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Flight Service Evaluation of Composite Components on the Bell Helicopter Model 206L

Final Report

Henry Wilson

Bell Helicopter TEXTRON
A Subsidiary of Textron Inc.

Fort Worth, TX 76101

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by

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Prepared under Contract NAS1-15279

Bell Helicopter Textron
Fort Worth, Texas 76121

FOREWORD

This is the final contract report pertaining to the flight service evaluation of advanced composite components on a series of Bell Helicopter Textron, Inc. (Bell) Model 206L LongRanger helicopters. The work was jointly sponsored by NASA Langley Research Center and the Vehicle Structures Directorate, Army Research Laboratory under Contract NAS1-15279. Previous reports have described the fabrication of the parts, as well as periodic test results. This reports contains all of the test data from the earlier reports, as well as new data collected after 1986. The NASA Langley Technical Monitor for this program is Mr. Donald J. Baker. The Bell Project Engineer is Mr. Henry Wilson.

Acknowledgement is made of the 206L commercial operators who have participated in this program, and who are identified in the body of this report. A special thanks is warranted for the many Bell Helicopter Customer Support Representatives for their efforts in maintaining accurate records and conducting thorough inspections.

Material names or codes and suppliers are identified herein for completeness in defining and providing traceability of the types of materials and processes utilized. In no case does such identification imply recommendation or endorsement of the material by NASA or Vehicle Structures Diretorate, nor does it imply that the materials are necessarily the only ones or the best ones available for the purpose of this program.

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1. INTRODUCTION

The Flight Service Evaluation Program began in 1978 as a joint contract between NASA Langley Research Center, U.S. Army and Bell Helicopter Textron, Inc. The primary objective of this program was to evaluate composite parts in field service environments throughout North America. At the time of the program inception, little was known regarding the performance and maintainability of composite parts over very long periods of time. The information obtained from this program was intended to provide valuable insight to the potential of using composite materials in active, and sometimes extremely harsh, environments for extended periods of time.

There have been two significant phases to this test program. The first of which was to evaluate actual flying components on light helicopters in various operating environments. The aircraft model chosen for this program was the Bell Model 206L LongRanger. This model aircraft, as well as its predecessor the JetRanger, has been in service throughout the world for over 20 years. These helicopters often operate in adverse conditions, far removed from advanced maintenance facilities, thereby requiring a high degree of reliability.

Four distinct operating environments were selected for this program: 1) Arctic Northwestern (Alaska) for a cold and dry climate; 2) Southwestern United States for a hot and dry climate; 3) Northeastern United States (New York) and Eastern Canada for a cold and wet climate; and 4) Gulf of Mexico coastal area for a hot and humid climate (mostly offshore operation). Figure 1 is a map of the 4 operating regions.

Of the 160 parts initially produced for this program, 19 are still in service at this time. One hundred and one (101) parts have been destructively tested, 16 parts have been destroyed in various incidents, and 24 parts have been lost or transferred to unknown aircraft. Figure 2 is a pie chart indicating the final status of the parts in this program. Figure 3 is a histogram of the components which indicates the approximate dates at which parts were removed from service. The second portion of this program was to evaluate exposed test coupons fabricated from materials representative of those used for the helicopter components. Correlations between the property retention characteristics of the flight components and the test coupons have been a secondary objective of this program.

Section 2 of this report provides an overview of the program, description of the selected components and their primary functions on the aircraft, and identification of the predominant loadings for each part. Additionally, the program status is provided by operational regions. The number of components, number of flight hours, time of installation, and other component information is provided. Section 3 contains descriptions of the service experiences of the components. Information regarding operator comments, field repairs, and other problems are included. Section 4 presents the results for all of the destructively tested components which were recalled from service. Descriptions of testing procedures are included, as well as discussions of failure modes. The test data is present in both tabular and graphical form, sorted by component type. Section 5 is a summary of the exposure coupon test results and includes a comparison to the component test data. Final conclusions are presented in Section 6.

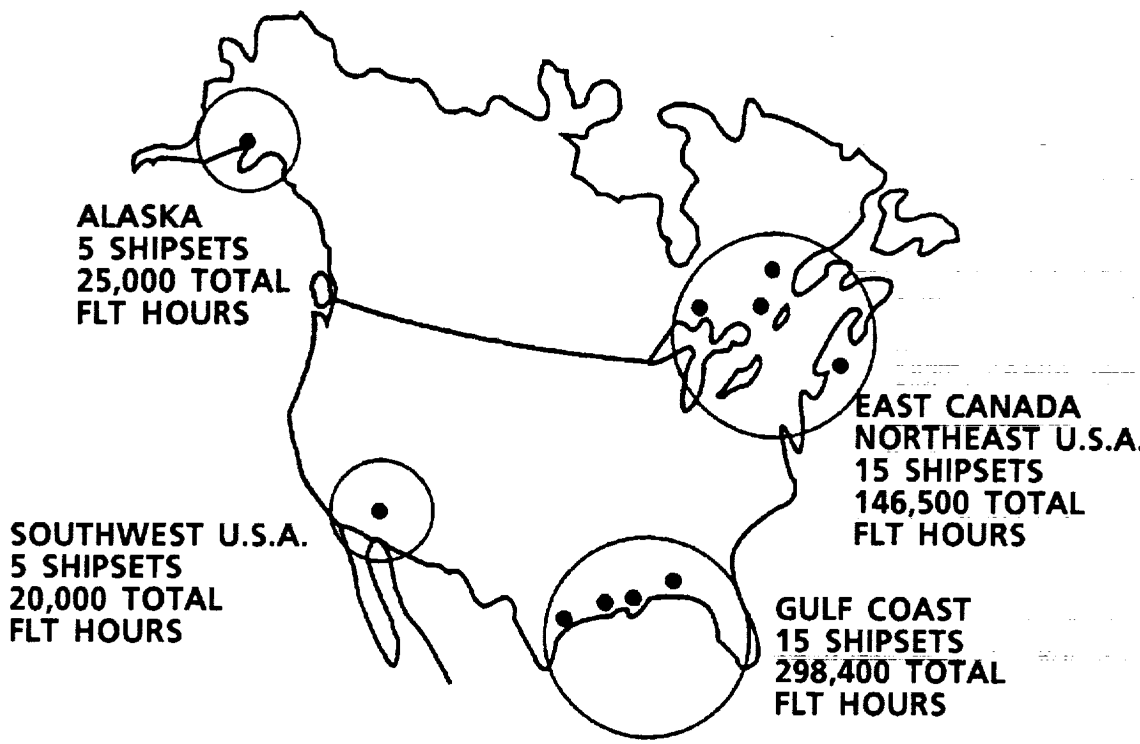

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Figure 1. Flight Service Evaluation Operating Regions

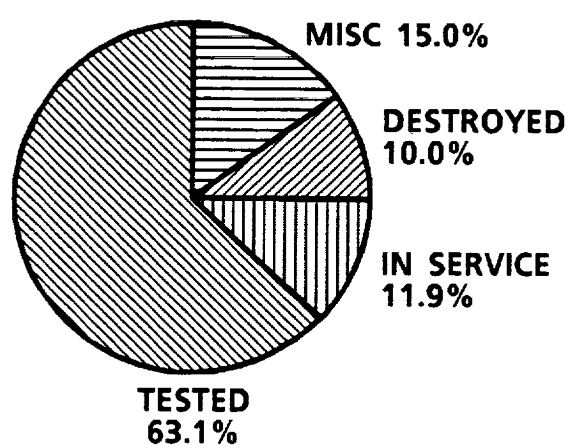

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Figure 2. Final Part Status - Total Program

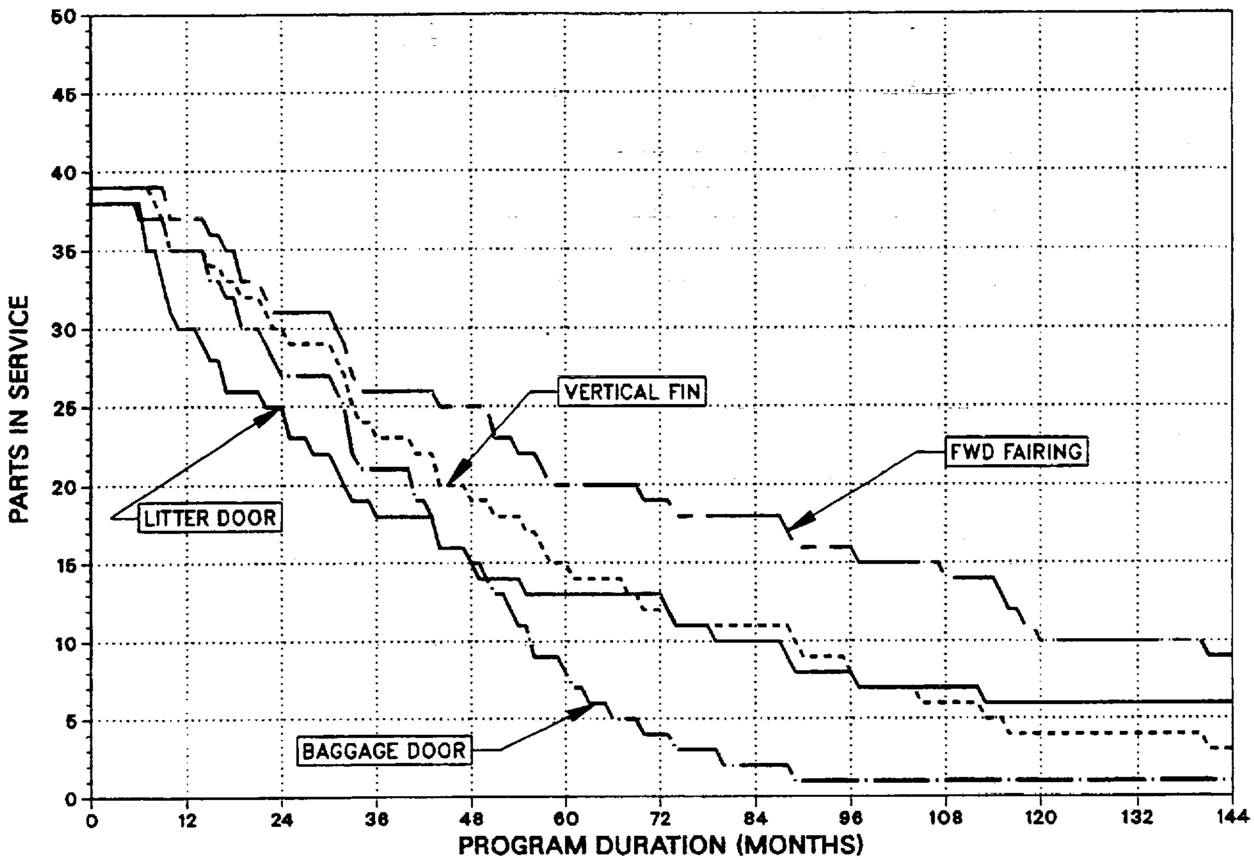

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Figure 3. Component Service History

2. PROGRAM OVERVIEW

2.1 COMPONENT SELECTION

The contract statement of work for this program set forth several requirements relating to the selection of the components to be studied. They were: 1) components must be external structure, fully exposed to operating environments, 2) components must be certified by the FAA, 3) parts must be built in a production environment and 4) components must be installed on a large enough sampling of helicopters in diverse environments to adequately examine environmental effects. Based upon these requirements, four parts were selected on the Model 206L: 1) vertical fin, 2) forward fairing, 3) litter door, and 4) baggage door. Figure 4 is a schematic indicating the location of each of these parts on the 206L helicopter. The following sections describe the construction of the parts, as well as their function on the airframe. Reference 1 contains detailed descriptions of the parts, as well as the fabrication methods of each.

2.1.1 Vertical Fin

The vertical fin is attached to the aft end of the tailboom, and is used for lateral directional stability. Loads are generally induced into the vertical fin by three sources: 1) distributed aerodynamic loads along the surface, 2) oscillatory loads caused primarily by main rotor wake impingement on the surface and by the tailrotor which rotates just to the left of the vertical fin (see Figure 4), and from 3) tail down landings. The vertical fin is a sandwich structure made from T300/E-788[1] graphite/epoxy skins over a high-strength fibertruss fiberglass honeycomb core[2], 1.25 inches in depth. The leading edge is constructed of Kevlar/epoxy, and the trailing edge is made of graphite/epoxy. The stinger (tail bumper) is a filament wound fiberglass tube, attached to the lower end of the fin. Lightning protection is provided by 200-grid aluminum alloy screens bonded to the outer surface of each fin face. Figure 5 is a photograph of the vertical fin. This part weighed 12.3 lb, yielding a 19.6% weight savings over the production aluminum vertical fin.

2.1.2 Forward Fairing

The forward fairing attaches to the roof of the fuselage, providing a smooth surface over the leading edge of the engine cowling (see Figure 4). Additionally, this part is often used to mount communication antennas by the operators in the field. This part is loaded primarily from aerodynamic surface loads.

The fairing has a single curvature at its aft end that changes to a severe double curvature in the vicinity of the forward end. Figure 6 is a photograph of this part. The fairing is a sandwich structure which uses a single ply of 281/CE306[3] Kevlar/epoxy for the inner and outer facesheets. The core is 0.38 inches thick Klegecell foam.[4] This part has a weight of 8.6 lb, which is 1.34 lb less than the production aluminum fairing (15.6% weight savings).

2.1.3 Litter Door

The litter door is located on the left side of the aircraft, between the crew and cabin doors. The cabin door is hinge-mounted on the aft edge of the litter door, which in turn is mounted on the airframe by two hinges at the forward edge (see Figure 7). The litter door is used primarily to load oversized cargo into the passenger cabin. This component is constructed by separately curing the inner and outer skins, and then bonding them together with Narmco 1113 adhesive.[5] The outer skin is made from two plies of 281/F-185 Kevlar/epoxy fabric, and one ply of 220/F-185 Kevlar/epoxy fabric. The inner skin is made of three plies of 281/F-185 Kevlar/epoxy fabric, reinforced with unidirectional Kevlar/F-560 tape.[2] The inner skins were formed into hat sections to provide additional stiffness where required. Figure 8 is a photograph showing the litter door

---

1 Manufactured by U.S. Polymeric Co., Santa Ana, CA.
2 Manufactured by the Hexcel Corp., Dublin, CA.
3 Manufactured by Ferro Corporation, Culver City, CA.
4 Manufactured by the Klegecell Corporation, Grapevine, TX.
5 Manufactured by Narmco Division of Celanese Corp., Costa Mesa, CA.

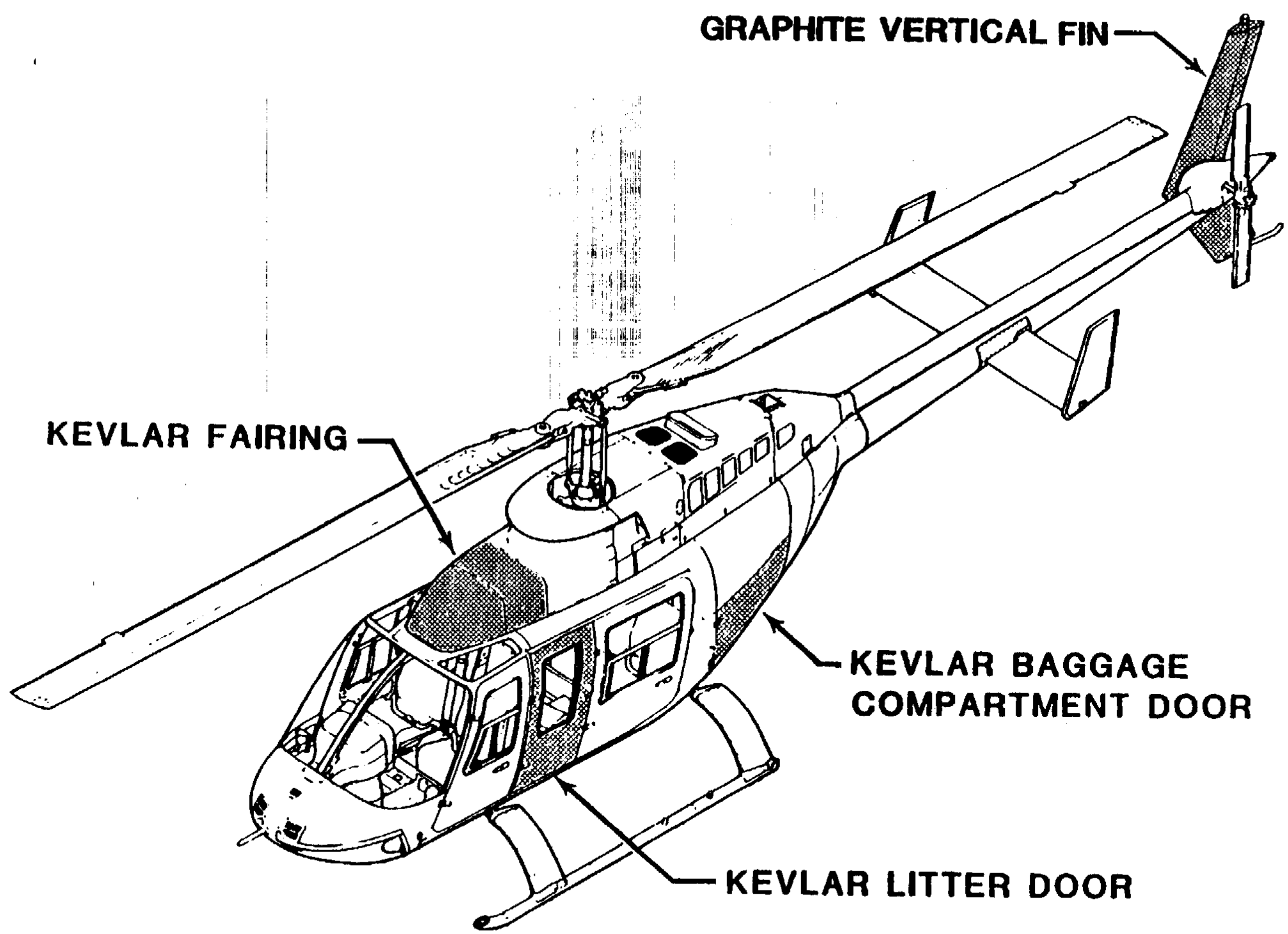

Figure 4. Location of Composite Parts on the 206L

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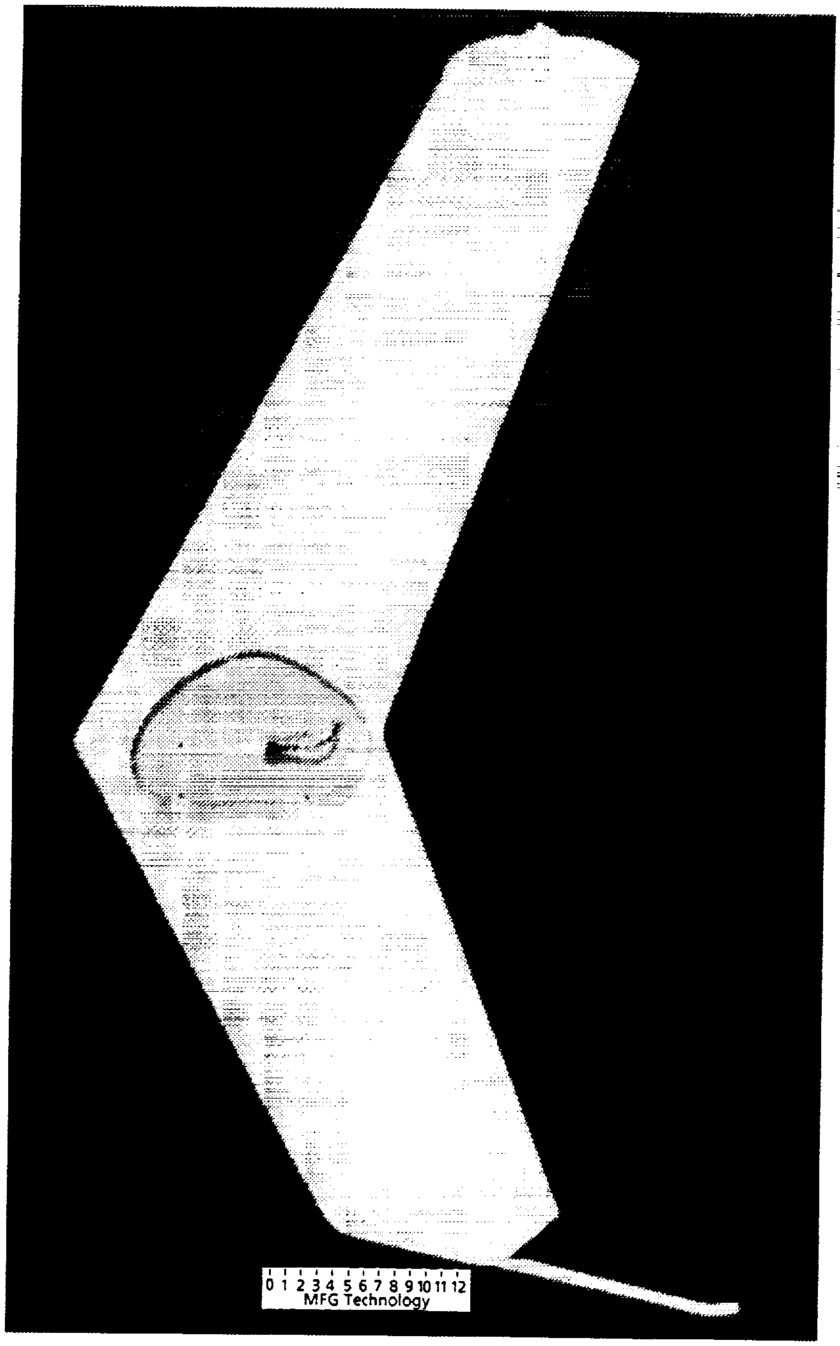

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Figure 5. Graphite/Epoxy Vertical Fin

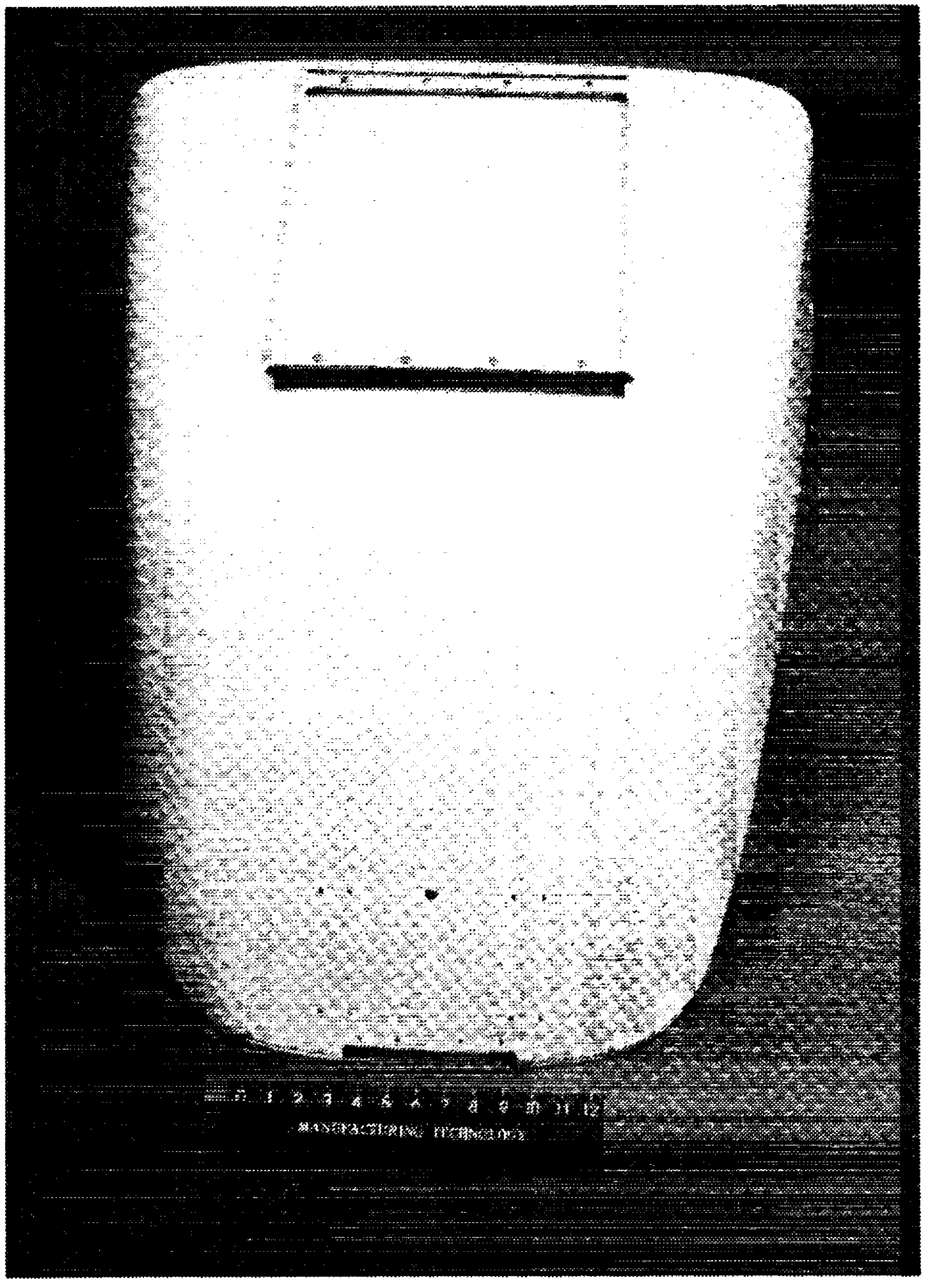

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Figure 6. Kevlar/Epoxy Forward Fairing

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Figure 7. Litter Door in Open Position

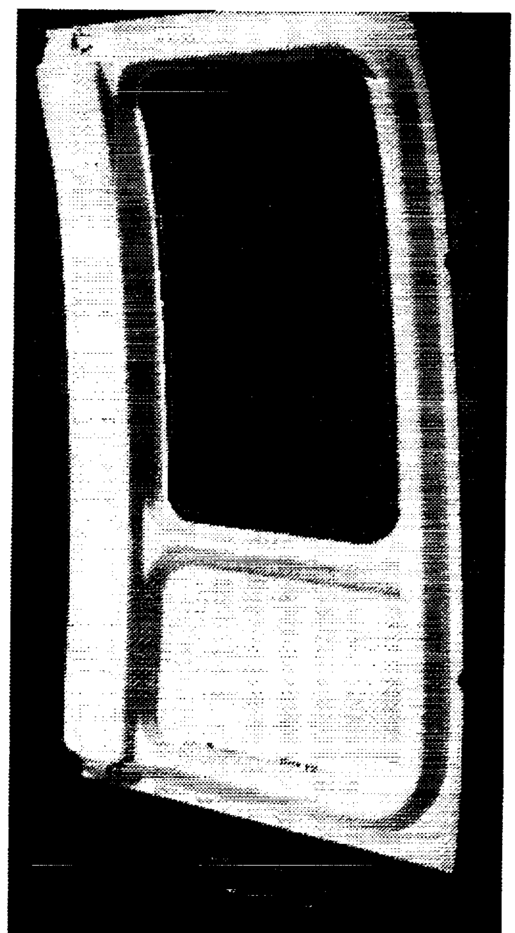

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Figure 8. Kevlar Epoxy Litter Door, Inner View

construction. The plexiglass window was bonded directly to the door after the skins were bonded together. Weight savings on this part was 4.9 lb (37.4%) over the production metal door.

2.1.4 Baggage Door

The baggage door is located on the left side of the aft section of the fuselage as shown in Figure 4. In addition to aerodynamic loads, and loads caused by normal handling of the door, impact loads may be induced as a result of shifting cargo or by rotor wake causing an open door to slam shut. The baggage door was the only component which was not manufactured by Bell Helicopter. This part was fabricated by the Brunswick Defense Division of Lincoln, Nebraska, using a conventional hand layup of Kevlar-49 fabric/LRF-277[6] epoxy over a Nomex honeycomb core. An adhesive was used between the core and the inner facesheet only, and the entire assembly was cured together. After the curing process, the part was trimmed and clean-cut holes for the lock and latches were made with a water jet cutter. Figure 9 is a photograph of the finished door. The composite part had exactly the same weight as the metal part (2.9 lb).

2.2 PROGRAM STATUS

This section contains a brief summary of the specific composite parts used in this study. Table I is a summary of the total flight hours and service months of the four composite components. This table also provides a breakdown as to the final status of each part. Figure 10 is a set of pie charts depicting this final status. Table II is a complete listing of every aircraft, and includes the flight hours and service time (in months) for each part. The final status of each part is also listed in this table. For the parts which have been tested, the reference to the test data is given. The test results for every part are reported in Section 4. Table II is broken into five sub-tables: II-A for the Northwest Region, II-B for the Southwest Region, II-C for the Northeast Region, and II-D for the Gulf of Mexico Coastal Region.

A total of 160 parts were placed into service throughout North America (40 ship sets of four parts each). Initially, 11 different operating agencies were issued composite parts as part of this study. Five operators in the North-eastern United States and Eastern Canada were issued a total of 15 ship sets, and four operators in the gulf coast region were provided a total of 15 ship sets. The bulk of the parts were placed in these two regions due to the fact that these regions of North America had a greater number of operating aircraft than other regions (primarily oil related industries). In the Southwest United States, five ship sets were issued to a single operator. Similarly, five sets were given to an operator based in Alaska to study the parts in the arctic regions of North America. Over the course of this program, four of these companies have ceased to conduct business; two in Canada, and two along the gulf coast. Additionally, many of the aircraft originally in this program have been sold to other operators with the composite parts installed. By the end of this program, a total of 20 operators have used aircraft with initial inventory composite parts installed. Each subsection below is a summary of the activities in the operating regions.

2.2.1 Northwest Region

ERA Helicopters was the only operator participating in this region. ERA is based in Anchorage, Alaska, with aircraft operating throughout Alaska. They were issued five ship sets of parts (20 total) at the beginning of this program. These 20 parts accumulated a total of 24,869 flight hours over the course of the program; yielding an average of 1,243 hours per part. The average part spent approximately 43 months in operation (see Table II-A). The litter doors did not record a significant amount of flight time due to early problems with the hinges. The adverse weather conditions in this region did not cause any apparent problems peculiar to these composite parts. Two parts from this region are listed as "unknown." Both parts (one vertical fin and one litter door) were removed from their respective helicopters for scheduled repainting, and the operator was unable to locate them. ERA still has three forward fairings in operation, which had recorded a total of 5,734 flight hours as of the last inspection. The fairing on A/C 45108 has recorded the most flight time in this region – 2,631 flight hours at the last inspection, and has been operating on this helicopter for approximately 10

6 Kevlar/epoxy matrix manufactured by the Brunswick Defense Division, Lincoln, NB.

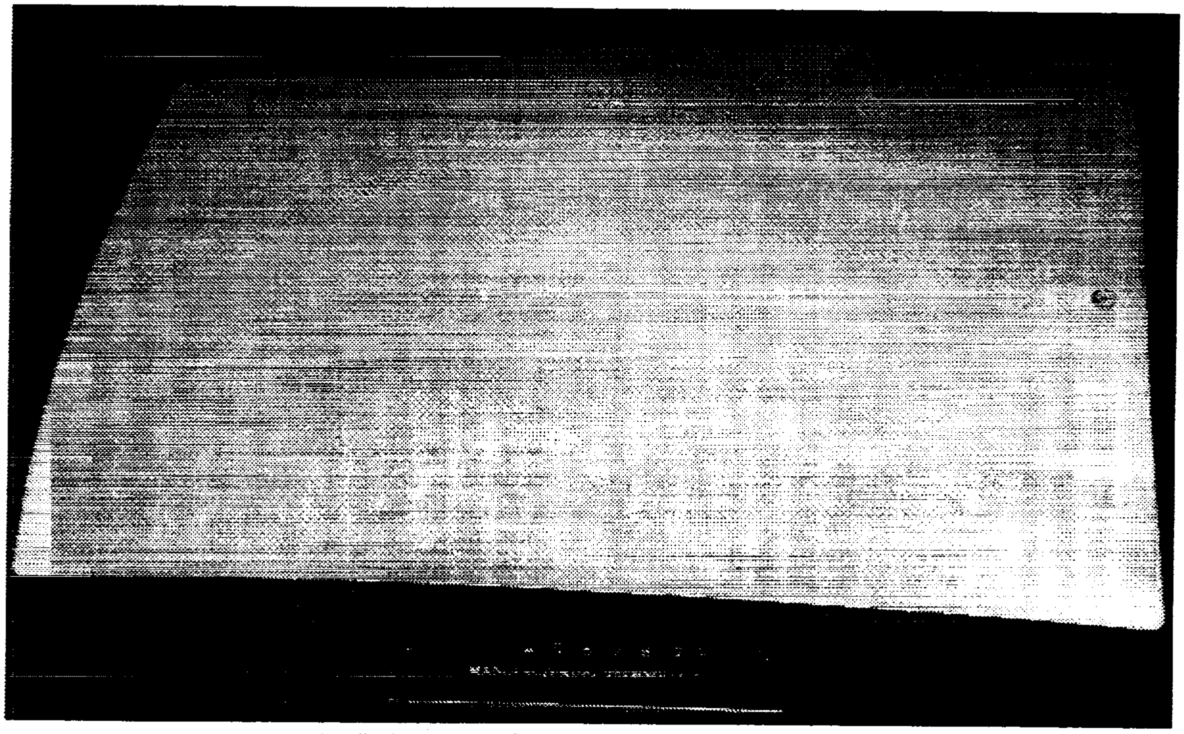

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Figure 9a. Kevlar/Epoxy Baggage Door, Outer View

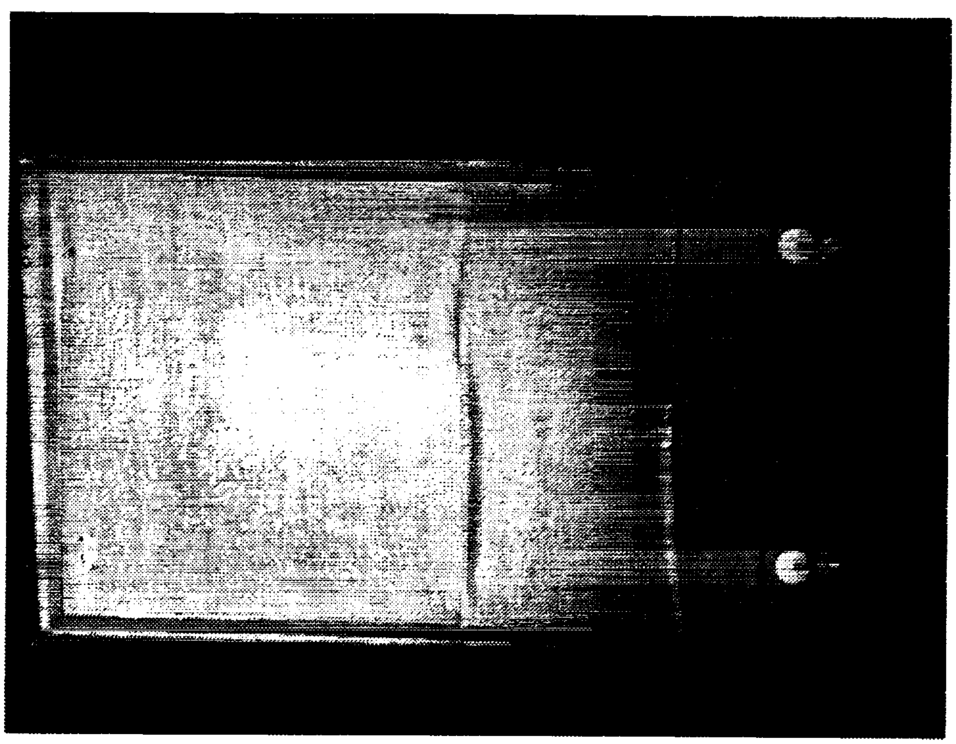

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Figure 9b. Kevlar/Epoxy Baggage Door, Inner View

TABLE I. TOTAL PROGRAM SUMMARY

COMPONENT	NUMBER OF PARTS				TOTAL FLIGHT HOURS	TOTAL MONTHS INSTALLED
	TESTED	IN SERVICE	DESTROYED	UNKNOWN		
VERTICAL FIN	25	3	7	5	133,818	2,243
FWD FAIRING	23	9	3	5	151,729	2,628
LITTER DOOR	26	6	2	6	116,539	1,881
BAGGAGE DOOR	27	1	4	8	87,789	1,642
TOTALS	101	19	16	24	489,875	8,394
				AVG/PART	3062	52

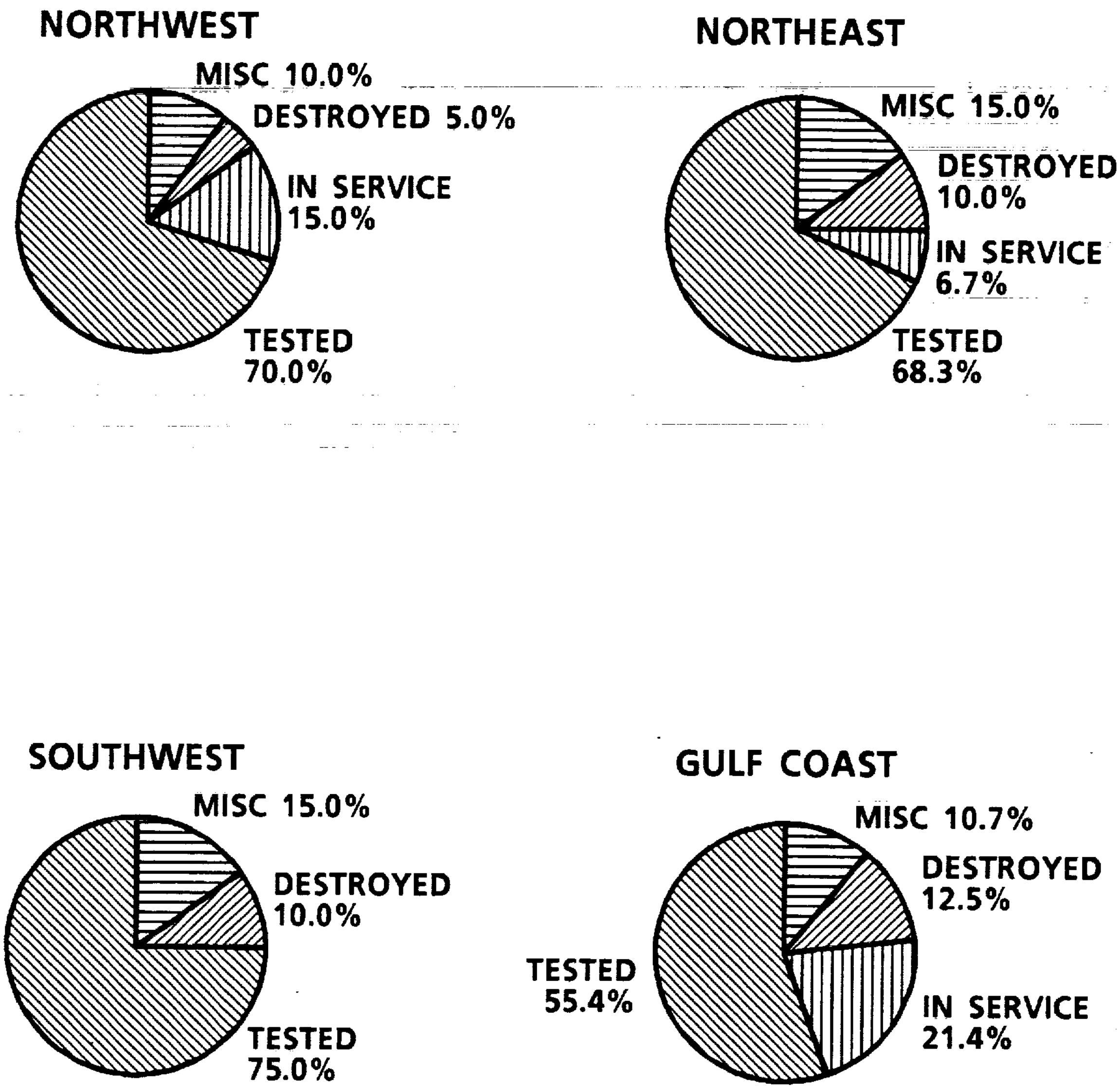

Figure 10. Final Part Status

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TABLE II-A
NORTHWEST REGION

PRIME OPERATOR: ERA HELICOPTERS
PRIMARY OPERATING LOCATION: ALASKA

S/N	COMPONENT	HOURS	MONTHS	FINAL STATUS	TEST DATA	COMMENTS
45108	VERTICAL FIN	970	25	TESTED	ML-B01	– MINOR DAMAGE
	FWD FAIRING	2631	75	IN SERVICE		
	LITTER DOOR	970	25	TESTED	ML-B02	– INITIAL PROBLEMS WITH HINGES FITTING
	BAGGAGE DOOR	2004	61	TESTED	ML-403	– MINOR DAMAGE
45109	VERTICAL FIN	1284	44	UNKNOWN		– REMOVED EARLY FOR PAINTING – NEVER LOCATED
	FWD FAIRING	1692	57	IN SERVICE		
	LITTER DOOR	534	17	TESTED	ML-400	– REMOVED EARLY DUE TO HINGE FIT PROBLEMS
	BAGGAGE DOOR	1284	44	TESTED	ML-404	
45113	VERTICAL FIN	1772	51	TESTED	ML-17	*** A/C SPENT TIME IN CALIFORNIA ***
	FWD FAIRING	1772	51	TESTED	ML-15	
	LITTER DOOR	1111	36	UNKNOWN		– REMOVED IN 1984 – NEVER LOCATED
	BAGGAGE DOOR	1772	51	TESTED	ML-402	
45114	VERTICAL FIN	1199	48	TESTED	ML-B02	
	FWD FAIRING	1411	61	IN SERVICE		
	LITTER DOOR	1199	48	TESTED	ML-B01	
	BAGGAGE DOOR	592	34	TESTED	ML-401	
45115	VERTICAL FIN	668	32	DESTROYED		– EXTENSIVE DAMAGE – RETURNED BUT NOT TESTED
	FWD FAIRING	668	32	TESTED	REF 3	
	LITTER DOOR	668	32	TESTED	REF 3	
	BAGGAGE DOOR	668	32	TESTED	REF 3	

REGIONAL SUMMARY
ARCTIC NORTHWEST

	NUMBER OF PARTS				TOTAL FLIGHT HOURS	TOTAL MONTHS INSTALLED
COMPONENT	TESTED	IN SERVICE	DESTROYED	UNKNOWN		
VERTICAL FIN	3	0	1	1	5893	200
FWD FAIRING	2	3	0	0	8174	276
LITTER DOOR	4	0	0	1	4482	158
BAGGAGE DOOR	5	0	0	0	6320	222
TOTALS	14	3	1	2	24869	856
				AVG PER PART	1243	43

2-L499

TABLE II-B
SOUTHWEST REGION

PRIME OPERATOR: AIR SERVICES INTERNATIONAL
PRIMARY OPERATING LOCATION: ARIZONA

S/N	COMPONENT	HOURS	MONTHS	FINAL STATUS	TEST DATA	COMMENTS
45418	VERTICAL FIN	1678	41	TESTED	ML-20	- REMOVED AND INSTALLED ON 45259
	FWD FAIRING	1419	54	TESTED	ML-16	
	LITTER DOOR	13	7	TESTED	ML-142	- WARPAGE IN DOOR FRAME (REF 2, PG. 23)
	BAGGAGE DOOR	1419	54	TESTED	ML-122	*** A/C SPENT TIME IN COLORADO ***
45607	VERTICAL FIN	1992	57	TESTED	ML-22	*** A/C SPENT TIME IN COLORADO ***
	FWD FAIRING	1992	57	TESTED	ML-A02	
	LITTER DOOR	22	7	TESTED	ML-143	- WARPAGE IN DOOR FRAME (REF 2, PG. 23)
	BAGGAGE DOOR	20	6	TESTED	ML-A82	- RETURNED DUE TO DELAMINATIONS
45608	VERTICAL FIN	2213	58	TESTED	ML-21	*** A/C SPENT TIME IN UTAH ***
	FWD FAIRING	2213	58	UNKNOWN		- INSTALLED AT TIME OF A/C SALE
	LITTER DOOR	374	9	UNKNOWN		- REMOVED FOR PAINTING - NEVER LOCATED
	BAGGAGE DOOR	948	24	TESTED	ML-121	
45609	VERTICAL FIN	781	17	DESTROYED		- DAMAGED IN HARD LANDING 8/83
	FWD FAIRING	781	17	UNKNOWN		- NEVER INSTALLED AFTER ACCIDENT - NEVER LOCATED
	LITTER DOOR	781	17	TESTED	ML-A84	- NEVER INSTALLED AFTER ACCIDENT
	BAGGAGE DOOR	781	17	DESTROYED		- DAMAGED IN HARD LANDING 8/83
45614	VERTICAL FIN	881	23	TESTED	ML-23	- DAMAGED IN HARD LANDING 3/84
	FWD FAIRING	881	23	TESTED	ML-A01	- DAMAGED IN HARD LANDING 3/84
	LITTER DOOR	9	7	TESTED	ML-141	- WARPAGE IN DOOR FRAME (REF 2, PG. 23)
	BAGGAGE DOOR	881	23	TESTED	ML-186	- DAMAGED IN HARD LANDING 3/84

