NASA-CR-172,296

NASA Contractor Report 172296



# FLIGHT SERVICE EVALUATION OF COMPOSITE COMPONENTS ON THE BELL HELICOPTER MODEL 206L -- FIRST ANNUAL FLIGHT SERVICE REPORT



HERBERT ZINBERG

BELL HELICOPTER TEXTRON INC.
FORT WORTH, TEXAS



CONTRACT NAS1-15279
MARCH 1984

NASA
National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23665

50 1 1 RN/NASA-CR-172296
DISPLAY 50/2/1
84N19479*# ISSUE 10 PAGE 1452 CATEGORY 24 RPT#: NASA-CR-172296 NAS 1.26:172296 AR-1 CNT#: NAS1-14279 84/03/00 37 PAGES UNCLASSIFIED DOCUMENT
UTTL: Flight service evaluation of composite components on the Bell helicopter model 206L, flight service report TLSP: Annual Report
AUTH: A/ZINBERG, H.
CORP: Textron Bell Helicopter, Fort Worth, Tex. AVAIL.NTIS SAP: HC A03/MF A01
MAJS: /*COMPONENT RELIABILITY/*FAILURE ANALYSIS/*FLIGHT TESTS/*HELICOPTERS
MINS: / DAMAGE ASSESSMENT/ ENVIRONMENTAL TESTS/ GRAPHITE-EPOXY COMPOSITES/ LIFE (DURABILITY)/ LONG TERM EFFECTS/ MAINTENANCE
ABA: Author
ABS: The flight service components for the Bell Model 206L JetRanger helicopter are examined. The components were placed in service in the Continental United States, Canada, and Alaska. The status of 34 sets of components is

# FLIGHT SERVICE EVALUATION OF COMPOSITE COMPONENTS ON THE BELL HELICOPTER MODEL 206L

--

## FIRST ANNUAL FLIGHT SERVICE REPORT

BY

HERBERT ZINBERG



CR-172296

PREPARED UNDER CONTRACT NAS1-15279

BY

BELL HELICOPTER TEXTRON INC.

FORT WORTH, TEXAS

FOR

LANGLEY RESEARCH CENTER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

N84-19479#

# FOREWORD

This is the first annual 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 is jointly sponsored by NASA-Langley Research Center and the Structures Laboratory, USARTL (AVRADCOM) under Contract NAS1-15279. A prior report (Reference 1) describes the design, fabrication, and testing of the components. This report covers the period from approximately February 1982 through July 1983. The NASA-Langley Technical Monitor for this program is Mr. Donald J. Baker. The Bell Project Engineer is Mr. Herbert Zinberg.

Acknowledgement is made of the 206L commercial operators who are participating in this program and who are identified in the body of the report. The program would not be possible without their aid and cooperation.

Certain materials are identified in this publication to adequately specify which materials were used. In no case does such identification imply recommendation or endorsement of the material by NASA or USARTL (AVRADCOM), nor does it imply that the materials are necessarily the only ones or the best ones available for the purpose.

TABLE OF CONTENTS

## LIST OF FIGURES

LIST OF FIGURES (Concluded)

LIST OF TABLES

# FLIGHT SERVICE EVALUATION OF COMPOSITE COMPONENTS ON THE BELL HELICOPTER MODEL 206L: FIRST ANNUAL FLIGHT SERVICE REPORT

By

Herbert Zinberg

Bell Helicopter Textron, Inc.
Fort Worth, Texas

## SUMMARY

This is the first flight service report on the advanced composite components that have been placed in service on 206L JetRanger helicopters in the continental United States, Canada, and Alaska. The report covers the period from approximately 1 February 1982 to 1 August 1983. A previous report (Reference 1) describes the design, fabrication, and testing of the four components, which are the 206L forward fairing, litter door, baggage door, and vertical fin.

The status of 34 sets of components is discussed in this report. Approximately 27,500 flight hours were accumulated on the components on 1 August 1983. The high-time helicopter accumulated 2244 hours.

