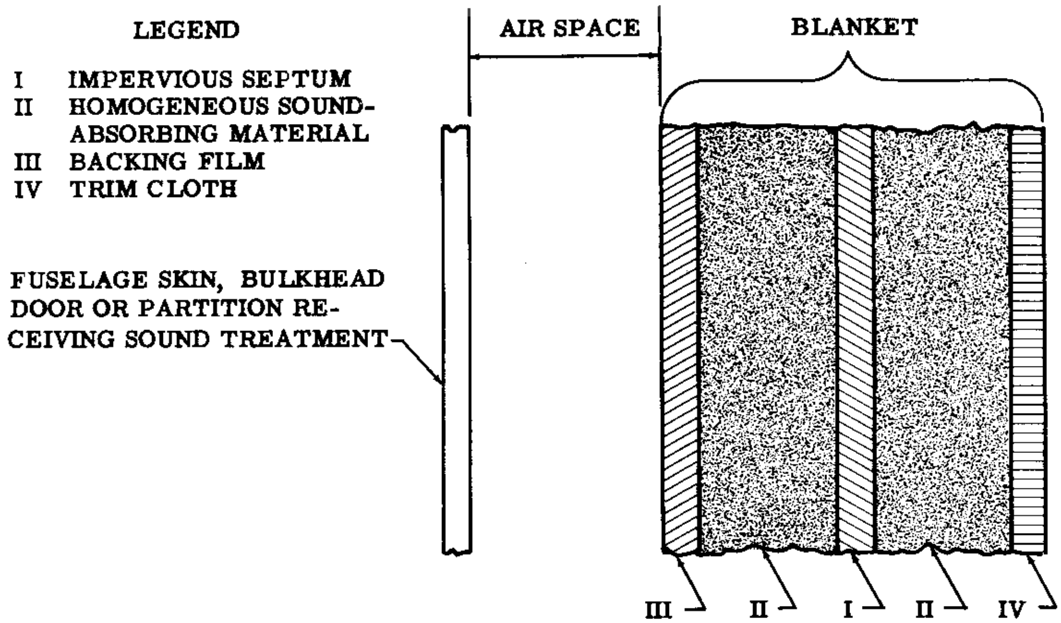

Figure 10. Optimum Blanket Types X and Y.

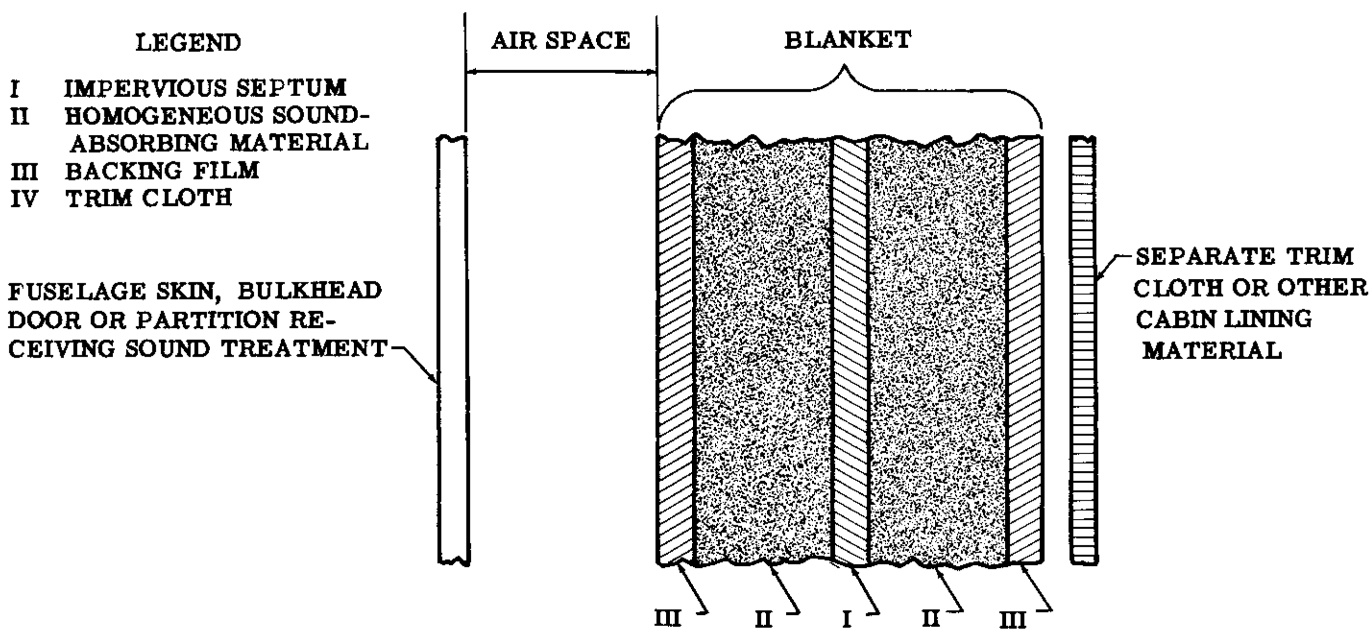

Figure 11. Optimum Blanket Type Z.

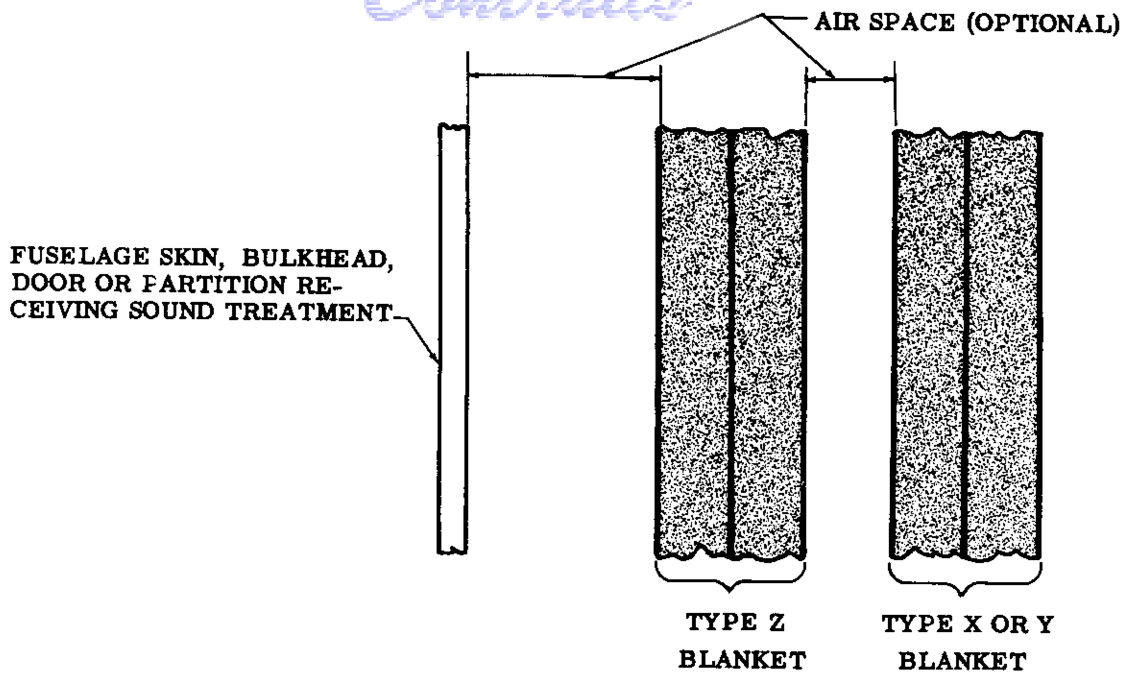

Figure 12. Type Z Blanket Used as Supplemental Acoustical Treatment.