REGIONAL SUMMARY
SOUTHWEST

	NUMBER OF PARTS				TOTAL FLIGHT HOURS	TOTAL MONTHS INSTALLED
COMPONENT	TESTED	IN SERVICE	DESTROYED	UNKNOWN		
VERTICAL FIN	4	0	1	0	7545	196
FWD FAIRING	3	0	0	2	7286	209
LITTER DOOR	4	0	0	1	1199	47
BAGGAGE DOOR	4	0	1	0	4049	124
TOTALS	15	0	2	3	20079	576
				AVG PER PART	1004	29

2-L500

TABLE II-C

NORTHEAST U.S. & EASTERN CANADA REGION

PRIME OPERATOR: HELI-VOYAGEUR
PRIMARY OPERATING LOCATION: EASTERN CANADA

S/N	COMPONENT	HOURS	MONTHS	FINAL STATUS	TEST DATA	COMMENTS
45017	VERTICAL FIN	901	33	TESTED	ML-09	*** ALL PARTS REMOVED AFTER COMPANY ***
	FWD FAIRING	901	33	TESTED	ML-02	*** FILED FOR BANKRUPTCY ***
	LITTER DOOR	901	33	TESTED	ML-04	
	BAGGAGE DOOR	901	33	TESTED	ML-051	
45028	VERTICAL FIN	1166	33	TESTED	ML-10	*** ALL PARTS REMOVED AFTER COMPANY ***
	FWD FAIRING	1166	33	TESTED	ML-01	*** FILED FOR BANKRUPTCY
	LITTER DOOR	687	25	TESTED	ML-06	- INSTALLED LATE DUE TO HINGE FIT PROBLEMS
	BAGGAGE DOOR	1166	33	TESTED	ML-052	
45085	VERTICAL FIN	1369	31	TESTED	REF 3	
	FWD FAIRING	1369	31	TESTED	REF 3	*** TEST DATA FOR A/C 45028 IN ***
	LITTER DOOR	1369	31	TESTED	REF 3	*** REF 3 IS ACTUALLY FOR 45085 ***
	BAGGAGE DOOR	1369	31	TESTED	REF 3	

PRIME OPERATOR: TRANSPORT CANADA (COAST GUARD)
PRIMARY OPERATING LOCATION: EASTERN CANADA

S/N	COMPONENT	HOURS	MONTHS	FINAL STATUS	TEST DATA	COMMENTS
45083	VERTICAL FIN	3987	113	TESTED	ML-B04	
	FWD FAIRING	3987	113	IN SERVICE		- REPLACEMENT PART AWAITING HINGE REPLACEMENT
	LITTER DOOR	3987	113	TESTED	ML-B03	
	BAGGAGE DOOR	1696	56	TESTED	ML-185	- RETURNED AND TESTED AFTER 1986 RECALL NOTICE
46007	VERTICAL FIN	3585	97	TESTED	ML-B03	
	FWD FAIRING	3585	97	TESTED	ML-B02	
	LITTER DOOR	3585	97	TESTED	ML-B04	
	BAGGAGE DOOR	1824	48	TESTED	ML-111	- RETURNED AND TESTED AFTER 1986 RECALL NOTICE

TABLE II-C (CONT.)
NORTHEAST U.S. & EASTERN CANADA REGION

PRIME OPERATOR: ISLAND HELICOPTER
PRIMARY OPERATING LOCATION: LONG ISLAND, NEW YORK

S/N	COMPONENT	HOURS	MONTHS	FINAL STATUS	TEST DATA	COMMENTS
45101	VERTICAL FIN	1413	22	TESTED	REF 2	
	FWD FAIRING	1413	22	TESTED	REF 2	
	LITTER DOOR	1413	22	TESTED	REF 2	
	BAGGAGE DOOR	1413	22	TESTED	REF 2	
45450	VERTICAL FIN	2661	36	TESTED	REF 3	- LIGHTNING STRIKE FIN TESTED IN 1985
	FWD FAIRING	3731	51	UNKNOWN		- INSTALLED AFTER SALE TO HELI-AIR - NOT FOUND
	LITTER DOOR	300	14	TESTED	ML-B06	- REMOVED AFTER SHORT TIME AND NOT RE-INSTALLED
	BAGGAGE DOOR	314	15	DESTROYED		- EXTENSIVE DAMAGE PREVENTED TESTING
46610	VERTICAL FIN	3558	61	UNKNOWN		- FIN PLACED ON 45076 -A/C LOST IN LEGAL DISPUTE
	FWD FAIRING	7666	108	TESTED	ML-B01	
	LITTER DOOR	1511	50	TESTED	ML-B05	- SPENT TIME OFF A/C AND STORED IN THE HANGAR
	BAGGAGE DOOR	7666	80	TESTED	ML-B07	

PRIME OPERATOR: ROYAL CANADIAN MOUNTED POLICE (R.C.M.P.)
PRIMARY OPERATING LOCATION: EASTERN AND WESTERN CANADA

S/N	COMPONENT	HOURS	MONTHS	FINAL STATUS	TEST DATA	COMMENTS
45086	VERTICAL FIN	4139	116	TESTED	ML-D06	
	FWD FAIRING	4139	116	TESTED	ML-D01	
	LITTER DOOR	2865	73	TESTED	ML-D04	
	BAGGAGE DOOR	2418	60	UNKNOWN		- REMOVED FOR TESTING BUT NEVER TESTED AT BHTI
45414	VERTICAL FIN	4479	90	TESTED	ML-D05	
	FWD FAIRING	5305	118	TESTED	ML-D02	
	LITTER DOOR	3905	79	TESTED	ML-D03	
	BAGGAGE DOOR	2293	41	UNKNOWN		- REMOVED FOR TESTING BUT NEVER TESTED AT BHTI

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TABLE II-C (CONT.)
NORTHEAST U.S. & EASTERN CANADA REGION

PRIME OPERATOR: TRANS-QUEBEC HELICOPTERS
PRIMARY OPERATING LOCATION: EASTERN CANADA

S/N	COMPONENT	HOURS	MONTHS	FINAL STATUS	TEST DATA	COMMENTS
45026	VERTICAL FIN	1485	44	DESTROYED		*** A/C SOLD TO KENTUCKY HELI IN 1985 ***
	FWD FAIRING	1485	44	DESTROYED		*** AND DESTROYED IN A PAINT SHOP FIRE ***
	LITTER DOOR	1485	44	DESTROYED		*** NO PARTS RECOVERED ***
	BAGGAGE DOOR	1485	44	DESTROYED		
45134	VERTICAL FIN	208	8	DESTROYED		- DAMAGED IN 1983 AND NOT REPAIRABLE
	FWD FAIRING	5122	92	IN SERVICE		- CURRENTLY OPERATED BY UNIVERSAL HELICOPTERS
	LITTER DOOR	2395	44	UNKNOWN		- REMOVED & RETURNED TO BHTI BUT NOT LOCATED
	BAGGAGE DOOR	2401	43	TESTED	ML-13	
45141	VERTICAL FIN	870	15	TESTED	REF 2	
	FWD FAIRING	870	15	TESTED	REF 2	
	LITTER DOOR	870	15	TESTED	REF 2	
	BAGGAGE DOOR	870	15	TESTED	REF 2	
45143	VERTICAL FIN	1969	55	UNKNOWN		- NOT INSTALLED WHEN SOLD TO COUGAR HELI IN 1986
	FWD FAIRING	4268	117	IN SERVICE		- CURRENTLY OPERATED BY UNIVERSAL HELICOPTERS
	LITTER DOOR	1969	55	UNKNOWN		- NOT INSTALLED WHEN SOLD TO COUGAR HELI IN 1986
	BAGGAGE DOOR	4268	117	IN SERVICE		- CURRENTLY OPERATED BY UNIVERSAL HELICOPTERS
45439	VERTICAL FIN	3100	74	UNKNOWN		- REPORTEDLY RETURNED - NEVER RECEIVED AT BHTI
	FWD FAIRING	3100	74	UNKNOWN		- REPORTEDLY RETURNED - NEVER RECEIVED AT BHTI
	LITTER DOOR	3100	74	TESTED	ML-113	*** LATEST OPERATOR WAS VIKING HELI ***
	BAGGAGE DOOR	3100	74	TESTED	ML-112	

REGIONAL SUMMARY
NORTHEAST U.S. & EASTERN CANADA

	NUMBER OF PARTS				TOTAL FLIGHT HOURS	TOTAL MONTHS INSTALLED
COMPONENT	TESTED	IN SERVICE	DESTROYED	UNKNOWN		
VERTICAL FIN	10	0	2	3	34890	828
FWD FAIRING	9	3	1	2	48107	1064
LITTER DOOR	12	0	1	2	30342	769
BAGGAGE DOOR	10	1	2	2	33184	712
TOTALS	41	4	6	9	146523	3373
				AVG PER PART	2422	56

TABLE II-D

GULF OF MEXICO COASTAL REGION

PRIME OPERATOR: AIR LOGISTICS

PRIMARY OPERATING LOCATION: LAFAYETTE, LOUISIANA

S/N	COMPONENT	HOURS	MONTHS	FINAL STATUS	TEST DATA	COMMENTS
45266	VERTICAL FIN	11974	141	TESTED	ML-C09	
	FWD FAIRING	11974	141	TESTED	ML-C02	
	LITTER DOOR	12584	147	IN SERVICE		
	BAGGAGE DOOR	2732	41	UNKNOWN		- REMOVED FOR UNKNOWN REASON AND NEVER LOCATED
45378	VERTICAL FIN	3387	34	TESTED	REF 3	*** BAGGAGE DOOR LISTED IN REF 3 AS 45378 ***
	FWD FAIRING	3387	34	TESTED	REF 3	*** WAS ACTUALLY FROM 45436 ***
	LITTER DOOR	1454	28	TESTED	REF 3	- SPENT TIME OFF A/C FOR HINGE PROBLEMS
	BAGGAGE DOOR	104	6	TESTED	ML-184	- RMVD PRIOR TO SHIP SET TSTNG & RETURNED LATER
45436	VERTICAL FIN	11497	105	TESTED	ML-C06	- INSTALLED ON A/C 45245 IN 1990
	FWD FAIRING	11503	120	TESTED	ML-C01	
	LITTER DOOR	14687	126	IN SERVICE		
	BAGGAGE DOOR	3528	33	TESTED	REF 3	- PART TESTED IN REF 3 BUT LISTED AS 45378 DOOR
45449	VERTICAL FIN	7972	96	DESTROYED		- HANGAR INCIDENT
	FWD FAIRING	8813	102	IN SERVICE		
	LITTER DOOR	851	6	IN SERVICE		- PRESENTLY INSTALLED ON A/C 45524
	BAGGAGE DOOR	3442	53	TESTED	ML-181	
45524	VERTICAL FIN	7399	68	TESTED	ML-C07	*** THE PARTS ON THIS AIRCRAFT WERE ***
	FWD FAIRING	10432	88	TESTED	ML-C03	*** ORIGINALLY TO BE USED BY HOUSTON ***
	LITTER DOOR	10432	88	TESTED	ML-C05	*** HELICOPTER BEFORE THEY WENT BANKRUPT ***
	BAGGAGE DOOR	4828	49	TESTED	ML-183	
45546	VERTICAL FIN	11669	106	IN SERVICE		- INSTALLED ON 45681 IN 1990
	FWD FAIRING	10461	115	TESTED	ML-C04	
	LITTER DOOR	13128	121	IN SERVICE		
	BAGGAGE DOOR	6765	56	TESTED	ML-182	

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TABLE II-D (CONT.)

GULF OF MEXICO COASTAL REGION

PRIME OPERATOR: COMMERCIAL HELICOPTERS
PRIMARY OPERATING LOCATION: LOUISIANA

S/N	COMPONENT	HOURS	MONTHS	FINAL STATUS	TEST DATA	COMMENTS
45330	VERTICAL FIN	2877	19	TESTED	ML-C08	– REMOVED FROM 45403 WHEN PURCHASED BY AIR LOG
***	FWD FAIRING	2877	19	DESTROYED		– ON 45403 WHEN INVOLVED IN MID-AIR COLLISION
SEE NOTE	LITTER DOOR	2368	11	UNKNOWN		– NOT ON 45403 WHEN PURCHASED FROM PUMPKIN AIR
BELOW	BAGGAGE DOOR	2877	19	UNKNOWN		– NOT ON 45403 WHEN PURCHASED FROM PUMPKIN AIR
45331	VERTICAL FIN	318	10	DESTROYED		– DAMAGED IN GROUND TRANSPORT ACCIDENT IN 9/82
***	FWD FAIRING	318	10	UNKNOWN		– REMOVED AFTER 9/82 ACCIDENT – NEVER LOCATED
SEE NOTE	LITTER DOOR	0	0	UNKNOWN		– FIT PROBLEMS, NEVER INSTALLED – NEVER LOCATED
BELOW	BAGGAGE DOOR	318	10	UNKNOWN		– PLACED ON 45442 – NEVER LOCATED SINCE

*** THE PARTS FROM 45330 WERE TRANSFERRED TO 45403 PRIOR TO A CRASH INVOLVING 45330 IN 1984. THIS AIRCRAFT WAS SOLD TO PUMPKIN AIR IN TEXAS WITH ALL PARTS INSTALLED. AIR LOGISTICS PURCHASED 45403 FROM AIR PUMPKIN, BUT ONLY THE FAIRING WAS INSTALLED. THE VERTICAL FIN WAS SLIGHTLY DAMAGED, AND RETURNED TO BHTI FOR TESTING AT THE TIME OF THIS SALE. THE LITTER AND BAGGAGE DOORS WERE NOT RECEIVED BY AIR LOGISTICS FROM PUMPKIN AIR. 45331 WAS INVOLVED IN A GROUND TRANSPORTATION ACCIDENT IN 1982. THE FAIRING AND LITTER DOOR WERE RETURNED TO BHTI, BUT NEVER LOCATED. THE FIN WAS COMPLETELY DESTROYED IN THE ACCIDENT. THE BAGGAGE DOOR WAS INSTALLED ON 4542 WHICH WAS LATER SOLD TO AERO ARCTIC IN WESTERN CANADA. THIS PART HAS NOT BEEN LOCATED.

PRIME OPERATOR: HOUSTON HELICOPTERS
PRIMARY OPERATING LOCATION: HOUSTON, TEXAS

S/N	COMPONENT	HOURS	MONTHS	FINAL STATUS	TEST DATA	COMMENTS
45458	VERTICAL FIN	0	0	TESTED	ML-08	*** THESE PARTS WERE ALLOCATED FOR 45458 ***
	FWD FAIRING	0	0	TESTED	ML-03	*** BUT NEVER INSTALLED. HOUSTON HELI ***
	LITTER DOOR	0	0	TESTED	ML-07	*** WENT BANKRUPT AND RETURNED ALL PARTS ***
	BAGGAGE DOOR	0	0	UNKNOWN		*** EXCEPT THE BAGGAGE DOOR. ***
45535	VERTICAL FIN	286	9	UNKNOWN		*** THESE PARTS WERE INSTALLED FOR A BRIEF ***
	FWD FAIRING	286	19	TESTED	ML-A04	*** PERIOD ON THIS AIRCRAFT PRIOR TO THE ***
	LITTER DOOR	286	9	TESTED	ML-A03	*** BANKRUPTCY OF HOUSTON HELI. ALL PARTS ***
	BAGGAGE DOOR	286	19	TESTED	ML-A01	*** RETURNED TO BHTI EXCEPT FOR THE FIN ***

TABLE II-D (CONT.)
GULF OF MEXICO COASTAL REGION

PRIME OPERATOR: PETROLEUM HELICOPTERS, INC.
PRIMARY OPERATING LOCATION: LAFAYETTE, LOUISIANA

S/N	COMPONENT	HOURS	MONTHS	FINAL STATUS	TEST DATA	COMMENTS
45160	VERTICAL FIN	4194	70	DESTROYED		*** A/C CRASHED INTO THE GULF OF MEXICO ***
	FWD FAIRING	4194	70	DESTROYED		*** ON 8/10/87 ***
	LITTER DOOR	799	10	DESTROYED		- LITTER DOOR SPENT TIME OFF A/C - HINGE PROBS.
	BAGGAGE DOOR	4194	70	DESTROYED		
45181	VERTICAL FIN	9306	132	IN SERVICE		
	FWD FAIRING	9306	132	IN SERVICE		
	LITTER DOOR	9306	132	IN SERVICE		
	BAGGAGE DOOR	3940	66	UNKNOWN		- REPORTEDLY RETURNED TO BHTI - NOT LOCATED
45367	VERTICAL FIN	6750	89	TESTED	ML-24	
	FWD FAIRING	6750	89	TESTED	ML-A03	
	LITTER DOOR	6750	89	TESTED	ML-A05	
	BAGGAGE DOOR	6750	89	TESTED	ML-19	
45373	VERTICAL FIN	879	10	TESTED	REF 2	
	FWD FAIRING	879	10	TESTED	REF 2	
	LITTER DOOR	879	10	TESTED	REF 2	
	BAGGAGE DOOR	879	10	TESTED	REF 2	
45385	VERTICAL FIN	6982	130	IN SERVICE		- REPAIRED IN 87 W/ PATCH AFTER HANGAR INCIDENT
	FWD FAIRING	6982	130	IN SERVICE		
	LITTER DOOR	6982	130	IN SERVICE		
	BAGGAGE DOOR	3593	63	UNKNOWN		- REPORTEDLY RETURNED TO BHTI - NOT LOCATED

REGIONAL SUMMARY
GULF OF MEXICO COASTAL REGION

	NUMBER OF PARTS				TOTAL FLIGHT HOURS	TOTAL MONTHS INSTALLED
COMPONENT	TESTED	IN SERVICE	DESTROYED	UNKNOWN		
VERTICAL FIN	8	3	3	1	85490	1019
FWD FAIRING	9	3	2	1	88162	1079
LITTER DOOR	6	6	1	2	80506	907
BAGGAGE DOOR	8	0	1	6	44236	584
TOTALS	31	12	7	10	298394	3589
				AVG PER PART	4973	60

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years. One vertical fin was returned in 1983 due to excessive cracking along the leading edge. The part was not repaired or tested by BHTI. A total of 14 parts from this region have been tested: 3 vertical fins, 2 forward fairings, 4 litter doors, and 5 baggage doors.

2.2.2 Southwest Region

Air Services International (ASI), based in Scottsdale, Arizona, was the only operator participating in this region. The aircraft operated by ASI, served a large region in the Western United States, including Colorado, Utah, Wyoming and Arizona. They were issued 5 ship sets of parts (20 total) at the beginning of this program. These twenty parts accumulated a total of 20,079 flight hours over the course of the program; yielding an average of 1,004 hours per part. The average part spent only 29 months in operation (see Table II-B). These totals represent the lowest numbers of any of the four regions. This fact is traced to two significant factors. First, two of the five aircraft experienced hard landings with less than two years in the program. All of the parts on these two helicopters (S/N 45609 and 45614) were removed from service after these separate accidents. Secondly, the litter doors on each aircraft in this region were removed after approximately seven months of service due to warping of the door frames. This problem was discussed extensively in Reference 2 (page 23). Although all of the doors were repaired by BHTI and returned to ASI, they were not all reinstalled. All parts were recalled from ASI, and four of these litter doors were returned after spending most of the time in storage at ASI. The fifth litter door was never located by ASI personnel. The litter doors recorded an average of 240 flight hours with an average service time of only 9 months. The vertical fins and forward fairings recorded an average of almost 1,500 hours each, and did not experience any problems peculiar to this region. The baggage doors performed well, recording an average of approximately 800 hours prior to being recalled in 1986 (see section 3.4).

2.2.3 Northeast U.S. and Eastern Canada Region

A total of five operators were originally chosen to participate in this region, which at the time of the program inception, was one of the busiest regions for helicopter activity. Four of the operators were located in Canada: Heli-Voyageur, Transport Canada (Canadian Coast Guard), Royal Canadian Mounted Police, and Trans-Quebec Helicopters. The fifth operator in this region was Island Helicopters located on Long Island, New York. Heli-Voyageur ceased operation in 1984, and all parts were returned to BHTI for testing. One of the five sets of parts operated by Trans-Quebec was returned after 15 months of service for testing (see Reference 2). The other four sets were on aircraft sold to other operators after Trans-Quebec ceased to conduct business. The other original operators have continued to participate in this program. The operators in this region have recorded very few operational problems, as compared to the other regions. The 15 ship sets in this region recorded over 36,000 hours (see Table II-C). The average part spent over four and one-half years in service, recording over 2,400 flight hours. The forward fairings spent the greatest number of hours installed on the aircraft (3,207 each), followed by the vertical fins, with an average of 2,326 hours each. The baggage doors recorded slightly more flight time than the litter doors, even though all baggage doors were recalled from service in 1986. The operators in this region had numerous problems with installation of the litter doors early in the program, which resulted in a significant amount of down time for these composite parts.

2.2.4 Gulf of Mexico Coastal Region

This region recorded more flight time on the composite parts than the other three regions combined (see Table II-D). One operator, Air Logistics, recorded over 46,000 total flight hours on six aircraft, for an average of 7,708 flight hours per part. PHI, the second busiest operator (also in this region), averaged 5,015 hours per part. Each part in this region averaged five years of service, recording almost 1000 flight hours per year. In contrast, the aircraft in the Northeast Region averaged 519 flight hours per year. The other two regions (Southwest and Northwest) averaged about 400 flight hours per year. The dramatic difference in flight hours is a reflection of the amount of time the aircraft spent in the air in the respective regions, as well as a reflection of the continuous operations of Air Logistics and PHI over the past 10 years.

The individual parts with the greatest time in service have operated in this region. Eleven parts in this region have recorded over 10,000 flight hours. All of these parts are flown on Air Logistics aircraft. The part with the greatest amount of flight hours is the forward fairing on aircraft serial number (S/N) 45449, with 14,687 hours over a period of 10 years. This part is still in service and is not reported as having any problems at all. A litter door still in service on aircraft S/N 45546 has accumulated 13,128 flight hours also over 10 years. The vertical fin from S/N 45266, which was recently tested, had recorded 11,974 flight hours in almost 12 years of service. Two baggage doors recorded over 6,700 flight hours prior to their recall - one with Air Logistics (6,765 hours), and one with PHI (6,750). The part with the greatest amount of time in service is the litter door on Air Logistics aircraft S/N 45266, with 147 months of service (over 12 years).

Two operators in this region ceased operation during this program: Commercial and Houston Helicopters. Three sets were issued to Houston Helicopters, but only one set was installed. All three sets were returned to BHTI, with the exception of two parts which were not located (see Table II-D). The set which had been installed was subsequently tested. The other two sets were issued to other operators for installation on different aircraft. The set from S/N 45458 was sent to Air Services International in Arizona, to replace the parts damaged from a hard landing on one of its aircraft. However, they did not install these parts prior to returning all of the parts for final testing. The other unused set was issued to Air Logistics in Louisiana to replace a set of parts which were recalled for annual testing (Reference 3). These parts were installed on S/N 45524, where they accumulated an average of 8,272 flight hours.

2.3 TOTAL PROGRAM SUMMARY

Figure 10 represents the final status and distribution of all parts used in this program. Twenty-four (24) parts are listed with an "unknown" status. Nine of the parts were removed by the operators for various reasons and never re-installed or located, seven parts were never recovered after the operators ceased operation, and eight parts were supposedly returned to BHTI for various reasons, but never received.

Sixteen (16) parts are listed as being "destroyed." This category includes parts which were damaged for various reasons to an extent which prevented testing or expedient repair. The reasons for these parts being removed from the program are listed in Table III.

Currently, there are 19 parts still operating at various locations. All of these parts have been

TABLE III. SUMMARY OF DESTROYED PARTS

S/N	REGION	PART(S)	DESCRIPTION
45115	N.W. U.S.	Fin	Minor Damage
45609	S.W. U.S.	Fin, Baggage	Hard Landing
45450	N.E. U.S.	Baggage Door	Impact Damage
45026	E. Canada	All Parts	A/C Burned in Hangar Fire
45134	E. Canada	Fin	Minor Damage
45160	Gulf Coast	All Parts	Crashed Into Gulf of Mexico
45330	Gulf Coast	Fairing	Mid-Air Collision
45331	Gulf Coast	Fin	Highway Accident During Ground Transportation
45449	Gulf Coast	Fin	Minor Damage

recalled within the past year but have not been removed from the respective aircraft. A total of 101 parts have been tested during this program. This represents over 60 percent of all parts originally issued. The results of the test data for these components are presented in Section 4.

3. SERVICE EXPERIENCES

A total of 82 discrepancies were reported on the 160 parts in this program. These reports are categorized as problems with the composite parts themselves, and do not include damage to parts as a result of aircraft incidents which likely would have destroyed a metal part as well (e.g., hard landings, etc.). The problems ranged from paint cracking to delaminations, and are discussed for each part below.

3.1 VERTICAL FIN

There were a total of 29 reported problems on the 40 vertical fins. Of these 29 problems, 22 described paint cracking on the leading and/or trailing edges of the fin. This problem was reported frequently throughout each region. Almost every operator attributed the paint cracking to the ground handling of the aircraft. In normal towing situations, a ground crew member walks behind the aircraft, balancing the aft end of the aircraft by holding onto the tail bumper (stinger). Additionally, the operator may grasp the leading or trailing edge for extra stability. The working of the stinger in the lower section of the vertical fin, as well as the handling of the flexible Kevlar leading edge, caused local paint cracking on the fin. Although the cracking of the paint on these parts did not degrade the structure, it did result in additional time required for painting of these fins. Metal fins may well have suffered similar paint degradation.

Two fins were reported to have separated trailing edges. However, it is noted that several other fins returned for testing showed similar problems. The aft portion of the fin consists of two graphite/epoxy face sheets bonded together. Over a period of time, this bond was found to deteriorate, especially in the areas which are handled during towing operations. It is noted that this damage did not degrade the load carrying capabilities of the fin, and no repairs were required for these fins.

Two vertical fins were reported as being struck by lightning. A detailed report on the fin from aircraft S/N 45450 operating in New York is contained in Reference 3. Static tests of this part indicated that there was no structural degradation as a result of this lightning strike. The other lightning-strike fin was recorded on aircraft S/N 45373 in the Gulf of Mexico. This part was visually inspected at PHI and allowed to continue operations. This fin was recalled as part of the first annual test process. The test results indicate no loss in strength due to the lightning strike (Reference 2).

Only one vertical fin sustained repairable damage during operations. The fin from aircraft S/N 45385 operating in the Gulf of Mexico broke loose from its moorings during high winds in 1982. The helicopter was blown into a piece of equipment and punctured the vertical fin. The repair of this fin is outlined in Reference 2. The part was returned to service and has recorded over 7000 additional flight hours without any additional problems being reported. This part is still operating on this aircraft.

Three reports have indicated problems in the area of the stinger attachment. Two of these reports were for minor cracking, which did not require any repairs. The cause of this damage was most likely due to ground handling operations, previously discussed. The third incident was a report of a damaged stinger. The stinger is a filament wound fiberglass tube, which attaches to a fitting in the lower end of the fin. The stinger on this aircraft had worn to a flattened area at the attachment location. The repair was made by applying three layers of EPON 28 Fiberglass to the worn area. After curing, the area was sanded smooth to the original shape, and re-installed without further incident.

Finally, one operator in Canada noted that the composite vertical fins became discolored from engine exhaust more so than the aluminum fins. Although the parts were easy to clean, it did require additional effort from the ground maintenance crew.

The vertical fin has had the most positive response from all operators, especially those along the coastlines (Texas, Louisiana and the Northeastern Seaboard). Most of the comments center around the corrosion resistance of these composite parts. An operator in Louisiana reported that the metal fins are sometimes covered with patches after about 6 years as a result of corrosion-related repairs. Additionally, the vertical fin had a significant weight savings over the metal parts (15%, Reference 1), which at its position at the aft end of the aircraft, provides a significant shift forward of the aircraft center of gravity. Since the LongRanger has an aft c.g. problem with nose ballast, this gives a multipling effect of the weight savings.

3.2 FORWARD FAIRINGS

The forward fairings have had the fewest reported problems of the four composite parts. Since this part does not experience high oscillatory flight loads (such as the vertical fin), and is not frequently handled (such as the baggage door), it was not expected to have many service problems. Only aircraft S/N 45546 reported any damage to the forward fairing. This part was observed to have a small crack near the right hand side latch. The damage did not require repair, and the part continued to record over 10,000 flight hours. This part was recalled from service and destructively tested in 1992. The test data from this part indicates that there was no apparent loss in strength of this part.

The only other comment frequently received on this part was regarding use of the fairing as an antenna base. Many operators generally use this part as an electrical ground for a HF antenna. Since the Kevlar fairing is non-metallic, a metal sheet had to be bonded to the inner surface of the part. Most operators bonded very thin aluminum sheets which added a negligible amount of weight. Although these modifications are minor, it is a factor which must be considered in manufacturing composite components.

3.3 LITTER DOORS

There were twenty-five reported incidents involving the composite litter doors. Four reports from the Southwest indicated that thermal buckling was occurring on the outer skins near the windows, causing the windows to break their seal. The aircraft at this location have been reported to experience external temperatures up to 250° F on comparable metal doors while sitting on the tarmac. The difference in thermal expansion between the Kevlar skins, and the windows caused the buckling problem to become apparent to the operator. A rubber seal was inserted between the glass and the Kevlar, to allow necessary expansion to occur. The litter doors were repaired and returned to service where they accumulated approximately 100 additional flight hours. Reference 2 contains a detailed description of this problem and subsequent repair. It is noted that this problem was the only environmentally related incident throughout this program.

Ten reports indicated that the litter doors had broken corners at various locations. This problem was directly related to handling incidents, and was also evident in the baggage doors. Although this did not cause any reduction in capability of the door, it did hinder the proper structural sealing of the door, as well as present aesthetic problems. The area which was breaking was outside of the hat sections, where the face sheets are bonded together to form the edge. For production purposes, this problem could be eliminated by locally strengthening the corners with additional material.

There were four reports of minor cracking in the local area around the hinge attach points. This was due to local flexibility at these locations, which allowed the hinges to be excessively worked during handling of the door. Of these four reports, none of the doors were required to be removed for repair. One of the operators, however, filled in the area around the attach point with a metal set to prevent additional cracking.

The most frequent problem with the litter doors was discovered early in the program, at the time of door installation. The original hinges used to attach the litter door to the passenger door were found to be under-designed. Almost every operator reported at least one incident of improper fit with these hinges, or broken hinges within a short period of time. These parts were replaced in 1985 with larger hinges which were found to solve all of the field hinge problems.

The litter door was rarely singled out by the operators as being any different from their metal counterparts. However, other than the early hinge problems, and the thermal buckling problems (which were all rectified), there were no complaints about the composite litter doors. This part, however, did represent the largest percentage weight savings of any of the four parts (37%, Reference 1), making it a very attractive composite application.

3.4 BAGGAGE DOORS

The baggage doors had the poorest service record of the four components in this study. As a result of the resin problems discussed in detail in Reference 3, all baggage doors were recalled from operation in December of 1986. Before that time, there had been twelve reported cases of extensive delaminations in these doors. The only other problem with these doors was with broken corners, a problem identical to that discussed in the litter door section. A total of ten cases were reported in which the baggage door corners had broken (10 separate doors). This problem was also discussed in Reference 3.

Despite the unsatisfactory performance of these baggage doors, many of the operators were pleased with them prior to the recall. The majority of the positive comments referred to the impact resistance of the Kevlar doors. Baggage doors are often subject to impact loads from shifting cargo, causing dents in the metal doors. These dents and scratches may subsequently spawn corrosive growth, as well as present a poor appearance of the door. The Kevlar doors did not experience any corrosion problems, and generally did not show dents as a result of minor impacts. It is noted that one baggage door is still in service in Northeast Canada, and has recorded almost 4500 flight hours, and has shown no signs of damage.

Future production considerations should obviously include a better resin system than that used on these doors. Additionally, the corners of the doors should be locally stiffened, as discussed with the litter doors.

4. COMPONENT TESTING

This section contains all of the test data acquired for the component testing over the course of this program. Test data gathered at the time of structural certification was used to establish the baseline strength and stiffness values of the four different parts (Reference 1).

4.1 TESTING PROCEDURES

All components were placed in fixtures which duplicated their attachment to the actual airframe, and statically tested to determine strength and stiffness. The design loads are given in Table IV-A. The stiffness data presented in this section is a linear curve fit of applied load vs. deflection at the point of greatest deflection for each part. Initial readings were made, followed by incremental static loading up to a value of 100 percent of the design limit load. The parts were then unloaded to record residual displacements, if any. The displacement gauges were then removed, and the parts were loaded to failure, to determine the ultimate strength of each part. Each section below describes in brief detail the testing procedures for each of the four components. A comprehensive description of the testing methods is found in Reference 1.

4.1.1 Vertical Fin

The vertical fin was attached to a large base structure, simulating the fin-to-fuselage installation, as shown in Figure 11. Load was applied to the fin by incrementally adding lead shot bags across the surface of the vertical fin, in a manner similar to an aerodynamic loading. Displacement was measured at the upper tip of the fin, using a tube scale. A total of 25 vertical fins were tested. Failure of every vertical fin occurred approximately 10 inches above the upper set of fuselage attach bolts in bending compression of the facesheet (Figure 12).

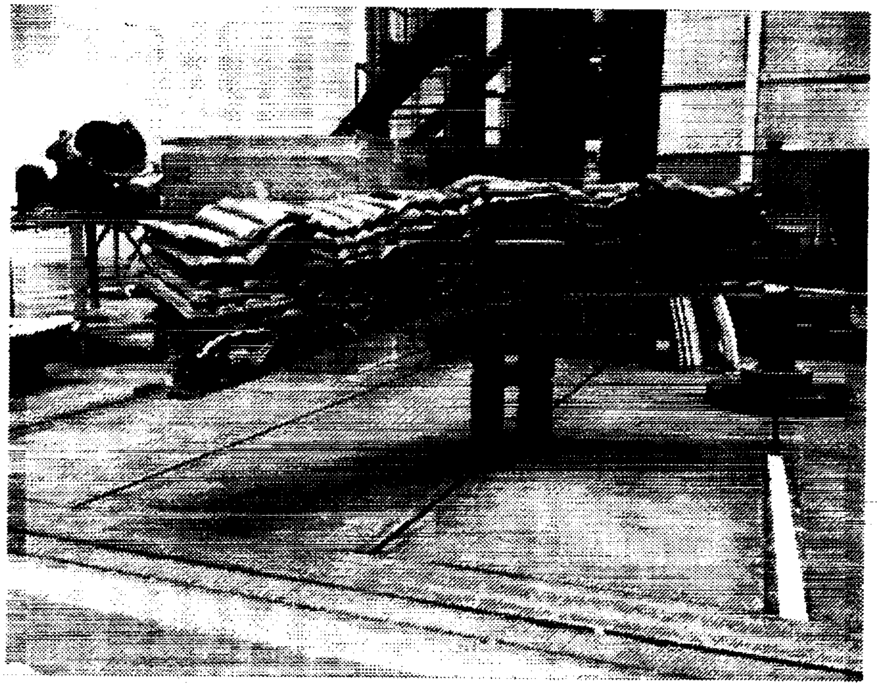
4.1.2 Forward Fairing

Figure 13 displays the test apparatus for the fairing. Due to the shape of this part, aerodynamic pressure testing had to be conducted using a vacuum chamber. Deflection measurements were made at the center of the upper side of the fairing as shown in Figure 14. The fairing was found to deflect very little for the design limit load, thereby making deflection comparisons difficult. There were two distinct failure modes for the forward fairings. A total of 23 fairings were

TABLE IV-A. DESIGN LOADS FOR FLIGHT SERVICE COMPONENTS

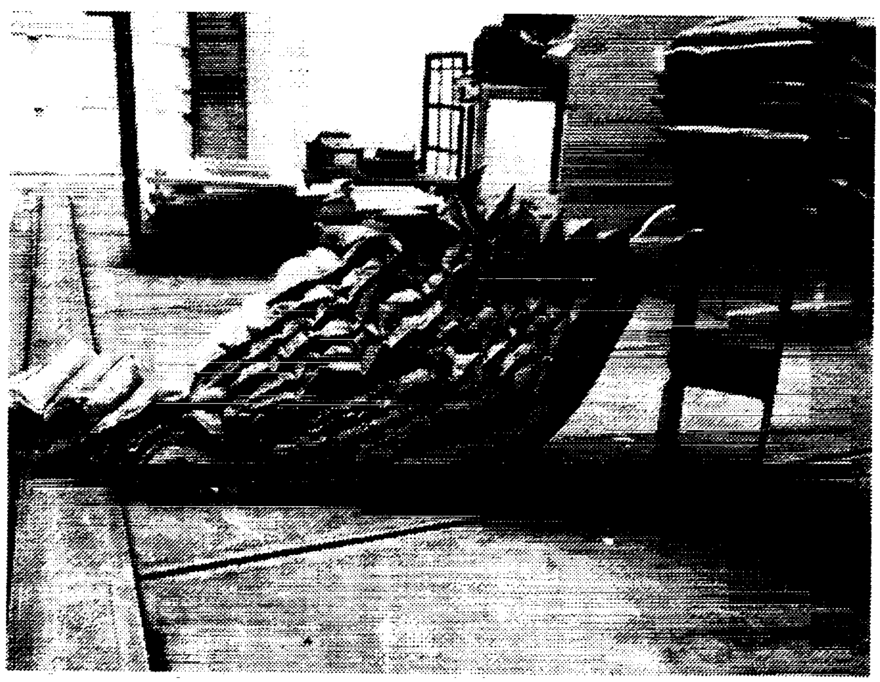
	Vertical Fin	Forward Fairing	Litter Door	Baggage Door
Limit	0.50 PSI	0.20 PSI	0.20 PSI + 53.0 lb Upper Hinge 140.0 lb Lower Hinge	0.33 PSI
Ultimate	0.75 PSI	0.30 PSI	0.30 PSI 79.5 lb Upper Hinge 210.0 lb Lower Hinge	0.50 PSI
Knockdown Factor	1.40	1.62	1.94	1.39
Required Strength*	1.05 PSI	0.49 PSI	0.58 PSI 154.0 lb Upper Hinge 407.0 lb Lower Hinge	0.70

* Required Strength = Ultimate x Knockdown Factor



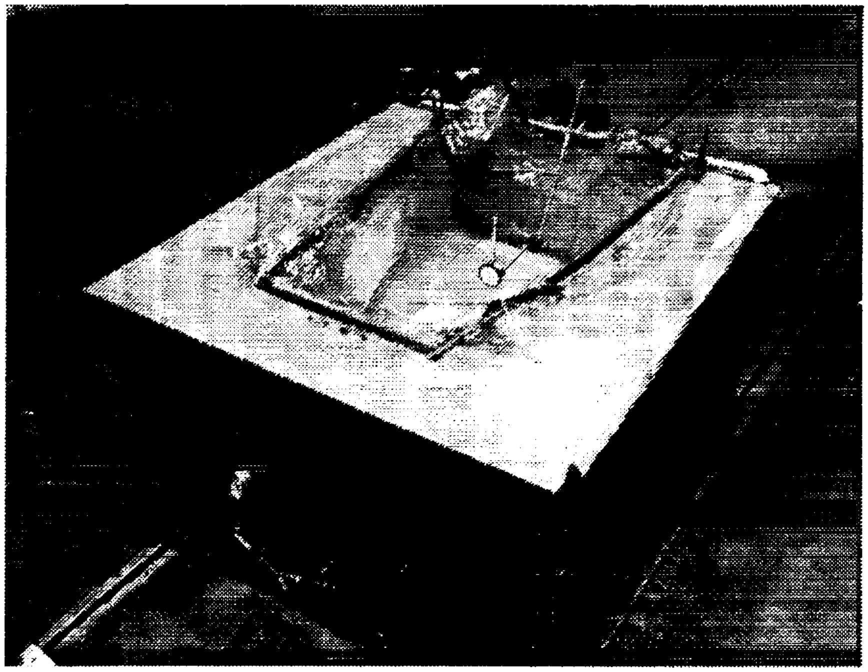
2-L508

Figure 11. Vertical Fin Test Set-Up



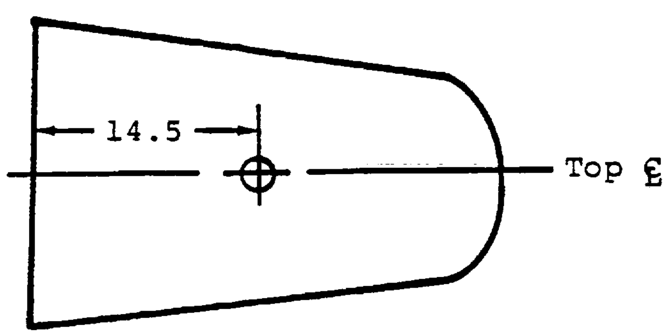
2-L509

Figure 12. Vertical Fin Static Failure Mode



2-L510

Figure 13. Forward Fairing Test Set-Up



2-L511

Figure 14. Forward Fairing Deflection Measurement Location

tested. The first, and most common, was a local failure around the latches. Approximately five of the fairings failed along the upper corner radius on the inner surface.

4.1.3 Litter Door

The litter door was attached to a fixture which simulated attachment to a door frame on one side, and to another door on the other side. Aerodynamic loads from the passenger door were introduced as point loads on the aft hinges, and as distributed loads on the door surface. The point loads represented the reactions of the hinges as a result of the aerodynamic loads on the adjacent cabin door. Six dial indicators were placed around the door as shown in Figure 15. The stiffness data which is reported in this section is from gauge number 2, located at the center of the door along the aft edge. This gauge produced the greatest deflections for the applied limit load. The failure mode of the litter door was found to be related to the compressive buckling of the inner skin at the center of the door. Under load, the the inner surface of the door would buckle slightly under compression, forming a crease at the center of the door. The door would then deflect excessively, pulling the pins out of the fixture, resulting in part failure (see Figure 16).

There were two methods used to determine the strength of the litter doors. During the certification process, four of the doors were tested by incrementally increasing the hinge point loads and the distributed loads beyond 100 percent limit, to the failure point. This method was also used during the 3-year and 5-year test intervals. The second method kept the hinge point loads at the 100 percent limit level, and only increased the aerodynamic load on the surface of the door. This method was used in the 8-, 11- and 11.5-year testing intervals. The latter method produces a higher failure load (point loads plus distributed loads) since the concentrated load near the attach pins is much lower. All comparisons to baseline data have been corrected to reflect the appropriate testing method. It is noted that the method to determine stiffness was identical for all litter door specimens.