Three sets of components and one-fifth of the exposure coupons were returned and tested. Neither the graphite/epoxy coupons nor the graphite/epoxy fin showed any structural degradation. However, the Kevlar/epoxy coupons and doors showed a loss of strength and/or stiffness. The strength loss was most prevalent in the matrix-dominated properties. This was especially noticeable in the specimens that experienced long-term exposure in the cold climates of Canada and Alaska.

The actual field problems have been nominal. The only significant problem was that of thermal buckling of four litter doors on helicopters that spent the summer parked in the desert sun outside of Phoenix, Arizona. The cause for the buckles was determined, and remedial action was taken.

## 1. DISTRIBUTION OF SERVICE EVALUATION KITS

The objective of this program is to evaluate 40 sets of advanced composite helicopter airframe components under commercial service environments for an extended period of time on the Bell 206L JetRanger. Reference 1 describes the components, which are the forward fairing, litter door, baggage door, and vertical fin. The first three are made from Kevlar/epoxy. The fin is made predominantly from graphite/epoxy. It is planned to keep most of these parts in service for five years. However, NASA has the option of extending the service period for an additional five years. As part of the evaluation process, a certain number of parts are removed after specified lengths of service for static test to chart any timewise degradation of the materials.

Table 1 of Reference 1 shows the distribution of kits to the commercial operators. Table 1 of this report shows the kits that have been installed, and specifies the number of hours on each kit as of 1 August 1983.

A summary of Table 1 shows that 34 helicopters reported an accumulation of 27,517 flight hours, for an average of 809.3 hours per helicopter. The aircraft with the most hours operated in the vicinity of the Gulf Coast and had accumulated 2244 flight hours. A breakdown of hours by geographical location is given in Table 2.

The program specifies that 40 ship sets be tested, but Table 1 only reports the status of 34 sets. One set was scheduled to be installed in Alaska in August 1983, and a second set is scheduled to be installed in September, so no time has been accrued on these. One of the two aircraft that are operated by the Royal Canadian Mounted Police was stationed in Northern Labrador and was not available for inspection. Two sets of components assigned to Houston Helicopters have not, as yet, been installed because of lack of work for the aircraft to which they have been assigned.

TABLE 1. FLIGHT SERVICE RECORD OF 206L COMPOSITE COMPONENTS AS OF 1 AUGUST 1983

| Operator | Location | No. of Kits Deliv | Date Installed | Heli Serial No. | No. Hr on Components | Remarks |
|---|---|---|---|---|---|---|
| Island Helicopters | Garden City, New York | 3 | 08/81 | 45101 | 1413 | Returned for scheduled static test (7/83) |
| | | | 09/81 | 45450 | 1495.6 | Light pulled out of fin cap. Light replaced |
| | | | 10/81 | 46601 | 1297.3 | |
| ERA Helicopters | Anchorage, Alaska | 5 | 11/81 | 45113 | 612 | |
| | | | 12/81 | 45108 | 506 | |
| | | | 05/82 | 45115 | 391 | |
| | | | - | 45109 | None | Installed Aug 1983 |
| | | | - | 45114 | None | Not yet installed |
| Trans-Quebec Helicopters | Les Cedres (Montreal), Canada | 5 | 05/81 | 45141 | 870 | Removed for scheduled static test (7/82) |
| | | | 05/81 | 45143 | 1099 | |
| | | | 04/83 | 45134 | None | Helicopter placed into service July 1983 |
| | | | 11/81 | 45206 | 328 | |
| | | | 11/81 | 45439 | 282 | |
| Royal Canadian Mounted Police | Ottawa, Canada | 2 | 12/81 | 45086 | 749.3 | |
| | | | 11/82 | 45414 | Not available | Aircraft was out of touch at report time |
| Ministry of Transport Canada | Ottawa, Canada | 2 | 06/82 | 45083 | 395 | |
| | | | 04/83 | 46608 | 300 | |