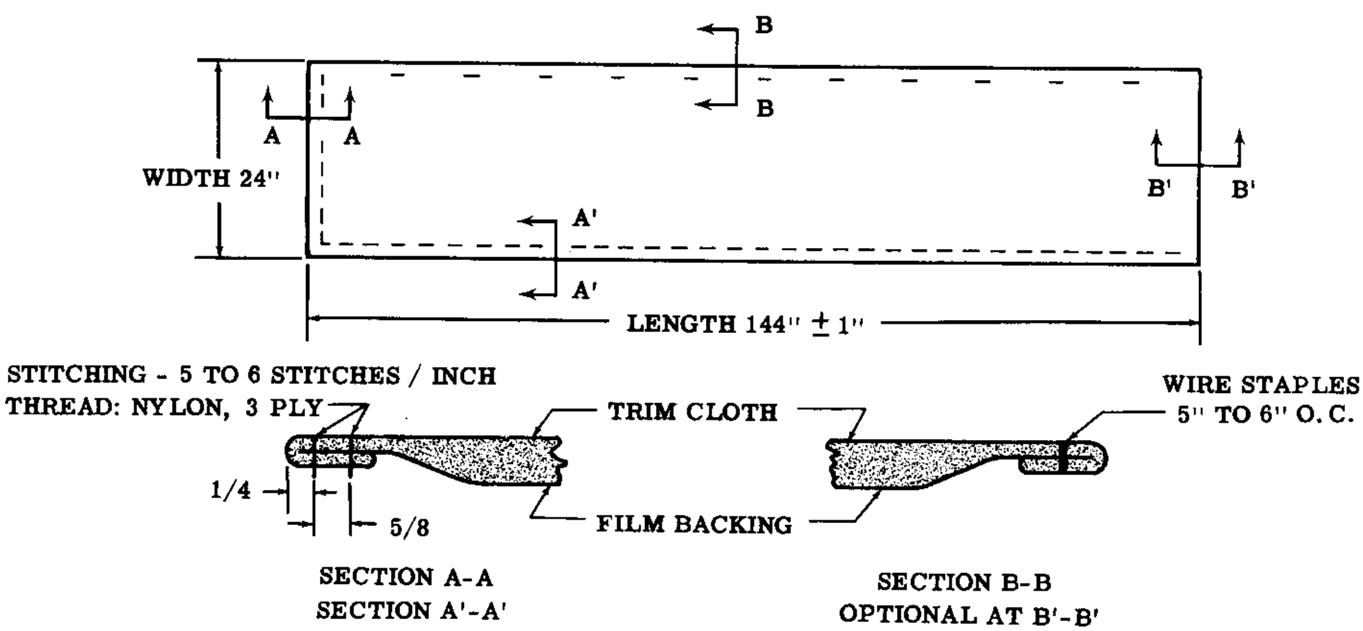

Figure 13. Optimum Blanket Details.

Figure 14. Test Installation of Optimum Blankets - Horizontal Method.

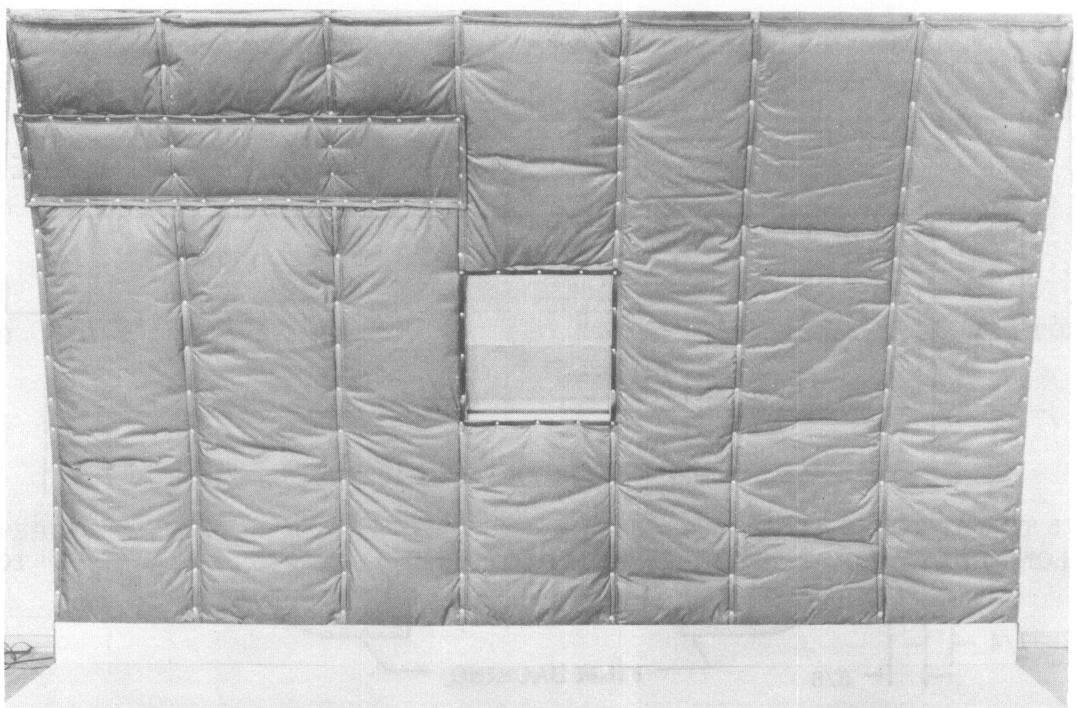

Figure 15. Test Installation of Optimum Blankets - Vertical Method.

3.4.4 Method at window openings, inspection panel cutouts, and structural or equipment protuberances - See Figure 16. - At openings, the blanket would be trimmed about one inch beyond the supporting surface, folded over and hand stapled within the area covered by either the inspection panel blanket or any material which may be used for trimming the opening, such as a formed plastic window frame. Fastening at such locations would be by means of the fastener stud, in the case of inspection panel blankets openings, or by screws or other fasteners which would retain the window frame, in the case of framed windows. Where no window frame is used, the blanket edge may be retained by narrow plastic strips held by any suitable fastener. Small cutouts and notches, for structural or equipment protuberances, may be made by trimming the blanket to suit leaving a suitable allowance for folding over, and then hand stapling to provide a neat edge; corners of such cut and folded cutouts or notches may be reinforced by brush application of a clear vinyl coating.

3.4.5 Method for locations subject to oil and fuel contamination. Both types of optimum blanket are provided with covering material suitably resistant to fuel and oil. Stitched edges of Type X blankets are vulnerable to seepage of fuel and oil through the needle holes. Both sides of finished edges (i.e., stitched edges) may be made impervious to such infiltration by brush application of a clear vinyl coating. Other edges, not stitched, may be made completely resistant by double folding, hand stapling at close intervals (approximately one inch on centers), and subsequently brushing on a clear vinyl coating along the inside of the fold. Type Z blankets may be made fuel and oil resistant in the same manner, as well as by the cement used for installation if care is taken that the cemented attachment is continuous.