4.1.4 Baggage Door

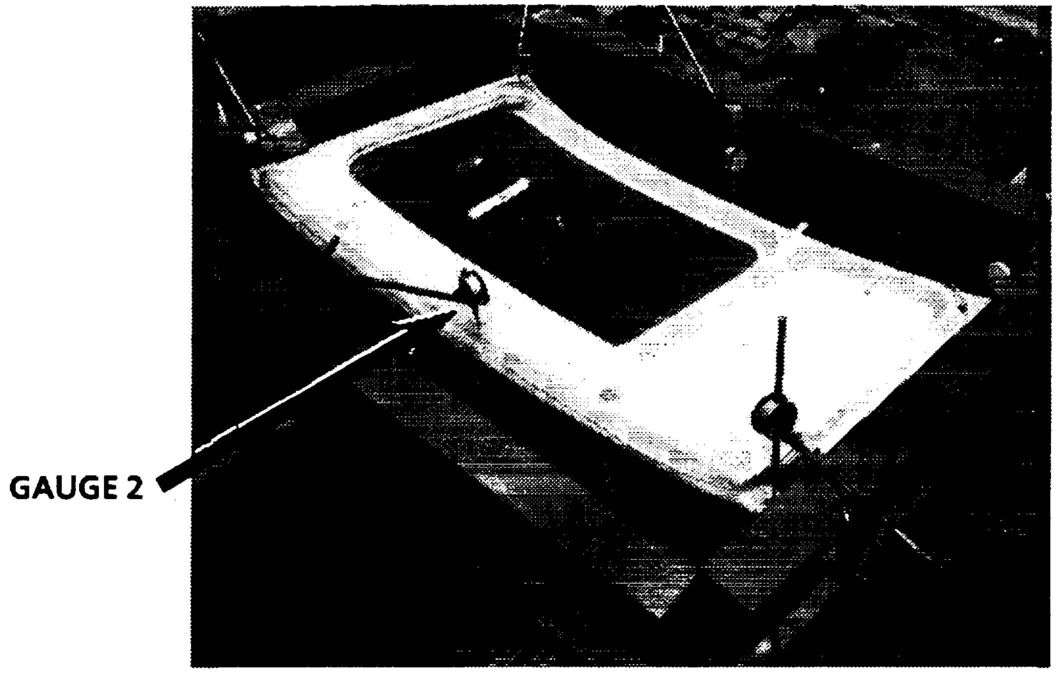
The test apparatus for the baggage doors was similar to that used for the litter doors (see Figure 17). The baggage doors, however, did not require point loads at the hinges since the baggage door attaches directly to the airframe on both sides. Loads were applied to the baggage doors by applying lead shot bags over the surface of the door. Displacement was measured at the geometric center of the door. A total of 27 baggage doors were tested. Several failure modes were found to occur with this part, and are discussed in detail in the baggage door test results section (Sec. 4.2.5).

4.2 TEST RESULTS

4.2.1 Methodology

The baseline strength data were established by destructively testing five sample parts for each component. A baseline scatter of the strength were determined from this data (Ref. 1, pg. 64). Subsequent test results which have fallen within this baseline scatter were determined to have no measurable change in strength. Baseline stiffness measurements were made on all parts except for the vertical fin. These initial stiffness values were the result of only a single sample for each component. Therefore, there is no scatter for which to base subsequent test results.

Tests were conducted at five different intervals after initial part installation: 3, 5, 8, 11 and 11.5 years. The data for the 3-year testing was reported in Reference 2, and the data from the 5-year testing was reported in Reference 3. The data for the 8-year testing is found in Appendix A, and the data for the 11- and 11.5-year testing is found in Appendix B. Tables IV-C through IV-F represent all of the acquired test data for the vertical fins, forward fairings, litter doors, and baggage doors, respectively. The information in each table includes the laboratory specimen number (or test data reference source for 3- and 5-year specimens), aircraft serial number, operator and operating region, service time in both flight hours and months, and the date at which the part was tested (used to calculate age of parts). A list of helicopter operator abbreviations applicable to these tables can be found on page 32. The test data in these tables represents the measured failure load (strength) and the measured stiffness. Stiffness was calculated based on a linear curve fit of load versus deflection measured between zero and 100 percent of limit load. Strength and stiffness are also tabulated as a percentage of the

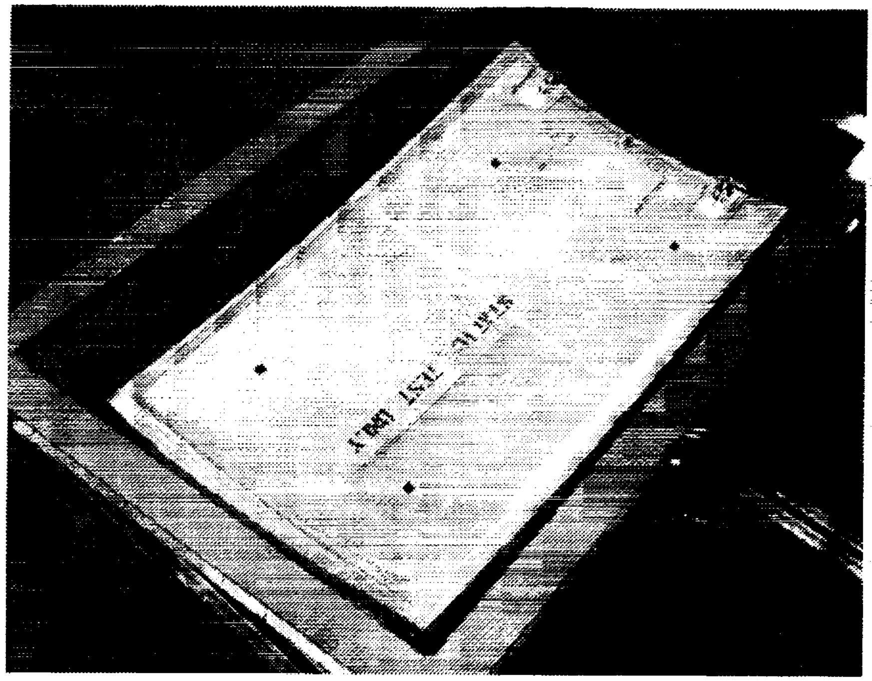


2-L512

Figure 15. Litter Door Test Set-Up

2-L513

Figure 16. Litter Door Static Failure Mode



2-L514

Figure 17. Baggage Door Test Set-Up

TABLE IV-B. HELICOPTER OPERATOR ABBRIEVIATION KEY

Abbreviation	Operator
HOUSTON	Houston Helicopters
HELI-VOYAG	Heli-Voyageur
ERA	ERA Helicopter
ASI	Air Services International
PHI	Petroleum Helicopters Incorporated
AIR LOG	Air Logistics
COMM	Commercial Helicopters
ISLAND	Island Helicopters
TRANS-QUEBEC	Trans Quebec Helicopters
RCMP	Royal Canadian Mounted Police
COAST GUARD	Ministry of Transport Canada

2-L515

TABLE IV-C
VERTICAL FIN TEST DATA

PART NO: 599-355-048-001
REQ'D STRENGTH: 971 LBS (REF 1, PG 56)
BASELINE STRENGTH: 2019 ± 134 LBS (REF 1, PG 64)
BASELINE STIFFNESS: N/A

							STRENGTH		STIFFNESS	
SPEC NO	S/N	REGION	OPERATOR	FLIGHT HOURS	SERVICE MONTHS	DATE TESTED	LOAD (LBS)	% BASELINE	(LB/IN)	% BASELINE
ML-08	45458	GULFCOAST	HOUSTON	0	0	3/89	2053	101.7	311	N/A
ML-09	45017	NORTHEAST	HELI-VOYAG	901	33	3/89	2066	102.4	210	N/A
ML-10	45026	NORTHEAST	HELI-VOYAG	1166	33	3/89	1928	95.5	252	N/A
ML-17	45113	NORTHWEST	ERA	1772	51	3/89	2066	102.4	389	N/A
ML-20	45418	SOUTHWEST	ASI	1678	41	3/89	2081	103.1	356	N/A
ML-21	45608	SOUTHWEST	ASI	2213	58	3/89	2176	107.9	259	N/A
ML-22	45607	SOUTHWEST	ASI	1992	57	3/89	2066	102.4	210	N/A
ML-23	45614	SOUTHWEST	ASI	881	23	3/89	1956	96.9	478	N/A
ML-24	45367	GULFCOAST	PHI	6750	89	3/89	1997	98.9	302	N/A
ML-B01	45108	NORTHWEST	ERA	970	25	3/92	1950	96.6	302	N/A
ML-B02	45114	NORTHWEST	ERA	1199	48	3/92	1650	81.7	356	N/A
ML-B03	46607	NORTHEAST	COAST GUARD	3585	97	3/92	1775	87.9	347	N/A
ML-B04	45083	NORTHEAST	COAST GUARD	3987	113	3/92	1700	84.2	375	N/A
ML-C06	45436	GULFCOAST	AIR LOG	11497	105	8/92	2154	106.7	514	N/A
ML-C07	45524	GULFCOAST	AIR LOG	7399	68	8/92	2251	111.5	408	N/A
ML-C08	45330	GULFCOAST	AIR LOG/COMM.	2877	19	8/92	1862	92.2	371	N/A
ML-C09	45266	GULFCOAST	AIR LOG	11974	141	8/92	2183	108.1	397	N/A

(FIN TABLE CONTINUED ON NEXT PAGE)

2-L516

TABLE IV-C (CONT.)
VERTICAL FIN TEST DATA

PART NO: 599-355-048-001
REQ'D STRENGTH: 971 LBS (REF 1, PG 56)
BASELINE STRENGTH: 2019 ± 134 LBS (REF 1, PG 64)
BASELINE STIFFNESS: N/A

SPEC NO	S/N	REGION	OPERATOR	FLIGHT HOURS	SERVICE MONTHS	DATE TESTED	STRENGTH		STIFFNESS	
							LOAD (LBS)	% BASELINE	(LB/IN)	% BASELINE
ML-D05	45414	NORTHEAST	R.C.M.P.	4479	90	9/92	1925	95.3	486	N/A
ML-D06	45086	NORTHEAST	R.C.M.P.	4139	116	9/92	1500	74.3	423	N/A
REF 2	45101	NORTHEAST	ISLAND	1413	22	3/84	2100	104.0	NOT AVAIL.	N/A
REF 2	45141	NORTHEAST	TRAN-QUEBEC	870	15	3/84	2219	109.9	NOT AVAIL.	N/A
REF 2	45373	GULFCOAST	PHI	879	10	3/84	2497	123.7	NOT AVAIL.	N/A
REF 3	45085	NORTHEAST	HELI-VOYAG	1369	31	8/86	1900	94.1	456	N/A
REF 3	45450	NORTHEAST	ISLAND	2661	36	8/86	1700	84.2	390	N/A
REF 3	45378	GULFCOAST	AIR LOG	3387	34	8/86	1551	76.8	415	N/A
			TOTAL	52524	976	MEAN	1972	97.7	380	N/A
			MEAN	2501	47					

2-L517

TABLE IV-D
FORWARD FAIRING TEST DATA

PART NO: 599-355-068-101
REQ'D STRENGTH: 0.49 PSI (REF 1, PG 46)
BASELINE STRENGTH: 3.11 ± 0.19 PSI (REF 1, PG 64)
BASELINE STIFFNESS: 2.08 PSI/IN (REF 4, PG. 2.08)

SPEC NO	S/N	REGION	OPERATOR	FLIGHT HOURS	SERVICE MONTHS	DATE TESTED	STRENGTH		STIFFNESS	
							PRES (PSI)	% BASELINE	(PSI/IN)	% BASELINE
ML-01	45028	NORTHEAST	HELI-VOYAG	1166	33	3/89	2.46	79.0	8.70	418.3
ML-02	45017	NORTHEAST	HELI-VOYAG	901	33	3/89	3.44	110.4	2.90	139.4
ML-03	45458	GULFCOAST	HOUSTON	0	0	3/89	3.68	118.1	2.17	104.3
ML-15	45113	NORTHWEST	ERA	1772	51	3/89	3.93	126.2	1.94	93.3
ML-16	45418	SOUTHWEST	ASI	1419	54	3/89	3.68	118.1	2.74	131.7
ML-A01	45614	SOUTHWEST	ASI	881	23	3/89	2.80	89.9	4.17	200.5
ML-A02	45607	SOUTHWEST	ASI	1992	57	3/89	3.73	119.7	2.33	112.0
ML-A03	45367	GULFCOAST	PHI	6750	89	3/89	2.70	86.7	3.08	148.1
ML-A04	45535	GULFCOAST	HOUSTON	286	19	3/89	2.11	67.7	2.67	128.4
ML-B01	46610	NORTHEAST	ISLAND	7666	108	3/92	2.80	89.9	0.88	42.3
ML-B02	46607	NORTHEAST	COAST GUARD	3585	97	3/92	2.50	80.3	1.16	55.8
ML-C01	45436	GULFCOAST	AIR LOG	11503	120	8/92	3.20	102.7	1.44	69.2
ML-C02	45266	GULFCOAST	AIR LOG	11974	141	8/92	2.50	80.3	0.87	41.8
ML-C03	45524	GULFCOAST	AIR LOG	10432	88	8/92	3.10	99.5	1.90	91.3
ML-C04	45546	GULFCOAST	AIR LOG	10461	115	8/92	2.98	95.7	1.21	58.2

(FWD FAIRING TABLE CONTINUED ON NEXT PAGE)

TABLE IV-D (CONT.)
FORWARD FAIRING TEST DATA

PART NO: 599-355-068-101
REQ'D STRENGTH: 0.49 PSI (REF 1, PG 46)
BASELINE STRENGTH: 3.11 ± 0.19 PSI (REF 1, PG 64)
BASELINE STIFFNESS: 2.08 PSI/IN (REF 4, PG. 2.08)

SPEC NO	S/N	REGION	OPERATOR	FLIGHT HOURS	SERVICE MONTHS	DATE TESTED	STRENGTH		STIFFNESS	
							PRES (PSI)	% BASELINE	(PSI/IN)	% BASELINE
ML-D01	45086	NORTHEAST	R.C.M.P	4139	116	9/92	2.15	69.1	1.76	84.5
ML-D02	45414	NORTHEAST	R.C.M.P	5305	118	9/92	2.30	74.0	3.06	147.3
REF 2	45101	NORTHEAST	ISLAND	1413	22	3/84	1.89	60.1	2.06	99.3
REF 2	45141	NORTHEAST	TRAN-QUEBEC	870	15	3/84	2.50	80.4	NOT AVAIL.	N/A
REF 2	45373	GULFCOAST	PHI	879	10	3/84	1.80	57.8	NOT AVAIL.	N/A
REF 3	45085	NORTHEAST	HELI-VOYAG	1369	31	8/86	2.47	79.3	1.58	76.0
REF 3	45115	NORTHWEST	ERA	668	32	8/86	2.69	86.4	2.67	128.4
REF 3	45378	GULFCOAST	AIR LOG	3387	34	8/86	2.34	75.1	2.86	137.5
			TOTAL	88818	1406	MEAN	2.77	89.1	2.52	121.4
			MEAN	3862	61					

2-L518

2-L519

TABLE IV-E
LITTER DOOR TEST DATA

PART NO: 599-356-0018-101
REQ'D STRENGTH: 1230 LBS (HINGES + DISTRIBUTED), (REF 1, PG 49)
BASELINE STRENGTH: 1182 ± 48 LBS (HINGES + DISTRIBUTED), (REF 1, PG 64) * – see note next page
BASELINE STIFFNESS: 2908 LBS/IN (REF 4, PG. 2.07)

							STRENGTH		STIFFNESS	
SPEC NO	S/N	REGION	OPERATOR	FLIGHT HOURS	SERVICE MONTHS	DATE TESTED	LOAD (LBS)	% BASELINE	(LB/IN)	% BASELINE
ML-04*	45017	NORTHEAST	HELI-VOYAG	901	33	3/89	1492	110.8	2631	90.5
ML-06*	45028	NORTHEAST	HELI-VOYAG	687	25	3/89	1750	124.9	2277	78.3
ML-07	45458	GULFCOAST	HOUSTON	0	0	3/89	*** LATCH DAMAGE DID NOT ALLOW STATIC TESTING ***			
ML-113	45439	NORTHEAST	TRAN-QUEBEC	3100	74	3/89	*** LATCH DAMAGE DID NOT ALLOW STATIC TESTING ***			
ML-141*	45614	SOUTHWEST	ASI	9	7	3/89	1093	81.1	2076	71.4
ML-142*	45418	SOUTHWEST	ASI	13	7	3/89	1768	131.3	1961	67.4
ML-143*	45607	SOUTHWEST	ASI	22	7	3/89	1593	118.3	1688	58.0
ML-400*	45109	NORTHWEST	ERA	970	25	3/89	1644	122.0	1883	64.8
ML-A05*	45367	GULFCOAST	PHI	6750	89	3/89	1618	120.1	1961	67.4
ML-A83	45535	GULFCOAST	HOUSTON	286	9	3/89	1262	106.8	2037	70.0
ML-A84*	45609	SOUTHWEST	ASI	781	17	3/89	1644	122.0	2076	71.4
ML-B01*	45114	NORTHWEST	ERA	1199	48	3/92	1768	131.3	1843	63.4
ML-B02*	45108	NORTHWEST	ERA	970	25	3/92	1518	112.7	1954	67.2
ML-B03*	45083	NORTHEAST	COAST GUARD	3987	113	3/92	1243	92.3	1893	65.1
ML-B04*	46607	NORTHEAST	COAST GUARD	3585	97	3/92	1318	97.8	1656	56.9
ML-B05*	46610	NORTHEAST	ISLAND	1511	50	3/92	1293	96.0	2451	84.3
ML-B06*	45450	NORTHEAST	ISLAND	300	14	3/92	1043	77.4	1559	53.6

(LITTER DOOR TABLE CONTINUED ON NEXT PAGE)

2-L520

TABLE IV- E (CONT.)
LITTER DOOR TEST DATA

PART NO: 599-356-0018-101
REQ'D STRENGTH: 1230 LBS (HINGES + DISTRIBUTED), (REF 1, PG 49)
BASELINE STRENGTH: 1182 ± 48 LBS (HINGES + DISTRIBUTED), (REF 1, PG 64) * - see note
BASELINE STIFFNESS: 2908 LBS/IN (REF 4, PG. 2.07)

SPEC NO	S/N	REGION	OPERATOR	FLIGHT HOURS	SERVICE MONTHS	DATE TESTED	STRENGTH		STIFFNESS	
							LOAD (LBS)	% BASELINE	(LB/IN)	% BASELINE
ML-C05	45524	GULFCOAST	AIR LOG	10432	88	8/92	** MISSING WINDOW DID NOT ALLOW STATIC TESTING **			
ML-D03*	45414	NORTHEAST	R.C.M.P	3905	79	9/92	1493	110.8	1588	54.6
ML-D04*	45086	NORTHEAST	R.C.M.P	2865	73	9/92	1668	123.8	1774	61.0
REF 2	45101	NORTHEAST	ISLAND	1413	22	3/84	1115	91.8	1563	53.7
REF 2	45141	NORTHEAST	TRAN-QUEBEC	870	15	3/84	980	80.7	NOT AVAIL.	N/A
REF 2	45373	GULFOCAST	PHI	879	10	3/84	1009	83.1	NOT AVAIL.	N/A
REF 3	45085	NORTHEAST	HELI-VOYAG	1369	31	8/86	1302	107.2	2052	70.6
REF 3	45115	NORTHWEST	ERA	668	32	8/86	931	76.6	2980	102.5
REF 3	45378	GULFCOAST	AIR LOG	1454	28	8/86	988	81.3	1870	64.3
			TOTAL	48926	1018	MEAN	1371	104.4	1816	62.5
			MEAN	1882	39					

* - ALL SPECIMENS MARKED WITH A * WERE TESTED TO FAILURE BY LEAVING THE HINGE LOAD AT 100% LIMIT AND ONLY INCREASING THE AERODYANMIC LOAD. THE BASELINE STRENGTH FOR THESE SPECIMENS IS FROM SPECIMEN NUMBER 1, TESTED IN AN IDENTICAL MANNER IN REFERENCE 1 (PAGE 64). THIS STRENGTH IS 1347 TOTAL LBS. ALL OTHER SPECIMENS USE A BASELINE AND SCATTER CALCULATED FROM THE REMAINING 4 SPECIMENS FROM REFERENCE 1, PG 64.

2-L521

TABLE IV-F
BAGGAGE DOOR TEST DATA

PART NO: 599-355-054-101
REQ'D STRENGTH: 613 LBS (REF 1, PG 46)
BASELINE STRENGTH: 613 ± 75 LBS (REF 1, PG 64)
BASELINE STIFFNESS: 242 LBS/IN (REF 4, PG. 2.06)

SPEC NO	S/N	REGION	OPERATOR	FLIGHT HOURS	SERVICE MONTHS	DATE TESTED	STRENGTH		STIFFNESS	
							LOAD (LBS)	% BASELINE	(LB/IN)	% BASELINE
ML-13	45134	NORTHEAST	TRAN-QUEBEC	2401	43	3/89	325	53.0	178	73.6
ML-19	45367	GULFCOAST	PHI	4194	70	3/89	525	85.6	268	110.7
ML-51	45017	NORTHEAST	HELI-VOYAG	901	33	3/89	475	77.5	287	118.6
ML-52	45028	NORTHEAST	HELI-VOYAG	1166	33	3/89	1196*	195.1	215	88.8
ML-111	46607	NORTHWEST	COAST GUARD	1824	48	3/89	434	70.8	267	110.3
ML-112	45439	NORTHEAST	TRAN-QUEBEC	3100	74	3/89	480	78.3	220	90.9
ML-121	45608	SOUTHWEST	ASI	948	24	3/89	425	69.3	247	102.1
ML-122	45418	SOUTHWEST	ASI	1419	54	3/89	425	69.3	224	92.6
ML-181	45449	GULFCOAST	AIR LOG	3442	53	3/89	400	65.3	233	96.3
ML-182	45546	GULFCOAST	AIR LOG	6765	56	3/89	625	102.2	260	107.4
ML-183	45524	GULFCOAST	AIR LOG	4828	49	3/89	600	97.9	289	119.4
ML-184	45378	GULFCOAST	AIR LOG	104	6	3/89	375	61.2	231	95.5
ML-185	45083	NORTHEAST	COAST GUARD	1696	56	3/89	500	81.6	259	107.0
ML-186	45614	SOUTHWEST	ASI	881	23	3/89	400	65.3	241	99.6
ML-401	45114	NORTHWEST	ERA	592	34	3/89	475	77.5	219	90.5
ML-402	45113	NORTHWEST	ERA	1772	51	3/89	475	77.5	204	84.3
ML-403	45108	NORTHWEST	ERA	2004	61	3/89	375	61.2	220	90.9

* - EXCESSIVE DEFLECTION OCCURRED WELL BEFORE THIS LOAD. ACUTAL FAILURE WAS NOTED AT 1196 LBS.
(BAGGAGE DOOR TABLE CONTINUED ON NEXT PAGE)

TABLE IV- F (CONT.)
BAGGAGE DOOR TEST DATA

PART NO: 599-355-054-101
REQ'D STRENGTH: 613 LBS (REF 1, PG 46)
BASELINE STRENGTH: 613 ± 75 LBS (REF 1, PG 64)
BASELINE STIFFNESS: 242 LBS/IN (REF 4, PG. 2.06)

SPEC NO	S/N	REGION	OPERATOR	FLIGHT HOURS	SERVICE MONTHS	DATE TESTED	STRENGTH		STIFFNESS	
							LOAD (LBS)	% BASELINE	(LB/IN)	% BASELINE
ML-404	45109	NORTHWEST	ERA	1284	44	3/89	325	53.0	178	73.6
ML-A81	45535	GULFCOAST	HOUSTON	286	19	3/89	525	85.6	248	102.5
ML-A82	45607	SOUTHWEST	ASI	20	6	3/89	475	77.5	182	75.2
ML-B07	46610	NORTHEAST	ISLAND	7666	80	3/92	564	92.0	202	83.5
REF 2	45101	NORTHEAST	ISLAND	1413	22	3/84	275	44.9	369	152.5
REF 2	45141	NORTHEAST	TRAN-QUEBEC	870	15	3/84	473	77.2	N/A	N/A
REF 2	45373	GULFCOAST	PHI	879	10	3/84	795	129.7	N/A	N/A
REF 3	45085	NORTHEAST	HELI-VOYAG	1369	31	8/86	1377	224.6	343	141.7
REF 3	45115	NORTHWEST	ERA	668	32	8/86	1214	198.0	333	137.6
REF 3	45436	GULFCOAST	AIR LOG	3528	33	8/86	1212	197.7	396	163.6
			TOTAL	56020	1060	MEAN	467*	76.2	253	104.4
			MEAN	2075	39					

* – MEAN STRENGTH VALUE DOES NOT INCLUDE REFERENCE 3 DATA OR ML-52 DATA (SEE DISCUSSION OF TEST RESULTS).

baseline data (where applicable). It is noted that several of the parts tested at the 3-year interval did not have deflection measurements recorded. The baseline data and required strength for each part are shown above the respective tables.

Figures 18 through 21 are property retention plots for the vertical fins, forward fairings, litter doors and baggage doors, respectively. Each figure contains 4 plots each. Sub-plots A and B indicate strength and stiffness as a function of recorded flight hours. Any deterioration of structural properties due to repeated flight loads would be evident on these plots. Sub-plots C and D indicate strength and stiffness as a function of the age of the parts. Where applicable, the baseline data is presented on the plots. The strength plots contain dashed lines defining the baseline envelope, and the stiffness plots contain a single solid line representing the stiffness of the single component measured prior to initial service. The strength plots (A and C) also contain a solid line which indicates the required strength necessary for certification. Parts with data below this line, have strength values which have degraded to an unacceptable point. The data associated with the four different components are discussed in the following sections.

4.2.2 Vertical Fin

Twenty-five (25) vertical fins have been destructively tested during this program: 10 from the northeast, 8 from the Gulf Coast, 4 from the southwest, and 3 from the northwest. Since deflections were not recorded during the certification process, there is no baseline stiffness data to be used for comparison. Therefore, Figures 18B and 18D, are plots of the actual stiffness values, and are not in terms of percent of the baseline.

There is no apparent trend developed which would indicate vertical fin strength degradation as a function of either flight hours or part age (Figures 18A and 18C). For example, two parts which operated in the gulfcoast region with over 11,500 flight hours and 11.5 years in service, have shown no loss in strength. Additionally, there is no evidence which would indicate that property retention differed between the various regions. All of the tested vertical fins maintained strength values greater than the required value necessary for certification.

Four vertical fins were scanned using a through transmission squirter technique to determine if any field damage had occurred prior to destructive testing (Appendix C). Only one fin was found to have any noticeable damage (Figure 3A of App. C). Test data revealed no loss in strength for this specimen (ML-22). This was expected since the damage was found near the tip of the fin, away from the heavily loaded sections.

Since there was no baseline stiffness data recorded for the vertical fin, conclusions on stiffness retention are difficult to assess. It is noted, however, that the two high-time fins from the gulfcoast, have stiffness measurements greater than the average of the tested parts. The four parts with the lowest stiffness measurements (2 from the southwest, and 2 from the northeast) were found to have retained strength values within the baseline scatter.

4.2.3 Forward Fairing

Figure 19A indicates that there was a great deal of scatter in the strength measurements of the forward fairings. The data gathered early in the program have strength values generally below the baseline scatter (Figure 19C). At the time of the 8 year testing, the strength data is widely scattered both above and below the baseline range. It is noted that none of the points from this test interval fell within the baseline scatter. The results from the destructive testing have shown that the strength of the forward fairing, even when degraded by almost 50 percent, is well above the required strength for this part. It is noted that the non-destructive evaluation of a random sampling of the fairings found no signs of field damage (Appendix C).

The stiffness measurements are extremely scattered, ranging from 40 percent of baseline, to almost 150 percent of baseline. This wide range of data is a result of the manner in which stiffness measurements are collected for this part. At 100 percent limit load, there is generally very little deflection at the critical location on the forward fairing. The measurement device (dial indicator) used during these tests, was not sensitive enough to register very small amounts of deflection. Therefore, small deviations in the measured deflection from specimen to specimen, resulted in large differences in recorded stiffness. It is noted that between the 8-year and 11-year test inter-

Figure 18A. Strength vs. Flight Hours

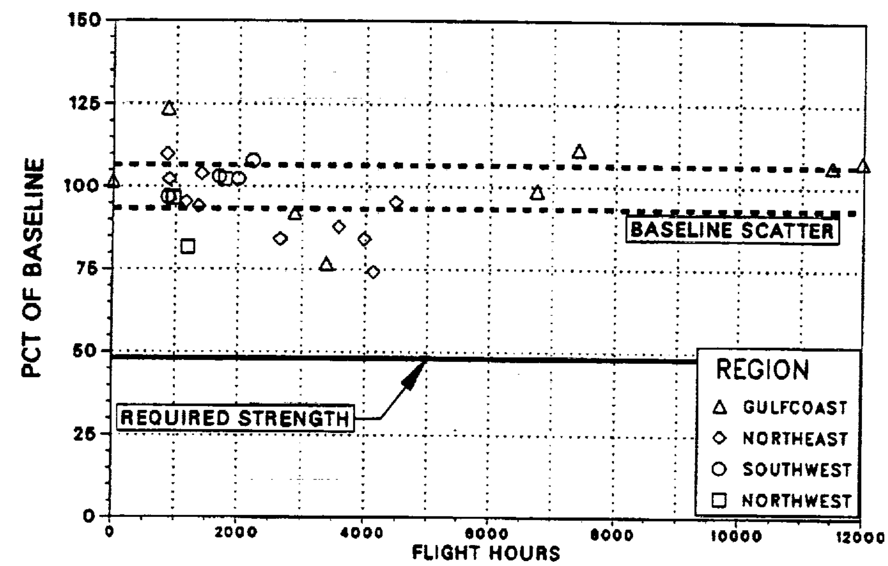
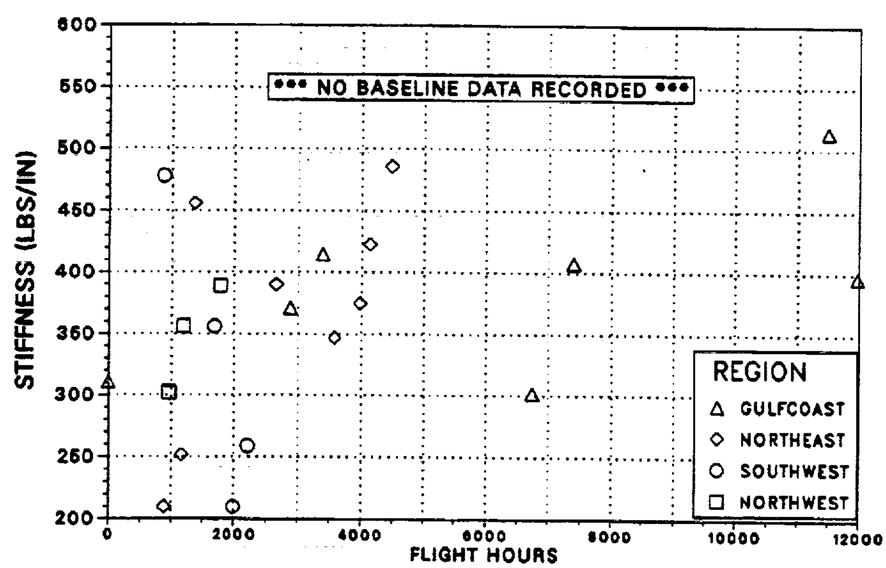


Figure 18B. Stiffness vs. Flight Hours



2-L523

Figure 18. Vertical Fin Test Data

Figure 18C. Vertical Fin Test Data

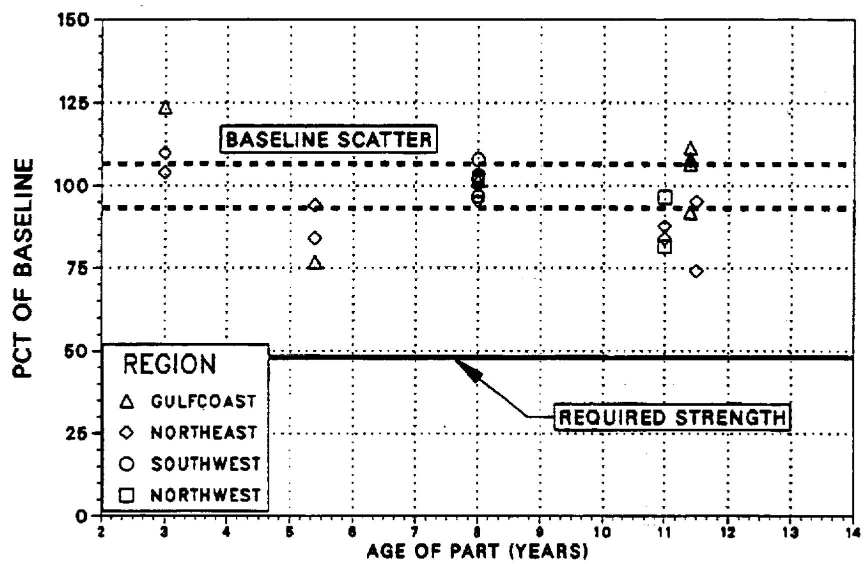
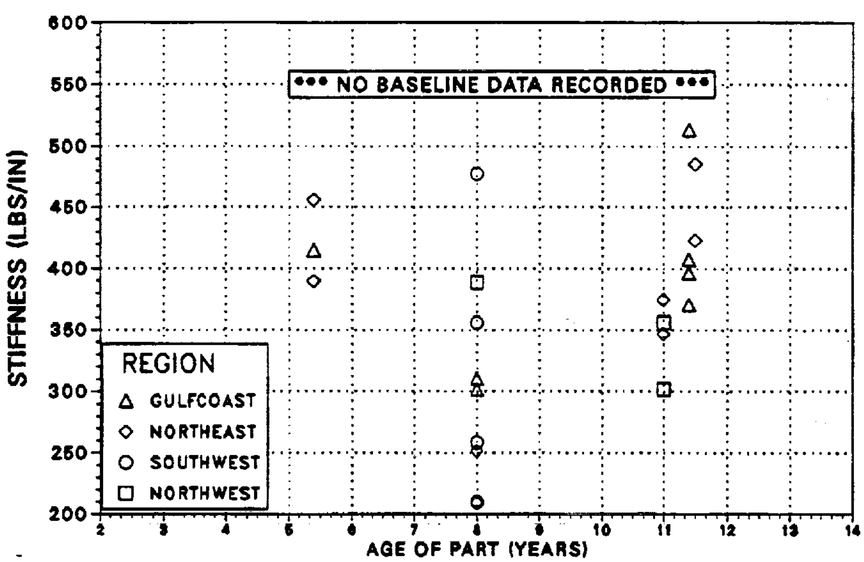


Figure 18D. Stiffness vs. Part Age



2-L525

Figure 18. Vertical Fin Test Data (Continued)

Figure 19A. Strength vs. Flight Hours

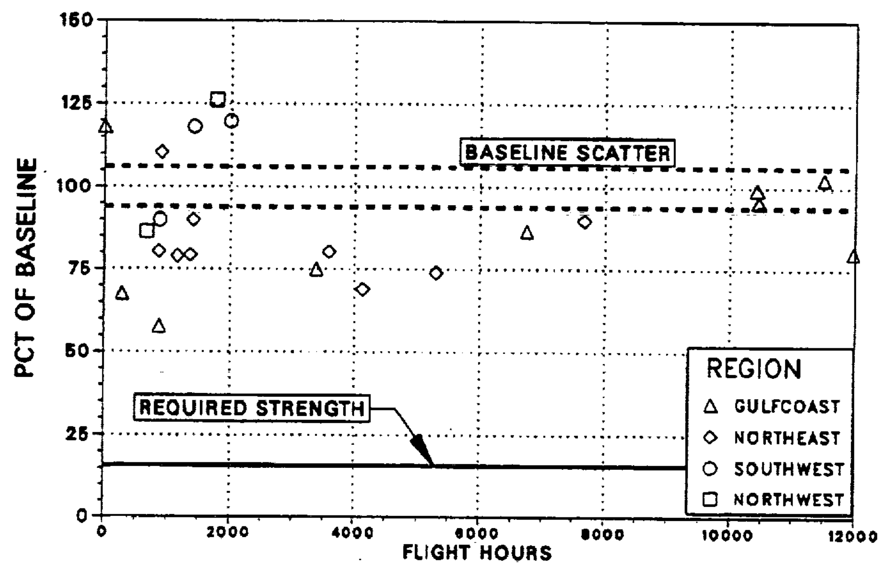
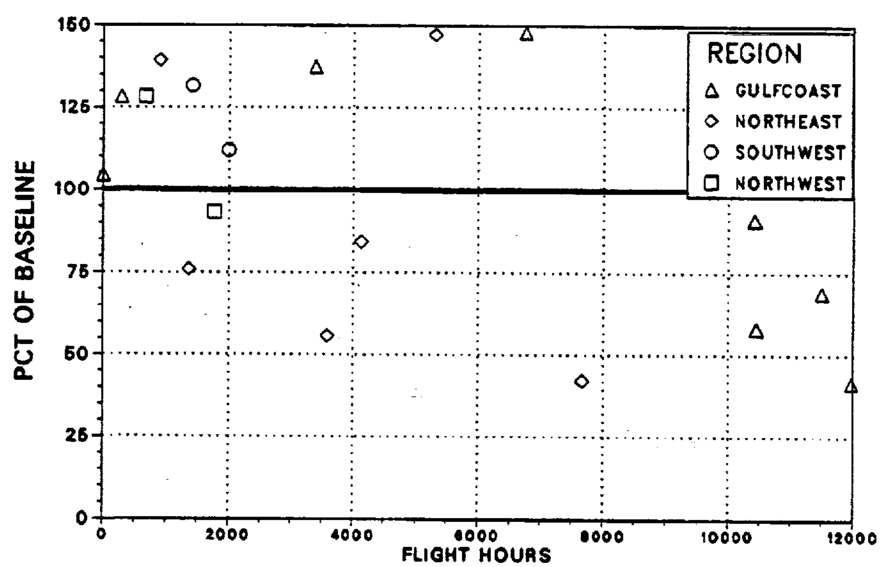


Figure 19B. Stiffness vs. Flight Hours



2-L527

Figure 19. Forward Fairing Test Data

Figure 19C. Strength vs. Part Age

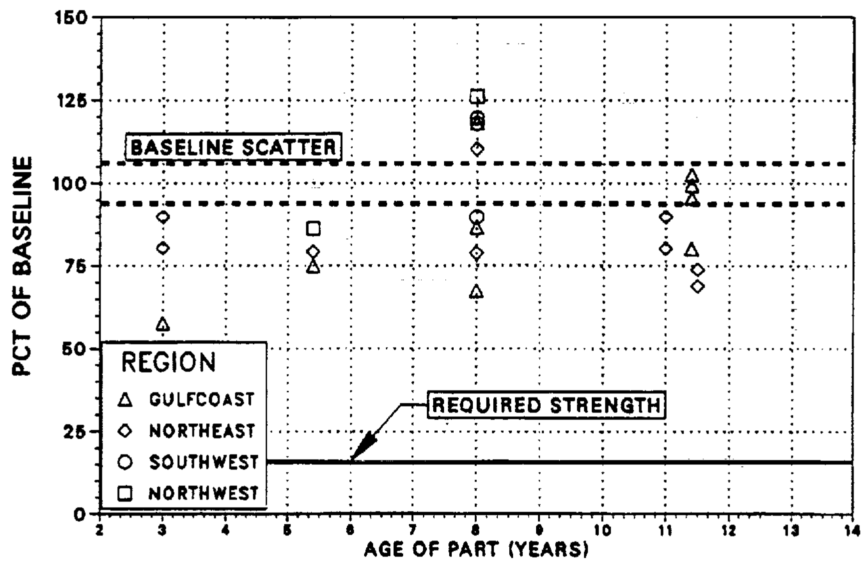
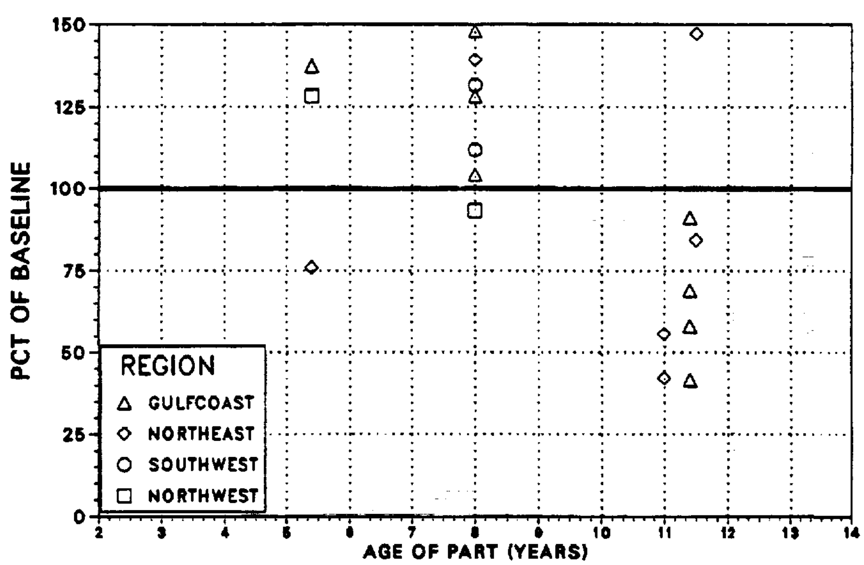


Figure 19D. Stiffness vs. Part Age



2-L529

Figure 19. Forward Fairing Test Data (Continued)

Figure 20A. Strength vs. Flight Hours

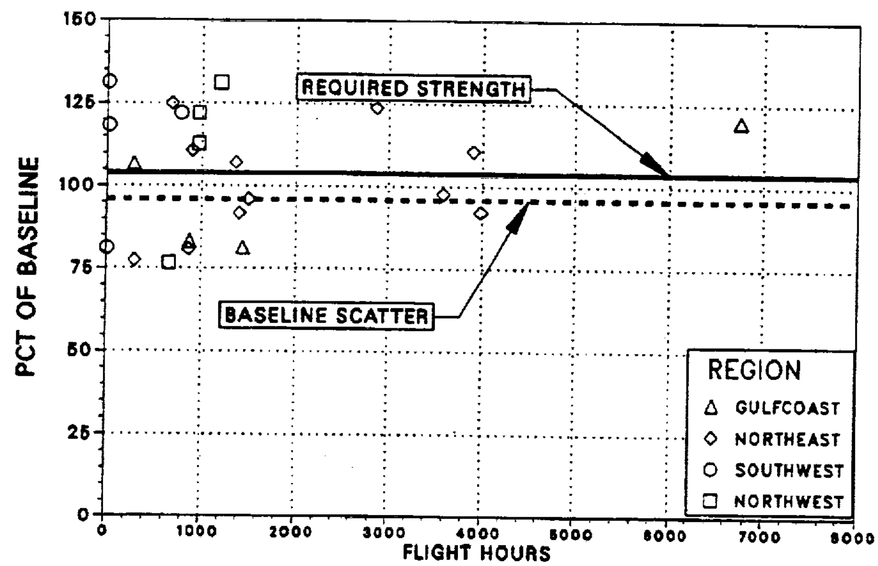
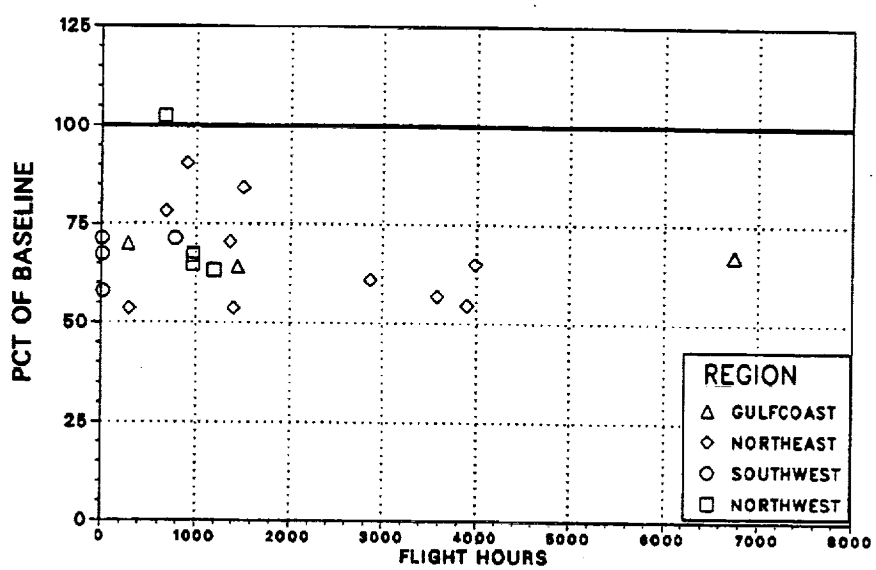