TABLE 1. (Concluded)

| Operator | Location | No. of Kits Deliv | Date Installed | Heli Serial No. | No. Hr on Components | Remarks |
|---|---|---|---|---|---|---|
| Air Services International | Scottsdale, Arizona | 5 | 05/82 | 45418 | 140.1 | Thermal buckles |
| | | | 05/82 | 45614 | 169.9 | Thermal buckles |
| | | | 05/82 | 45607 | 23.2 | Thermal buckles |
| | | | 05/82 | 45609 | 612.9 | |
| | | | 04/82 | 45608 | 484.8 | Thermal buckles |
| Houston Helicopters | Pearland (Houston), Texas | 3 | 04/82 | 45535 | 112 | |
| | | | | Not assigned | | Kits to be installed when aircraft get work |
| | | | | Not assigned | | |
| Commercial Helicop-ters | Lafayette, Louisiana | 2 | 02/82 | 45330 | 1586 | |
| | | | 02/82 | 45331 | - | See text for explanation |
| | | | 03/82 | 45442 | 490 | |
| Petroleum Helicopters Inc. | Lafayette, Louisiana | 5 | 06/81 | 45373 | 879 | Lightning strike. Returned for scheduled static test (6/82) |
| | | | 08/81 | 45181 | 1301.1 | |
| | | | 11/81 | 45160 | 1491.5 | |
| | | | 10/81 | 45367 | 2244.1 | |
| | | | 10/81 | 45305 | 1940.4 | |
| Air Logistics | New Iberia, Louisiana | 5 | 03/82 | 45436 | 1244.5 | |
| | | | 02/82 | 45378 | 937.1 | |
| | | | 07/82 | 45266 | 847.2 | |
| | | | 08/82 | 45546 | 1202.7 | |
| | | | 11/82 | 45449 | 401.9 | |
| Heli-Voyageur | Val d'OR Quebec | 3 | 03/82 | 45017 | 551 | |
| | | | 04/82 | 45028 | 643 | |
| | | | 04/82 | 45085 | 476 | |

TABLE 2. DISTRIBUTION OF HELICOPTERS BY GEOGRAPHICAL LOCATION

| Location | No. of Helicopters | Hours Accumulated |
|---|---|---|
| Northeastern U.S. & Eastern Canada | 10 | 8,455 |
| Central Canada | 3 | 1,444 |
| Alaska | 3 | 1,509 |
| Southwest (desert) U.S. | 5 | 1,431 |
| Gulf Coast | 13 | 14,678 |

Finally, one set was on a helicopter assigned to Commercial Helicopters. The aircraft was being transported by truck when the rotor mast struck a low bridge. Most of the aircraft was destroyed. However, the two composite doors and the fairing escaped damage and were transferred from S/N 45331 to S/N 45442.

It is emphasized that although the aircraft are owned by operators who are located in certain geographical areas, there is no certainty that the aircraft will always be operated close to their home bases. In fact, they are often sent out for extended periods of time to areas whose environments are different from their home environments. One such example is the five sets of components sent to Air Services International located in Phoenix, Arizona. The first summer, four helicopters remained in the hot, dry Phoenix environment, but the fifth one was operated in the cool Wyoming-Montana area. Another example is the helicopters operated by Trans-Quebec. The operator is located in a suburb of Montreal, but two of their five helicopters spent most of one winter in the vicinity of Newfoundland. These examples are given to emphasize the fact that, although the home bases of the components are known, the components may be sent to remote areas on short notice. One exception is the components assigned to the Gulf Coast. These normally remain in the area because they are assigned to offshore oil exploration and production.

From a practical standpoint, it has not been possible to phase the components into service as rapidly as desired; and there is a gap of about two years between the time the first ones went into service, and the scheduled date for the last ones. This timespread can be partially attributed to a slowing of the national economy -- most especially in the oil industry. Most operators wait until their 1200-hour major overhaul to install the composite parts. At that time, they have the helicopters in a down status, with mechanics scheduled to work on them. Because of the slow workload, there is a long period of time between 1200-hour overhauls, and this has slowed installations. It also has the effect of not accumulating flight hours as rapidly as desired. All components, however, are scheduled to be in flight status by the winter of 1984.