3.4.6 Method for installing Type Z blankets - See Figure 17. - This procedure is intended for locations where the blanket is used as additional treatment. Where this type of blanket is used in lieu of the Type X blanket, variations of the horizontal and vertical methods may be employed, depending upon installation conditions. This procedure consists of placing the blanket between fuselage frames. Retention of the blanket is by means of spot cementing along frame webs and stringer or longeron flanges. A spacing of cement spots of about six inches should be satisfactory in practically all installations. Cementing may be continuous along webs and at blanket ends, although this procedure is not justified unless the blanket is subject to fuel and oil contamination. The method described above has been used for some time for the installation of blankets of this nature.

In locations where this type of blanket may sag and interfere with control cables or moving parts it is necessary to provide suitable retaining means. Flexible vinyl, or other plastic straps may be used for this purpose, retained by sheet metal screws fastened to stringers or other structure behind the blanket.

3.5 Test Installation

3.5.1 Test panel - A simulated fuselage side wall section was fabricated of aluminum alloy materials The panel was eight feet high by twelve feet long. Stringer and frame sizes and spacing closely approximated a composite of the airframe structures in current production. See Figure 18. Provisions were made for simulating window and inspection panel openings. No special provisions were made for installation of soundproofing blankets.

3.5.2 Type X, Y and Z blankets, together with inspection opening blankets, were ordered from a local fabricator. A cardboard template was supplied to the fabricator in order to establish fastener locations on the inspection panel blankets. Type X material was ordered in sufficient quantities for test of both horizontal and vertical type installations. Type Y material was ordered only for the horizontal installation.

3.5.3 Type Z blankets were installed between frames in three bays, using the method discussed in para 3.4.6. Vinyl straps were installed in the simulated control cable and piping locations as shown in Figure 17.

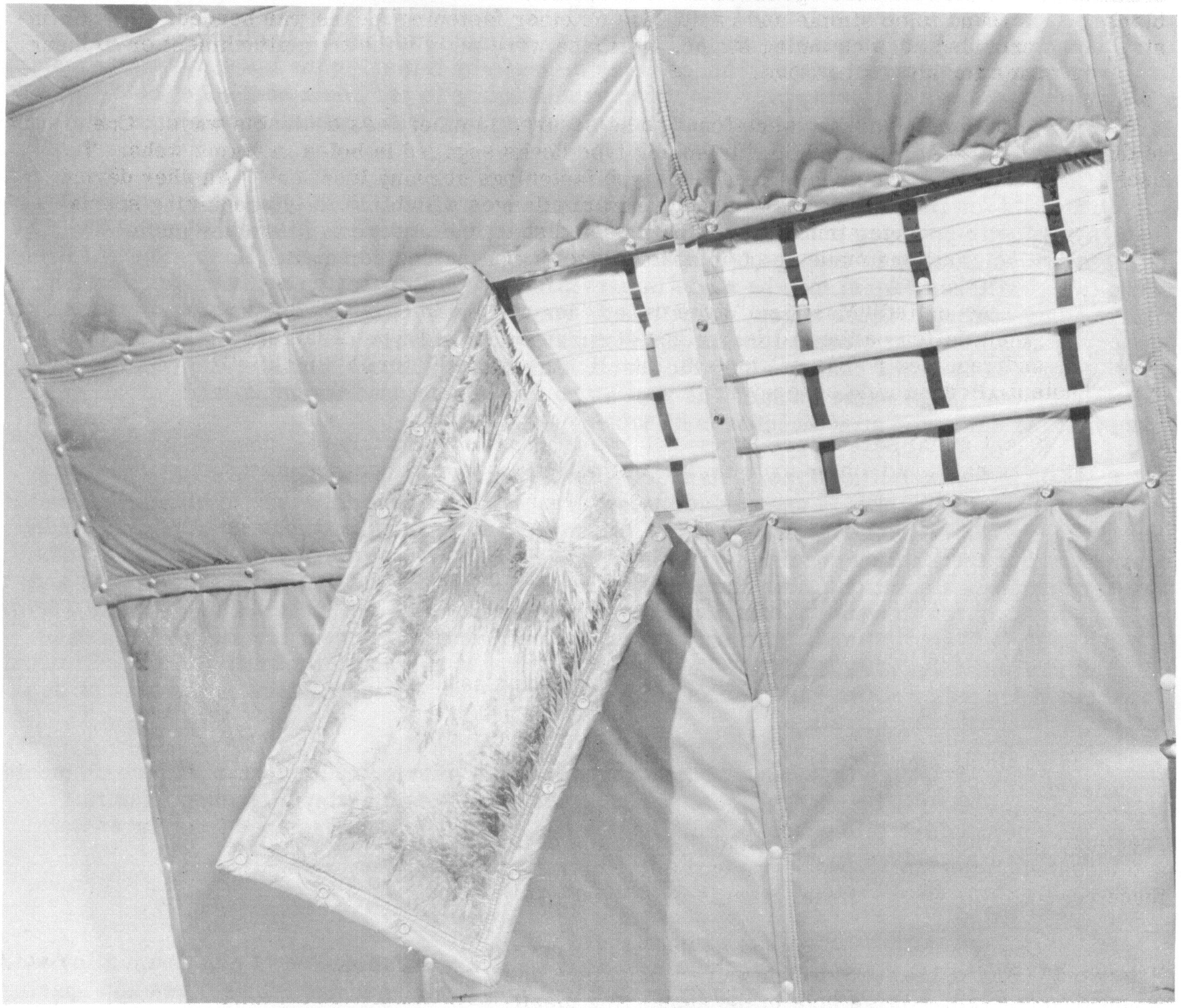

Figure 16. Installation at Openings.

Figure 17. Type Z Blanket Installed on Test Panel.

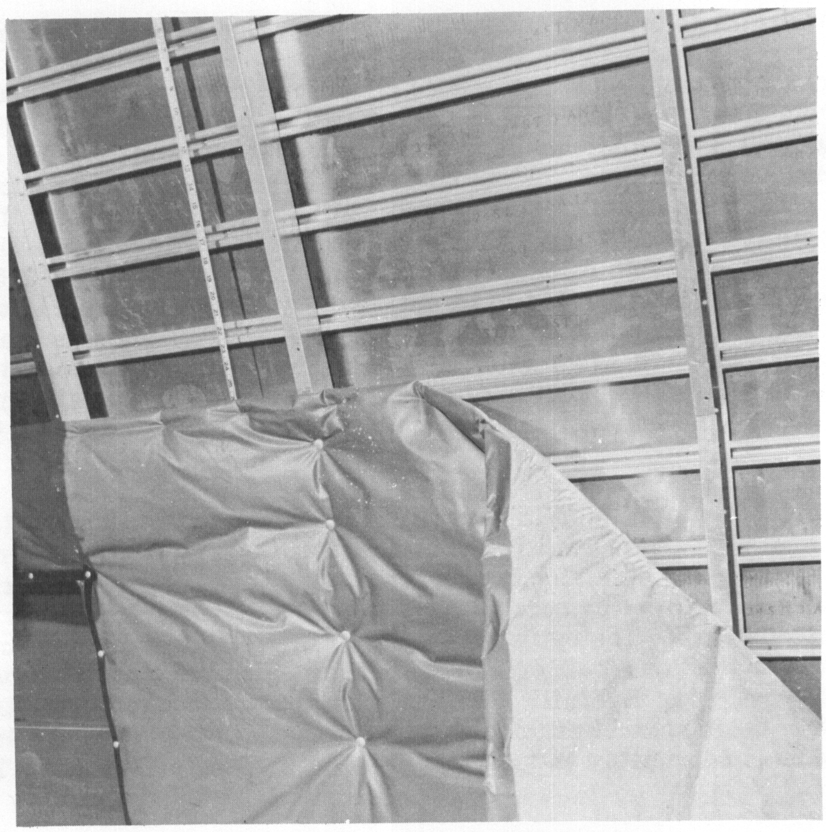

Figure 18. Test Panel Structure.