Figure 20B. Stiffness vs. Flight Hours



2-L531

Figure 20. Litter Door Test Data

Figure 20C. Strength vs. Part Age

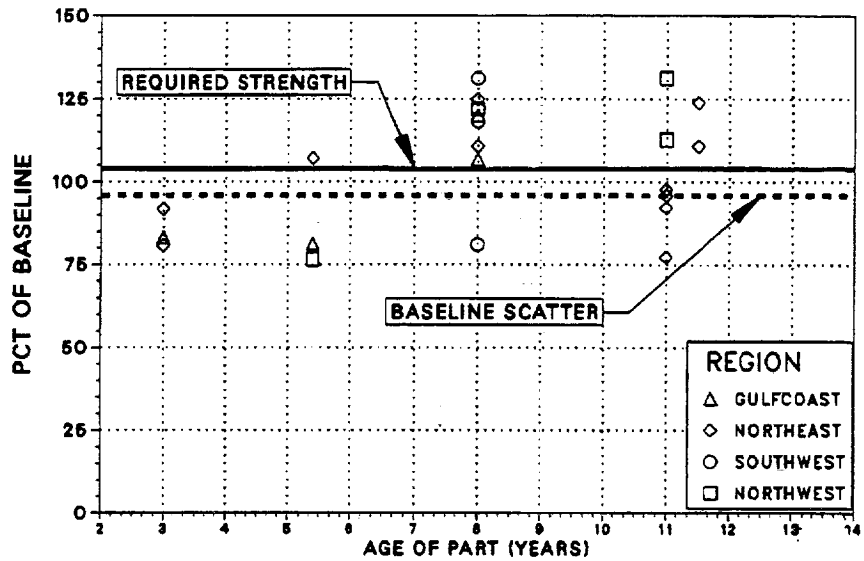
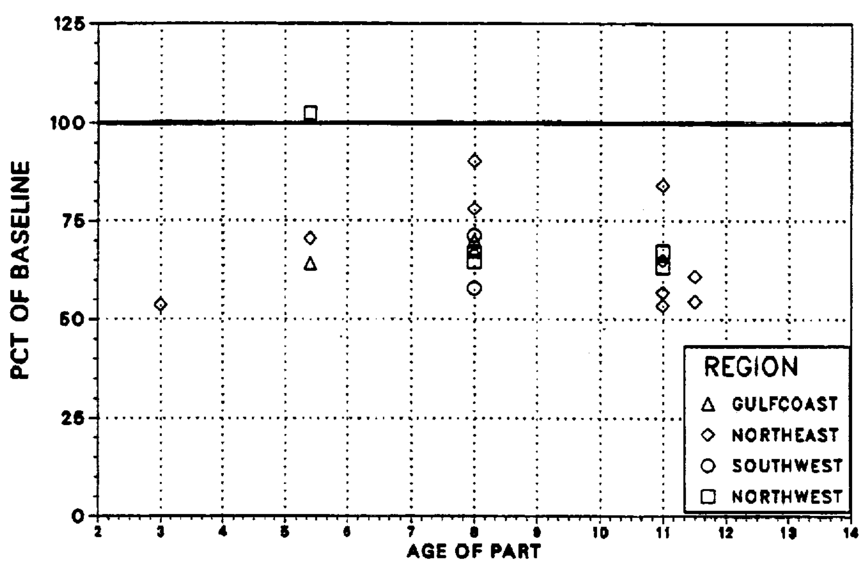


Figure 20D. Stiffness vs. Part Age



2-L533

Figure 20. Litter Door Test Data (Continued)

Figure 21A. Strength vs. Flight Hours

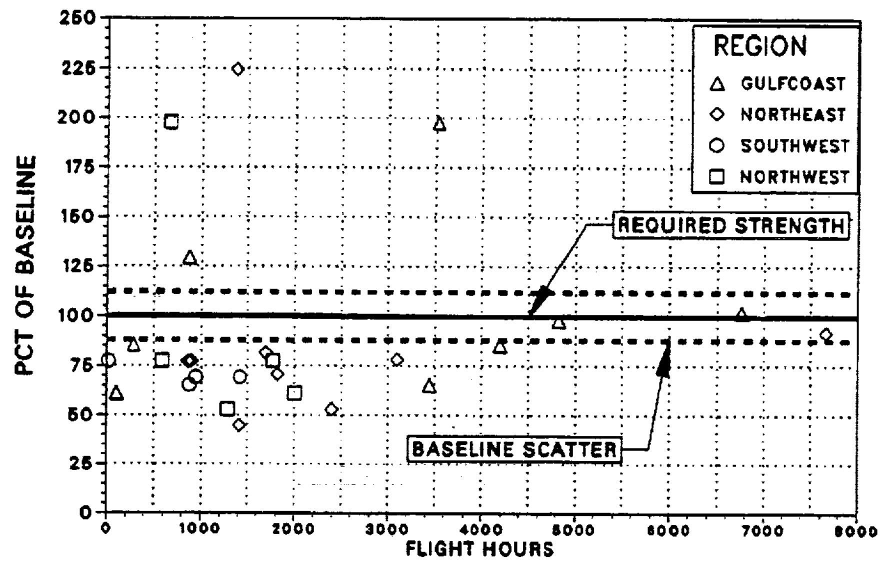
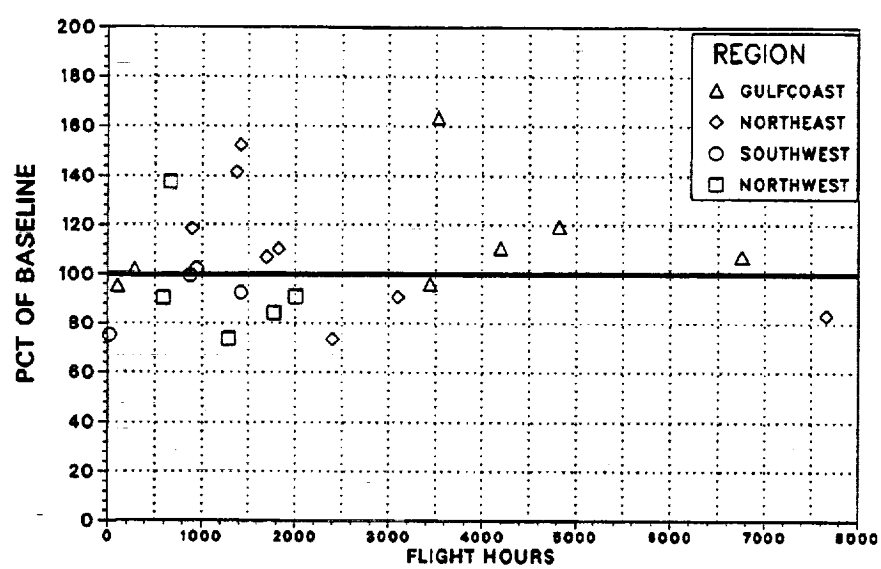


Figure 21B. Stiffness vs. Flight Hours



2-L545

Figure 21. Baggage Door Test Data

Figure 21C. Strength vs. Part Age

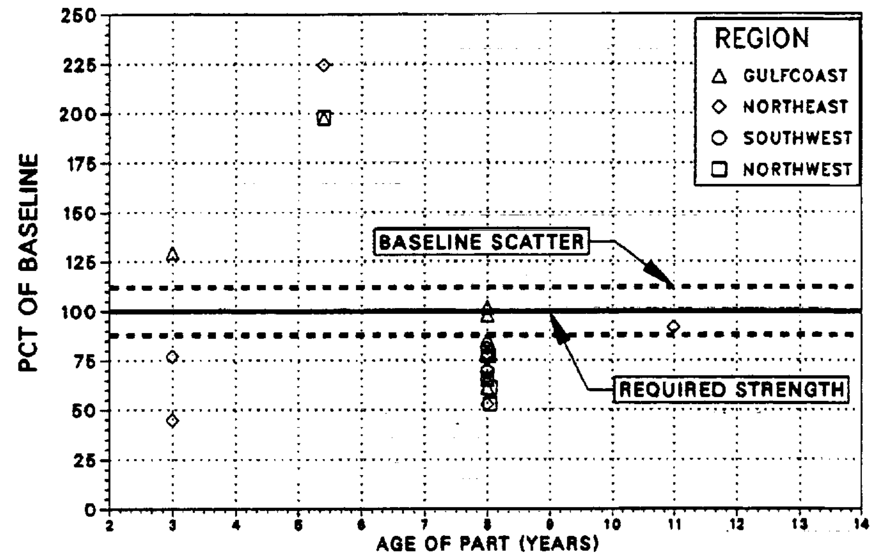
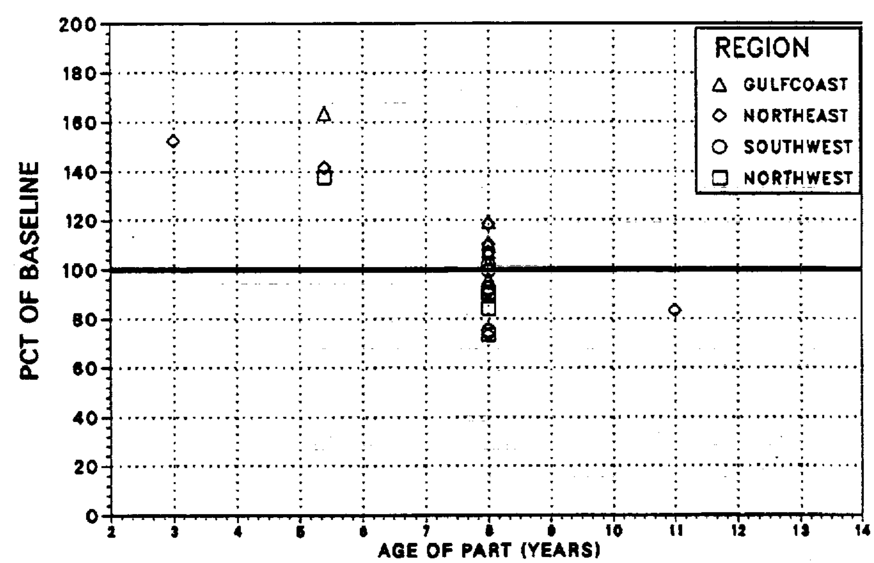


Figure 21D. Stiffness vs. Part Age



2-L547

Figure 21. Baggage Door Test Data (Continued)

vals, a new vacuum chamber was manufactured in which to perform these tests. The stiffness data between these two intervals is vastly different (Figure 19D). The deflections measured with the newer vacuum chamber were greater than those measured with the original chamber. The difference in deflection measurements may very well have been a function of the two chamber constructions.

4.2.4 Litter Door

Twenty-six litter doors were returned for testing: 12 from the northeast, 6 from the Gulf Coast, 4 from the northwest, and 4 from the southwest. Two of the litter doors which were returned were not tested due to missing hinge pins. Since the litter doors generally fail by pulling the hinge pins out of the fixture, it was felt that installing pins just for the test would affect the resulting data. One of the doors which was returned was missing the window in the center of the panel. It was determined that installing a new window for the sole purpose of obtaining test data on this part was not cost effective.

A very high percentage of the tested parts recorded strength values well above the original baseline data (Figures 20A and 20C). It was noted in a previous section that the doors operating in the southwest region had experienced thermal buckling problems early in the program. Although these parts did not record many subsequent flight hours, there does not appear to be any property degradation as a function of age (Figures 20C and 20D, circular symbols). Also, the door rework to remove the buckles did not significantly effect the residual strength or stiffness.

The stiffness retention plots (Figures 20B and 20D) indicate that most of the components had stiffness values well below the baseline stiffness. Non-destructive investigation of the litter doors found that the doors had experienced significant delaminations in small areas near the edges and hinges (Appendix C). This local softening of the structure over a period of time, may have lead to the reduction in measured stiffness of the litter door. Additionally, the baseline stiffness (which is based on only one test component) may not have been completely representative of the original stiffness of this part.

4.2.5 Baggage Door

A total of 27 baggage doors were tested over the course of the program. Many of these doors had significant delaminations at the time of return. The non-destructive testing reported in Appendix C indicated that two of the four examined doors had measurable delamination. The two doors which had no delaminated areas (specimens ML-19 and ML-182), recorded the highest strength of all of the doors tested during the 8-year interval.

The strength data indicates that the strength of the baggage doors degraded significantly over the course of this program. From Figure 21C, it is noticed that the three specimens tested at the 5-year interval, and one specimen tested at the 3-year interval had strength values significantly greater than the baseline strength. Two distinct failure modes have been reported in References 1 and 2. The first mode was failure of the metal hinge, which occurred during the certification process as well as at the 3-year test interval. The other mode, which was observed on all specimens at the 8- and 11-year intervals, was disbonding of the outer skin from the core. The response of the structure under static loading is to deflect excessively, resulting in a large crease in the outer skin. One specimen tested at the 8-year interval was loaded beyond this point to investigate the additional load carrying capability of the door after the disbonding became evident. The part continued to carry load up to approximately 200 percent of the baseline (see Table IV-D, specimen ML-52), at which point the creased skin failed completely. Although the door was found to carry load beyond the point of initial debonding, it was felt that the excessive deflection and the creased skin constituted part failure. It is postulated that this phenomena occurred during the 5-year test interval, and the failure point was interpreted to be at the much greater load. Therefore, the data gathered for the baggage doors at the 5-year interval should be discounted. The single point taken at the 3-year test interval which is much greater than the baseline data has been documented as a hinge failure, thus explaining the higher strength value.

5. EXPOSURE COUPON TESTING

5.1 DISCUSSION

This section contains a brief summary of the exposure coupon testing which was conducted in conjunction with the component testing. This portion of the program has been monitored by NASA-Langley, and detailed reports of the test setup and results can be found in Reference 4. The following paragraphs have been extracted from Reference 4 for convenience.

Material test specimens were exposed at five locations on the North American Continent (Figure 22). The selected locations are in the general areas where the composite components were flown. Each location contains one rack as shown in Figure 23. The racks were installed in 1980 and contain five trays, each for removal after 1, 3, 5, 7, and 10 years of exposure. A tray contains 24 each of tension, short-beam-shear (SBS), and Illinois Institute of Technology Research Institute (IITRI) compression specimens and four 2.0-in-wide specimens to provide information on the weathering characteristics of each material system. The tension, compression, and SBS specimens are painted with a polyurethane paint (IMIRON)[7] that is used on the flight service helicopters.

The four composite material systems in the ground exposure program are given as follows: (1) Kevlar-49 fabric (style 281)/F-185 epoxy $[0/45/0]_S$; (2) Kevlar-49 fabric (style 120)/LRF-277 epoxy $[0/90/+45]_S$; (3) Kevlar-49 fabric (style 281)/CE-306 $[0/90]_S$; and (4) T-300/E-788 [0/+45/0] graphite/epoxy. These material systems correspond to those used for the litter door, baggage door, forward fairing, and vertical fin, respectively.

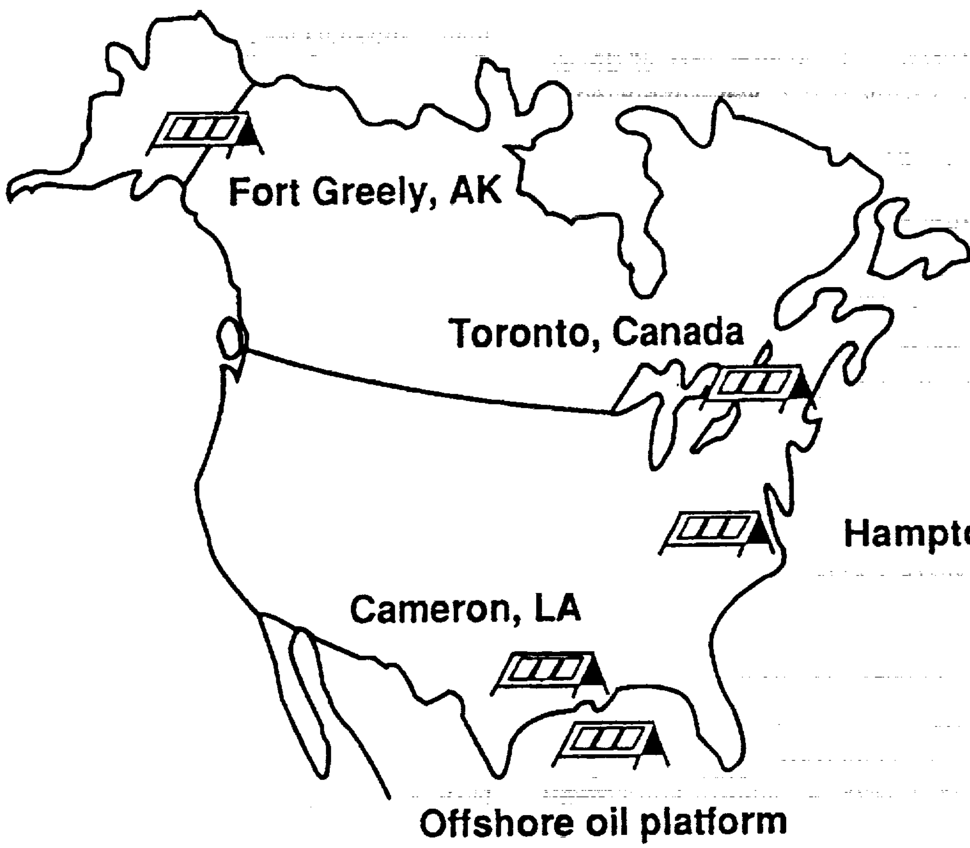
5.2 RESULTS

Figures 24a through 24c indicate the various property retention characteristics of the different material systems. The data indicates that the Kevlar-49/LRF-277 material has the lowest compressive and short-beam-shear strength of the four systems (Figures 21a and 21b). It is noted at the 7-year test interval, the Kevlar-49/F-185 and T-300/E-788 materials fell to a value of 93 percent, which was slightly below the lower edge of the baseline scatter. The residual tension strength of all material systems equals or exceeds the baseline strength (Figure 21c).

5.3 COMPARISONS TO COMPONENT TEST RESULTS

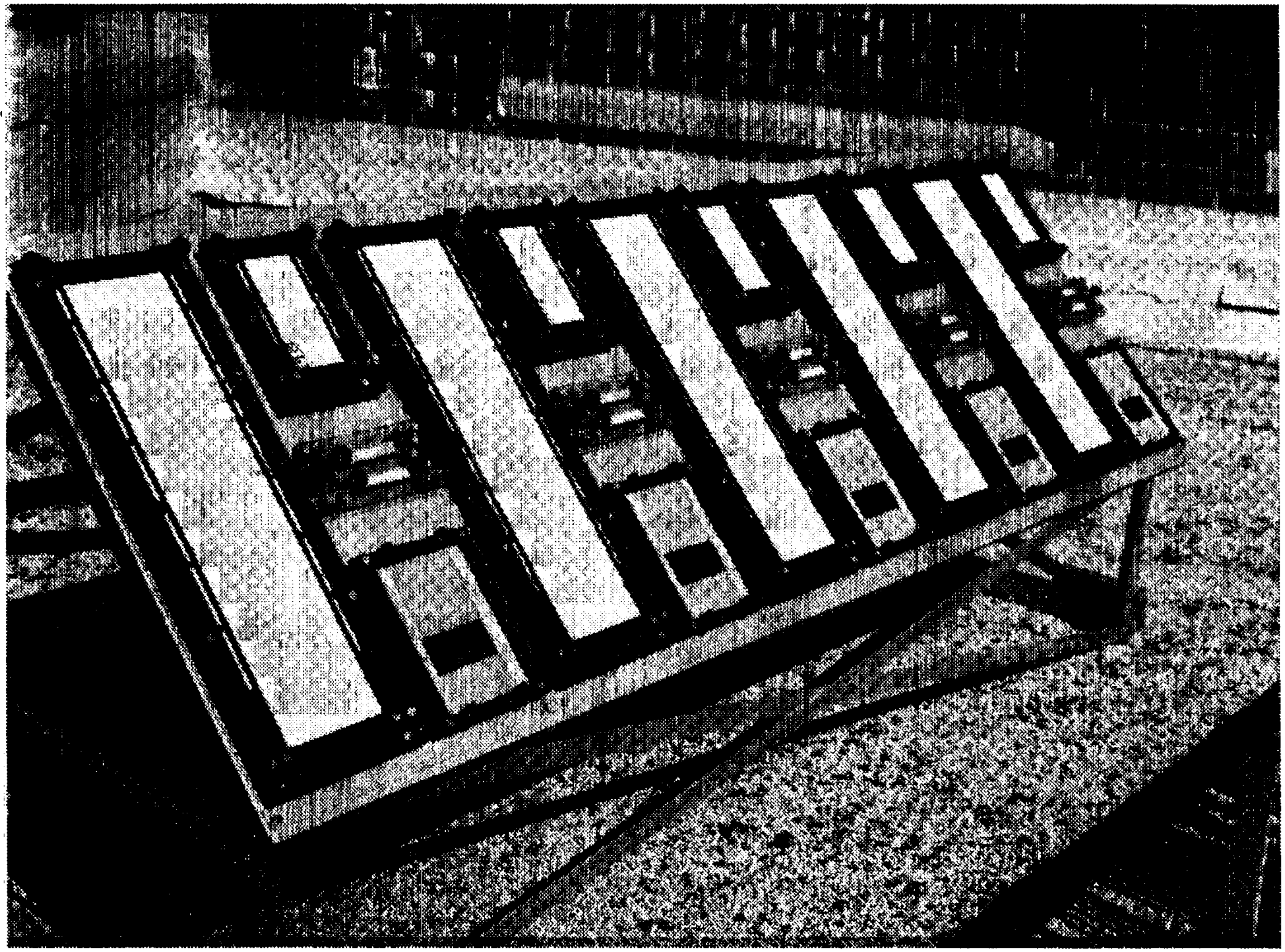
The problems associated with the matrix system used to manufacture the baggage doors with the Kevlar-49/LRF-277 material are apparent in both the component and coupon testing. The disbonding of the facesheets and the core by the components, lead to degraded strength on almost every part. Similarly, the compressive and shear strengths (matrix-dominant properties) of the coupons for this system degraded a significant amount. The retention of properties by the coupons produced from the other material systems agrees with the property retention of the vertical fins, litter doors and fairings.

7 IMIRON: Trademark of E. I. du Pont de Nemours & Co., Inc.



2-L550

Figure 22. Distribution Map of Exposure Coupons



2-L551

Figure 23. Exposure Coupon Test Rack

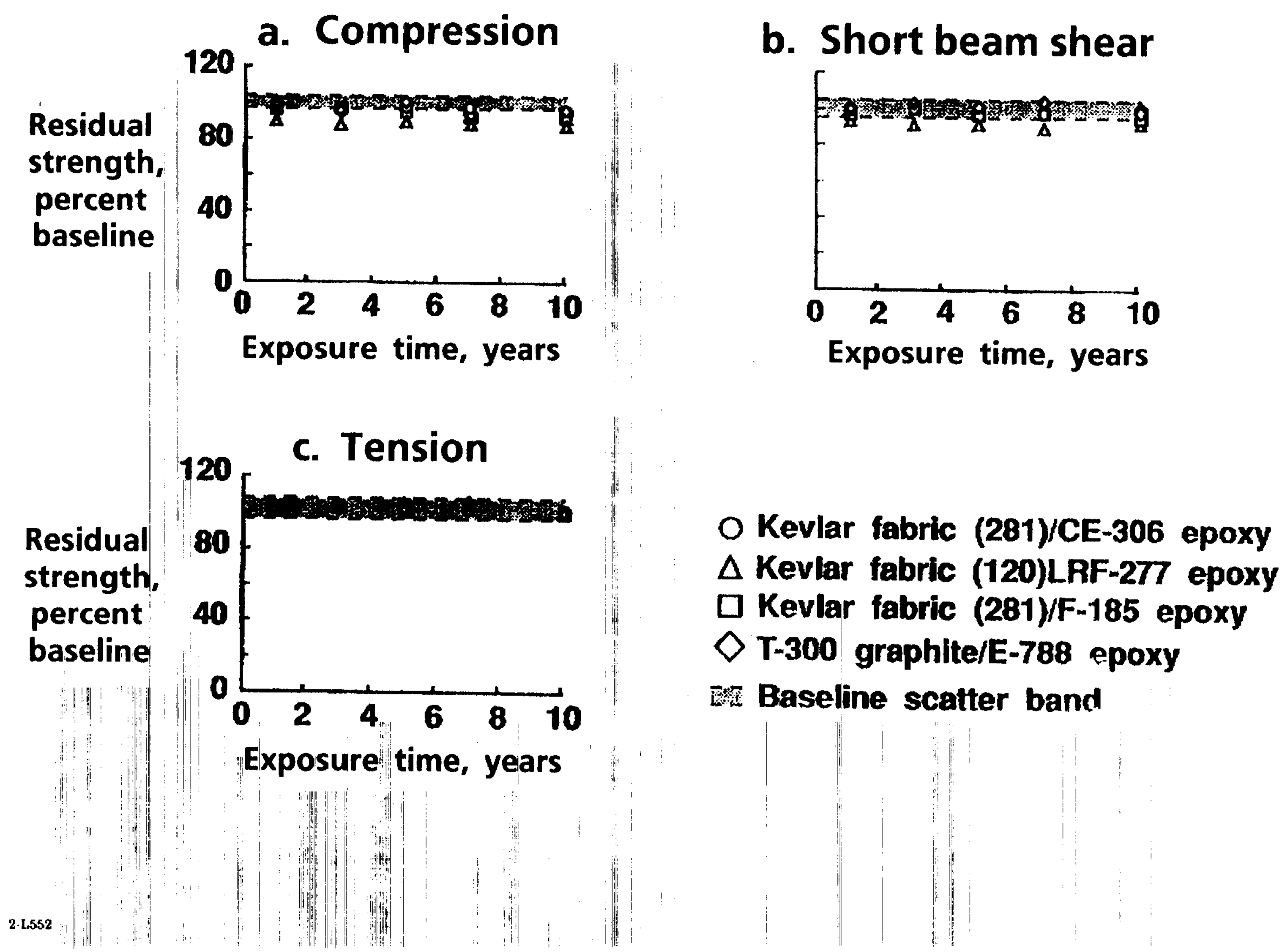


Figure 24. Residual Strength of Exposure Coupons

6. CONCLUSIONS

A total of 160 flight components were installed on 40 aircraft, and accumulated 490,000 total flight hours over a period of almost 13 years. The part with the greatest number of flight hours was a forward fairing operating in the Gulf of Mexico Coastal Region, with over 14,000 hours.

The following conclusions are drawn from the evaluation of the four selected helicopter components fabricated of different composite materials and subjected to various field environments in four regions of North America. The operating regimes were represented by 20 operators over a 12-year period.

6.1 FIELD ENVIRONMENTAL EFFECTS

The study has indicated that, in general, composite materials subjected to normal environmental conditions can retain structural characteristics (strength and stiffness) over a significant period of time (at least 10 years).

Composite materials, as compared to metal, were shown to be significantly less affected by corrosion; in fact, corrosion was essentially nonexistent on the composite parts studied in this program.

Limited data has indicated that composites may survive lightning strike when provided with an adequate means of grounding.

Composite materials were shown to present operational problems when directly bonded to parts with significantly different coefficients of thermal expansion (Kevlar to plexiglass). An intermediate bonding layer (rubber) was found to solve this problem.

6.2 MATERIAL EFFECTS

Three of the four material systems chosen for this study displayed adequate capabilities to operate in normal environmental conditions without undue degradation. One Kevlar component fabricated with LRF-277 epoxy was found to suffer significant delaminations. However, this resin system was found to be unacceptable for production usage and was never used outside of an experimental program.

6.3 REGIONAL EFFECTS

The study has shown no major differences in structural characteristics or other effects between the four operating regions.

6.4 OPERATIONAL DURATION (FLIGHT HOURS)

There was no evidence that the structural capabilities of the four components was adversely affected with the accumulation of flight hours.

6.5 COMPONENT AGE

The age of the parts was not shown to affect the property retention capabilities of the four selected components.

In summary, this program has demonstrated that composite materials are viable for helicopter operations in various environments, and in some cases, provide significant advantages over metal parts.

7. REFERENCES

1. Zinberg, Herbert, "Flight Service Evaluation of Composite Components on the Bell Helicopter Model 206L: Design, Fabrication, and Testing," NASA CR 166002, November 1982.

2. Zinberg, Herbert, "Flight Service Evaluation of Composite Components on the Bell Helicopter Model 206L: First Annual Flight Service Report," NASA CR 172296, March 1984.

3. Wilson, H.E., "Flight Service Evaluation of Composite Components on the Bell Helicopter Model 206L: Second Annual Flight Service Report August 1983 through December 1985," NASA CR 178148, August 1986.

4. Baker, Donald J., "Evaluation of Composite Components on the Bell 206L and Sikorsky S-76 Helicopters," NASA Technical Memorandum 4195, AVSCOM Technical Report 90-B-004, August 1990.

APPENDIX A

STRUCTURAL TEST DATA

FOR 8-YEAR INTERVAL

BHTI REPORT NO. 20689M-018

26 MAY 1989

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Bell Helicopter TEXTRON

A Subsidiary of Textron Inc.

ENGINEERING LABORATORIES

Report No. 20689M-018
26 May 1989

Memo To: Scott Smith

Copy To: Henry Wilson, Lab Files

Subject: **FIELD SERVICE EVALUATION OF COMPOSITE COMPONENTS**

References:
(a) BHTI Report No. 599-335-063, "206L Composite Components Stiffness and Static Tests"
(b) BHTI Report No. 599-098-015, "Structural Tests of the 599-335-048-1 Composite Vertical Fin Assembly for the Model 206L and 206L-1"
(c) BHTI Engineering Laboratory Notebook N86-117

INTRODUCTION

This report presents the results of static tests conducted to determine the structural quality of four composite components of the Model 206L helicopter. A total of forty-nine parts were received for test; twenty 599-335-054-101 baggage doors, eleven 599-356-001-101 litter doors, nine 599-335-068-101 forward fairings, and nine 599-355-048-1 vertical fins were tested under simulated aerodynamic loading. Two 599-356-001-101 litter doors were missing production hardware and mounting points and were not tested.

Testing was conducted in a manner similar to that used in two previous programs, Ref. (a) and (b). In each test a specimen was mounted in a test fixture, and loads were applied evenly over one surface of the specimen. Methods of applying the loads are discussed in Ref. (a) and (b). The loads were reacted at normal aircraft attachment points using production hardware.

Testing was conducted in the Structural Test Laboratory of Bell Helicopter Textron, Inc., Fort Worth, Texas, between January 16, 1989, and April 14, 1989. All test data can be found in Ref. (c).

RESULTS

The results of static tests of 47 specimens are presented in Table I. Deflection data is presented in Tables II, III, IV and V. Dial indicator locations are as described in Ref. (a) and (b). Dial indicator number 5 was the only dial indicator used on the 599-335-054-101 baggage door and the 599-335-068-101 fairing assembly.

TEST SPECIMEN

A detailed description of the 599-335-054-101 baggage door, the 599-356-001-101 litter door, and the 599-335-068-101 forward fairing are presented in the Test Specimen section of BHTI Report No. 599-335-063, Ref. (a). A description of the 599-335-048-1 vertical fin is presented in the Test Specimen section of BHTI Report No. 599-098-015, Ref. (b).

APPARATUS AND METHOD

Twenty specimens of the 599-335-054-101 baggage doors, nine of the 599-356-001-101 litter doors, and nine 599-335-068-101 forward fairings were tested under simulated aerodynamic loading using the methods described in BHTI Report No. 599-335-063, Ref. (a).

Nine specimens of the 599-335-048-1 vertical fin were tested under simulated aerodynamic loading using the methods described in BHTI Report no. 599-098-015, Ref. (b).

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TABLE I. SUMMARY OF TEST RESULTS OF COMPOSITE COMPONENTS

COMPONENT	SERIAL NO.	FAILURE LOAD LBS/IN²	FAILURE LOAD / LIMIT LOAD	HINGE POINT LOADS (LBS) ⚠1 UPPER	HINGE POINT LOADS (LBS) ⚠1 LOWER
599-356-001-101 Litter Door Area = 1,153 in² Limit Load = .20 psig	ML-A83	.594	2.97	157	420
	ML-6	1.518	7.59	0	0
	ML-141	.781	3.90	53	140
	ML-142	1.366	6.83	53	140
	ML-4	1.127	5.64	53	140
	ML-A5	1.236	6.18	53	140
	ML-143	1.214	6.07	53	140
	ML-A84	1.258	6.29	53	140
	ML-400	1.258	6.29	53	140
599-335-054-101 Baggage Door Area = 876 in² Limit Load = .33 psig	ML-111	.495	1.50		
	ML-52	1.365	4.14		
	ML-13	.371	1.12		
	ML-185	.571	1.73		
	ML-122	.485	1.47		
	ML-A82	.542	1.64		
	ML-A81	.599	1.82		
	ML-186	.457	1.38		
	ML-181	.457	1.38		
	ML-184	.428	1.30		
	ML-183	.685	2.08		
	ML-182	.713	2.16		
	ML 112	.548	1.66		
	ML-51	.542	1.64		
	ML-19	.599	1.82		
	ML-121	.485	1.47		
	ML-401	.542	1.64		
	ML-402	.542	1.64		
	ML-403	.428	1.30		
	ML-404	.599	1.82		
599-335-068-101 Forward Fairing Limit Load = .2 psig	ML-A3	2.70	13.5		
	ML-A01	2.80	14.0		
	ML-1	2.46	12.3		
	ML-A4	2.11	10.6		
	ML-16	3.68	18.4		
	ML-2	3.44	17.2		
	ML-A2	3.73	18.7		
	ML-3	3.68	18.4		
	ML-15	3.93	19.7		

TABLE I. SUMMARY OF TEST RESULTS OF COMPOSITE COMPONENTS
(Concluded)

COMPONENT	SERIAL NO.	FAILURE LOAD LBS/IN^2	FAILURE LOAD LIMIT LOAD	HINGE POINT (1) LOADS (LBS)	
				UPPER	LOWER
599-335-048-1 Vertical Fin Area = 1,387 in^2 Limit Load = .5 psig	ML-10	1.39	2.78		
	ML-24	1.44	2.88		
	ML-08	1.48	2.96		
	ML-20	1.50	3.00		
	ML-21	1.57	3.14		
	ML-23	1.41	2.81		
	ML-17	1.49	2.98		
	ML-22	1.49	2.98		
	ML-9	1.49	2.98		

(1) Hinge point loads on specimen ML-A83 were maintained at the same percent of limit as the distributed loads while loading to failure. Specimen ML-6 hinge point loads were zero while loading to failure. For the balance of the specimens, the point loads were maintained at 100% of limit values while loading to failure.

TABLE II. SUMMARY OF DEFLECTION TEST RESULTS FOR THE 599-335-054-101 COMPOSITE BAGGAGE DOOR

SERIAL NO.	DEFLECTION (INCHES) [1]						
	PERCENT LOAD						
	0	20	40	60	80	100	20
ML-111	0.0	.173	.363	.559	.811	1.084	.264
ML-52	0.0	.173	.364	.567	.969	1.343	.557
ML-13	0.0	.224	.579	.894	1.292	1.626	.331
ML-185	0.0	.144	.352	.609	.896	1.115	.248
ML-122	0.0	.183	.405	.616	.867	1.292	.545
ML-A82	0.0	.172	.434	.647	.944	1.584	.352
ML-A81	0.0	.147	.326	.516	.778	1.166	.323
ML-186	0.0	.159	.323	.524	.811	1.200	.291
ML-181	0.0	.209	.437	.670	.944	1.243	.326
ML-184	0.0	.099	.275	.504	.804	1.254	.224
ML-183	0.0	.162	.331	.547	.753	1.002	.291
ML-182	0.0	.112	.377	.578	.812	1.110	.291
ML-112	0.0	.207	.422	.658	1.041	1.315	.350
ML-51	0.0	.170	.332	.520	.735	1.009	.223
ML-19	0.0	.171	.385	.552	.791	1.080	.295
ML-121	0.0	.112	.320	.530	.798	1.170	.226
ML-401	0.0	.150	.345	.569	.858	1.319	.323
ML-402	0.0	.141	.338	.526	.907	1.416	.236
ML-403	0.0	.152	.344	.587	.963	1.313	.265
ML-404	0.0	.186	.408	.620	.962	1.241	.356

[1] Only dial indicator No. 5 as described in Ref. (a) was used.

TABLE III. SUMMARY OF DEFLECTION TEST RESULTS FOR THE 599-356-001-101 COMPOSITE LITTER DOOR

DEFLECTIONS (INCHES)							
SERIAL NO.	LOAD % LIMIT	DIAL INDICATOR NO.					
		1	2	3	4	5	6
ML-A83	0	0	0	0	0	0	0
	20	.027	.051	.028	.036	.010	.001
	40	.054	.096	.037	.088	.028	-.005
	60	.077	.135	.048	.117	.045	.006
	80	.097	.175	.064	.115	.058	.014
	100	.104	.208	.074	.128	.066	.026
	20	.043	.064	.035	.083	.038	.004
ML-6	0	0	0	0	0	0	0
	20	.057	.040	.015	0	.010	.036
	40	.076	.080	.023	.002	.018	.056
	60	.088	.119	.026	.005	.013	.066
	80	.097	.149	.025	.011	.034	.081
	100	.100	.186	.028	.020	.038	.092
	20	.097	.054	.019	.005	.020	.042
ML-141	0	0	0	0	0	0	0
	20	.039	.017	.041	.011	.007	.008
	40	.065	.072	.067	.021	.015	.011
	60	.070	.115	.079	.024	.024	.025
	80	.074	.160	.091	.026	.038	.035
	100	.077	.204	.100	.028	.048	.049
	20	.061	.040	.048	.010	.011	.014
ML-142	0	0	0	0	0	0	0
	20	.019	.044	.024	.003	.006	.008
	40	.048	.090	.042	.005	.014	.022
	60	.075	.135	.058	.005	.025	.050
	80	.094	.177	.074	.004	.031	.066
	100	.109	.216	.088	.008	.032	.085
	20	.046	.072	.037	0	.017	.035
ML-4	0	0	0	0	0	0	0.
	20	.002	.016	.012	.012	.001	010
	40	.008	.045	.025	.019	.006	.018
	60	.017	.082	.037	.023	.010	.037
	80	.027	.122	.049	.024	.016	.054
	100	.036	.161	.064	.024	.020	.073
	20	.029	.040	.023	.019	.008	.018

TABLE III. SUMMARY OF DEFLECTION TEST RESULTS FOR THE 599-356-001-101 COMPOSITE LITTER DOOR (Concluded)

DEFLECTIONS (INCHES)							
SERIAL NO.	LOAD % LIMIT	DIAL INDICATOR NO.					
		1	2	3	4	5	6
ML-A5	0	0	0	0	0	0	0
	20	.045	.062	.039	.002	.009	.015
	40	.075	.110	.061	0	.031	.047
	60	.092	.145	.072	.005	.037	.079
	80	.107	.184	.084	.006	.053	.089
	100	.120	.216	.094	.016	.057	.099
	20	.053	.078	.051	.006	.028	.047
ML-143	0	0	0	0	0	0	0
	20	.048	.064	.039	.002	.005	.007
	40	.093	.122	.055	0	.010	.019
	60	.117	.166	.067	0	.018	.040
	80	.132	.207	.077	-.001	.027	.066
	100	.147	.251	.089	0	.036	.080
	20	.061	.083	.047	-.002	.006	.018
ML-A84	0	0	0	0	0	0	0
	20	.020	.047	.036	.002	.005	.004
	40	.052	.088	.049	.005	.010	.010
	60	.075	.131	.071	.005	.019	.033
	80	.092	.169	.084	.004	.030	△1
	100	.105	.204	.095	.003	.037	△1
	20	.032	.062	.047	-.002	.017	△1
ML-400	0	0	0	0	0	0	0
	20	.018	.051	.030	.012	.007	.005
	40	.056	.105	.047	.011	.016	.016
	60	.080	.150	.055	.008	.021	.030
	80	.095	.186	.060	.009	.026	.052
	100	.106	.225	.068	.010	.032	.058
	20	.086	.094	.032	.005	.013	.020

△1 Dial indicator bottomed out after 60% load.

TABLE IV. SUMMARY OF DEFLECTION TEST RESULTS FOR THE 599-335-068-101 COMPOSITE FAIRING ASSEMBLY

SERIAL NO.	DEFLECTION (INCHES) ⚠1								
	PERCENT LOAD								
	0	20	40	60	80	100	125	150	200
ML-A3	0	-.003	-.001	.024	.047	.065	.074	.112	.156
ML-A01	0	0	0	.003	.033	.048	.075	.115	.194
ML-1	0	0	0	0	.003	.023	.047	.073	.123
ML-A4	0	0	0	.018	.050	.075	.098	.122	.172
ML-16	0	0	.018	.019	.048	.073	.090	.108	.146
ML-2	0	.006	.016	.039	.056	.069	.109	.128	.180
ML-A2	0	.024	.034	.059	.074	.086	.114	.134	.184
ML-3	0	.020	.035	.052	.070	.092	.119	.150	.200
ML-15	0	.026	.041	.066	.087	.103	.136	.181	.240

⚠1 Only dial indicator No. 5 as described in Ref. (a).

TABLE V. SUMMARY OF DEFLECTION TEST RESULTS FOR THE 599-335-048-1 COMPOSITE CERTICAL FIN ASSEMBLY

SERIAL NO.	DEFLECTION (INCHES)							
	PERCENT LOAD							
	0	20	40	60	80	100	125	150
ML-10	0	.54	1.03	1.55	2.15	2.75		
ML-24	0	.42	.85	1.31	1.85	2.30		
ML-8	0	.38	.84	1.25	1.80	2.23		
ML-20	0	.48	.85	1.20	1.55	1.95		
ML-21	0	.49	1.10	1.58	1.91	2.68		
ML-23	0	.50	.65	.85	1.15	1.45	1.95	2.40
ML-17	0	.28	.53	1.13	1.46	1.78	2.48	2.88
ML-22	0	.20	.45	1.20	1.35	1.75	2.30	2.60
ML-9	0	.30	.75	1.25	2.30	3.30	3.90	4.75

APPENDIX B

STRUCTURAL TEST DATA

FOR 11- and 11.5-YEAR INTERVAL

BHTI REPORT NO. 20692M-133

8 DECEMBER 1992

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Bell Helicopter TEXTRON
A Subsidiary of Textron Inc

ENGINEERING LABORATORIES Report No. 20692M-133
8 December 1992

MEMO TO: H. Wilson

COPY TO: H. Lawton, Lab Files

SUBJECT: **FIELD SERVICE EVALUATION OF COMPOSITE COMPONENTS**

REFERENCES:
(a) BHTI Report No. 599-335-063, "206L Composite Components Stiffness and Static Tests"
(b) BHTI Report No. 599-098-015, "Structural Tests of the 599-335-048-1 Composite Vertical Fin Assembly for the Model 206L and 206L-1"
(c) BHTI Report No. 20681M-236, "Field Service Evaluation of Composite Components"
(d) BHTI Report No. 20682M-109, "Field Service Evaluation of Composite Components"
(e) BHTI Report No. 0082M-128, "Field Service Evaluation of Composite Components"
(f) BHTI Report No. 20685M-038, "Field Service Evaluation of Composite Components"
(g) BHTI Report No. 20689M-018, "Field Service Evaluation of Composite Components"
(h) BHTI Engineering Laboratory Notebooks N86-117, N92-11, N86-109, and N90-39

INTRODUCTION

This report presents the results of static tests conducted to determine the structural quality of four different composite components of the Model 206L helicopter. These tests were part of the NASA Flight Service Evaluation Program (Contract NAS1-15279) to certify these components for use on the M206L helicopter. The objective of these tests is to obtain static stiffness and strength data on these parts after an extended period of time in service. Thirty-three parts were received from the field for test, a total of thirty-two parts were tested; ten 599-356-001-101 litter doors, one 599-335-054-101 baggage door, ten 599-335-068-101 forward fairings, and eleven 599-355-048-1 vertical fins were tested under simulated aerodynamic loading. One 599-356-001-101 litter door was missing the window and was not tested.

Testing was conducted in a manner similar to that used in three previous programs, References (a) through (g). In each test a specimen was mounted in a test fixture, and loads were applied evenly over one surface of the specimen. Methods of applying the loads are discussed in References (a) and (b). The loads were reacted at normal aircraft attachment points using production hardware.