# 2. TESTS OF ENVIRONMENTALLY EXPOSED COMPOSITES

## 2.1 TESTS OF FLIGHT COMPONENTS

After approximately one year of service, three sets of components were returned to Bell for static testing. Components were returned from Island Helicopters (S/N 45101) after 1413 hours, Trans-Quebec Helicopters (S/N 45141) after 870 hours, and Petroleum Helicopters (S/N 45373) after 879 hours of service. The results of the tests to date are shown in Table 3, and are compared with the preservice tests which were the average of the certification and selected production components. The preservice tests are described in Reference 1. In addition, deflection measurements were made on the litter door and forward fairing that were returned from Island Helicopters. These too are compared with preservice deflection measurements.

TABLE 3. RESIDUAL STRENGTH COMPARISON OF COMPOSITE AIRFRAME COMPONENTS AFTER (APPROX) ONE YEAR SERVICE

| | Preservice Strength | | | Residual Strength | | |
|---|---|---|---|---|---|---|
| Component | Average | Minimum | Av - 3σ | 879 hr Gulf Coast | 870 hr Canada | 1413 hr New York |
| Fwd fairing[1] | 2.73 | 1.73 | 0.84 | 1.8 | 2.5 | 1.89 |
| Baggage door | 629 | 551 | 406 | 795 | 473 | 275 |
| Litter door | 1208 | 1176 | 927 | 1009 | 980 | 1115 |
| Vertical fin | 2020 | 1872 | 1662 | 2497 | 2219 | 2100 |

[1]Pressure, psi. All other data in pounds.

An examination of Table 3 reveals that the graphite fin has, thus far, shown no strength degradation. In fact, the minimum strength of the three fins is higher than the average of the preservice tests. All three fins failed in bending in the same manner as shown in Figure 23 of Reference 1. Accordingly, it is concluded that the graphite fins were unaffected by a year of field service.

No conclusions can, as yet, be drawn from the tests of the Kevlar components. The three forward fairings failed below the average of the preservice fairings, but not below the minimum value; so on that basis, it can be said that, thus far, there has been little or no loss of strength due to service. Failure of two of the fairings was by local tearing of the buildup structure at an aft latch. The third fairing, from Island Helicopters, failed in bending at the inner radius as shown in Figure 1. Both failure modes have been observed in the preservice tests.

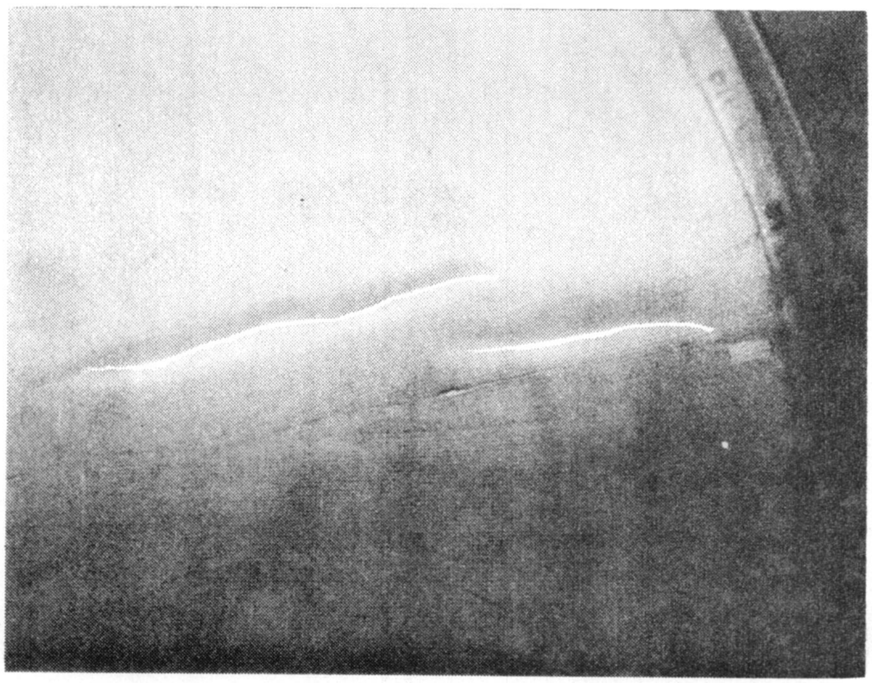

Figure 1. Static test failure of forward fairing after a year's flight service. Failure is compression bending of inner skin.