3.5.4 Horizontal method installation - See Figure 14. - Type X and Type Y material was used for this installation. The two lower rows were of Type X blanket material; the upper portion of Type Y material. The installation was made using the method discussed in para 3.4.2. Inspection panel snap fasteners were installed per template. The procedure at the inspection panel opening and at the simulated window opening followed that described in para 3.4.4.

3.5.5 Vertical method installation - See Figure 15. - Type X material was used exclusively, and the method of installation followed that described in para 3.4.3. Blanket material at one end was brought around the frame and secured as shown in Figure 19. Openings were treated as previously described. See Figure 20.

3.6 Test Installation Evaluation

3.6.1 The following remarks concerning evaluation of the optimum blankets and their installation are broken down into the same categories used in the Evaluation Form, with the various characteristics numbered in the same order in which they are found in that form. The specific points mentioned in the Introduction are covered in this manner, except for certain items of a broader nature. These are introduced in appropriate places in the text.

3.6.2 Blanket design: -

(1.1) The optimum design is believed to be conducive to keeping engineering layout manhours to a minimum.

(1.2) Complex production drawings are not necessary for specification and installation of optimum blanket materials.

(1.3) A large number of production drawings is not required to specify optimum blankets and installations.

(1.4) Few drawings, easy to interpret, are needed in connection with the optimum types.

(1.5) High unit weight is characteristic of all trim cloth covered blankets which are satisfactory from a service standpoint. The homogeneous sound-absorbing material specified for optimum blankets conforms to specification requirements from a weight standpoint. The impervious septum material weight is slightly lower than permitted by existing specifications. The weight of the backing material is almost negligible. The sole high weight producing item is the trim cloth, the weight of which is almost directly proportional to its strength. The trim cloth selected for the Type X blanket is only 0.015 lbs./sq. ft. heavier than the only material observed to be satisfactory in service from a wear standpoint. The selected material is resistant to penetration of oil, etc., whereas the lighter material was not resistant. The trim cloth selected for the Type Y blanket is considerably lighter than most trim cloth materials currently specified, without substantial sacrifice in strength; The Type Y material can be used only in areas not subject to damage induced by personnel or cargo.

(1.6) Acoustical insulation efficiency of the optimum blanket materials is expected to be relatively high. The homogeneous soundabsorbing material and the impervious septum specified conform substantially with current requirements. The thickness of the batting is the minimum required by current specifications. This thickness is greater than that used in many installations. The optimum soundproofing installation system proposed herein permits the installation of material as needed to suit conditions disclosed by acoustical tests on the particular aircraft. The specification of a non-porous trim cloth should not unduly lower the acoustical efficiency of the system, if current installations of such material have been reasonably satisfactory from acoustical standpoint. The sealing of the

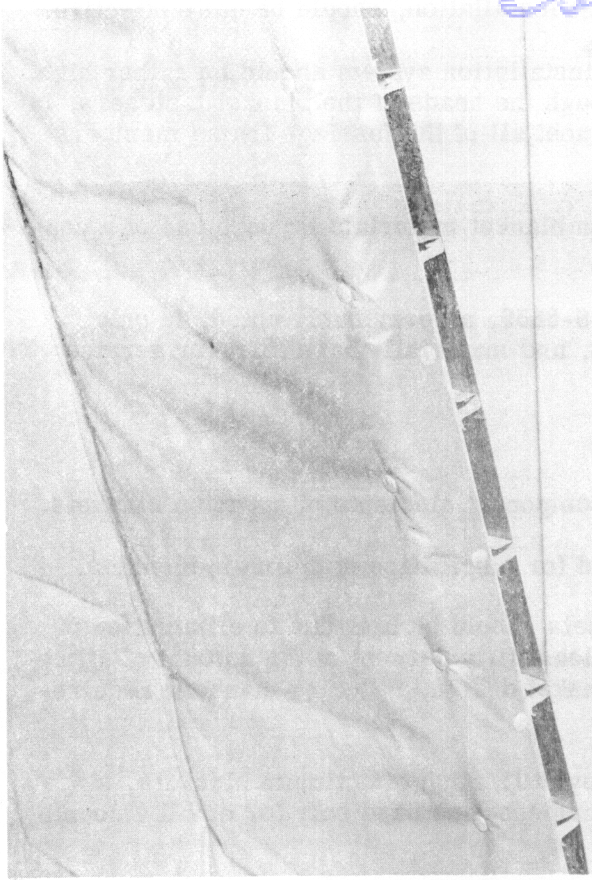

Figure 19. Blanket Edge Attachment at End of Test Panel.

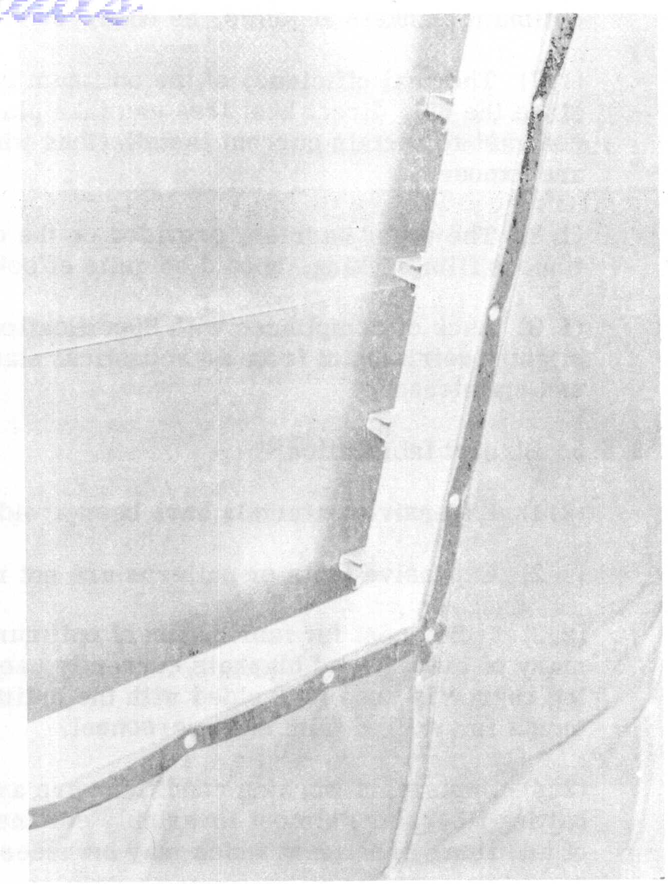

Figure 20. Simulated Window Opening on Test Panel.