Testing was conducted in the Structural Test Laboratory of Bell Helicopter Textron, Inc., Fort Worth, Texas, between June 12, 1989, and September 28, 1992. All test data can be found in Ref. (h).

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RESULTS

The results of the static test of 32 specimens are presented in Table I. Deflection data is presented in tabular form in Tables II, III, IV and V and graphical form in Figures 1 through 15. Dial indicator locations are described in References (a) and (b), and shown in Figures 16 and 17. Dial indicator number 5 was the only dial indicator used on the 599-335-054-101 baggage door and the 599-335-068-101 fairing assembly.

CONCLUSION

It is concluded that the results presented in this report are representative of the composite parts tested.

It is further concluded that the time in service did not reduce the strength of the composite parts. The failure loads presented in Table I were slightly higher for the litter doors and baggage doors and slightly lower for the forward fairing and vertical fin than the failure loads of the original baseline specimens presented in Reference (c).

TEST SPECIMEN

A detailed description of the 599-335-054-101 baggage door, the 599-356-001-101 litter door, and the 599-335-068-101 forward fairing are presented in the Test Specimen section of BHTI Report No. 599-335-063, Ref. (a). A description of the 599-335-048-1 vertical fin is presented in the Test Specimen section of BHTI Report No. 599-098-015, Ref. (b).

APPARATUS AND METHOD

Eleven specimens of the 599-356-001-101 litter doors, one 599-335-054-101 baggage door, and ten 599-335-068-101 forward fairings were tested under simulated aerodynamic loading using the methods described in BHTI Report No. 599-335-063, Ref. (a).

Eleven specimens of the 599-335-048-1 vertical fin were tested under simulated aerodynamic loading using the methods described in BHTI Report No. 599-098-015, Ref. (b).

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Chris Whitlock
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Structural Test Laboratory

APPROVED:

John R. Slack
John R. Slack
Group Engineer
Structural Test Laboratory

TABLE I SUMMARY OF TEST RESULTS OF COMPOSITE COMPONENTS

COMPONENT	SERIAL NO.	FAILURE LOAD (LBS/IN^2)	FAILURE LOAD / LIMIT LOAD
599-356-001-101 Litter Door Area = 1,153 in^2 Limit Load = 0.2 Psig Upper Hinge Point Limit Load = 140 Lb Lower Hinge Point Limit Load = 53 Lb Hinge Point Loads Maintained At Limit Load While Loading To Failure.	ML-502	1.27	6.33
	ML-503	1.17	5.85
	ML-B01	1.37	6.83
	ML-B02	1.15	5.75
	ML-B03	0.91	4.55
	ML-B04	0.98	4.88
	ML-B05	0.95	4.77
	ML-B06	0.74	3.70
	ML-C05	WINDOW MISSING	-
	ML-D03	1.13	5.64
	ML-D04	1.28	6.40
599-335-054-101 Baggage Door Area = 876 in^2 Limit Load = 0.33 psig	ML-B07	0.64	1.95
599-335-068-101 Forward Fairing Limit Load = 0.20 psig	ML-500	3.00	15.0
	ML-501	3.59	17.9
	ML-B01	2.75	13.0
	ML-B02	2.46	12.3
	ML-C01	3.14	15.7
	ML-C02	2.46	12.3
	ML-C03	3.09	15.5
	ML-C04	2.90	14.5
	ML-D01	2.11	10.6
	ML-D02	2.26	11.3
599-335-048-001 Vertical Fin Area = 1,387 in^2 Limit Load = 0.5 psig	ML-504	1.67	3.33
	ML-B01	1.41	2.81
	ML-B02	1.19	2.38
	ML-B03	1.28	2.56
	ML-B04	1.23	2.45
	ML-C06	1.55	3.11
	ML-C07	1.62	3.25
	ML-C08	1.34	2.68
	ML-C09	1.57	3.15
	ML-D05	1.39	2.78
	ML-D06	1.08	2.16

TABLE II. SUMMARY OF TEST RESULTS FOR THE 599-356-001-101
M206L COMPOSITE LITTER DOOR

SERIAL NUMBER	PERCENT LIMIT LOAD	DEFLECTIONS (INCHES) DIAL INDICATOR NUMBER [1]					
		DI 1	DI 2	DI 3	DI 4	DI 5	DI 6
ML-502	0	0.000	0.000	0.000	0.000	0.000	0.000
	20	0.003	0.034	0.016	0.033	0.017	-0.003
	40	0.018	0.087	0.044	0.039	0.027	-0.006
	60	0.038	0.128	0.060	0.061	0.041	-0.002
	80	0.055	0.168	0.068	0.072	0.051	0.008
	100	0.069	0.208	0.076	0.082	0.062	0.014
	20	0.015	0.057	0.040	0.072	0.034	-0.002
ML-503	0	0.000	0.000	0.000	0.000	0.000	0.000
	20	0.011	0.042	0.023	0.000	0.011	0.022
	40	0.044	0.093	0.043	-0.002	0.019	0.032
	60	0.070	0.142	0.063	-0.002	0.023	0.042
	80	0.092	0.189	0.078	0.003	0.024	0.065
	100	0.109	0.235	0.091	0.005	0.027	0.083
	20	0.033	0.063	0.034	-0.002	0.016	0.027
ML-B01	0	0.000	0.000	0.000	0.000	0.000	0.000
	20	0.027	0.059	0.042	-0.008	0.023	0.001
	40	0.047	0.112	0.062	-0.013	0.034	0.037
	60	0.066	0.157	0.074	-0.016	0.044	0.056
	80	0.081	0.192	0.084	-0.017	0.051	0.066
	100	0.092	0.227	0.092	-0.018	0.058	0.074
	20	0.043	0.078	0.048	-0.003	0.037	0.035
ML-B02	0	0.000	0.000	0.000	0.000	0.000	0.000
	20	0.022	0.052	0.032	0.004	0.007	0.000
	40	0.042	0.104	0.058	0.018	0.010	-0.006
	60	0.057	0.134	0.067	0.030	0.021	-0.009
	80	0.070	0.177	0.074	0.047	0.030	0.004
	100	0.082	0.217	0.085	0.045	0.036	0.006
	20	0.026	0.060	0.031	0.049	0.018	-0.006
ML-B03	0	0.000	0.000	0.000	0.000	0.000	0.000
	20	0.028	0.058	0.039	0.008	0.000	0.006
	40	0.048	0.105	0.064	0.012	0.013	0.019
	60	0.069	0.153	0.080	0.016	0.020	0.022
	80	0.087	0.194	0.088	0.022	0.030	0.029
	100	0.105	0.244	0.097	0.033	0.036	0.050
	20	0.047	0.078	0.049	0.026	0.006	-0.001

[1] Dial indicator locations are shown in Figure 16

TABLE II. SUMMARY OF TEST RESULTS FOR THE 599-356-001-101
M206L COMPOSITE LITTER DOOR
(concluded)

SERIAL NUMBER	PERCENT LIMIT LOAD	DEFLECTIONS (INCHES) DIAL INDICATOR NUMBER [1]					
		DI 1	DI 2	DI 3	DI 4	DI 5	DI 6
ML-B04	0	0.000	0.000	0.000	0.000	0.000	0.000
	20	0.015	0.054	0.034	-0.003	0.000	0.009
	40	0.030	0.114	0.067	-0.007	0.010	0.018
	60	0.054	0.160	0.079	-0.007	0.016	0.028
	80	0.069	0.205	0.087	-0.005	0.021	0.036
	100	0.092	0.256	0.091	0.001	0.028	0.044
	20	0.054	0.091	0.051	0.002	0.006	0.015
ML-B05	0	0.000	0.000	0.000	0.000	0.000	0.000
	20	0.028	0.055	0.043	-0.005	0.008	0.007
	40	0.056	0.099	0.054	-0.010	0.018	0.018
	60	0.071	0.142	0.072	-0.014	0.026	0.027
	80	0.087	0.179	0.082	-0.016	0.031	0.026
	100	0.093	0.203	0.087	-0.012	0.034	0.050
	20	0.036	0.069	0.051	-0.004	0.013	0.013
ML-B06	0	0.000	0.000	0.000	0.000	0.000	0.000
	20	0.058	0.089	0.054	-0.008	0.011	0.012
	40	0.082	0.140	0.076	-0.011	0.019	0.025
	60	0.102	0.181	0.086	-0.013	0.025	0.041
	80	0.122	0.232	0.097	-0.015	0.032	0.047
	100	0.131	0.272	0.105	-0.012	0.038	0.057
	20	0.068	0.103	0.063	-0.006	0.017	0.022
ML-D03	0	0.000	0.000	0.000	0.000	0.000	0.000
	20	0.035	0.067	0.070	-0.006	0.009	0.017
	40	0.060	0.125	0.097	-0.007	0.021	0.016
	60	0.090	0.186	0.111	-0.008	0.024	0.028
	80	0.103	0.231	0.123	-0.015	0.035	0.031
	100	0.111	0.267	0.131	-0.006	0.035	0.056
	20	0.056	0.086	0.077	-0.008	0.066	0.016
ML-D04	0	0.000	0.000	0.000	0.000	0.000	0.000
	20	0.051	0.059	0.026	-0.006	0.027	0.054
	40	0.093	0.109	0.036	-0.008	0.036	0.064
	60	0.120	0.155	0.046	-0.006	0.042	0.073
	80	0.139	0.192	0.056	-0.007	0.044	0.093
	100	0.166	0.239	0.064	-0.007	0.051	0.107
	20	0.054	0.065	0.027	-0.003	0.032	0.052

[1] Dial indicator locations are shown in Figure 16

TABLE III. SUMMARY OF DEFLECTION TEST RESULTS FOR THE 599-335-054-101 COMPOSITE BAGGAGE DOOR

SERIAL NUMBER	DEFLECTION OF DIAL INDICATOR NO 5 (INCHES) [1]						
	PERCENT LIMIT LOAD						
	0	20	40	60	80	100	125
ML-B07	0.000	0.190	0.436	0.654	0.913	[2]	[2]

[1] Dial indicator locations are shown in Figure 16
[2] No measurement taken

TABLE IV. SUMMARY OF DEFLECTION TEST RESULTS FOR THE 599-335-068-101 COMPOSITE FAIRING ASSEMBLY

SERIAL NUMBER	DEFLECTION OF DIAL INDICATOR NO 5 (INCHES) [1]								
	PERCENT LIMIT LOAD								
	0	20	40	60	80	100	125	150	200
ML-500	0.000	0.005	0.032	0.062	0.097	0.109	0.132	0.152	0.207
ML-501	0.000	0.010	0.040	0.075	0.100	0.120	0.140	0.165	0.205
ML-B01	0.000	0.035	0.070	0.092	0.113	0.230	0.265	0.305	0.380
ML-B02	0.000	0.040	0.075	0.105	0.135	0.173	0.215	0.305	0.355
ML-C01	0.000	0.054	0.087	0.105	0.127	0.139	0.160	0.186	0.217
ML-C02	0.000	0.060	0.134	0.161	0.203	0.230	0.256	0.275	0.344
ML-C03	0.000	0.018	0.044	0.071	0.087	0.107	0.127	0.145	0.205
ML-C04	0.000	0.021	0.056	0.083	0.137	0.165	0.238	0.262	0.298
ML-D01	0.000	0.022	0.047	0.067	0.092	0.115	0.139	0.207	0.256
ML-D02	0.000	0.011	0.024	0.039	0.059	0.078	0.130	0.191	0.235

[1] Dial indicator locations are shown in Figure 17

TABLE V. SUMMARY OF DEFLECTION TEST RESULTS FOR THE 599-335-048-101 COMPOSITE VERTICAL FIN ASSEMBLY

SERIAL NUMBER	DEFLECTION (INCHES) [1]							
	PERCENT LIMIT LOAD							
	0	20	40	60	80	100	125	150
ML-504	0.000	0.450	1.000	1.450	1.850	2.600	3.200	3.600
ML-B01	0.000	0.300	0.650	1.350	1.750	2.300	2.900	3.650
ML-B02	0.000	0.320	0.600	1.150	1.450	1.950	2.500	2.930
ML-B03	0.000	0.200	0.650	1.200	1.600	2.000	2.200	2.700
ML-B04	0.000	0.300	0.750	1.300	1.750	1.850	2.350	2.950
ML-C06	0.000	0.250	0.580	0.750	1.000	1.350	2.100	2.600
ML-C07	0.000	0.350	0.750	1.000	1.450	1.700	2.050	2.550
ML-C08	0.000	0.350	0.500	1.000	1.250	1.870	2.400	2.940
ML-C09	0.000	0.400	0.750	0.900	1.250	1.750	2.100	2.550
ML-D05	0.000	0.250	0.650	0.830	1.150	1.500	1.900	2.280
ML-D06	0.000	0.270	0.750	1.020	1.320	1.720	2.220	2.700

[1] Tube Scale locations are shown in Figure 17

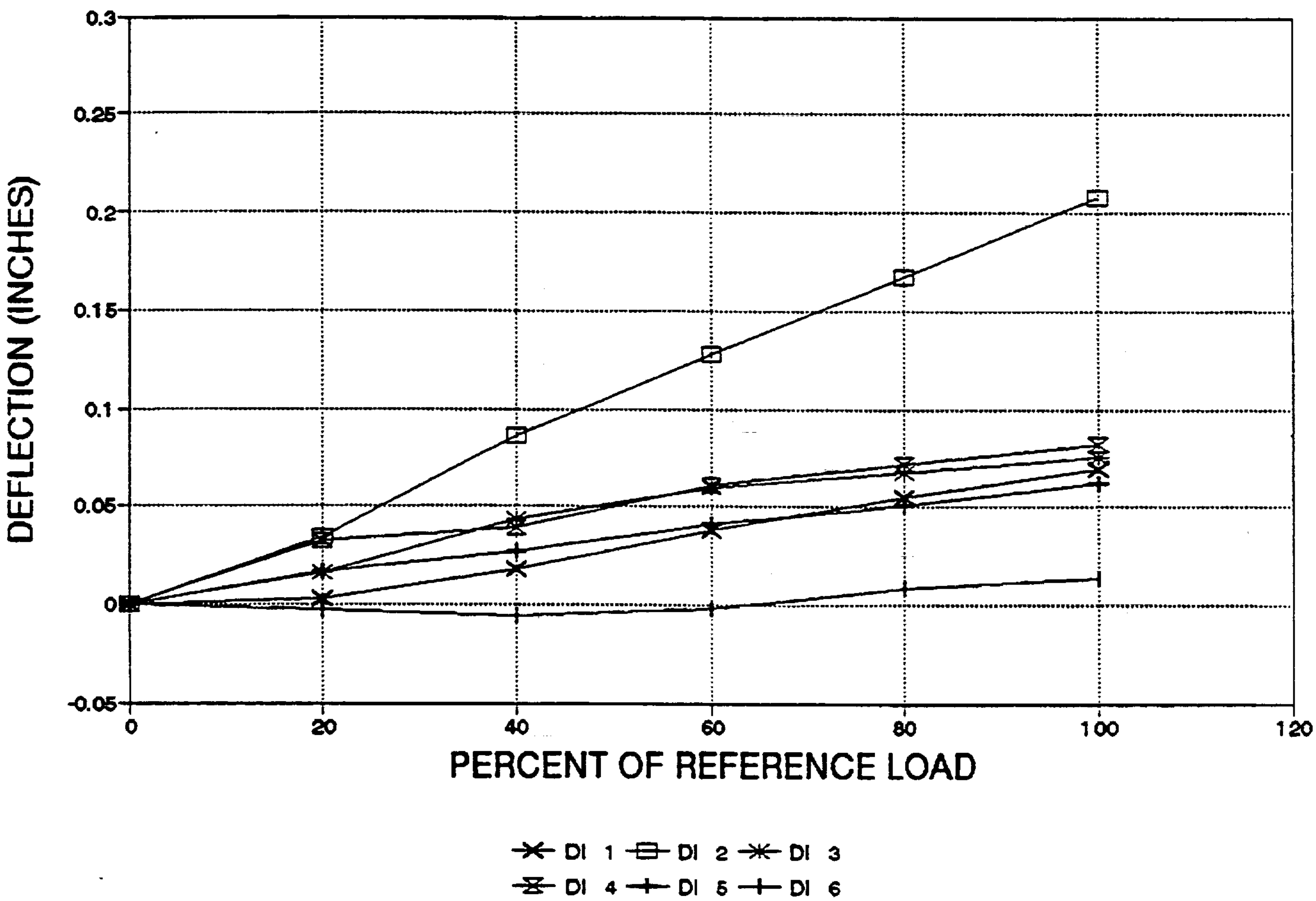


FIGURE 1

Dial Indicator Deflections for the 599-356-001-101 M206L Composite Litter Door, S/N ML-502, Reference Figure 16 for the Dial Indicator Locations.

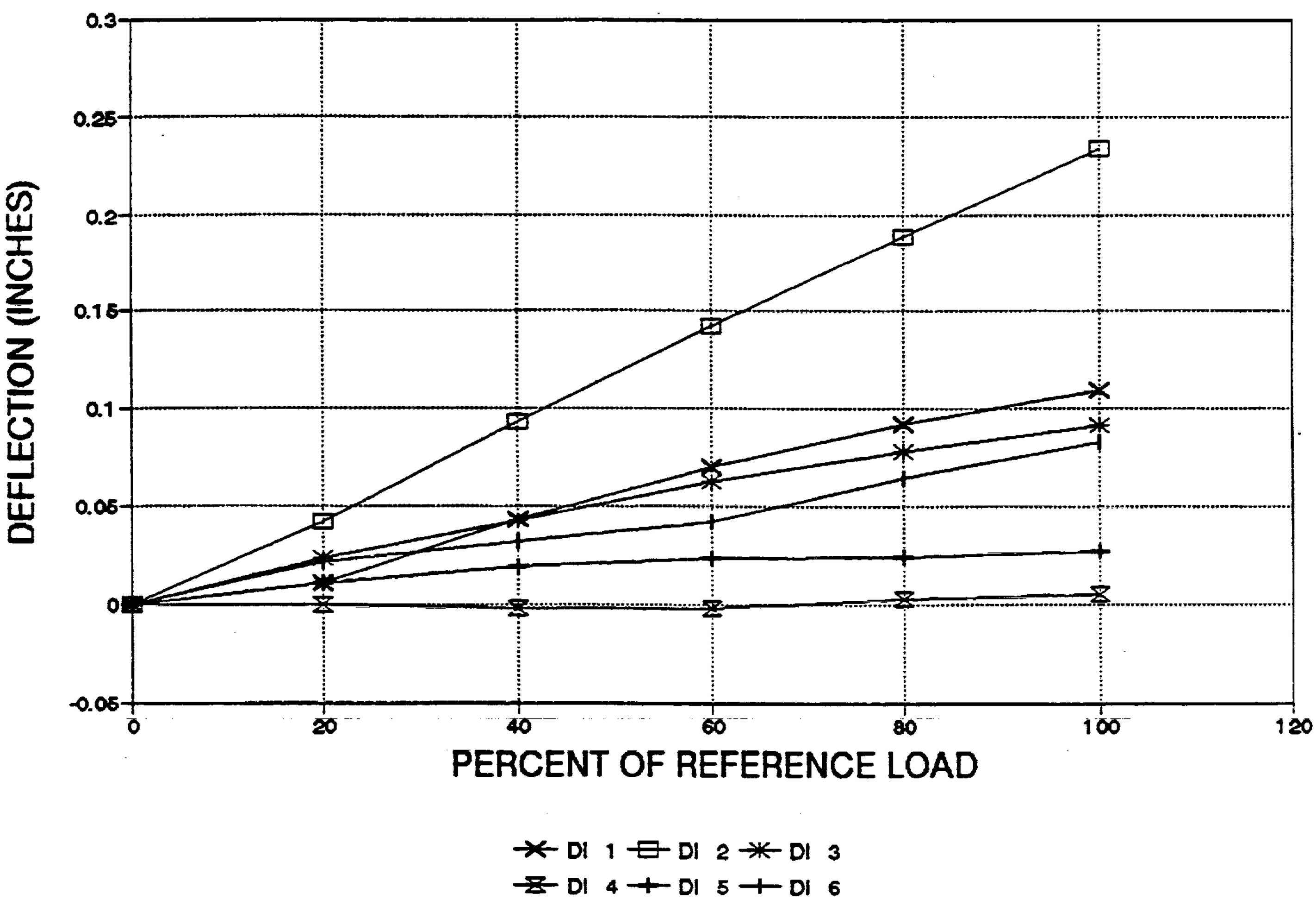


FIGURE 2

Dial Indicator Deflections for the 599-356-001-101 M206L Composite Litter Door, S/N ML-503, Reference Figure 16 for the Dial Indicator Locations.

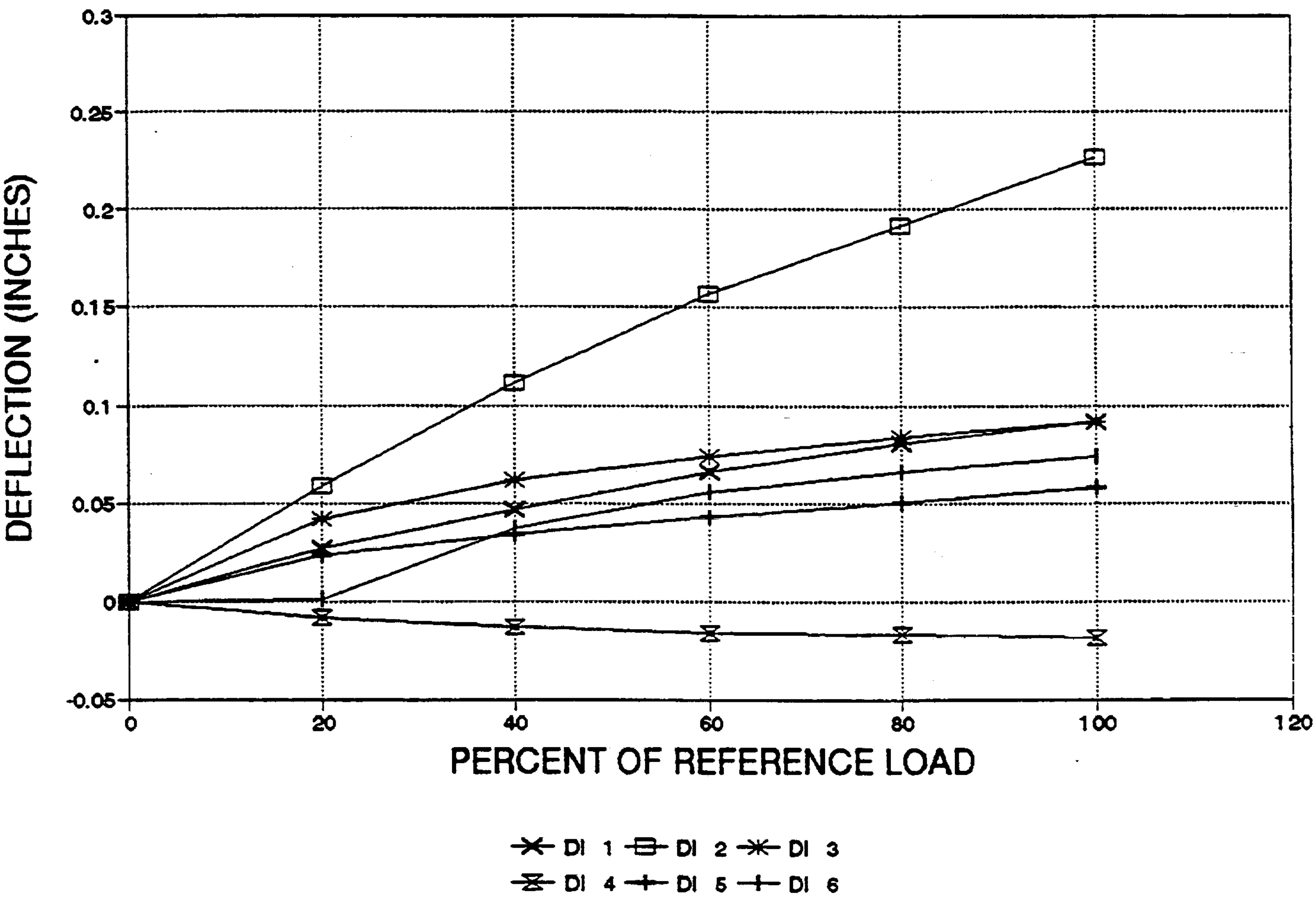


FIGURE 3

Dial Indicator Deflections for the 599-356-001-101 M206L Composite Litter Door, S/N ML-B01, Reference Figure 16 for the Dial Indicator Locations.

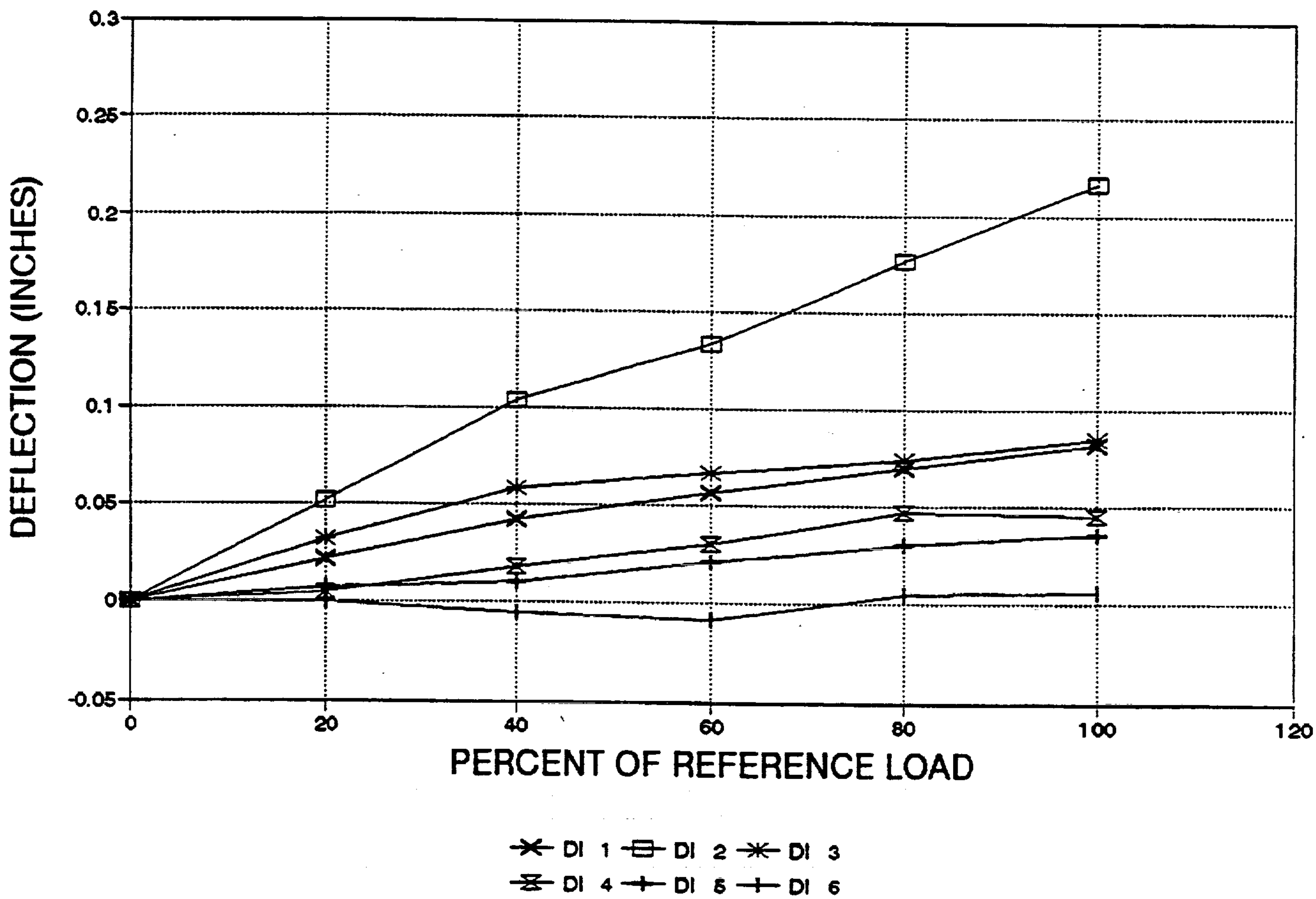


FIGURE 4

Dial Indicator Deflections for the 599-356-001-101 M206L Composite Litter Door, S/N ML-B02, Reference Figure 16 for the Dial Indicator Locations.

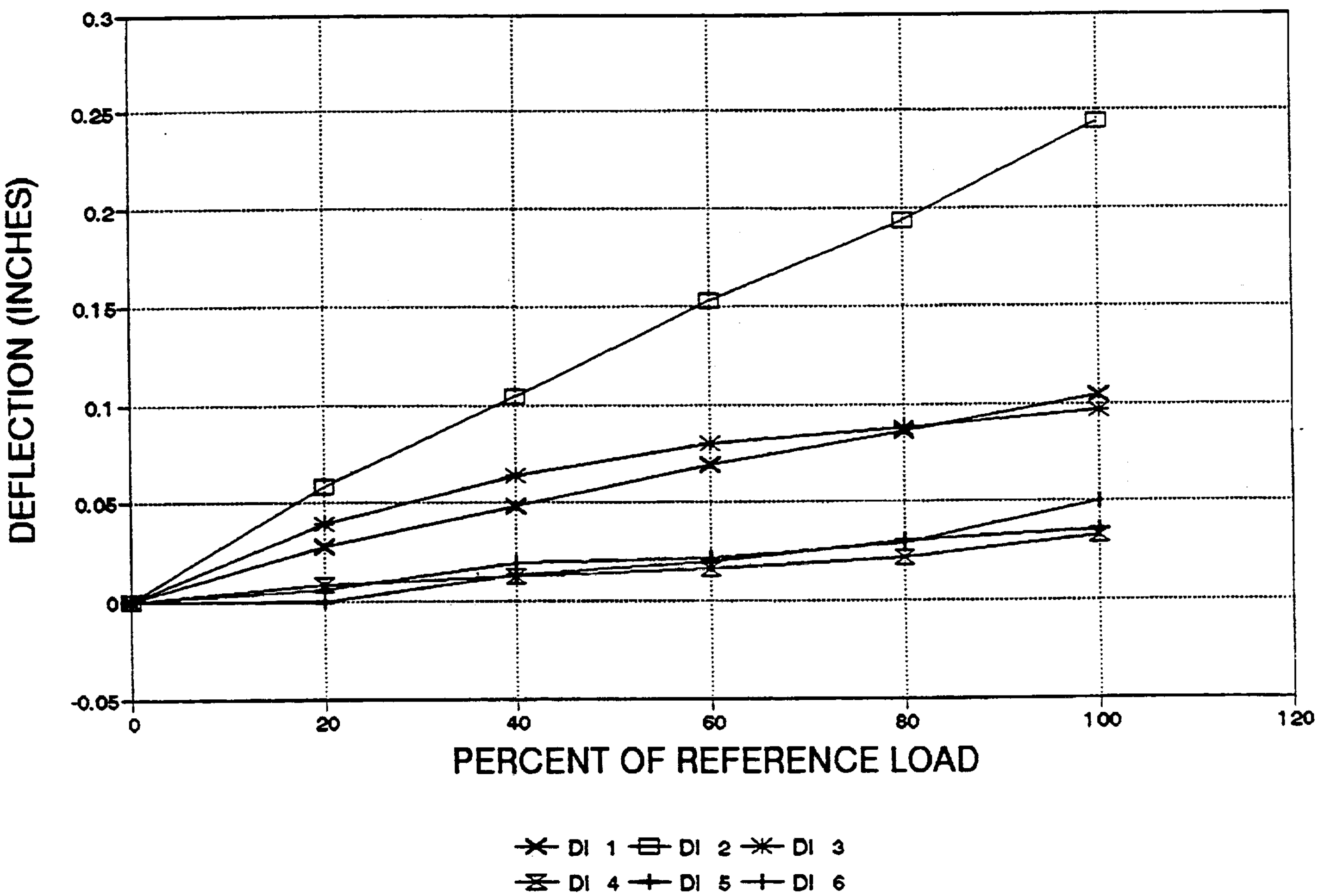


FIGURE 5

Dial Indicator Deflections for the 599-356-001-101 M206L Composite Litter Door, S/N ML-B03, Reference Figure 16 for the Dial Indicator Locations.

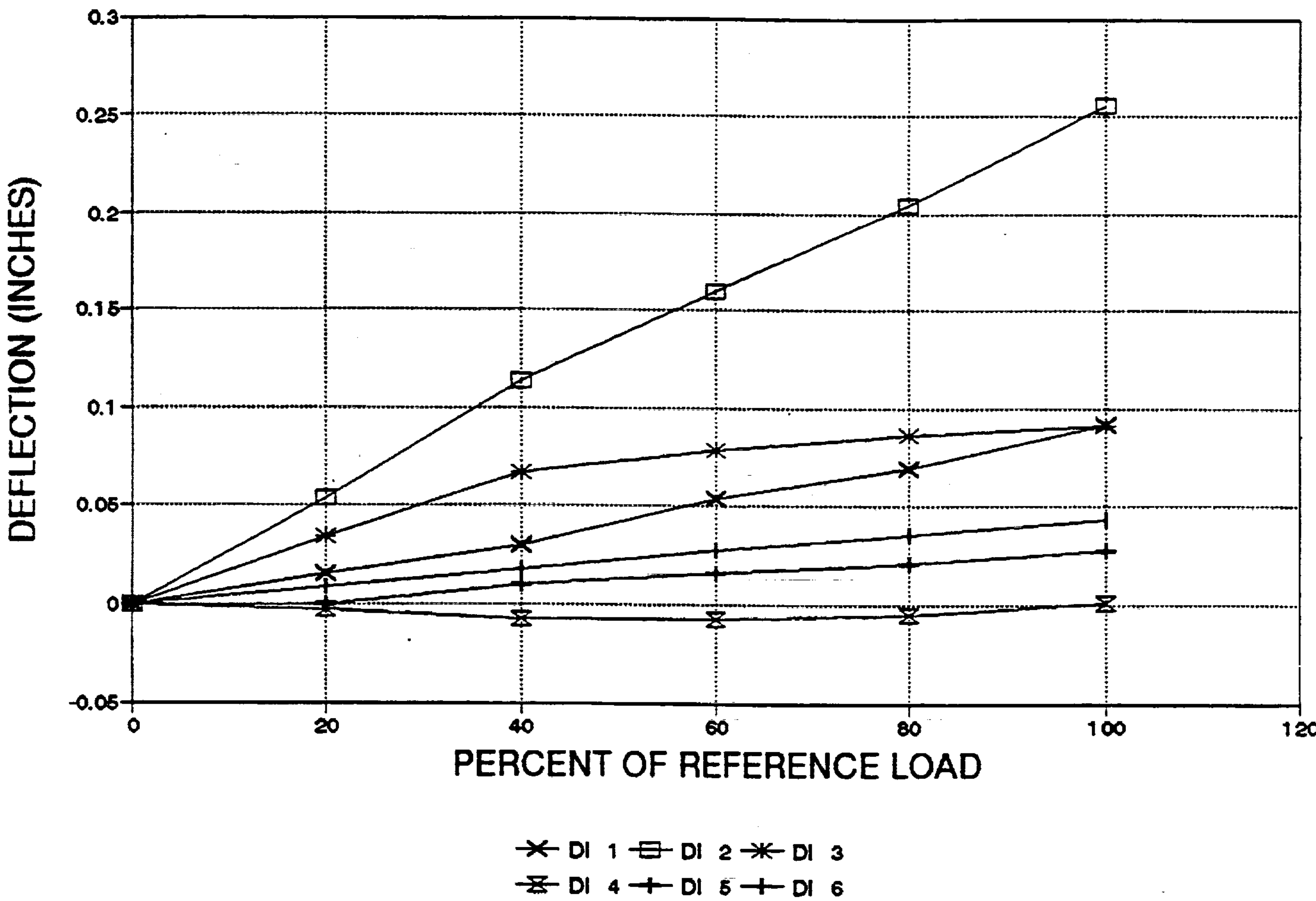


FIGURE 6

Dial Indicator Deflections for the 599-356-001-101 M206L Composite Litter Door, S/N ML-B04, Reference Figure 16 for the Dial Indicator Locations.

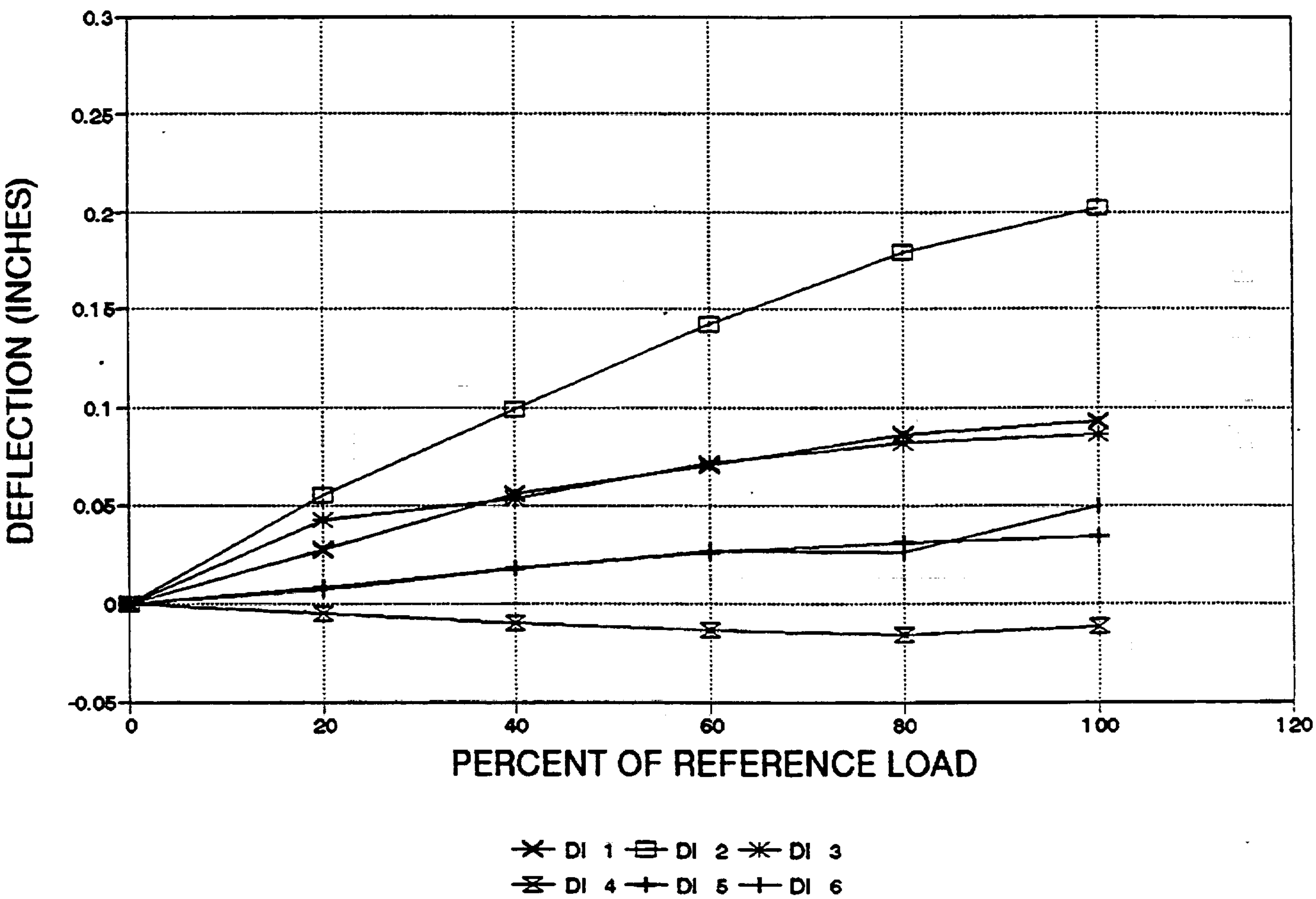


FIGURE 7

Dial Indicator Deflections for the 599-356-001-101 M206L Composite Litter Door, S/N ML-B05, Reference Figure 16 for the Dial Indicator Locations.

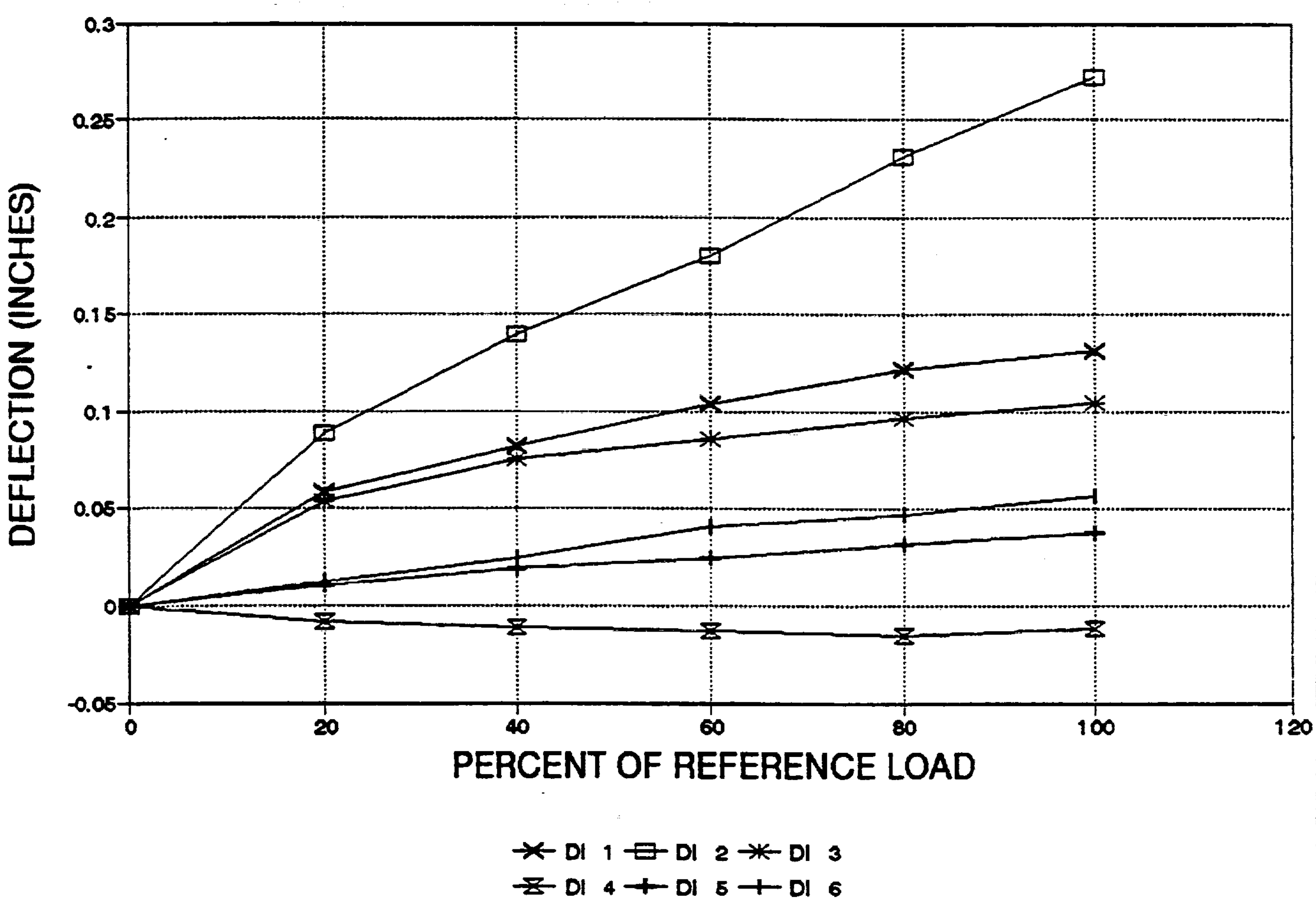


FIGURE 8

Dial Indicator Deflections for the 599-356-001-101 M206L Composite Litter Door, S/N ML-B06, Reference Figure 16 for the Dial Indicator Locations.