Figure 2 shows the load-deflection curve of the top centerline of the forward fairing and compares it with the load-deflection of a fairing (Reference 1) used for certification. Both sets of data were for a point located 14.5 inches forward of the aft end of the fairing. The figure shows that there was no change in stiffness after 1413 hours of service in the metropolitan New York City area.

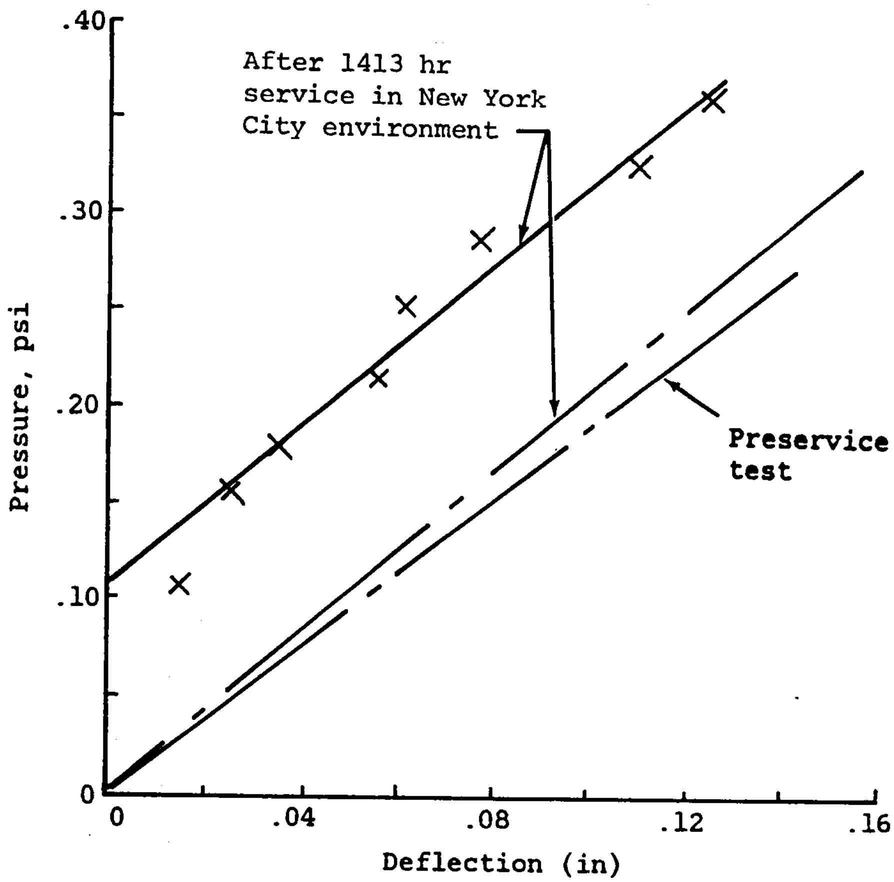


Figure 2. Load-deflection curve of forward fairing after 1413 flight hours in New York City area.

The baggage door tests show a large scatter in both failing strength and failure modes. The door that was located on the Gulf Coast failed at a higher load than the average of the preservice doors. Failure occurred when one of the hinges broke. This is similar to the preservice failures (Reference 1, Figure 22). The door that returned from Canada failed in compressive buckling of the inner skin at a load that was lower than the minimum of the preservice tests. It was not possible to get a photograph which showed the buckle. Its location could be found by feeling a separation of the inner skin from the honeycomb core. The failure was approximately at the fore and aft center of the door and extended for most of its width.

The baggage door that was returned from Island Helicopters in the New York City area failed at a low load, and the mode of failure was different from that of any previous baggage door. A loud noise was heard when the distributed load reached 275 pounds, and the door deflected noticeably. There was no observable failure after the load was removed, but the outer (tension) surface felt soft. Local tapping, followed by ultrasonic inspection revealed large areas of disbonding between the outer skin and core. Figure 3 shows the areas of disbonding.