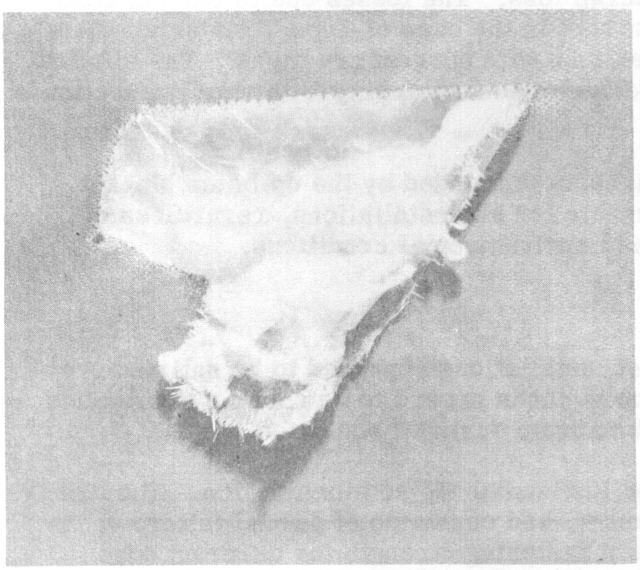

Figure 21. Damaged Area on Test Installation

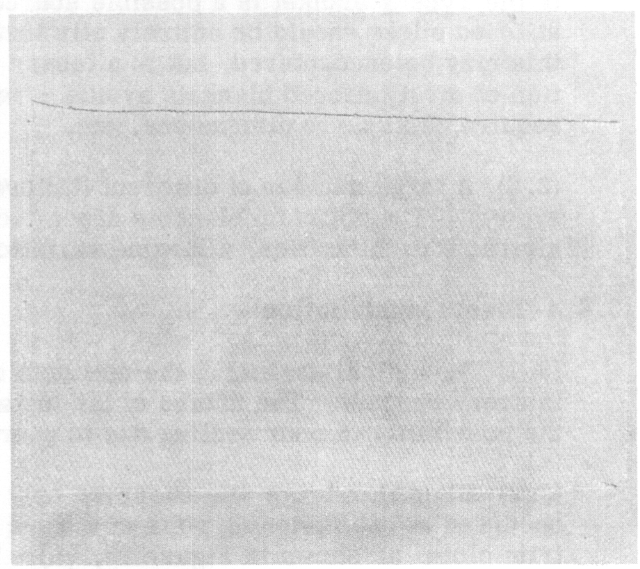

Figure 22. Repair Over Damaged Area.

optimum blankets at joints, as observed on the test installation, should be quite effective.

(1.7) Thermal efficiency of the optimum blanket installation system should be rather high, since the only direct heat loss can take place through the heads of the blanket fasteners, in contrast to certain current installations where almost all of the fuselage frame members are exposed.

(1.8) The vapor barrier, provided on the optimum blanket materials through use of a continuous film backing, should be quite effective.

(1.9) Lack of compliance with Specification MIL-S-5659, as previously noted, is only slightly detrimental from an acoustical standpoint, and materially beneficial for service and maintenance.

3.6.3 Blanket fabrication -

(2.1) Expensive materials have been avoided in component elements of optimum blankets.

(2.2) Expensive tools or patterns are not required for fabrication of optimum blankets.

(2.3) Labor cost for fabrication of optimum blankets should be less due to elimination of many of the tailored blankets currently used. At least fifty percent of the amount of stitching currently done is avoided with the optimum blanket design, reducing manhour requirements for skilled trim shop personnel.

(2.4) Unpleasant working conditions are avoided by utilization of optimum blankets, since batting fibers are almost invariably confined and cements are used only for small amounts of additional treatment which may be necessary.

(2.5) Scrap losses should be low with the optimum blankets. The basic blanket size was established as a multiple of the stock sizes of the component materials. The elimination of a multiplicity of different blanket sizes cuts edge scrap losses. The use of strong materials for covering avoids damage to the delicate batting. The relatively weak trim cloth of the Type Y blanket is a possible source of scrap loss. The losses due to tearing along stitched edges should be entirely eliminated, except in the case of Type Y material where this may be encountered, but to a lesser degree than with current practices. The elimination of most tailored blankets avoids scrappage due to nonconformity with rigid inspection requirements as to dimensions, etc.

(2.6) A large number of different (tailored) blankets is avoided by the optimum blanket system. The optimum blankets appear to be usable for all installations, regardless of airframe peculiarities, airframe variations, and environmental conditions.

3.6.4 Blanket installation -

(3.1) Acoustical sealing of the optimum blanket installations appeared to be satisfactory in every respect. The nature of the installation methods proved to be such as to preclude the possibility of poor sealing due to poor workmanship during installation.

(3.2) Blanket damage was observed only on the Horizontal Method installation. The damage occurred at one fastening point of a Type Y blanket, and consisted of partial failure of the trim cloth, as shown in Figure 23, (A). Tests of fastening strength for different edge stitching procedures were conducted on the Type X and Type Y blankets, as well as on a