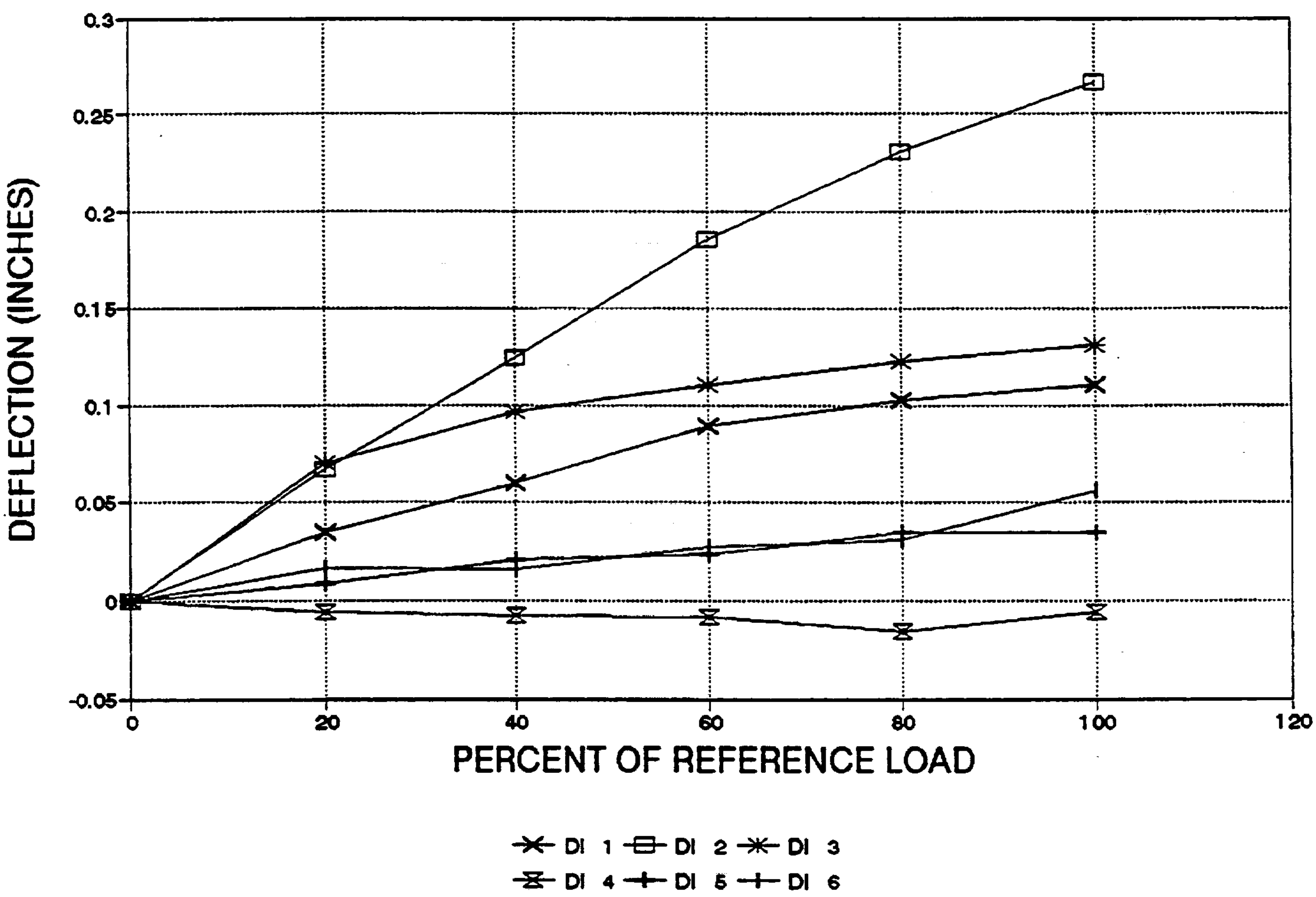


FIGURE 9

Dial Indicator Deflections for the 599-356-001-101 M206L Composite Litter Door, S/N ML-D03, Reference Figure 16 for the Dial Indicator Locations.

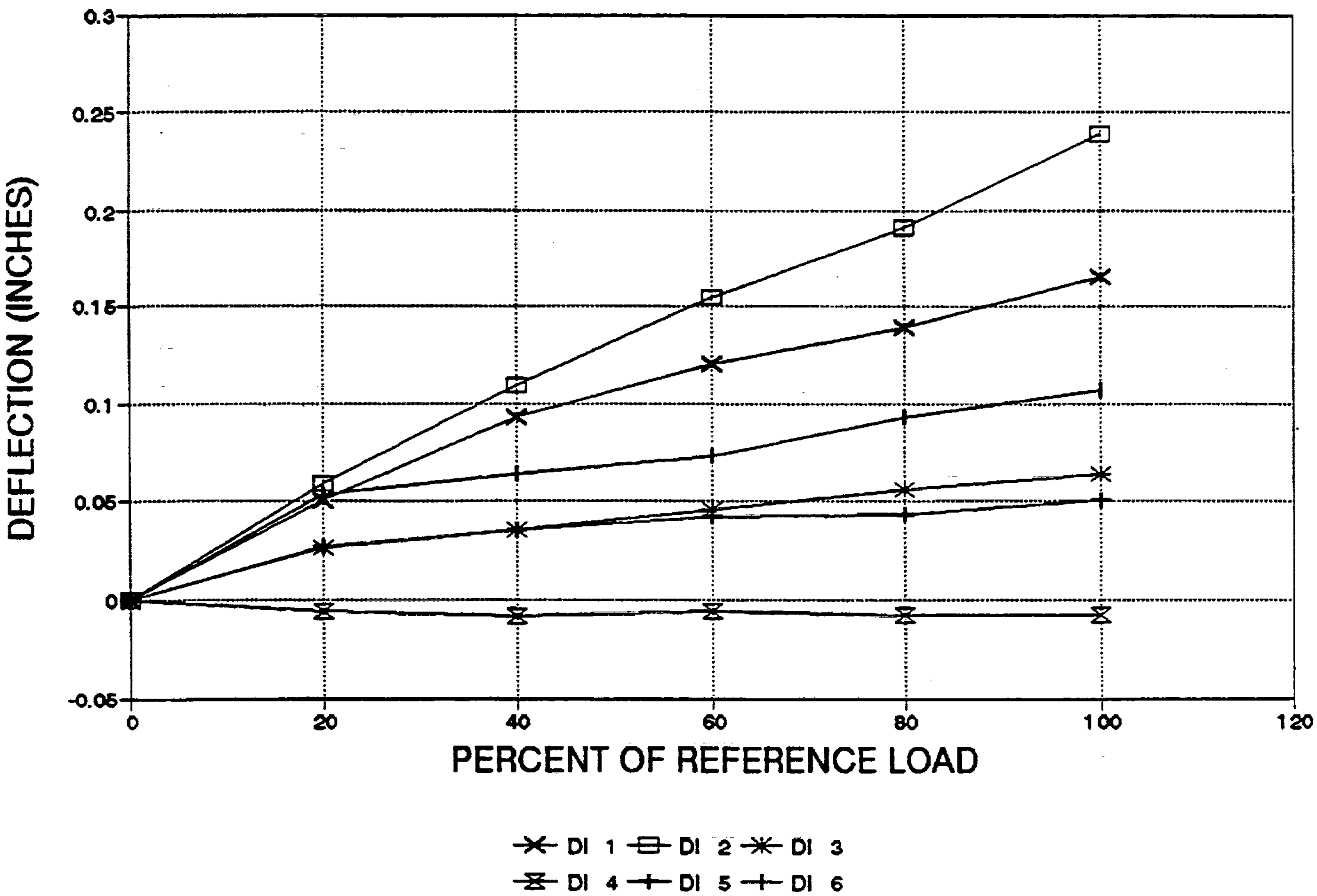


FIGURE 10

Dial Indicator Deflections for the 599-356-001-101 M206L Composite Litter Door, S/N ML-D04, Reference Figure 16 for the Dial Indicator Locations.

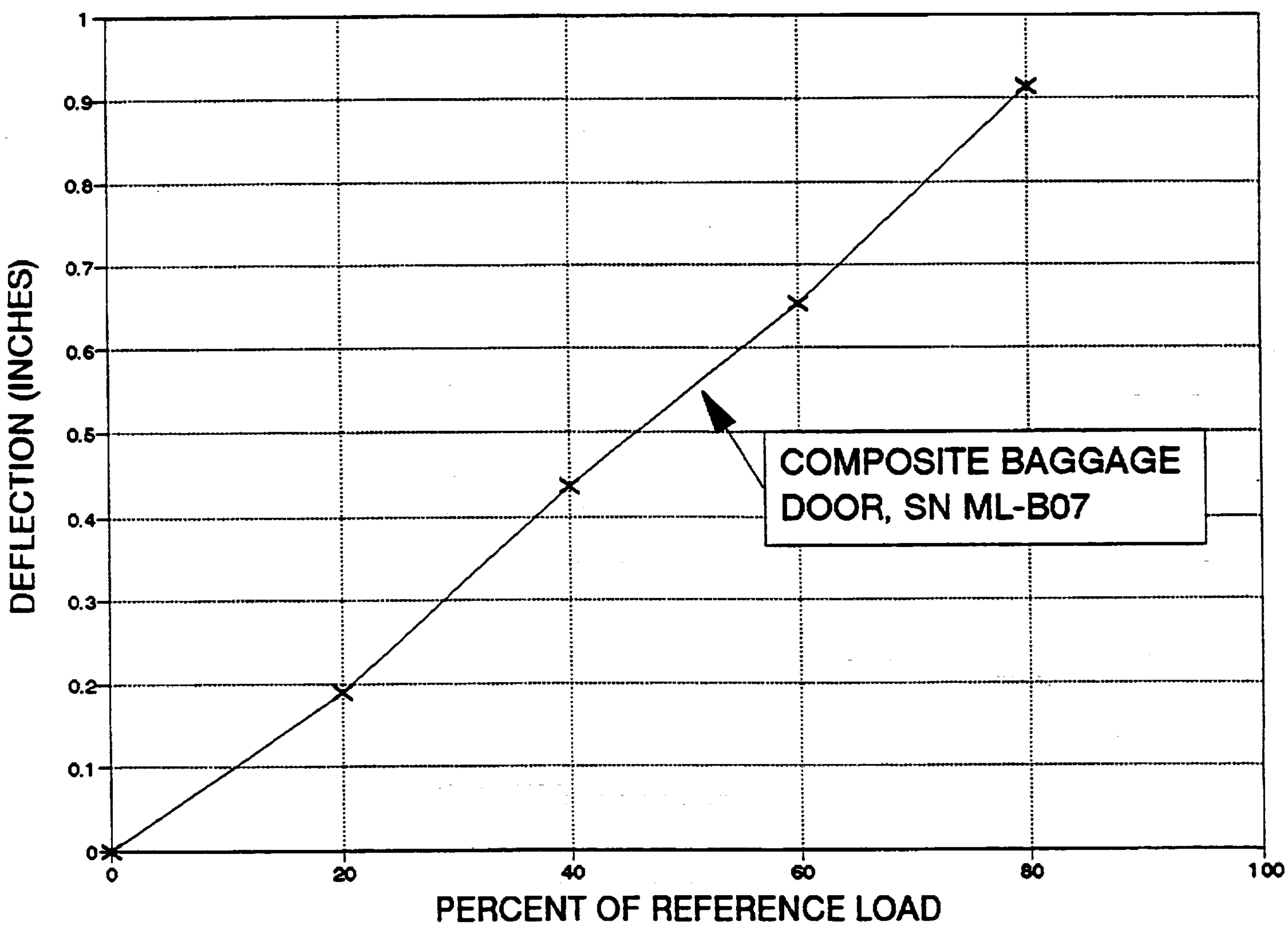


FIGURE 11

Dial Indicator Number 5 Deflections for the 599-335-054-101 M206L Composite Baggage Door, S/N ML-B07, Reference Figure 16 for the Dial Indicator Location.

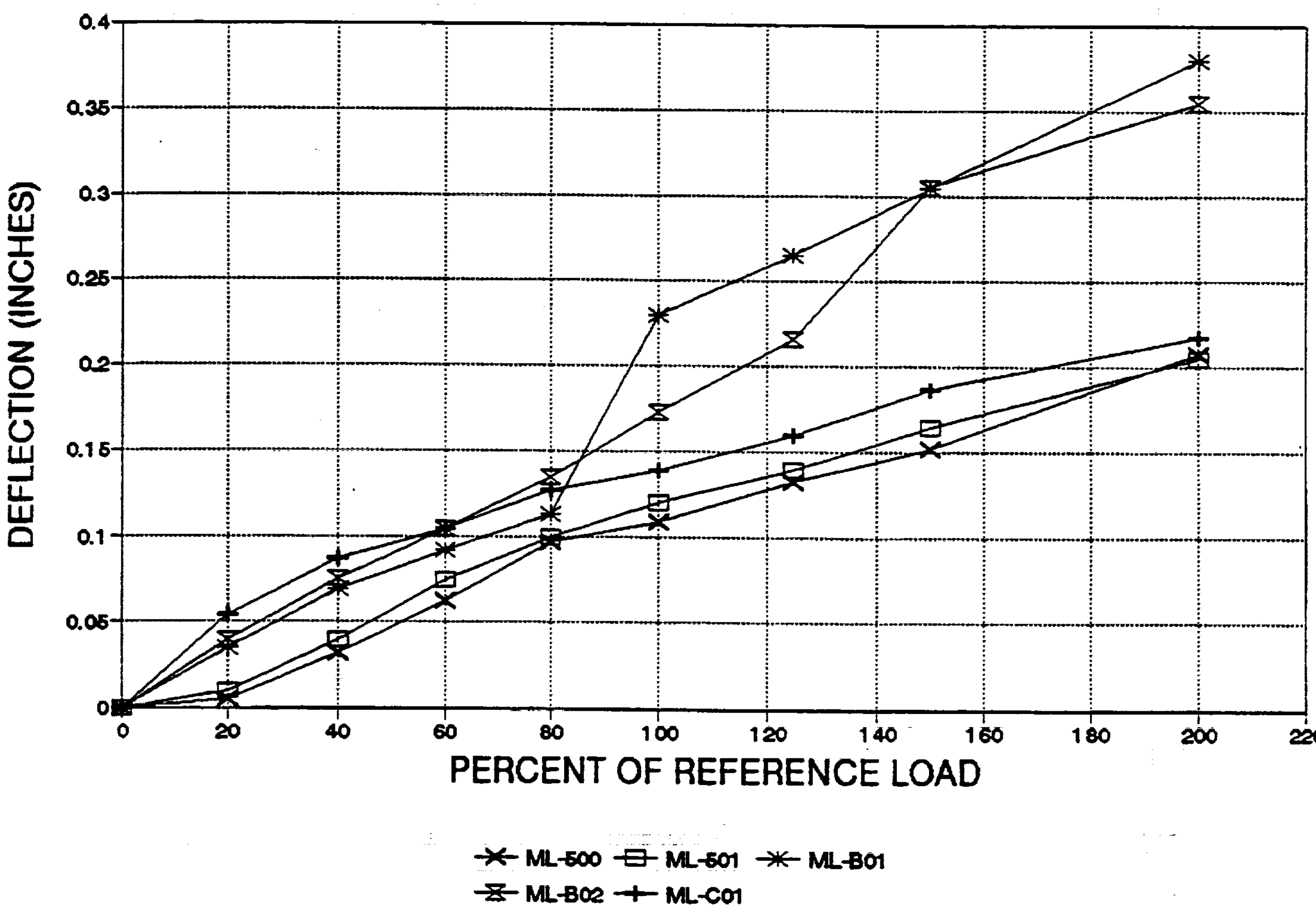


FIGURE 12

Dial Indicator Number 5 Deflections for the 599-335-068-101 M206L Composite Fairing Assembly, S/N's ML-500, ML-501, ML-B01, ML-B02, and ML-C01, Reference Figure 17 for Dial Indicator Location.

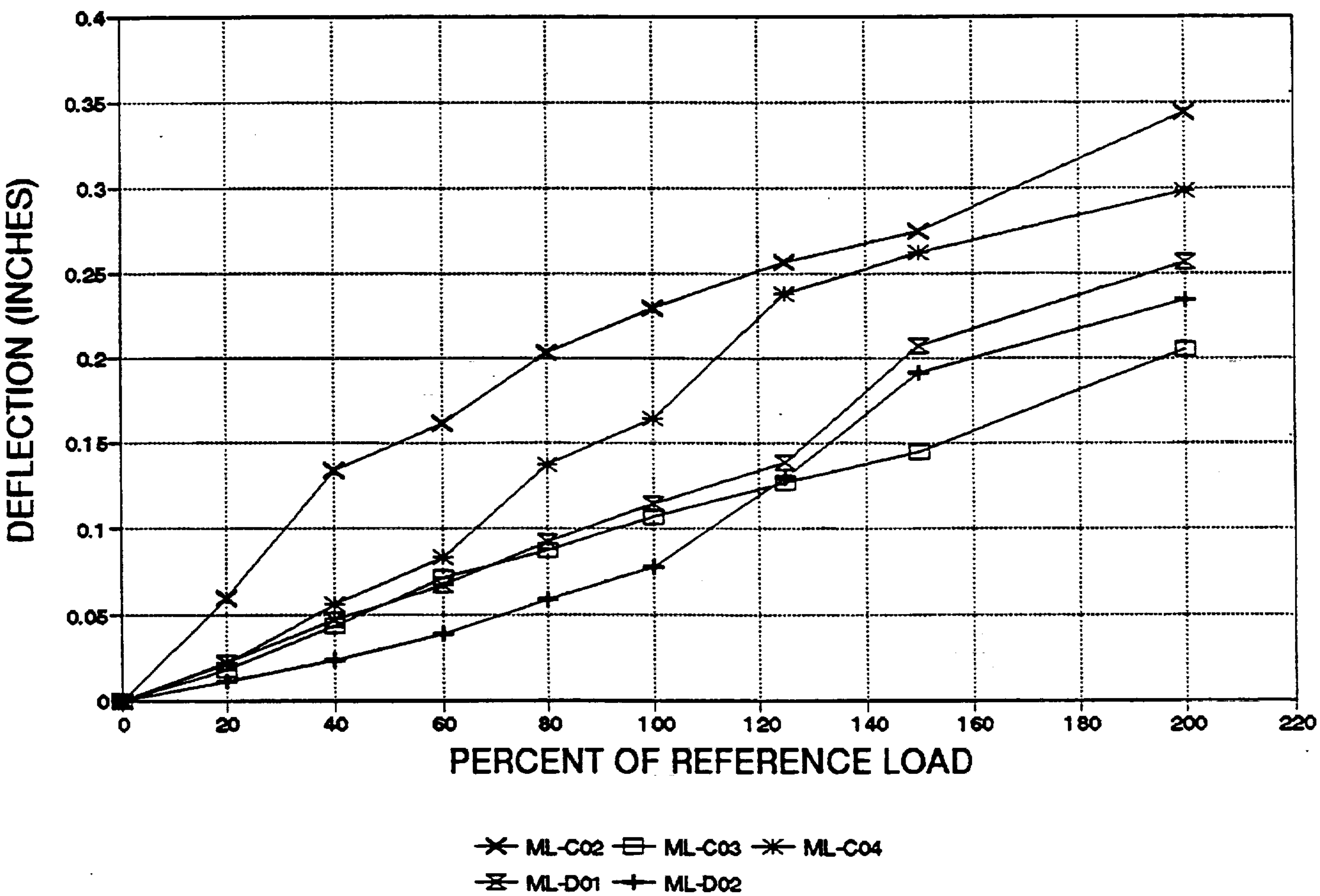


FIGURE 13

Dial Indicator Number 5 Deflections for the 599-335-068-101 M206L Composite Fairing Assembly, S/N's ML-C02, ML-C03, ML-C04, ML-D01, and ML-D02, Reference Figure 17 for Dial Indicator Location.

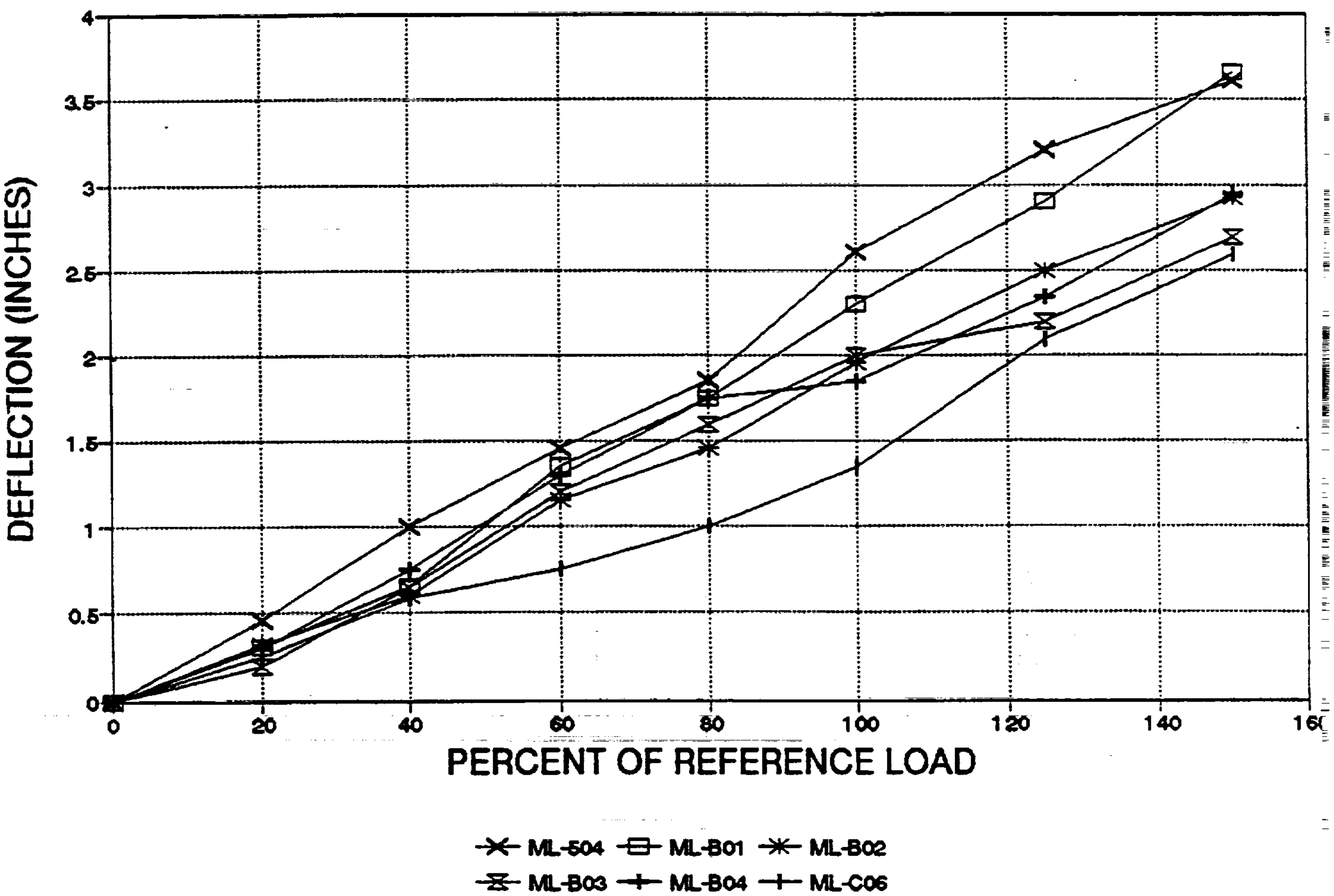


FIGURE 14

Tube Scale Deflections for the 599 335-048-001 M206L Composite Vertical Fin Assembly, S/N's ML-504, ML-B01, ML-B02, ML-B03, ML-B04, and ML-C06, Reference Figure 17 for Tube Scale Location.

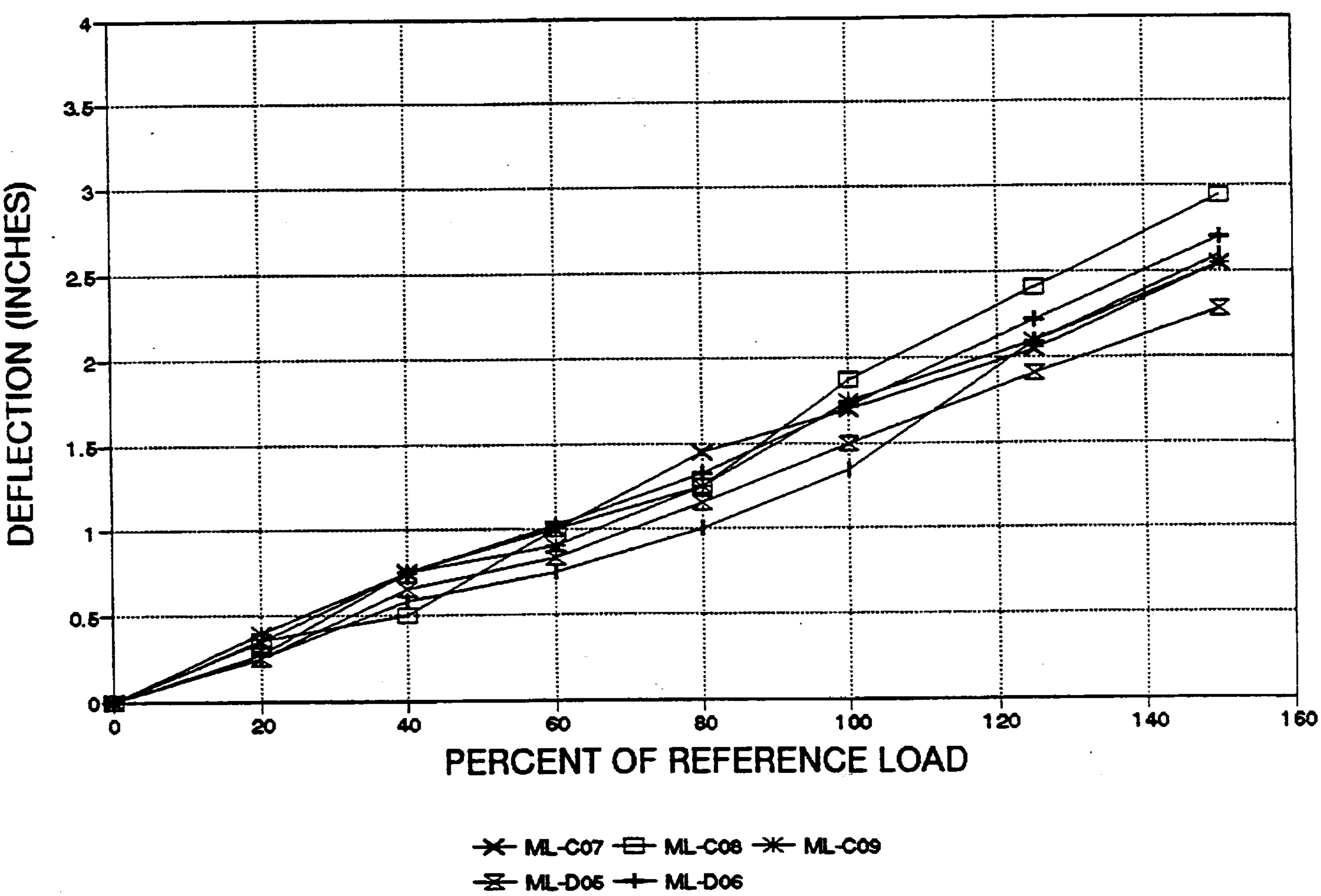
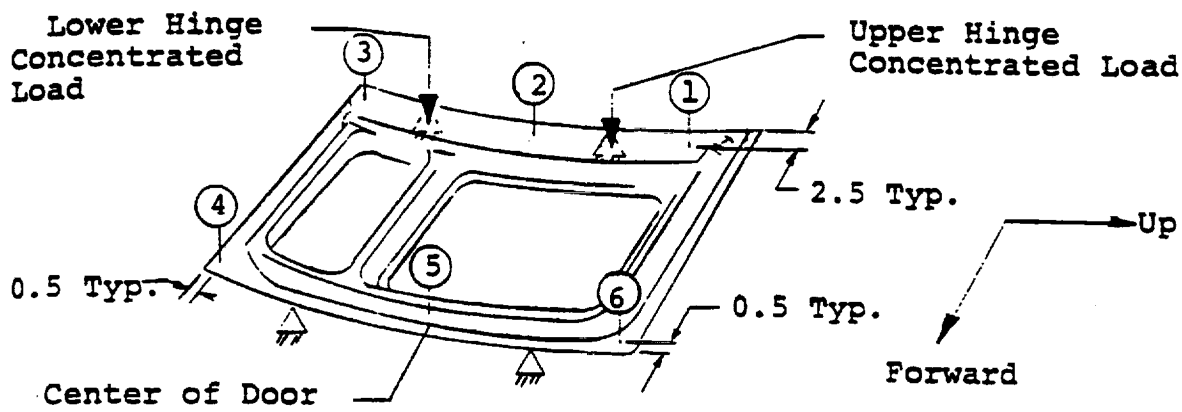
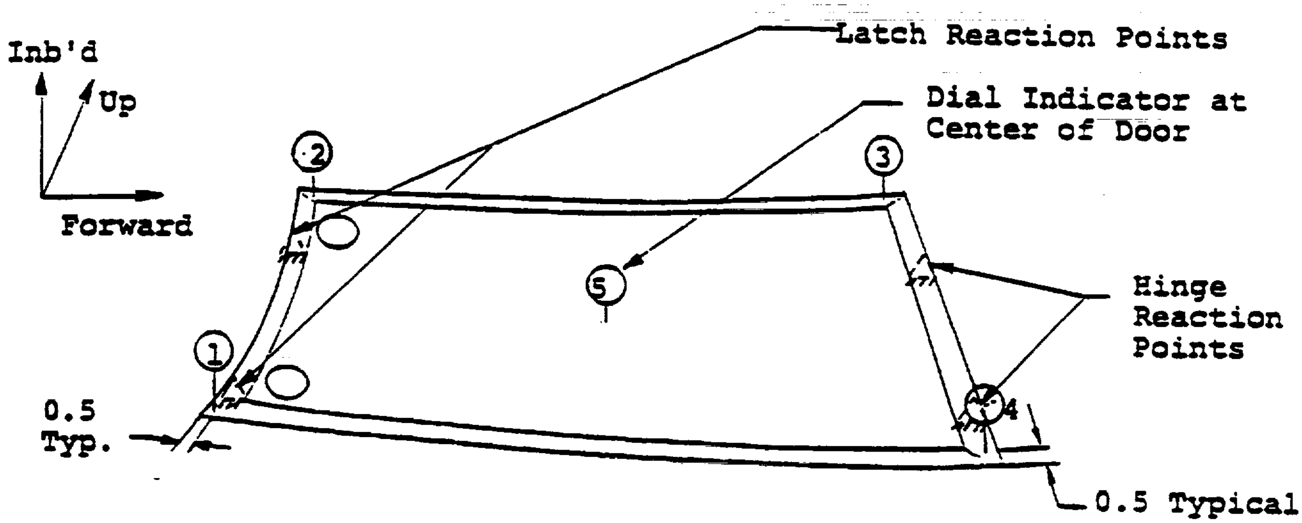


FIGURE 15

Tube Scale Deflections for the 599 335-048 001 M206L Composite Vertical Fin Assembly, S/N's ML-C07, ML-C08, ML-C09, ML-D05, and ML-D06 Reference Figure 17 for Tube Scale Location.



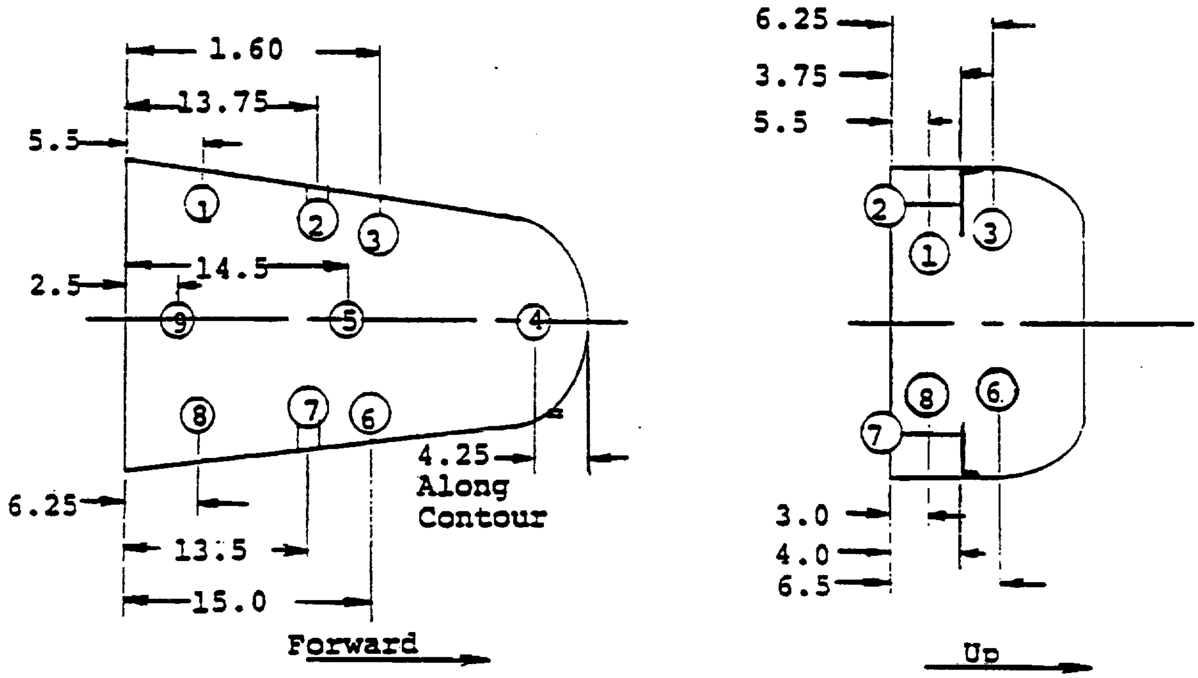
Dial Indicator Locations for the Deflection Tests of the 599-356-001 M206L Composite Litter Door



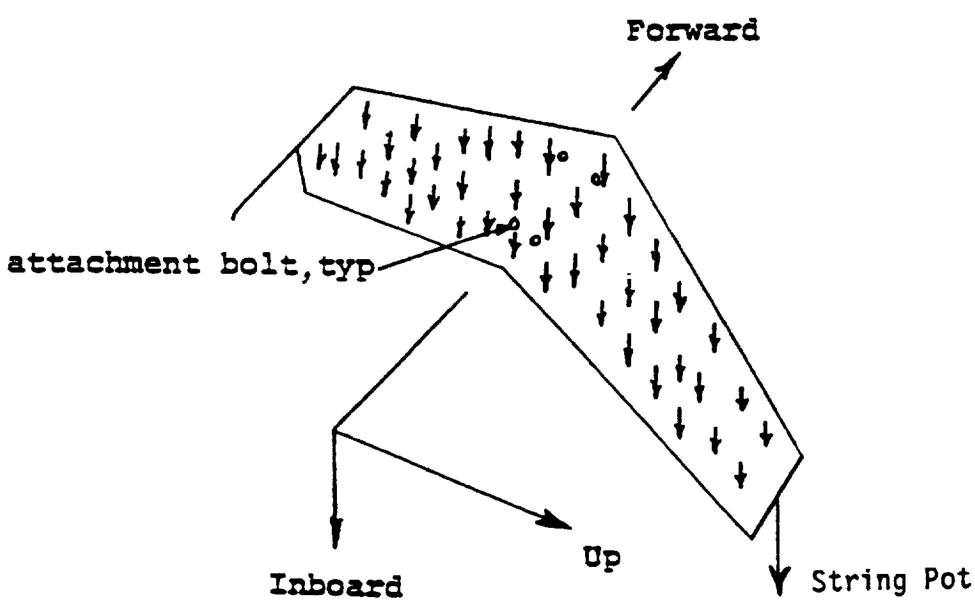
Dial Indicator Locations for the 599-335-054-1 M206L Composite Baggage Door

FIGURE 16

Dial Indicator Locations for the Deflection Tests of the Composite Litter Door and the Composite Baggage Door.



Dial Indicator Locations for the 599-335-068-101
M206L Composite Forward Fairing



Tube Scale Location for the 599-335-048-001
M206L Composite Vertical Fin

FIGURE 17

Deflection Measurement Locations for the Deflection Tests of the Composite Forward Fairing and the Composite Vertical Fin.

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APPENDIX C

NON-DESTRUCTIVE INVESTIGATION FOR

SELECTED COMPOSITE COMPONENTS TESTED

DURING THE 8-YEAR INTERVAL

BHTI LABORATORY REPORT NO. 89-001A

21 APRIL 1989

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Bell Helicopter TEXTRON

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POST OFFICE BOX 482 • FORT WORTH, TEXAS 76101

PART NO. ______

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L. King
K. Porter
S. Smith

REPORT NO. 89-001A

DATE 4-21-89

TESTED BY P. Acres
P. ACRES

APPROVED ______

APPROVED J. G. Gerber
J. G. GERBER

LABORATORY REPORT

TITLE NDI OF MODEL 206 COMPOSITE COMPONENTS FOR FIELD/SERVICE DAMAGE

ITEM ______

SPEC. NO ______

VENDOR ______

A total of 18 Model 206 composite components, cowlings (4), vertical fins (4), baggage doors (5), and litter doors (5) were delivered to NDT Lab for inspection to detect impact or user damage from the field. Table 1 is a listing of part numbers, serial numbers, inspection equipment and results.

Vertical Fins & Baggage Doors

The vertical fins and baggage doors were inspected using a through transmission squirter technique. This technique used two 1 MHz transducers in conjunction with a tone burst pulse. The received ultrasonic signal was then processed by a computer using a level file that equated a 1 volt drop to 3 dB steps. This level file created the scans shown in Figures 1 - 9, by assigning numbers to each volt drop 1. . .9, with 0 being the worst case.

RESULTS

The vertical fin scans are shown in Figures 1 - 4. The vertical Fins ML-09, ML-17 and ML-23 show no field/service damage. The ML-22 scan (Figure 3A) shows field/service damage of 1,013 sq. in.

The baggage door scans are shown in Figures 5 - 9. The baggage doors ML-19 and ML-182 show no field/service damage. The ML-051 scan (Figure 6A) shows field/service damage of .763 sq. in. The ML-112 scan (Figures 7A and B) shows fourteen field/service damage areas with a maximum 43.64 sq. in. Review Figures 7A and B for individual damage area and dimensions. The ML-121 scan (Figure 8B) shows two field/service damage areas with a maximum 4.586 sq. in. Review Figure 8B for individual damage area and dimensions.

Litter Doors

The litter doors were thin laminates of varying thickness which were covered on the inside by a hollow interior panel. These interior panels prevented using squirter through transmission and also made pulse echo inspection extremely difficult; therefore, both tap hammer and visual methods were used to evaluate these components.

RESULTS

Photographs 1 - 4 are the litter doors with service damage identified on the surface. These doors are ML-04, ML-A05, ML-A084, and ML-143. All four doors had service/field damage. The majority of the damage was located around the corners.

Cowling

The cowling geometry was such that contact inspection using S1-A sondicator was required. The sondicator introduces ultrasonic energy at 25 KHz into the material via the transmitter transducer contact tip and propagates through the internal structure. The transmit energy is sensed through the receivers contact tip and electronically evaluated. Changes in the components properties, such as thickness, unbonds, and defects cause change in the received energy amplitude and/or phase. The condicator is capable of detecting defects of 1/2" diameter and larger.

RESULTS

The contact ultrasonic inspection of 4 cowlings listed in Table 1 detected no field/service damage.

TABLE 1

Part Number	Part Name	Serial#	Equipment	Results
599-335-048-001	Vertical Fin	ML-09	Through-transmission squirter	No service damage was detected, as shown in Fig. 1
599-335-048-001	Vertical Fin	ML-17	Through-transmission squirter	No service damage was detected, as shown in Fig. 2
599-335-048-001	Vertical Fin	ML-22	Through-transmission squirter	Service damage was deteced, as shown in Fig. 3
599-335-048-001	Vertical Fin	ML-23	Through-transmission squirter	No service damage was detected, as shown in Fig. 4
599-335-054-101 N5367330	Baggage Door	ML-19	Through-transmission squirter	No service damage was detected, as shown in Fig. 5
599-335-054-101 N5367330	Baggage Door	ML-051	Through-transmission squirter	Service damage was detected, as shown in Fig. 6
599-335-054-101 N5367330	Baggage Door	ML-112	Through-transmission squirter	Service damage was detected, as shown in Fig. 7
599-335-054-101 N5367330	Baggage Door	ML-121	Through-transmission squirter	Service damage was detected, as shown in Fig. 8
599-335-054-101 N5367330	Baggage Door	ML-182	Through-transmission squirter	No service damage was detected, as shown in Fig. 9.