It cannot be said, for certain, whether the low failing load on this baggage door was caused by a year's field service or by a poorly manufactured bond between the outer skin and core. It may be significant that there was no failure on the compression side. Also, in the manufacture of the baggage door, an adhesive was used between the inner skin and core, but only the matrix resin was used to bond the outer skin to the core. This is the only baggage door to fail in this manner in static test. There have been, however, occasions when the outer skins disbonded from the core in service. This is discussed in Section 4.3.

Table 3 shows an apparent loss in strength for the exposed litter doors. All three of the doors failed at a lower load than the minimum of the preservice doors; and the one located in Canada was only 6% stronger than the (average - $3\sigma$) preservice strength. All failures were caused by the posts pulling out of the jig. This failure mode is the same as for the preservice tests. Figure 4 shows how the post fits into the test jig that simulates the fuselage fitting.

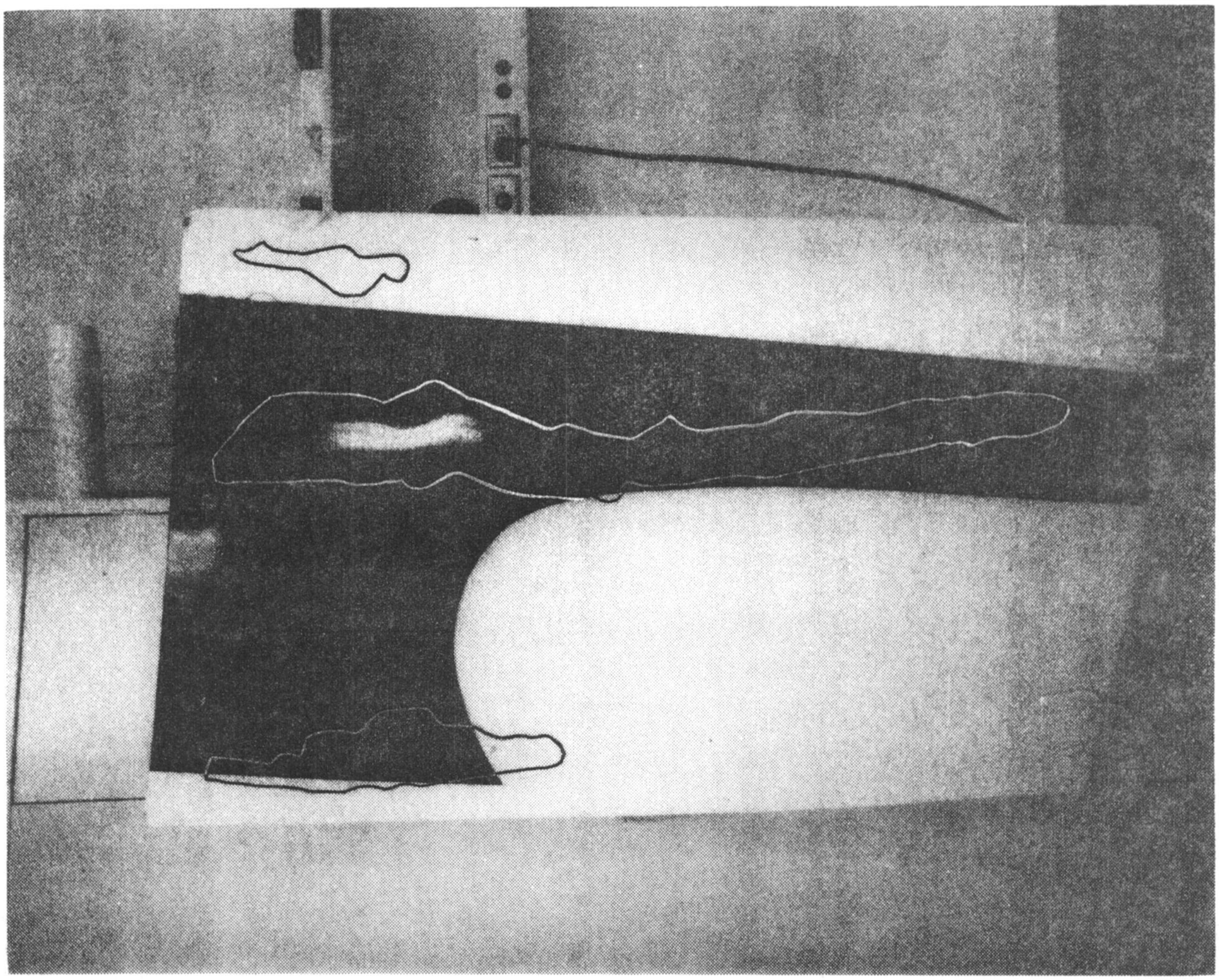

Figure 3. Static test failure of baggage door after 1413 flight hours in New York City area. Areas of disbond of outer skin-to-core is shown.

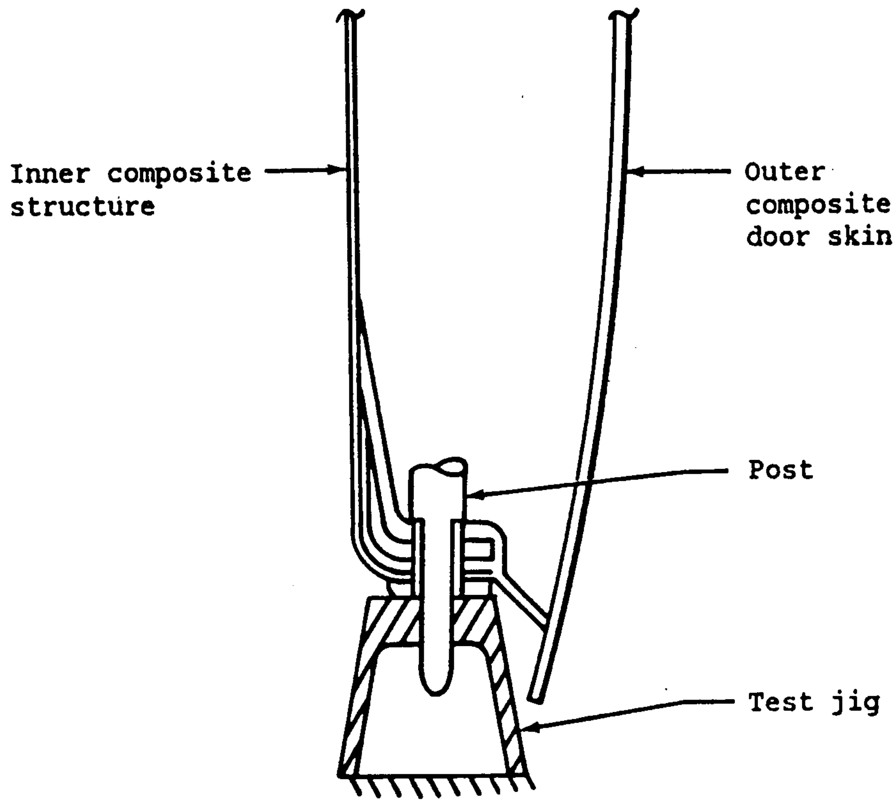


Figure 4. Attachment of lower litter door post to static test jig.

It was thought that, although the failure mode was not a composite structural failure, it might be related to a loss in structural stiffness, which could cause excessive rotation at the end posts. Therefore, deflection data was taken during the test of the door that was returned from Island Helicopters to see if there was any loss of stiffness. Figure 5 is a comparison of deflections, at one location, between this door and the average of three doors tested before service. The figure shows a substantial loss of stiffness after 1413 hours of service. This could have caused the posts to slip out at a low load, despite the fact that the door apparently suffered no loss of structural strength.