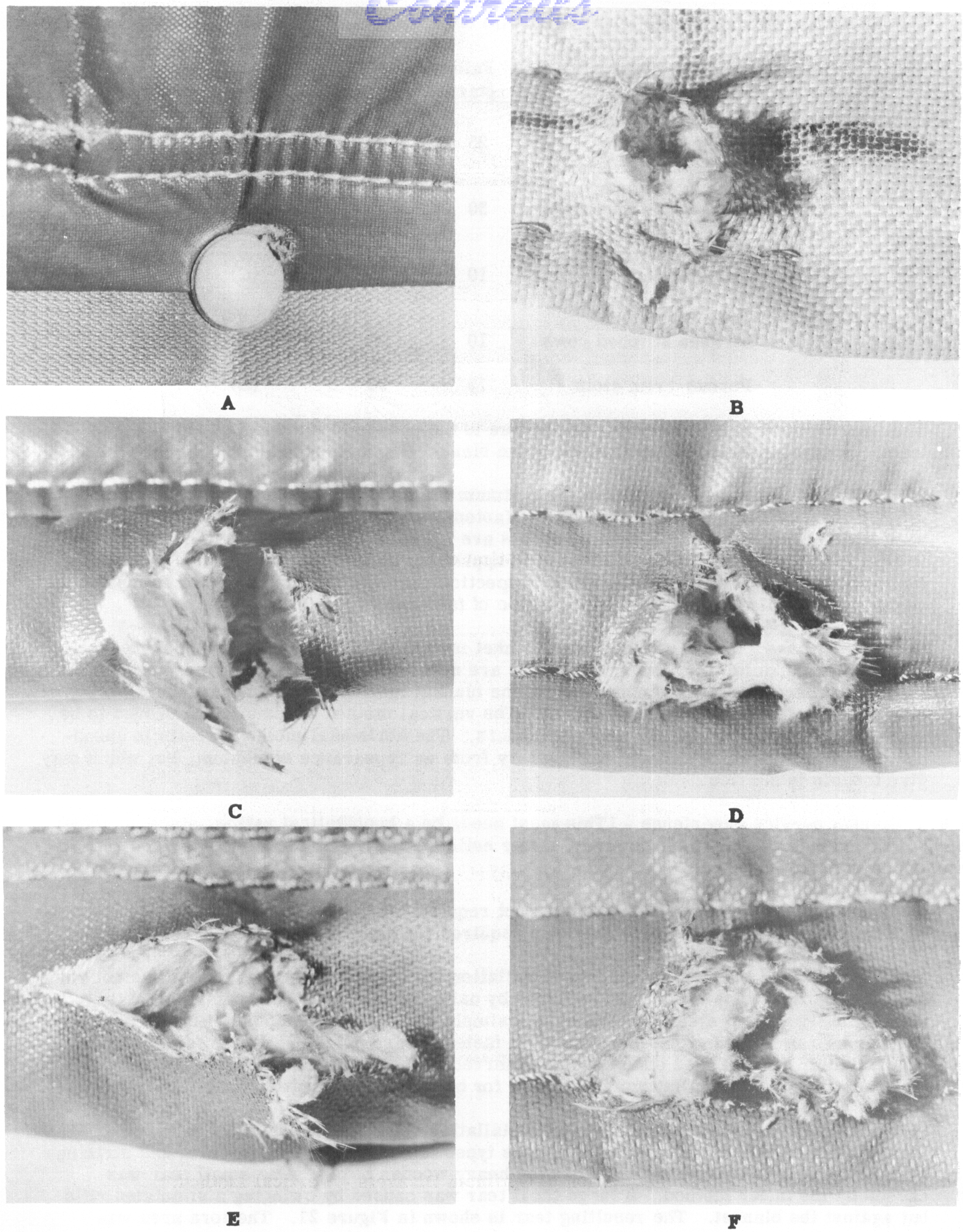

Figure 23. Blanket Edge Fastening Strength Test Specimens.

sample using a strong porous trim cloth, with the following results:

Blanket description	Failure load (lbs) Start	Complete	Figure 23 (Ref.)
Type X, fastener outside stitching	25	35	(E)
Type X, fastener between stitched rows	30	50	(F)
Type Y, fastener outside stitching	10	15	(C)
Type Y, fastener between stitched rows	10	20	(D)
Porous trim cloth	15	30	(B)

The improvement in load carrying ability due to the change in stitching as disclosed by the tests, was incorporated in the final optimum blanket fabrication scheme. See Figure 13.

(3.3) Fastening means employed in the optimum blanket installation is inexpensive and readily obtainable. Only one basic type of fastener is required, regardless of structural variations. Fasteners for inspection panels are AN hardware items. Fitting and drilling is kept to a minimum. The system used is applicable to any type of aircraft. Manhours for installation of studs for fasteners at inspection openings are not high, nor is much time required for drilling holes for the basic type of fastener.

(3.4) Fitting and trimming of optimum blanket materials is necessary, but manhour requirements are quite low. No special tools are necessary and the tools used are ordinary shears and hand staplers. Appearance of the blanket installation is neat and trim, using either the horizontal or vertical method. The vertical method of installation proved to be somewhat easier and required fewer manhours. The horizontal method results in unsupported blanket edges, which are satisfactory from an appearance standpoint, but which may give trouble in service.

3.6.5 Blanket service experience - (This must needs be a hypothetical rating, since no actual service experience can be cited; however, a fair estimate may be made by comparison with installations observed.)

(4.1) Cleaning of optimum blankets does not require removal. No special precautions need be excercised during cleaning. The time required for blanket cleaning should not be high.

(4.2) Removal of blankets on the test installation indicated that special tools were not required, although some time could be saved by using an oversize "tack lifter", readily fabricated from strip steel. Use of such a simple tool reduces the possibility of damaging the blanket, as is sometimes the case when fasteners are pried out with a screw driver. No particular caution need otherwise be observed. There was no indication of damage to the test "airframe" installation. Manhours for blanket removal were quite low.

(4.3) Durability of the optimum blanket installation should be satisfactory in service. The Type X blankets were subjected to various types of abuse, such as punching and striking by hand as well as by pushing and throwing heavy wooden boxes. One small tear was caused by the latter method. A large local tear was caused by swinging a simulated rifle but against the blanket. The resulting tear is shown in Figure 21. The torn area was repaired by cementing on a patch of trim cloth, as shown in Figure 22. Attachment points were examined after the abusive treatment and found to be free from any damage.

(4.4) Repair of tears in optimum blankets may readily be accomplished without blanket removal. No difficutly should be experienced in obtaining repair materials.

(4.5) Reinstallation manhours are not high. It was found that a small percentage of the fasteners were not reusable. Replacement fasteners are readily obtainable.

(4.6) Replacement blankets would present few problems upon adoption of these optimum blankets as stocked material at USAF bases. Manhours for preparation and installation would be materially reduced, and the amount of skilled labor required for this activity would also be reduced.

3.6.6 Weight and cost estimates - The following figures were obtained from a local fabricator of soundproofing materials. They are believed to be a fair estimate of costs at the time of preparation of the report.

Blanket Description	Unit Weight (lbs/sq. ft.)	Unit Cost (per sq. ft.)
Type X	0.188	$0.70
Type Y	0.172	0.66
Type Z	0.159	0.58

Edge stitching of Type X and Type Y blankets is estimated to cost an additional twenty cents per blanket.

SECTION IV

SUMMARY AND CONCLUSIONS

4.1 Soundproofing Installation Specifications

4.1.1 The requirements of current specifications are not being followed in actual practice. Specifications for material intended for use in soundproofing blankets are not presently included by reference in overall soundproofing specifications. It is believed that this deficiency can be readily overcome. This applies to Specifications MIL-S-5659 and MIL-S-6144.

4.1.2 The optimum blanket materials and installation methods developed during this study offer considerable opportunity for improvement over existing methods. It is felt that the Type X and Type Z materials may be incorporated to advantage in Specifications MIL-S-5659 and MIL-S-6144. The optimum installation methods should be incorporated in the body of data used by aircraft designers, either by incorporation into the aforementioned specifications or by inclusion in the Handbook of Instructions for Airplane Designers, ARDCM 80-1.

4.2 Soundproofing Material Specifications

4.2.1 The trim cloth materials intended for use in soundproofing blankets are currently covered in Specification MIL-C-7514A. The procurement of materials to this specification does not appear to be possible due to unrealistic unit weight requirements. Revision of this specification in this respect would simplify procurement and result in cost reduction. The trim cloth used in the optimum blanket Type X could be incorporated in this specification.

4.2.2 Fastener procurement and stocking would be simplified and reduced in cost by inclusion of fasteners such as the Loop Type Trimount Studs in AN or MS standards.

4.2.3 Optimum blanket material, in finished or unfinished form, as assembled into Type X and Type Z blankets could be covered by a suitable specification. Such a specification would promote uniformity of treatment. Material could be procured in larger quantities and some cost economies would result from the reduction in number of different combinations ordered, made up, and stocked. Stocking of standardized replacement blanket materials at USAF bases would be made possible, with attendant savings in replacement blanket fabrication manhours and material cost.

4.2.4 Flexible, foamed plastic sheets sometimes used in areas subject to severe damage may be satisfactory from a thermal insulation standpoint, but their acoustical properties are not well established. Acoustical tests are needed to determine the extent to which this material may be used in soundproofing installations.

4.3 Engineering Data

4.3.1 Engineering drawings prepared by airframe manufactures could be simplified and made more readily understandable by shop and materials procurement personnel. The adoption of the optimum blankets and installation methods would further simplify these data, and would reduce the engineering manhours for their preparation.

4.3.2 Military aircraft based upon commercial types present a problem in materials specification which would be overcome if a military specification would offer advantages for use as a basis for engineering data preparation for commercial aircraft.