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TABLE 1 (Concluded)

Part Number	Part Name	Serial#	Equipment	Results
599-356-001-103 206-033-602-237	Litter Door	ML-04	Tap & Visual	Service damage was detected, as shown in Photo 1
599-356-001-103 206-033-602-237	Litter Door	ML-A05	Tap & Visual	Service damage was detected, as shown in Photo 2
599-356-001-103 206-033-602-237	Litter Door	ML-A084	Tap & Visual	Service damage was detected, as shown in Photo 3
599-356-001-103 206-033-602-237	Litter Door	ML-143	Tap & Visual	Service damage was detected, as shown in Photo 4
599-356-001-103 206-033-602-237	Litter Door	ML-7	Tap & Visual	Was not tested and no Photo was taken
599-335-068-101 72C0749	Cowling	ML-A02	S1-A Sondicator	No service damage was detected
599-335-068-101 72C0749	Cowling	ML-02	S1-A Sondicator	No service damage was detected
599-335-068-101 72C0749	Cowling	ML-03	S1-A Sondicator	No service damage was detected
599-335-068-101 72C0749	Cowling	ML-15	S1-A Sondicator	No service damage was detected

Bell Helicopter TEXTRON A Subsidiary of Textron Inc. NONDESTRUCTIVE INSPECTION PROCEDURE CONTINUATION PAGE	REPORT NO. 89-001 DATE 4-21-89 PAGE 5 OF 30

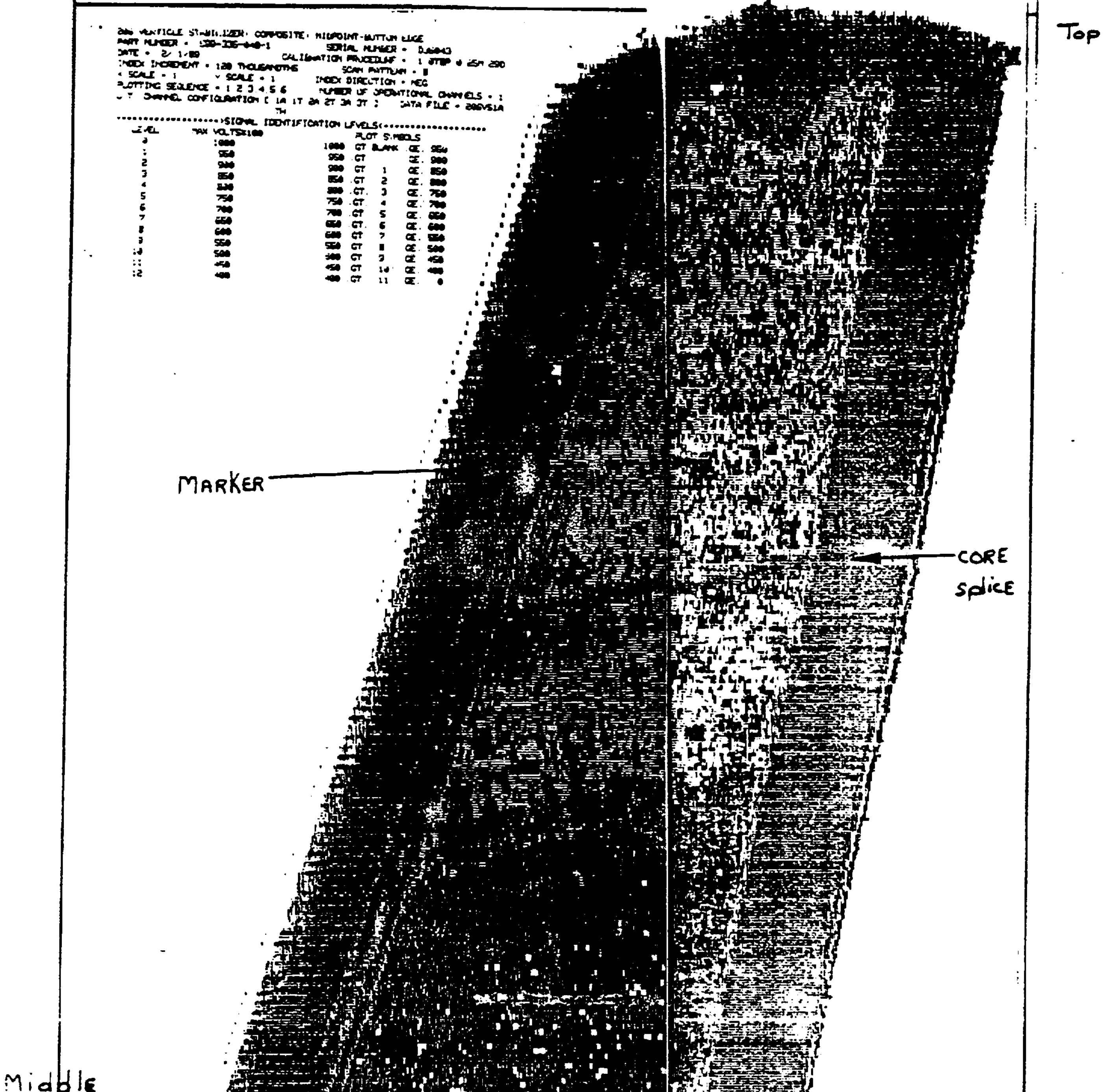

Figure 1A. Scan of Vertical Fin D35043, But Indentified as ML-9

7812 60888

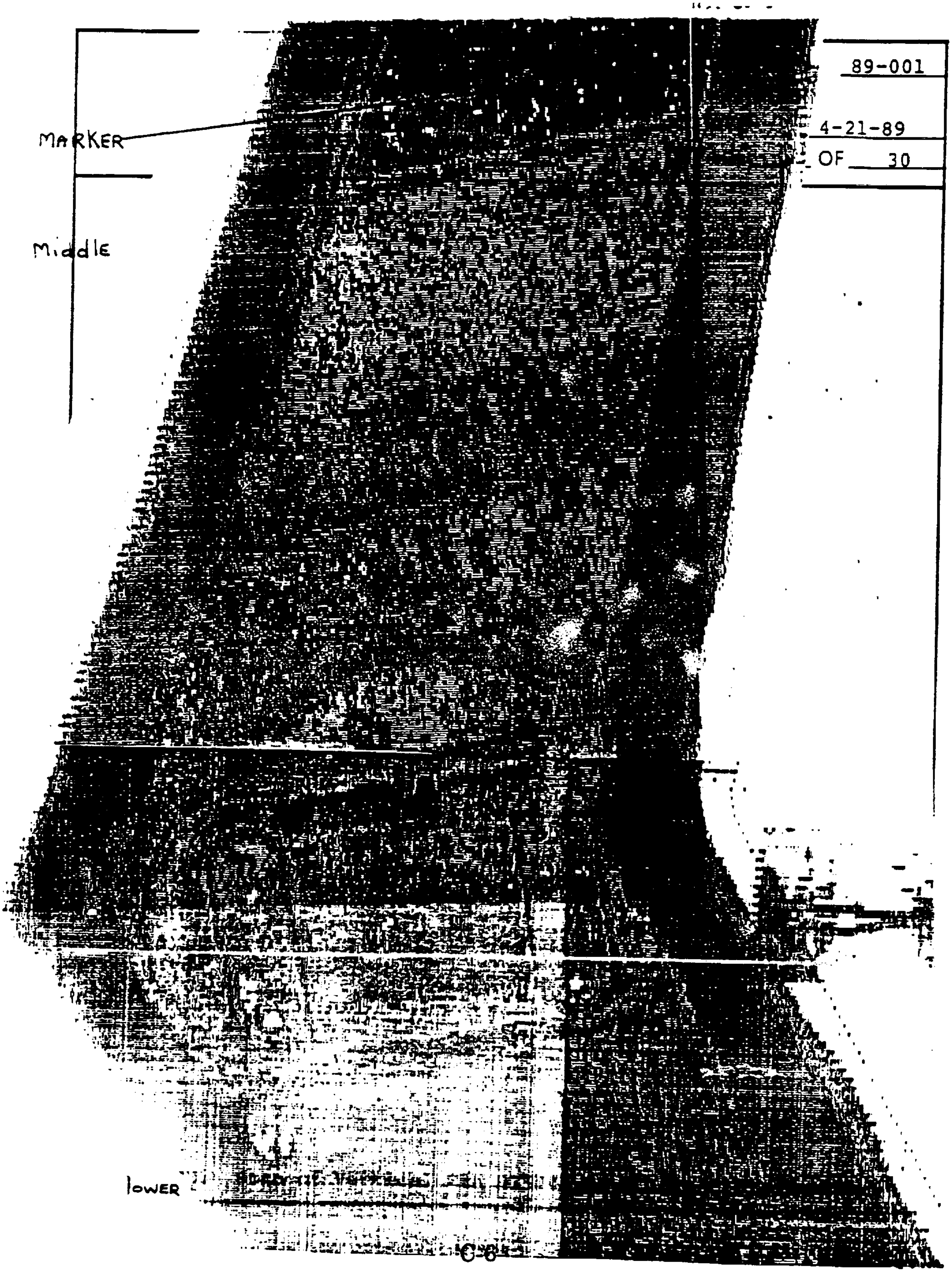

Figure 1B. Scan of Vertical Fin D35043, But Indentified as MT-9

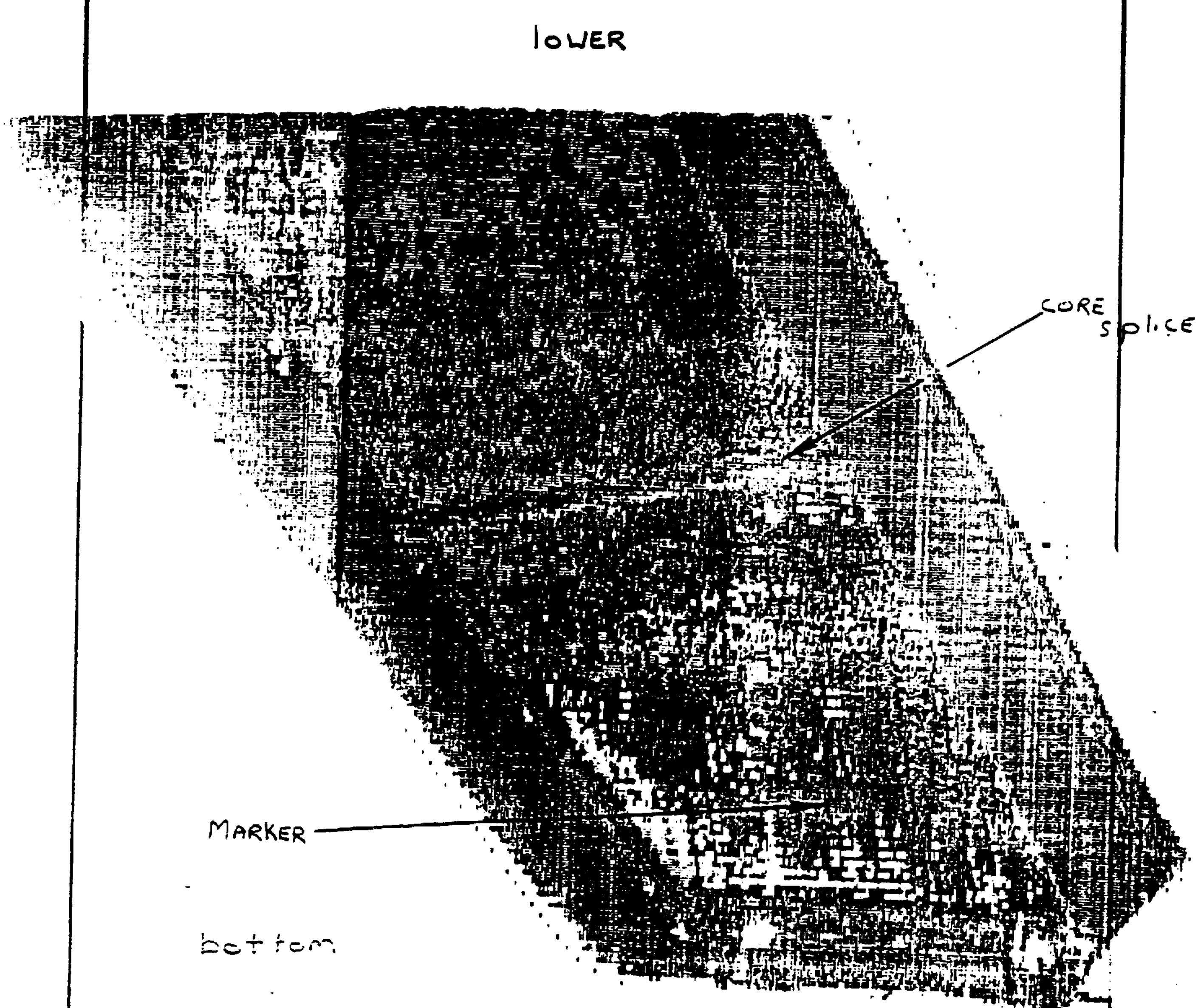

Figure 1C. Scan of Vertical Fin D35043, But Indentified as ML-9

Figure 2A. Scan of Vertical Fin C83160, But Indentified as ML-17

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DATE 4-21-89

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886 VERTICLE STABILIZER- COMPOSITE
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DATE = 2/ 1/89 SERIAL NUMBER = C83160
INDEX INCREMENT = 130 THOUSANDTHS CALIBRATION PROCEDURE = 1 STEP @ 25° [illegible]
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PLOTTING SEQUENCE = 1 2 3 4 5 6 INDEX DIRECTION = NEG
U T CHANNEL CONFIGURATION (1A 1T 2A 2T 3A 3T) NUMBER OF OPERATIONAL CHANNELS =
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3	850	850	GT.	2	GE.	800
4	800	800	GT.	3	GE.	750
5	750	750	GT.	4	GE.	700
6	700	700	GT.	5	GE.	650
7	650	650	GT	6	GE.	600
8	600	600	GT.	7	GE.	550
9	550	550	GT	8	GE.	500
10	500	500	GT	9	GE.	450
11	450	450	GT	10	GE.	400
12	400	400	GT	11	GE.	0

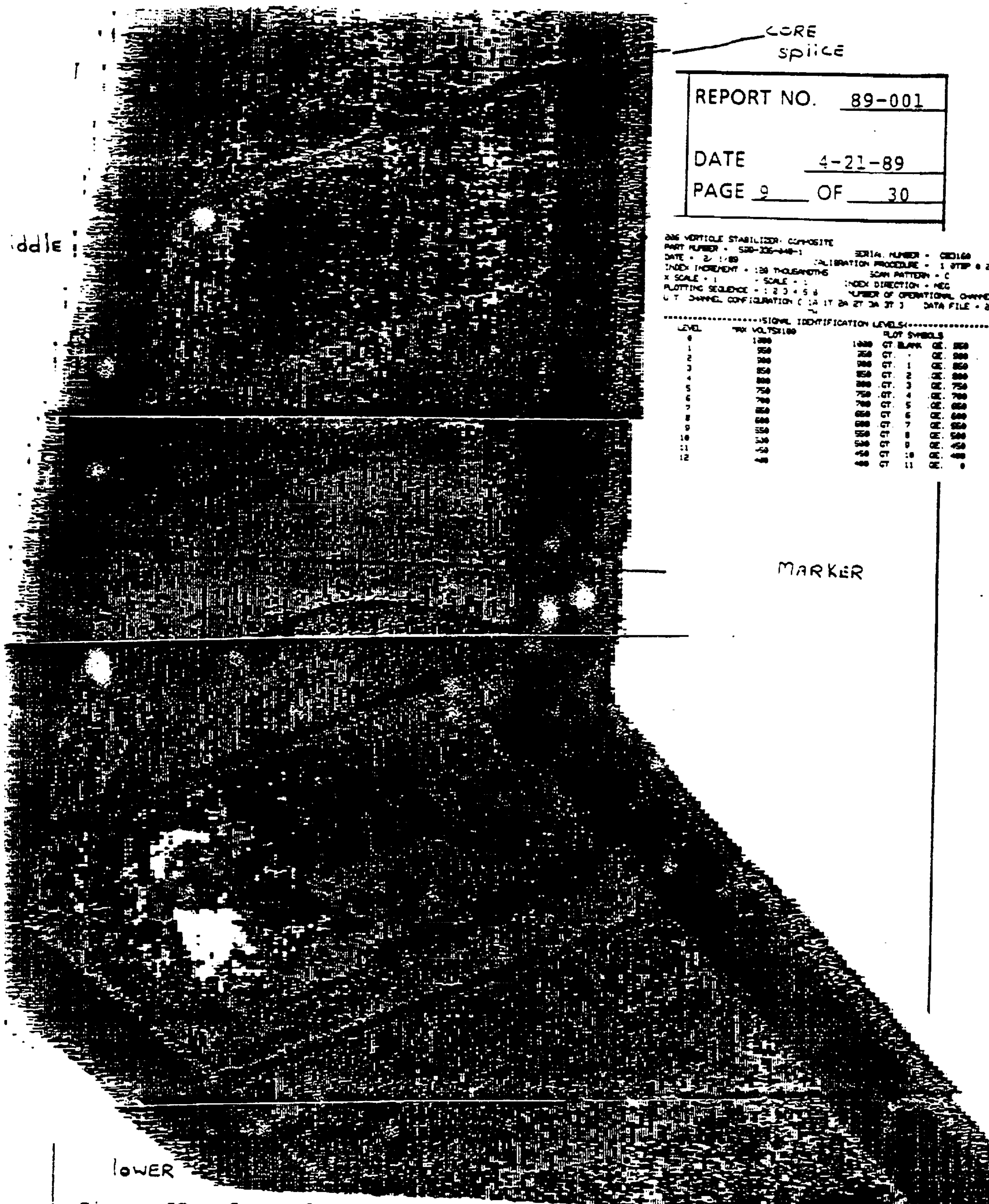

Figure 2B. Scan of Vertical Fin C83160, But Indentified as ML-17

7812 60888

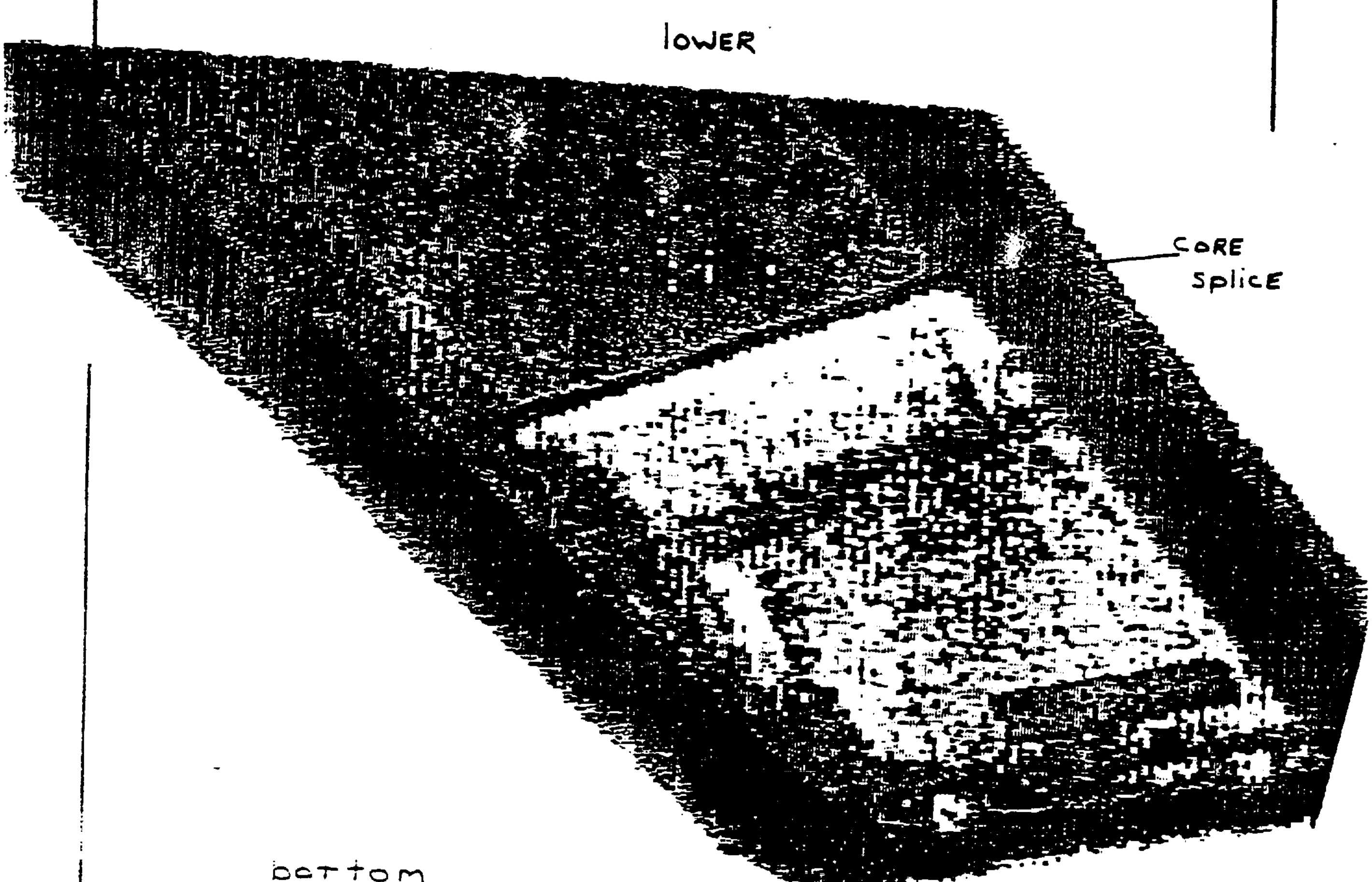

Figure 2C. Scan of Vertical Fin C83160, But Indentified as ML-17

7812 60888

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REPORT NO.	89-001
DATE	4-21-89
PAGE 11	OF 30

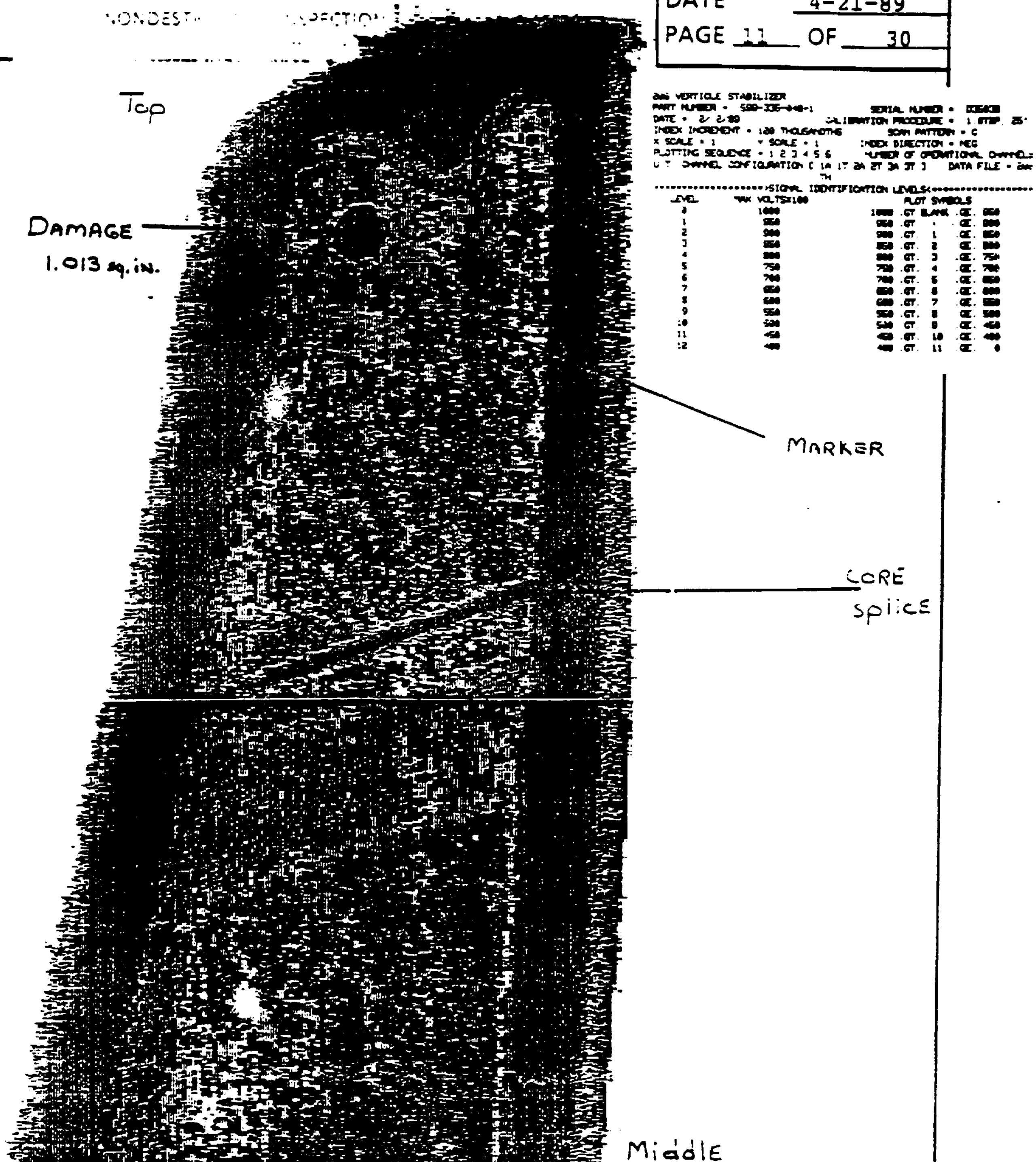

Figure 3A. Scan of vertical Fin D35038, But Indentified as ML-22

7812 60888

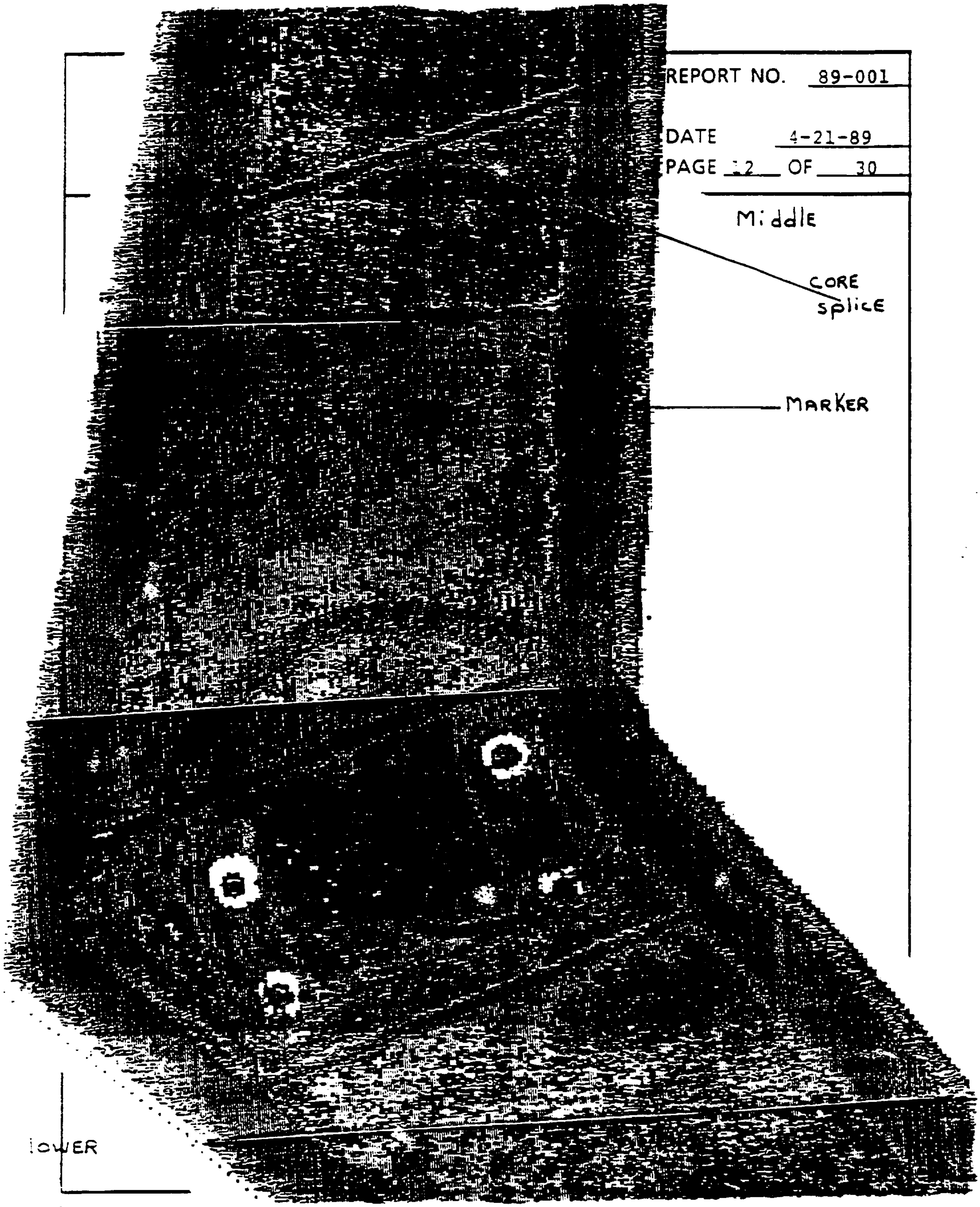

Figure 3B. Scan of Vertical Fin D35038, But Indentified as ML-22

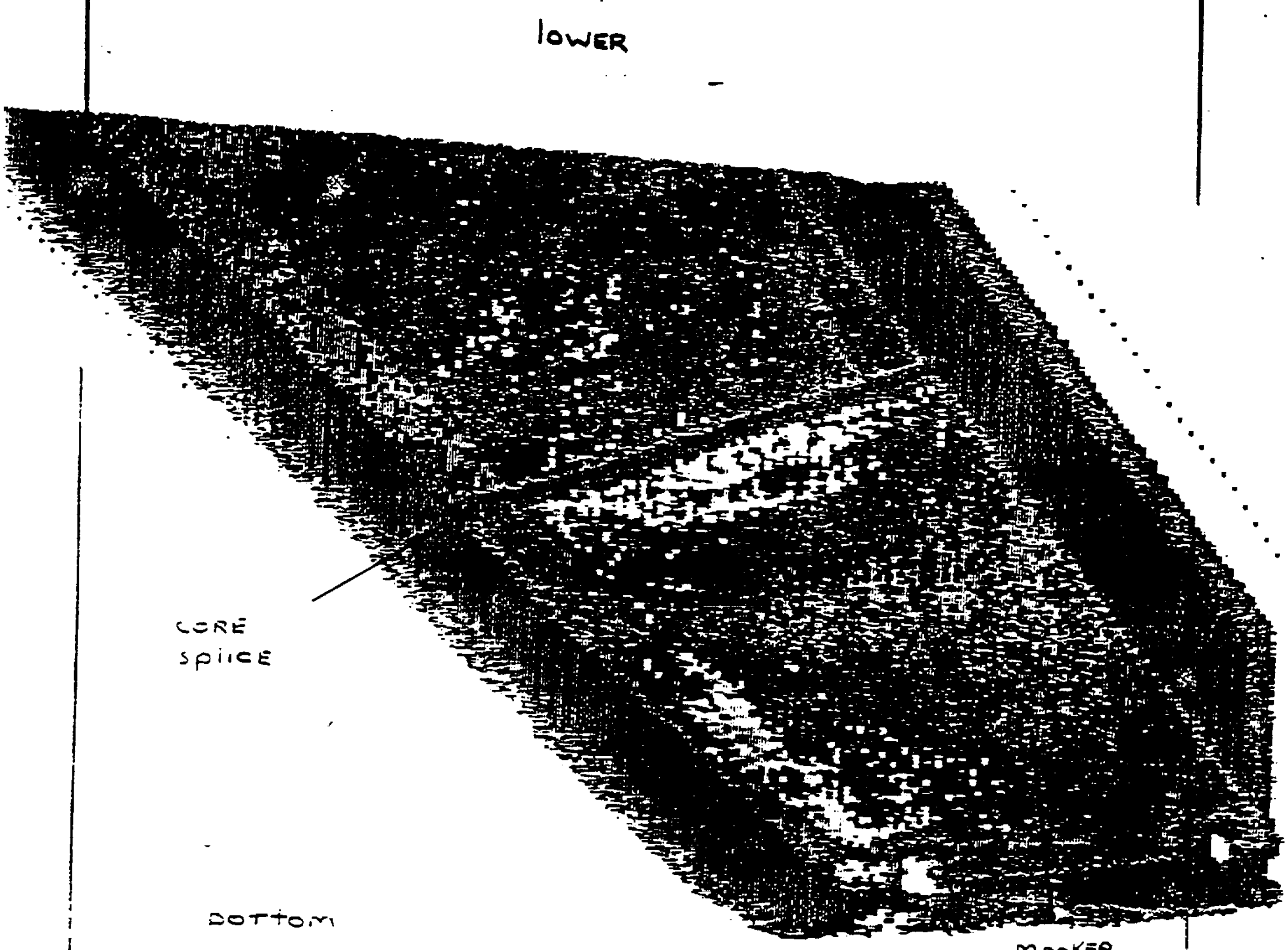

Figure 3C. Scan of Vertical Fin D35038, But Indentified as ML-22

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X SCALE = 1 Y SCALE = 1 INDEX DIRECTION = NEG
PLOTTING SEQUENCE = 1 2 3 4 5 6 NUMBER OF OPERATIONAL CHANNELS = 1
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3	850	850 .GT. 2 .GE. 800
4	800	800 .GT. 3 .GE. 750
5	750	750 .GT. 4 .GE. 700
6	700	700 .GT. 5 .GE. 650
7	650	650 .GT. 6 .GE. 600
8	600	600 .GT. 7 .GE. 550
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[illegible]	[illegible]	500 .GT. 9 .GE. 450
[illegible]	[illegible]	450 .GT. 10 .GE. 400
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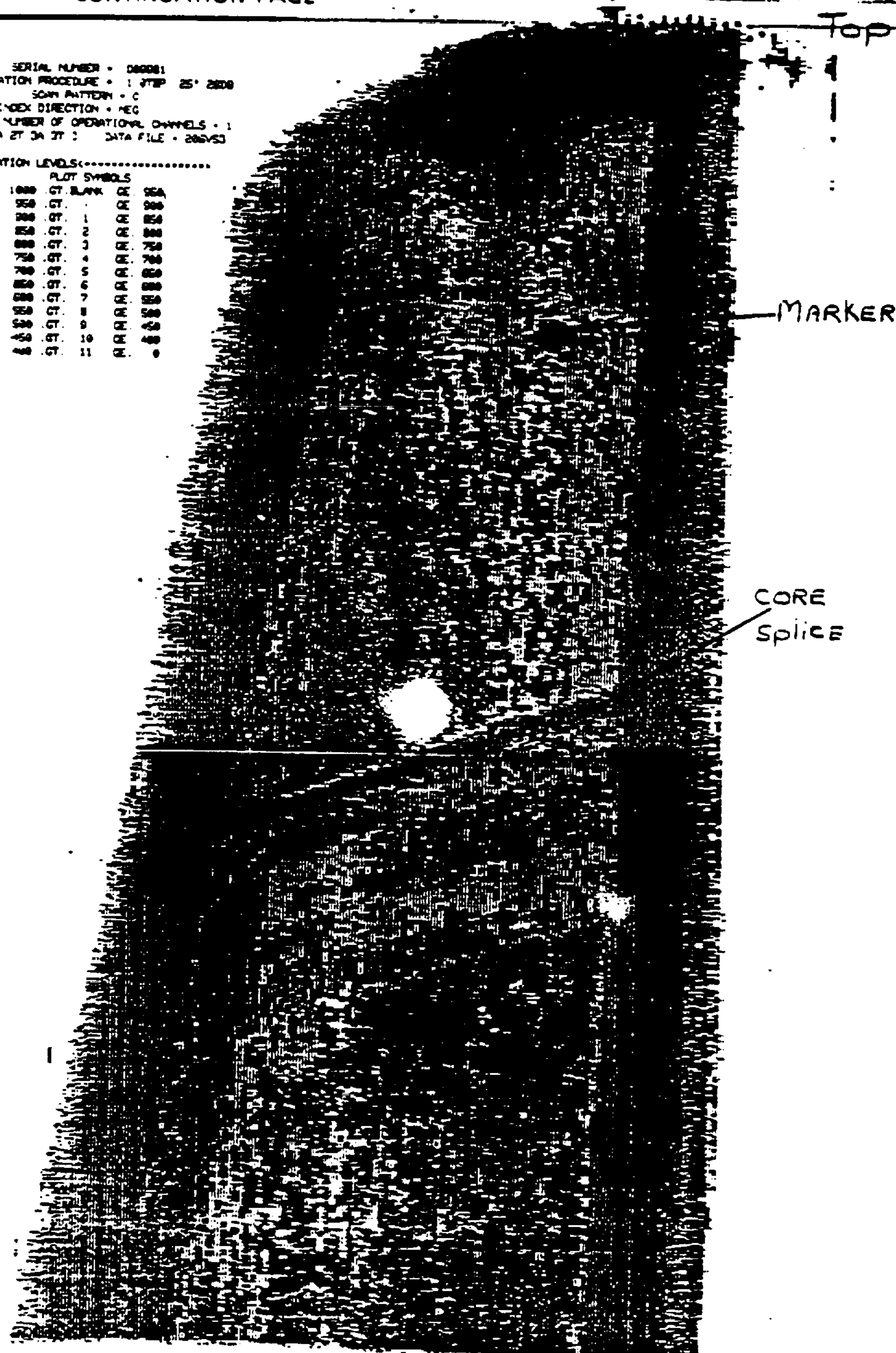

Middle

Figure 4A. Scan of Vertical Fin D09981, But Indentified as ML-23

7812 60888

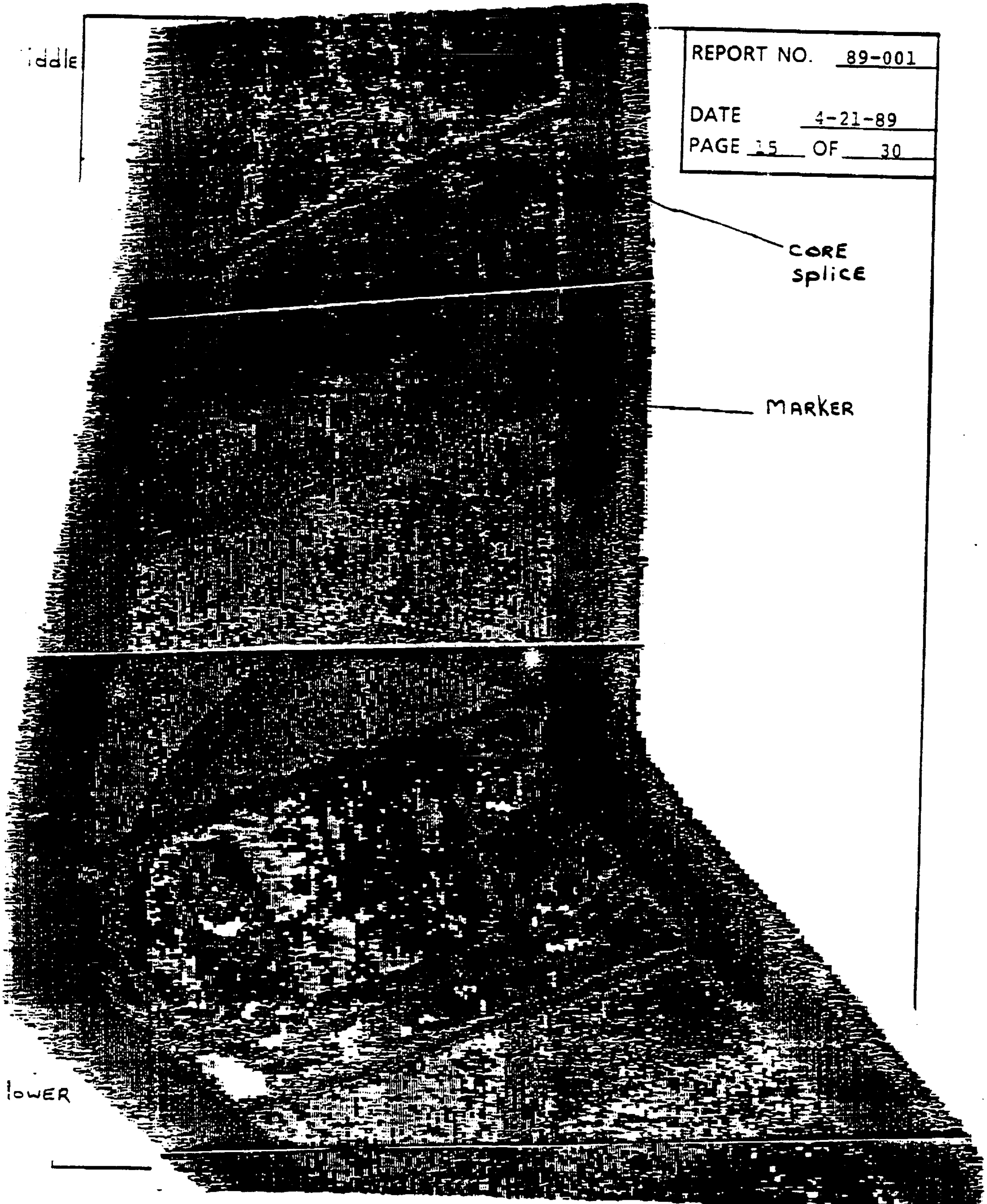

Figure 4B. Scan of Vertical Fin D09981, But Indentified as ML-23

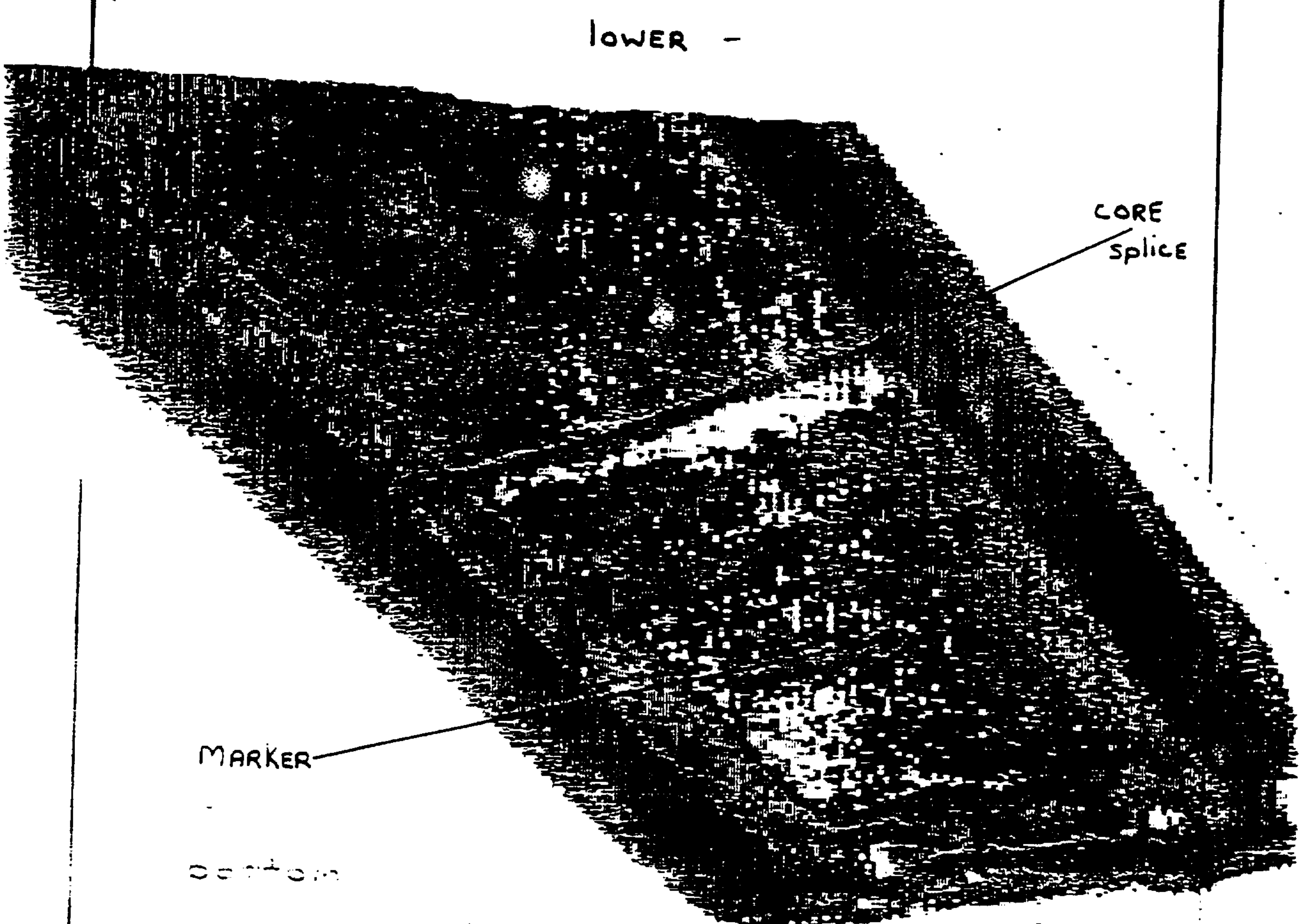

Figure 4C. SCan of Vertical Fin D09981, But Indentified as ML-23

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NONDESTRUCTIVE INSPECTION PROCEDURE
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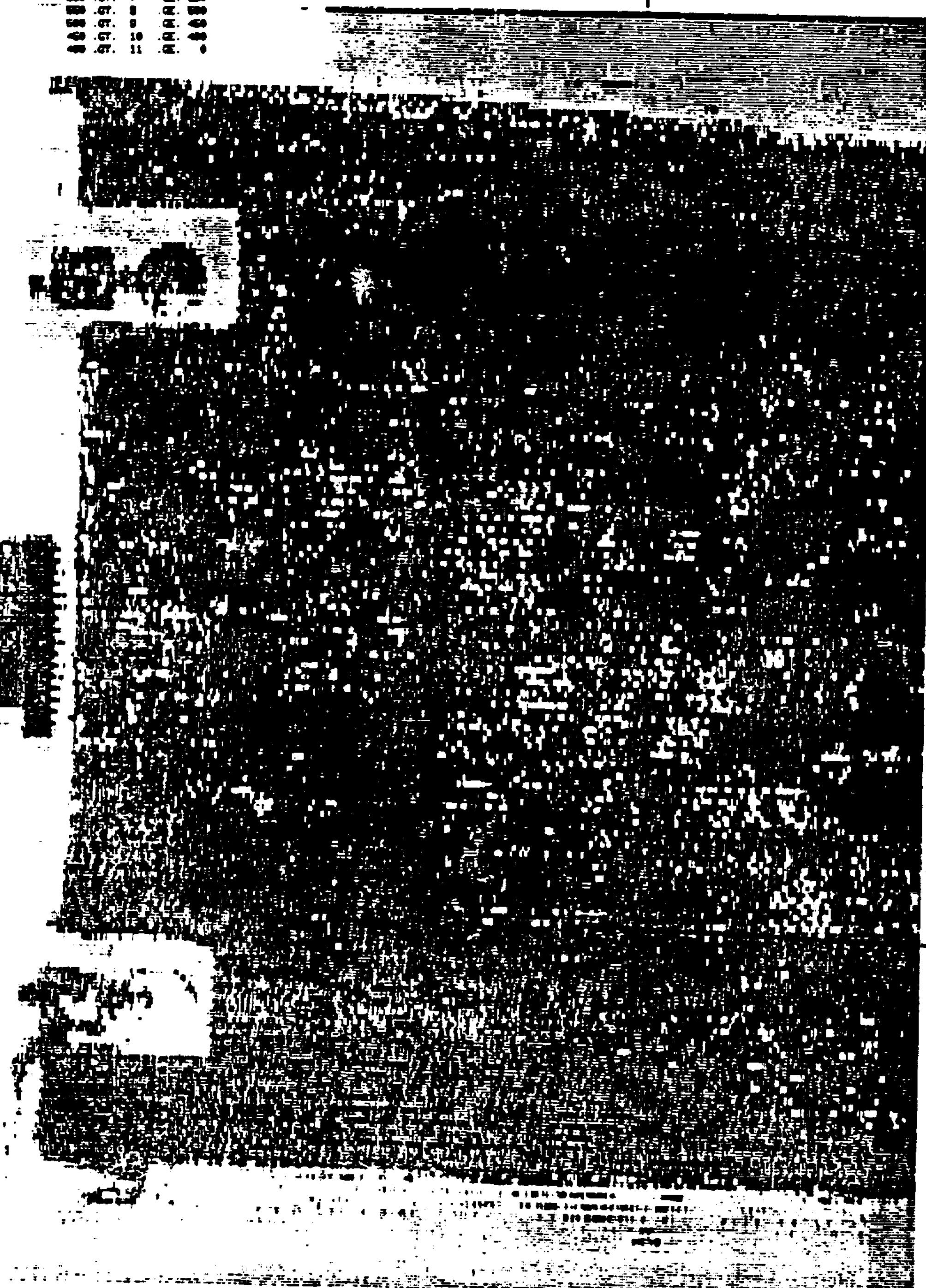