4.4 Soundproofing Blanket Fabrication

4.4.1 Considerable improvement in blanket fabrication procedures, by airframe manufacturers as well as by USAF base fabric units, is believed to be possible. Adoption of the optimum blanket types would materially simplify the fabrication work, with substantial reduction in material cost and skilled labor manhours.

4.4.2 Fabrication techniques employed in the optimum blankets are a combination of well established procedures (edge stitching) with realistic, simplified methods (stapling). Stapling is used by at least one large fabricator of blankets as a means of positioning prior to stitching. These staples are not removed, and there appears to be no objection to the use of coated wire staples from the standpoint of electrolytic action, or environmental conditions.

4.4.3 Blankets intended for installation in areas subject to fuel, oil, etc. are not always satisfactory due to deficiency in tightness at edges; cemented edges currently used to overcome this deficiency are prepared by hand at high cost or necessitate the use of special presses and tooling. Sealing of conventional stitched edges with a brushed on vinyl coating is sometimes done in current practice and is incorporated in the optimum blanket installation system; this sealing technique is simple and may be performed during the blanket installation phase in such areas as may require protection.

4.4.4 Quilted materials are undesirable from an acoustical standpoint and are not employed to any great extent in current installations.

4.5 Soundproofing Blanket Installation

4.5.1 The wide variations in current installation methods are not justified by the results. Special fasteners, blind rivets, and other items have been used without appreciable improvement in the installation cost or effectiveness. Sometimes these items have actually resulted in poor installation. The optimum blanket installation methods resulting from this study may be universally employed without special tools or equipment.

4.5.2 The acoustical effectiveness of installations surveyed varied widely. In contrast to the many excellent installations, some were scarcely effective as thermal insulation. The proposed optimum blanket installation methods, as tested, appeared to be completely satisfactory in this regard.

4.5.3 The appearance of soundproofing blanket installations surveyed was generally quite satisfactory. The appearance of the optimum installations tested compared favorably with current installations.

4.6 Service and Maintenance

4.6.1 Ruggedness of blankets varied greatly between the installations surveyed. The principal weakness was in the trim cloth material. Weak materials, specified in order to achieve weight reduction, were the principal cause for tears requiring repair or replacement of the blanket. Small torn areas were generally repaired in place with cemented patches. Weak materials almost invariably required extensive repairs along attachment points. The optimum blanket test installation was subjected to abuse closely approximating that which could be expected in service, and was found to be substantially equal to the most rugged installation.

4.6.2 Repairs, touched upon in the preceding paragraph, presented few problems at any of the USAF bases visited. Repair of optimum blankets should differ little from current practice, except that the volume of such repairs may be considerably lower in view of the higher strength of the trim cloth, compared to the material used on the majority of the installations.

4.6.3 Replacement of blankets was found to be required only in case of oil soaked or extensively torn blankets. The optimum blanket installation system, by using generally stronger materials, oil and fuel resistant, with a suitable sealant method, should materially lower the amount of blanket replacement.

4.6.4 Blanket fastenings, often lost or damaged during blanket removal, sometimes presented a replacement problem to service personnel. Elimination of special fasteners and stocking of fasteners proposed for the optimum type installation would be quite desirable. The fastener type indicated for use on the optimum installation is widely used at the present time, but is not a regularly stocked item.

4.6.5 Materials for repair and replacement blankets presented a difficult procurement problem at most USAF bases visited. The lack of information as to sources, specifications, colors, etc. contributed to this problem. Standardization of color, in addition to standardization of (optimum) blanket materials, would simplify procurement and reduce the total inventory requirements.

4.6.6 Cleaning of soundproofing blankets presented no problems at any of the bases visited. Personnel had learned to avoid the use of solvents for this purpose after unsatisfactory attempts with various materials. Unskilled labor was used for all cleaning operations, which were performed in the aircraft without removing blankets. Requirements for cleaning of optimum blankets are no different from those surveyed.

4.6.7 Reconsideration of the Type Y optimum blanket material from a service and maintenance standpoint indicates that the probable difficulties which would be encountered would more than offset the very small cost and weight saving which would result from its adoption. Much of the cost saving would be lost due to the added cost of procurement and stocking of material. It has been estimated that not more than 300 square feet of this type of blanket could be used in a large aircraft; the saving in original material cost would be only twelve dollars, while the weight saving would be less than five pounds. It may be concluded that Type Y material should not be incorporated in optimum blanket installations.

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APPENDIX I

WEIGHT DATA

AIRCRAFT	AIRCRAFT EMPTY WT (LBS)	0.5% OF EMPTY WT (LBS)*	TOTAL WEIGHT OF SOUND-PROOF'G (LBS)	REMARKS
B-52 Recon	169,476	847	151	Incl. Photo Capsule Treatment; Blanket Weight - 136 Lbs.
B-52	164,866	824	121	Blanket Weight - 106 Lbs.
KC-97G	77,943	389	542	Incl. Carpets; Blanket Wt. - 358 Lbs.
B-47E	78,822	394	19	Blanket Weight - 16 Lbs.
C-124C	102,230	511	560	
RB-66	39,074	195	31	
C-118A	56,692	283	541	Main Cabin Installation - 335 Lbs.
YC-130	57,293	286	402	
C-121A	59,837	299	406	
YC-121C	79,890	399	593	
F-94C	12,708	63	4	
T-29C	30,750	154	169	Fasteners & Cement Weight - 8 Lbs.
T-29D	30,632	153	177	Fasteners & Cement Weight - 8 Lbs.
C-131A	27,942	140	214	

*Ref. (HIAD) ARDCM 80-1

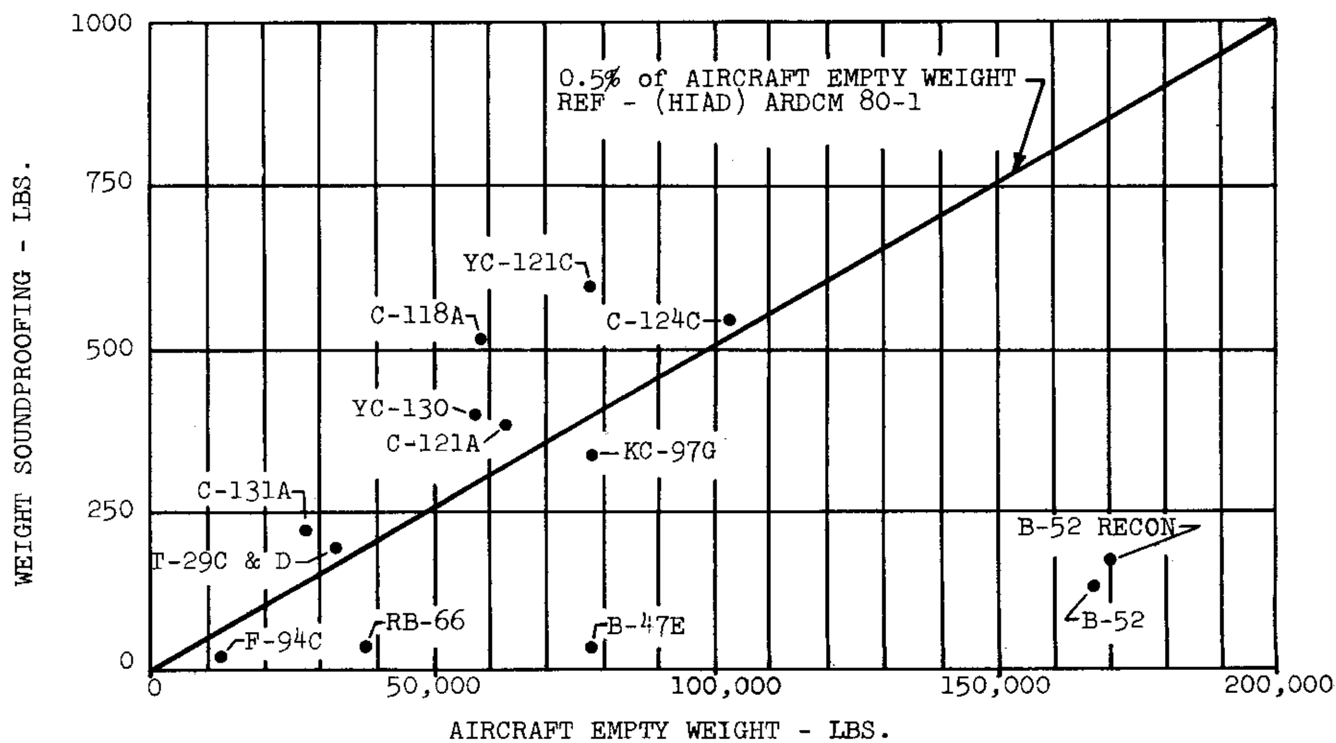

Figure 24. Soundproofing Installation Weight Comparison

ENGINEERING DATA

The following listed airframe manufacturer's drawings and data were used in the survey and evaluation :

Boeing Airplane Co., Seattle, Washington

15-23742	5-50893	5-33403	5-50523
9-22500	5-58107	5-72159	5-55001
9-22144	5-59781	5-59448	5-47638
5-59455	5-58408	5-59454	5-54006
3-37820	5-59460	15-23742	5-61129
9-43446	5-59182	5-49123	
6-21168	5-59322		

Consolidated-Vultee Aircraft Corp., San Diego, California

240-0090200	240-3097200	240-3398207	240-3397262
340-3090201	240-3097201		

Douglas Aircraft Co., Inc., Long Beach, California

5288456	5412189	5465504	3465510
5293925	5412905		

Douglas Aircraft Co., Inc., Santa Monica, California

5362885	7363141	5362874	5363143
5498820	7359689	5490677	5359301
5359758	7359745	5362788	7399551
5363142	5359759	5361894	

Lockheed Aircraft Corp., Burbank, California

341788	338896	M302490	451412
338928	340979	311354	Spec. 1-982

Northrop Aircraft, Inc. Hawthorne, California

Spec. NAI-1045	Process Manual Bulletin MA-26A
Spec. NAI-1056b	

Cost and Manhour data supplied by airframe manufacturers was generally sketchy and incomplete; some manufacturers were unable to supply data of any nature on these items. These data are not included by reason of their incompleteness.

EVALUATION FORM - USAF CONTRACT NO. AF33(616)-2379

Blanket Type__________________ Used on A/C Model(s) __________________

Item	Merit Value (Range)	Assigned Value
1. Blanket Design		
1.1 High Engineering man-hours for layout	-2	
1.2 Complex production drawings	-2	
1.3 Large number of production drawings	-1	
1.4 Few drawings, but difficult to interpret	-3	
1.5 High unit weight	-5	
1.6 Low acoustical insulation efficiency	-5 to -1	
1.7 Low thermal insulation efficiency	-5 to -1	
1.8 Vapor barrier questionable	-5 to -1	
1.9 Detrimental lack of compliance with Spec MIL-S-5659	-5 to -1	
Sub-Total: (Item 1.)		
2. Blanket Fabrication		
2.1 Very expensive materials used	-5	
2.2 Very expensive tools or patterns	-3	
2.3 Very high labor cost		
2.31 Due to man-hour requirements	-5	
2.32 Due to need for skilled labor	-5	
2.4 Unpleasant working conditions		
2.41 Due to materials used	-3	
2.42 Due to assembly process	-3	
2.5 High scrap losses		
2.51 Due to uneconomical raw mat'l sizes	-2	
2.52 Due to delicacy of material	-2	
2.53 Due to fabrication process deficiencies	-2	
2.54 Due to too rigid inspection requirements	-2	
2.6 Excessive number of different blankets		
2.61 Due to airframe peculiarities	-1	
2.62 Due to poor adaptability of blanket type to airframe	-4	
2.63 Due to inability to meet differing environmental conditions	-3	
Sub-Total: (Item 2.)		
3. Blanket Installation		
3.1 Acoustical (joint) sealing		
3.11 Very bad	-10	
3.12 Poor	-5	
3.13 Unreliable	-10	
3.14 Unsatisfactory sealing inherent in design	-5	
3.15 Unsatisfactory sealing due to workmanship	-5	
3.2 Blankets Damaged During Installation		
3.21 Due to delicacy of blanket	-3	
3.22 Due to airframe sharp edges, etc.	-1	
3.23 Due to carelessness during install. of piping, conduit, wiring, etc.	-1	
3.24 Due to poor fastening method	-5	
3.3 Fastening Means		
3.31 Fastening means intrinsically costly	-1	
3.32 More than one type of fastener for each type of structural element	-2	
3.33 Fitting, drilling, riveting, etc. involved	-1	
3.34 Not readily adaptable to other aircraft	-2	
3.35 High fastening means installation man-hours	-3	
3.4 Fitting and Installation		
3.41 Fitting and/or trimming required	-6 to -2	
3.42 Special tools required	-1	
3.43 High installation man-hours	-10 to -5	
3.44 Poor appearance as installed	-2	
Sub-Total: (Item 3.)		
4. Blanket Service Experience		
4.1 Cleaning		
4.11 Necessary to remove for cleaning	-3	
4.12 Excessive caution required for cleaning	-2	
4.13 High cleaning man-hours	-4 to -1	
4.2 Removal		
4.21 Special tools required	-1	
4.22 Excessive caution or skill required	-2	
4.23 Blankets sometimes damaged (during removal)	-5 to -1	
4.24 Blankets invariably damaged (during removal)	-10 to -5	
4.25 Airframe sometimes damaged (during blanket removal)	-10 to -5	
4.26 Airframe invariably damaged (during blanket removal)	-15 to -10	
4.27 High man-hour req's. for removal	-10 to -5	
4.3 Damaged Blankets		
4.31 Damage due to lack of protective means	-2	
4.32 Damage due to delicacy of blanket	-3	
4.33 High incidence (due to 4.31)	-5 to -1	
4.34 High incidence (due to 4.32)	-10 to -5	
4.35 High incidence of non-repairable blankets	-15 to -5	
4.36		
4.4 Repair		
4.41 Difficult to repair	-5	
4.42 Difficult to repair in place	-2	
4.43 Repair mat'ls difficult to obtain	-1	
4.5 Reinstallation		
4.51 Fastening means not always reusable	-4	
4.52 Spare fasteners not always available	-1	
4.53 High reinstallation man-hours	-10 to -5	
4.6 Replacement (Spare) Blankets		
4.61 Blankets not always available (if stocked)	-2	
4.62 If blankets made up, not stocked:		
4.621 Mat'ls not always available	-2	
4.622 Special tools, if req'd, not always available	-1	
4.623 Special skills or techniques req'd.	-2	
4.624 High blanket assembly man-hours	-4	
Sub-Total: (Item 4.)		

Figure 25. Evaluation Form.