Figure 5A. Scan of Baggage Door ML-19

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NONDESTRUCTIVE INSPECTION PROCEDURE
CONTINUATION PAGE

REPORT NO. 89-001

DATE 4-21-89

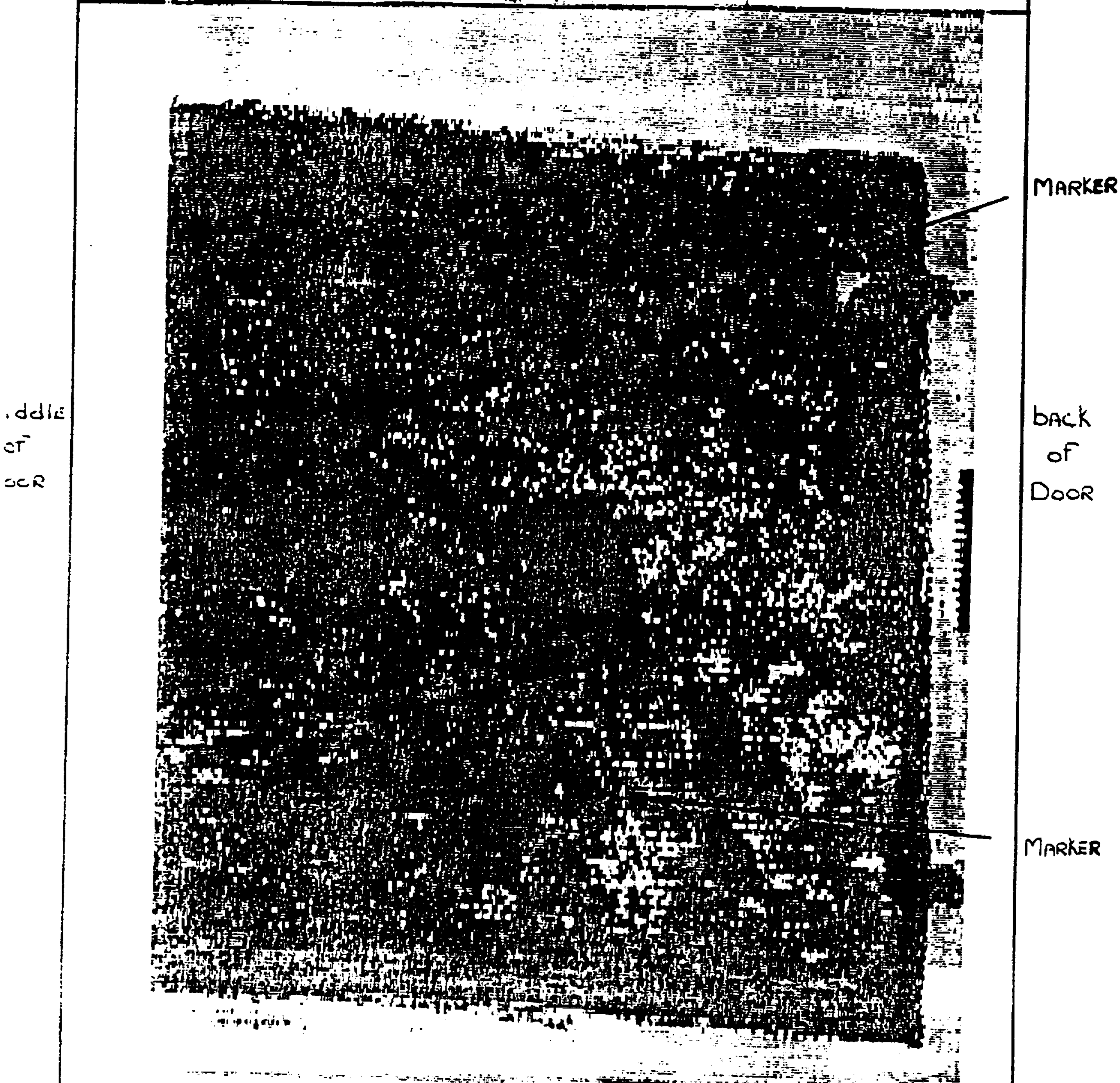

Figure 5B. Scan of Baggage Door ML-19

7812 60888

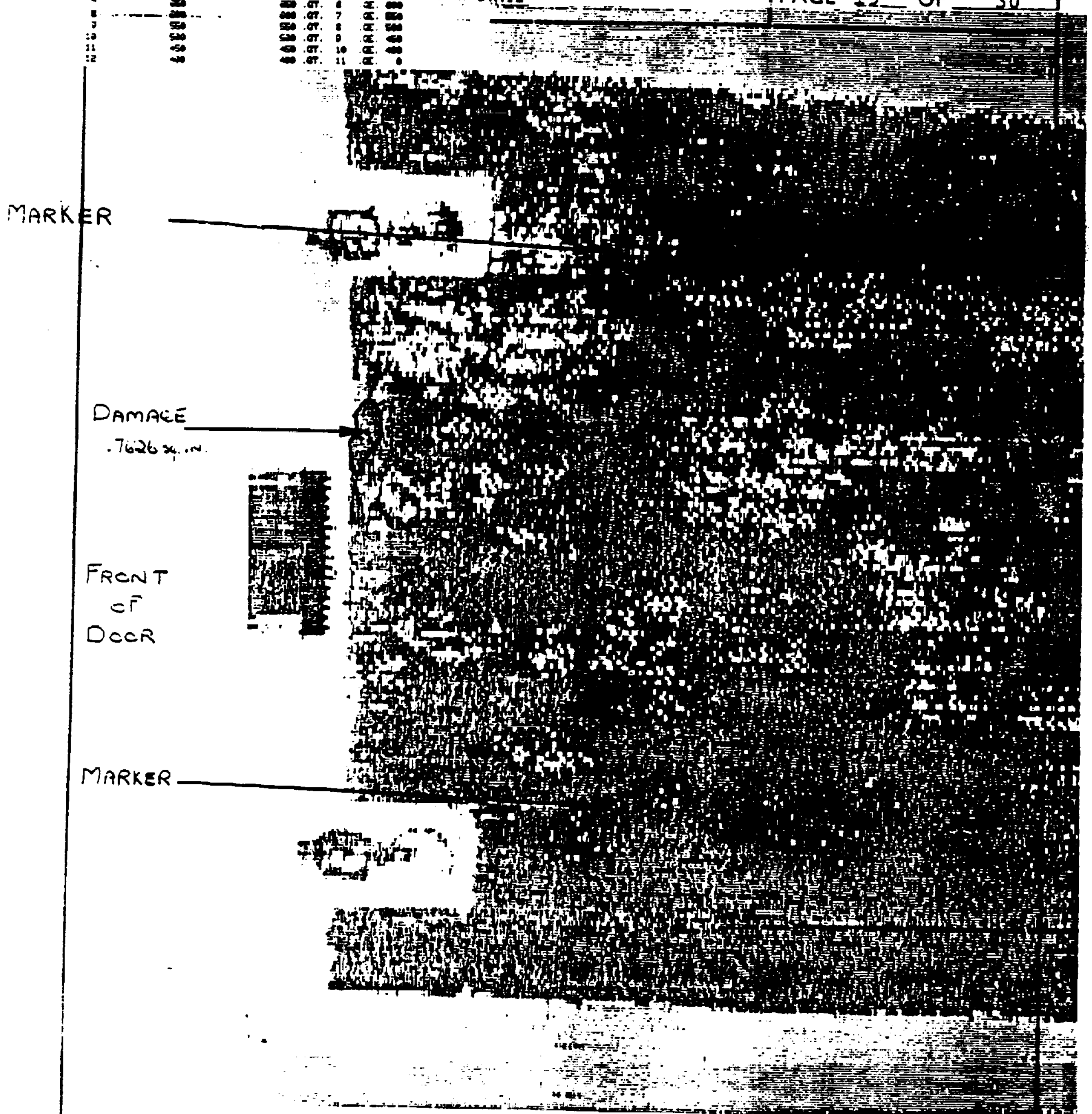

Figure 6A. Scan of Baggage Door A-35, But Indentified as ML-051

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Figure 6B. Scan of Baggage Door A-35, But Indentified as ML-051

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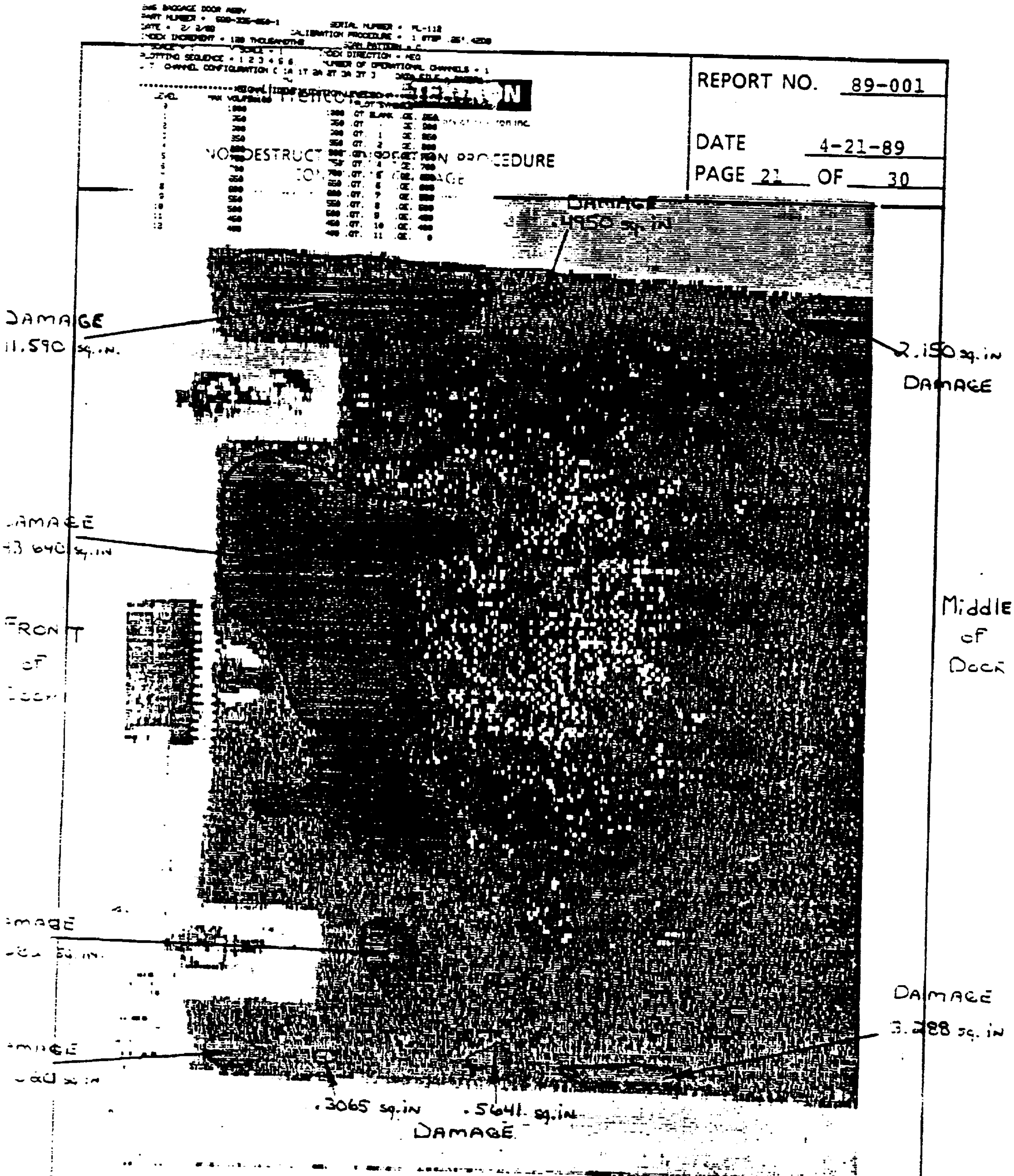

Figure 7A. Scan of Baggage Door ML-112

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NONDESTRUCTIVE INSPECTION PROCEDURE
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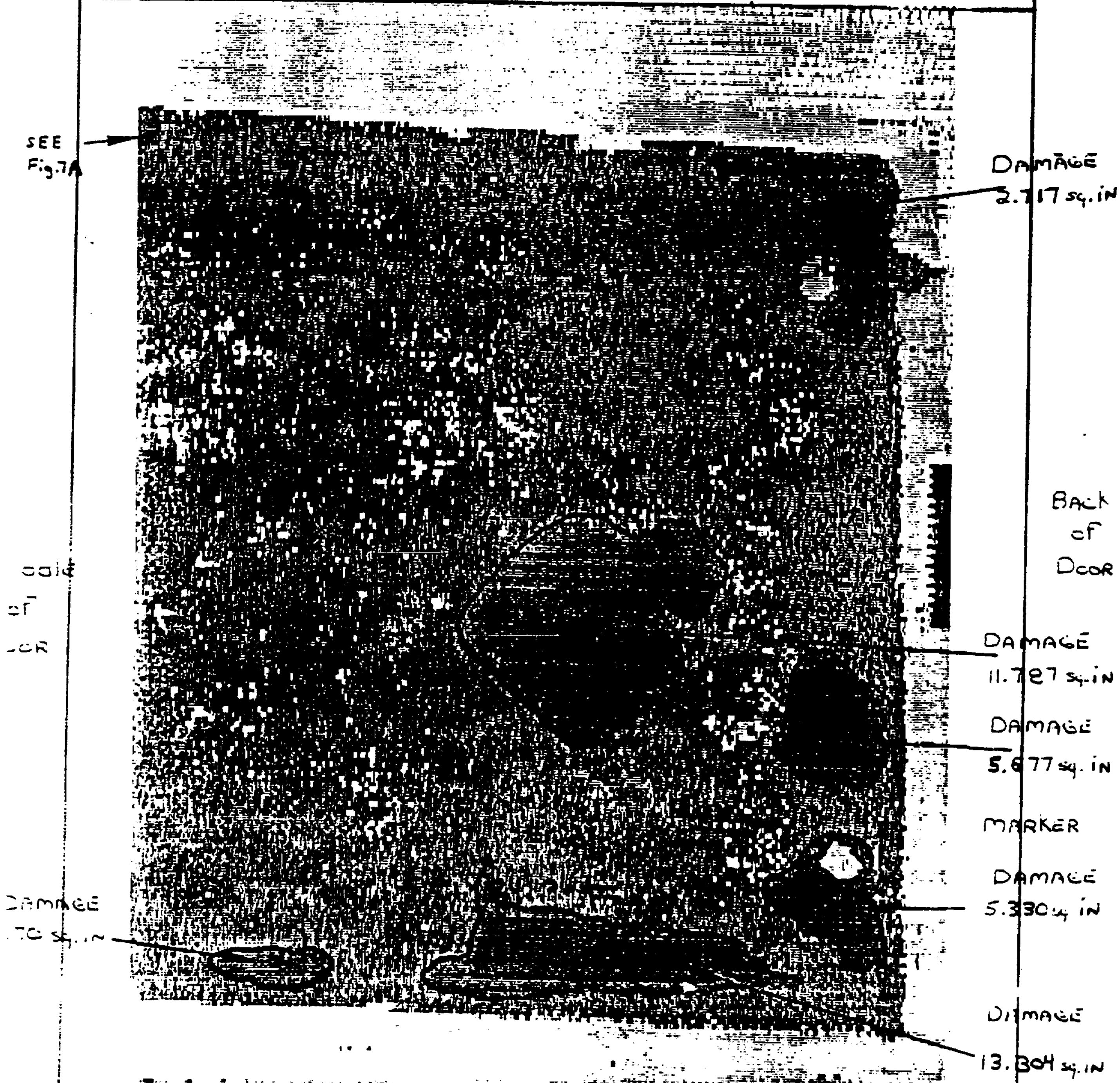

Figure 7B. Scan of Baggage Door ML-112

7812 60888

Bell Helicopter TEXTRON

NONDESTRUCTIVE INSPECTION PROCEDURE

REPORT NO. 89-001

DATE 4-21-89

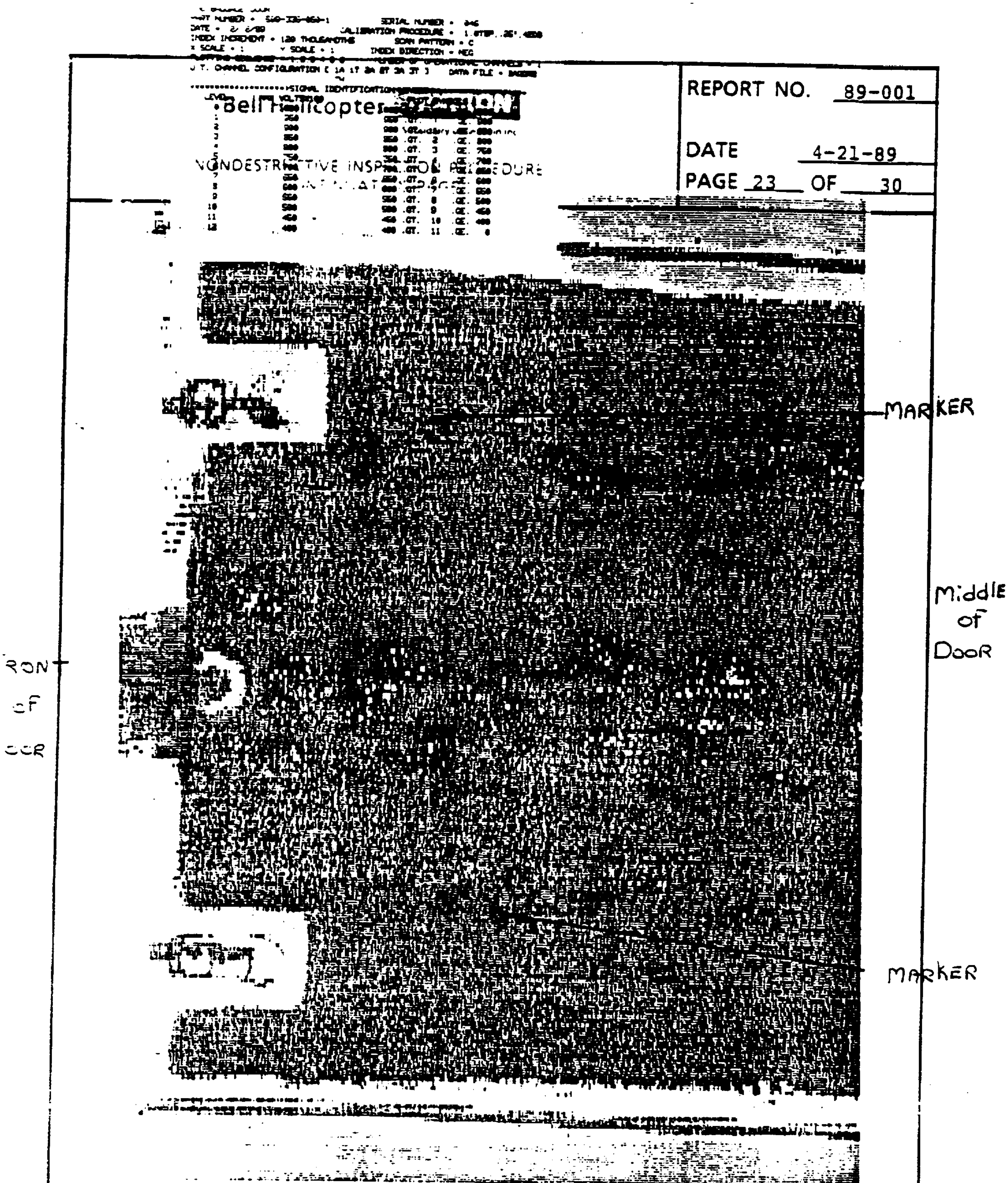

Figure 8A. Scan of Baggage Door 046, But Indentified as ML-121

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

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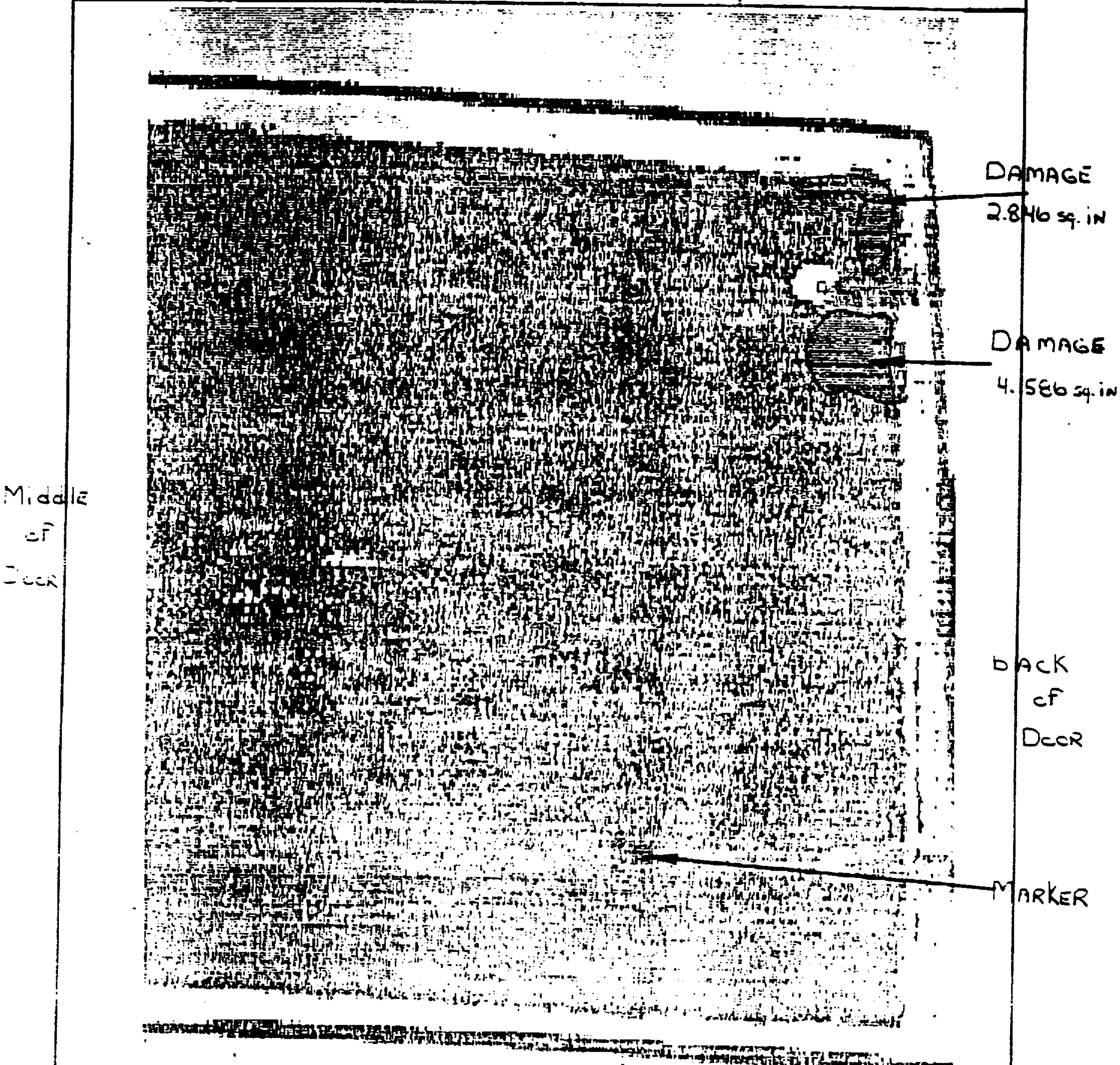

Figure 8B. Scan of Baggage Door 046, But Indentified as ML-121

7812 60888

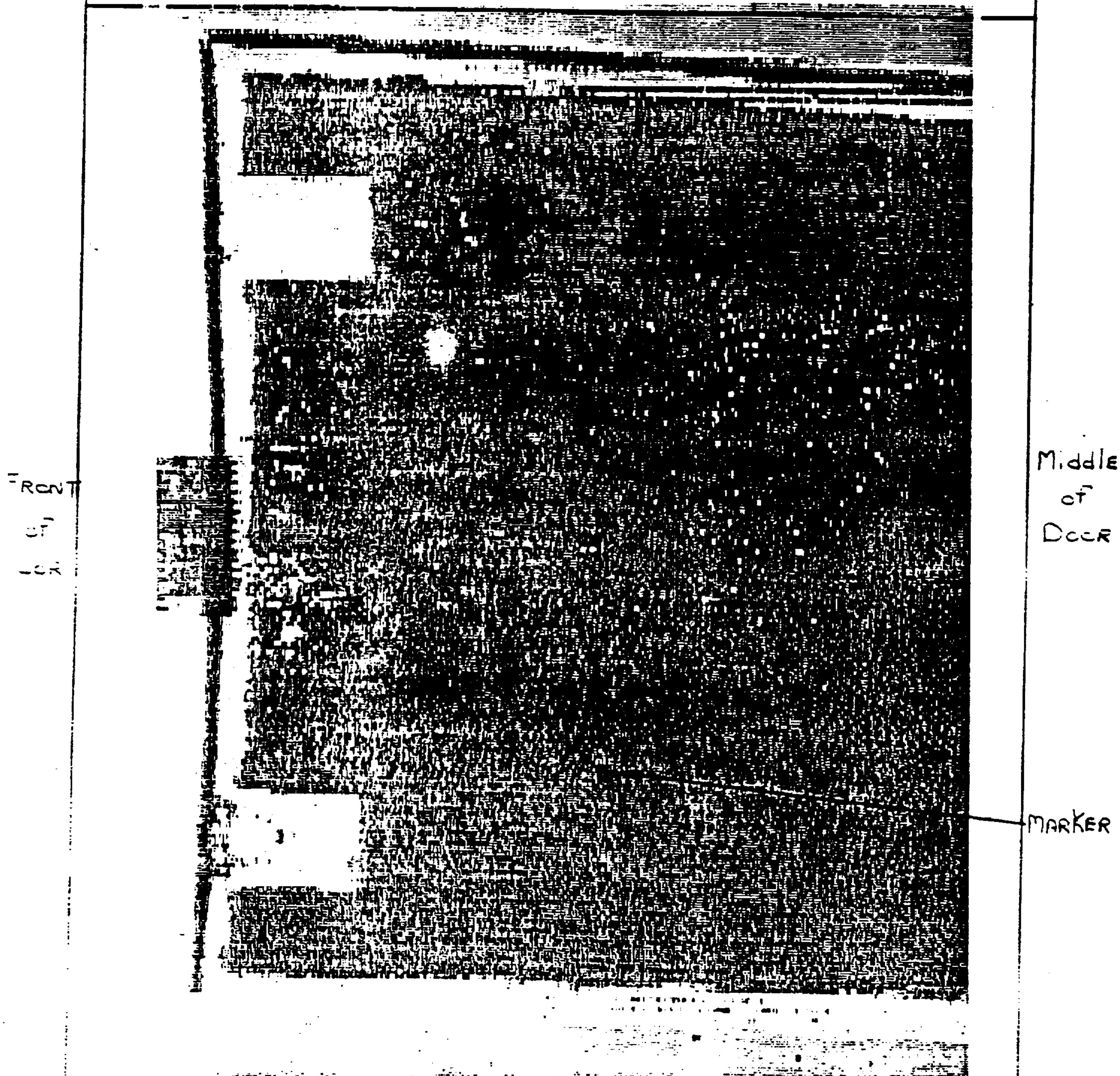

Figure 9A. Scan of Baggage Door ML-182

Bell Helicopter

NONDESTRUCTIVE INSPECTION PROCEDURE

REPORT NO. 89-001

DATE 4-21-89

SERIAL NUMBER = ML-182

CALIBRATION PROCEDURE

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U.T. CHANNEL CONFIGURATION (1A 1T 2A 2T 3A 3T) DATA FILE = BAGDR4

SIGNAL IDENTIFICATION

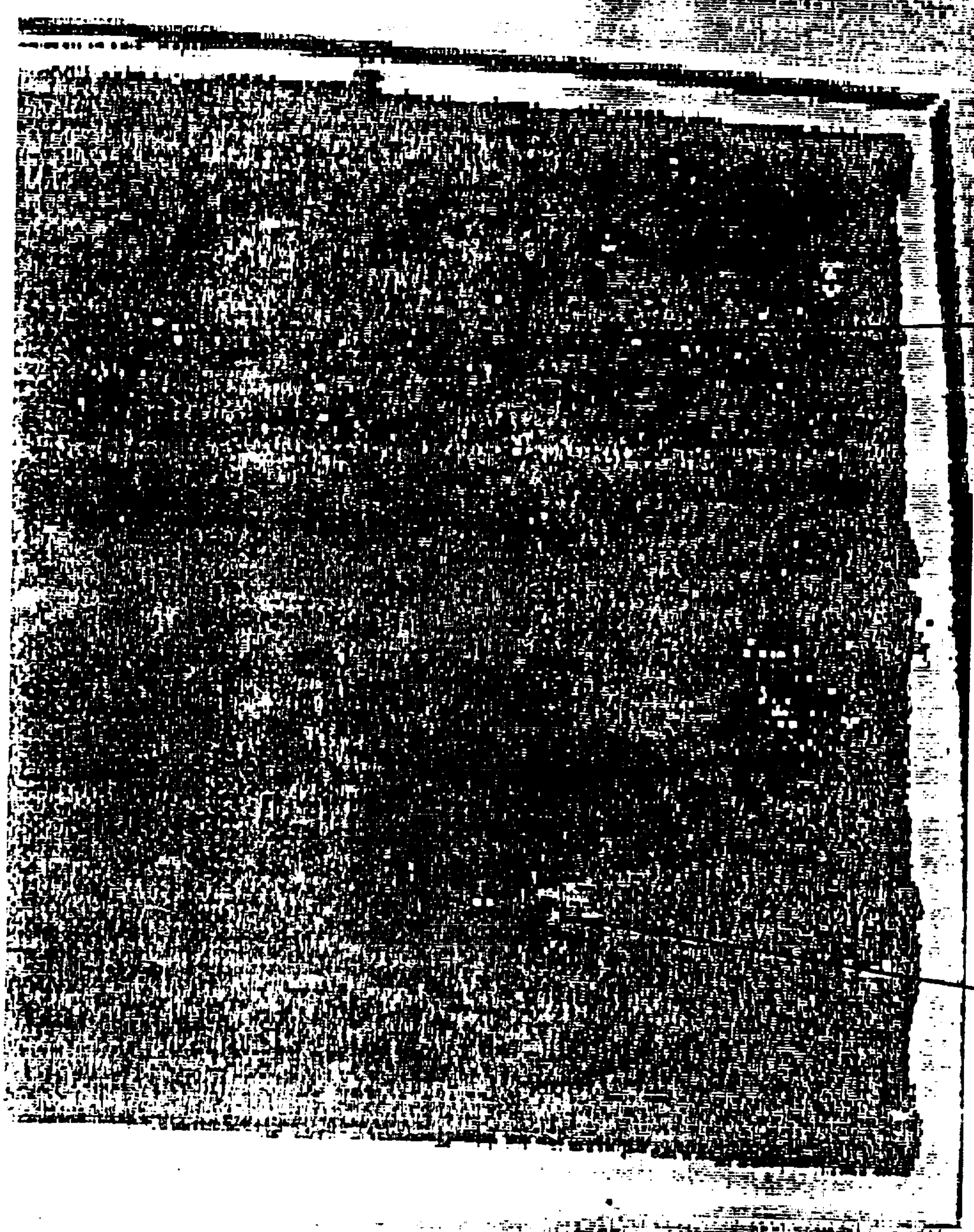
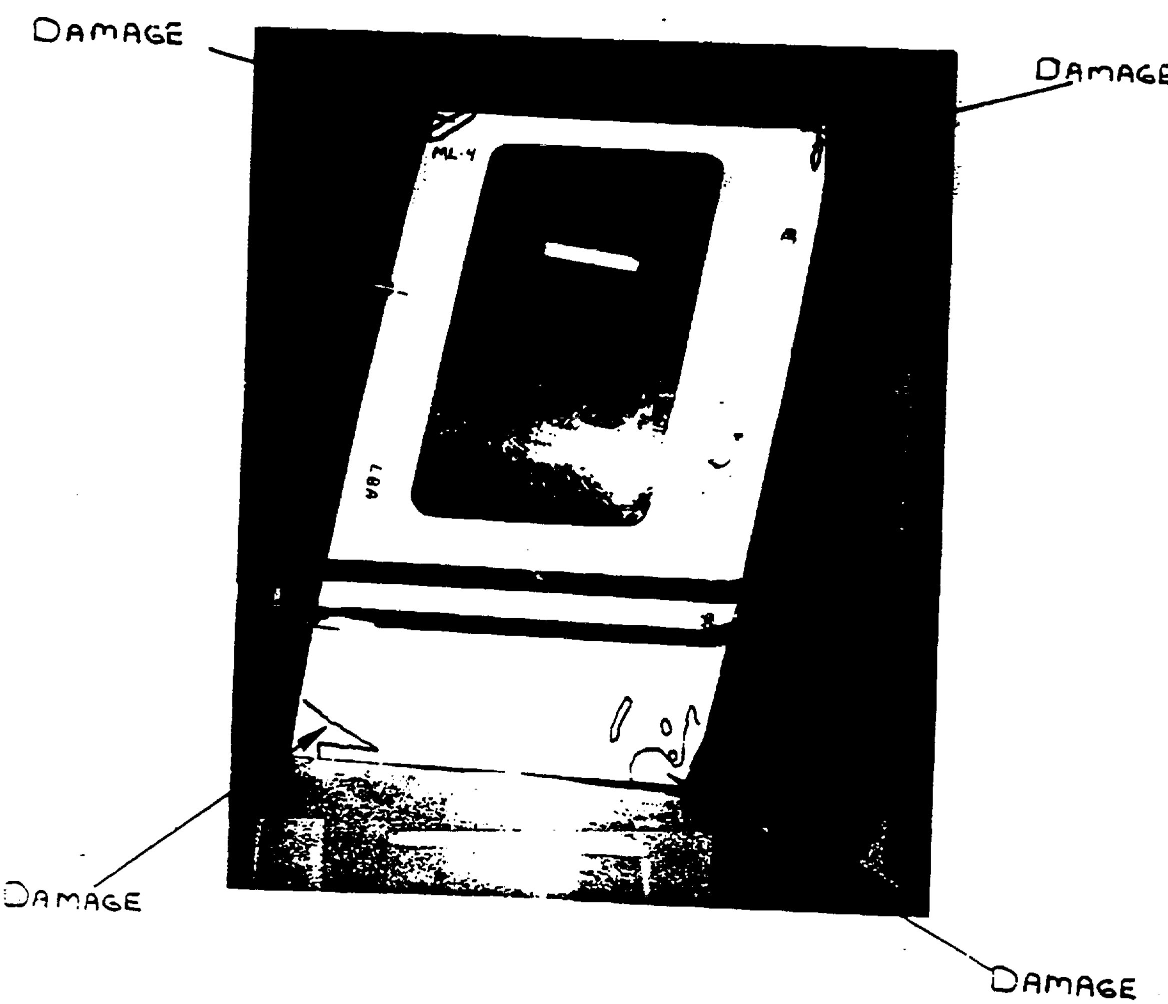


Figure 9B. Scan of Baggage Door ML-182

7812 60888



Photograh 1. Litter Door ML-4 With Service Damage Indentified

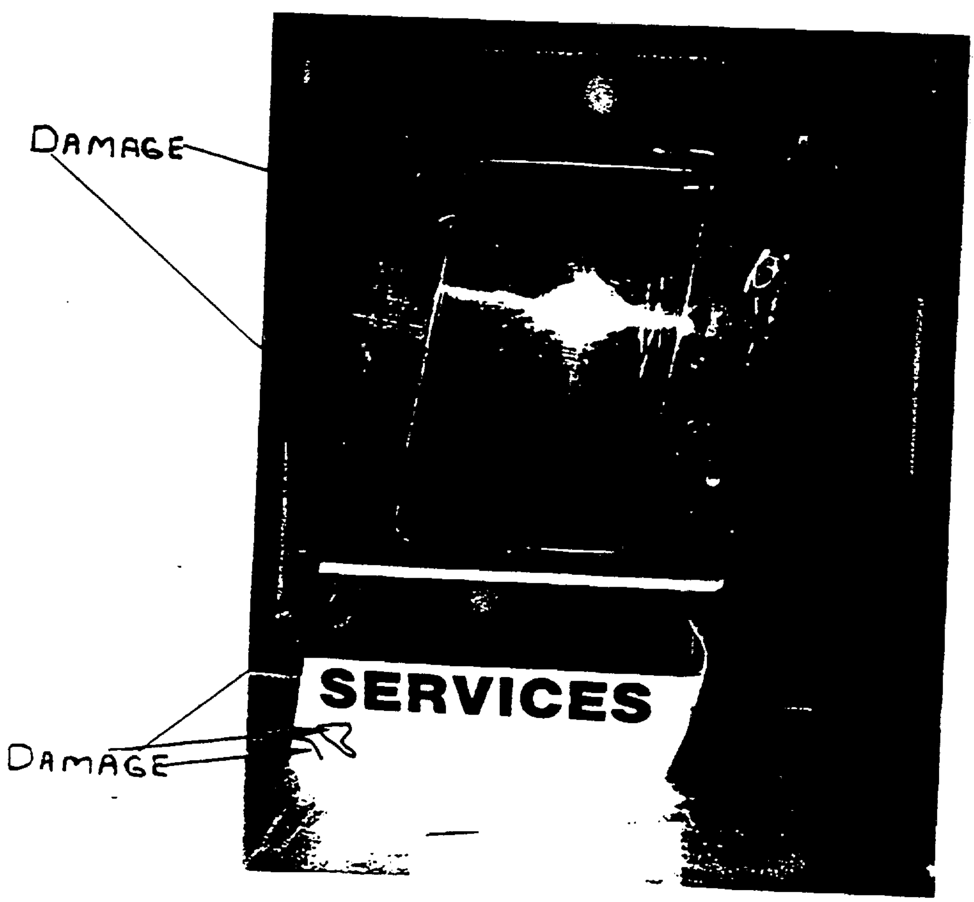
[illegible]

DAMAGE

DAMAGE

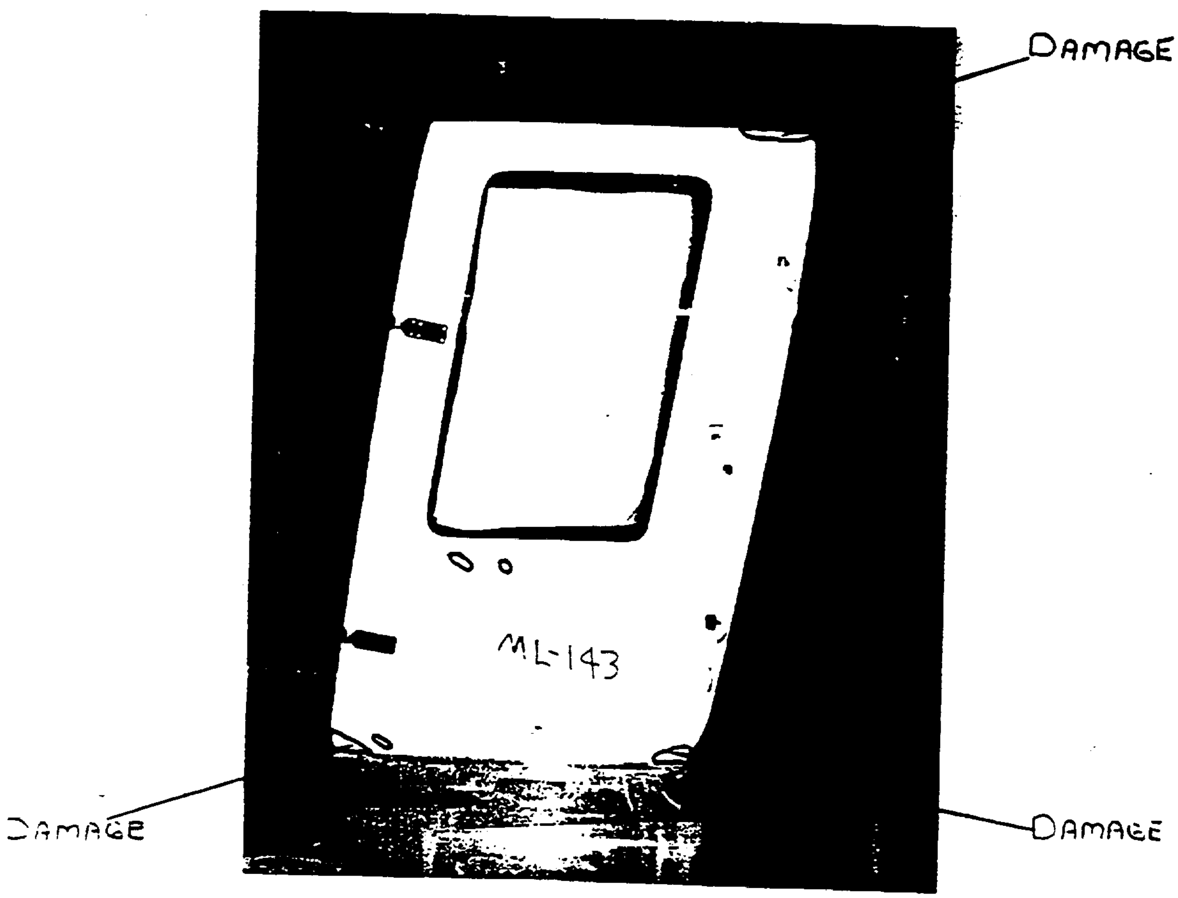
Photograph 2. Litter Door ML-A5 With Servic edamage Indentified

7812 60888



Photograph 3. Litter Door ML-A84 With Service Damage Indentified

7812 60888



Photograph 4. Litter Door ML-143 With Service Damage Indentified

REPORT DOCUMENTATION PAGE

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Final Report

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13.. ABSTRACT (Maximum 200 words)

This is the final report on the advanced composite components which were placed in service on the 206L LongRanger helicopters in the continental Unites States, Canada, and Alaska. This report covers all test data which has been gathered, as well as maintenance histories of the parts. The previous reports (References 1 through 3) describe the fabrication, service experiences and test data through 1986. This report contains information from these references, as well as data gathered after 1986.

The status of the 40 sets of components is discussed in this report. Each set consisted of a vertical fin, forward fairing, litter door and baggage door. Almost 500,000 flight hours have been accumulated on the 160 parts, with the high-time part accumulating 14,687 flight hours.

Over 60 percent of the parts have been destructively tested to measure strength and stiffness retention over the course of the program. The vertical fins had the greatest strength retention, followed by the litter doors. The baggage doors had the poorest retention of strength. There was very little difference in property retention between the four primary operating regions: Northwest U.S., Southwest U.S., Gulf of Mexico Coastal Region and the Northeast U.S. and Eastern Canada Region.

The field problems have ranged from two lightning-struck fins to significant delaminations in the baggage doors. There was only one environmentally related field incident, in which the glass windows on the litter doors were found to loosen due to high temperatures experienced in the southwest region.

14. SUBJECT TERMS
Flight service; Composite; Kevlar; Graphite; Environmental Exposure

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