Although only three sets of components have been tested, and only one year of service has been accumulated on the parts, some observations can be made. The

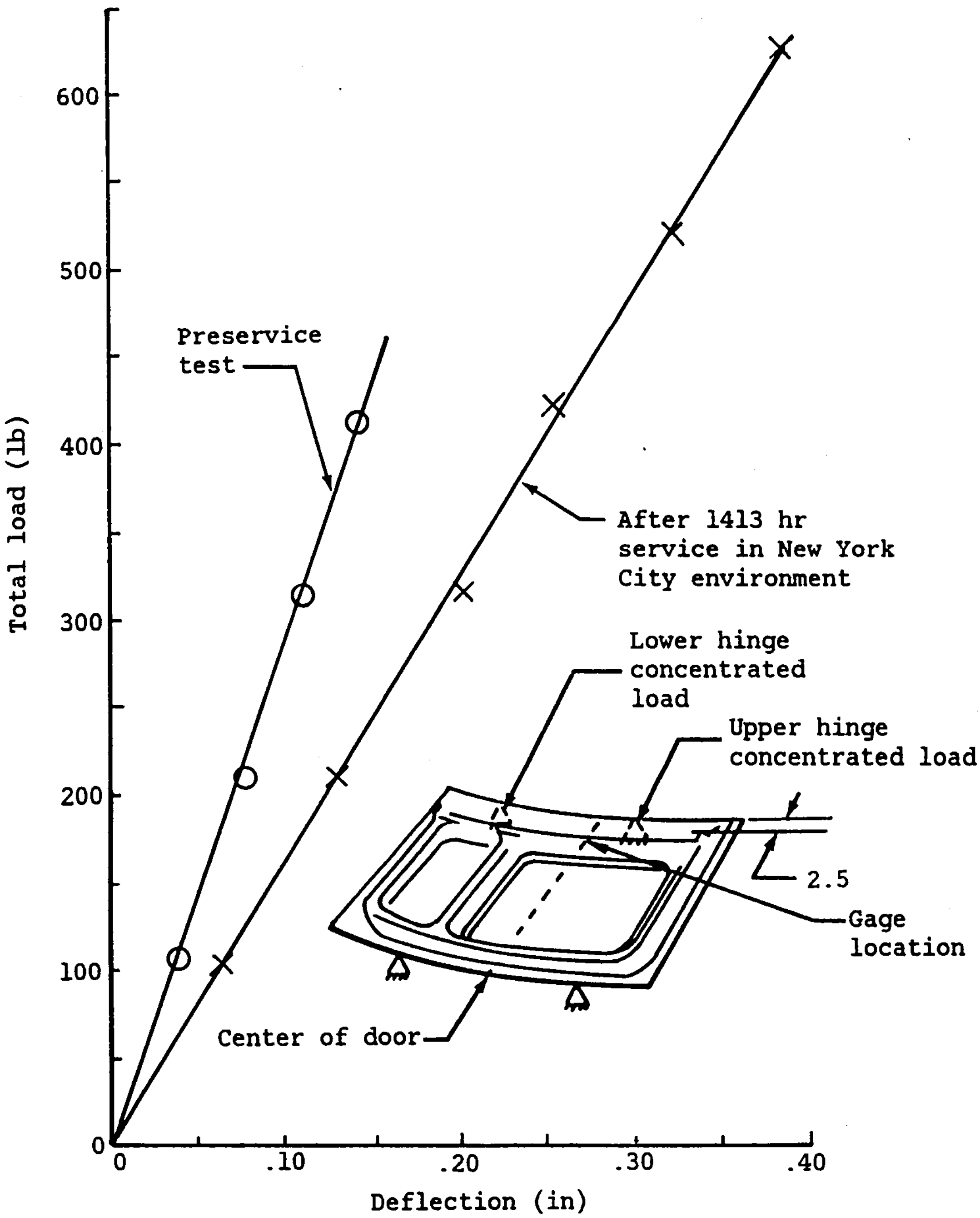


Figure 5. Load-deflection comparison of litter door before service and after 1413 hours of flight in New York City area.

first is that the only graphite component, the vertical fin, showed no signs of structural degradation. In fact, all three of the exposed fins were stronger than the average of the preservice fins.

The Kevlar components did not fare as well as the graphite fin. After one year of service, they showed some loss of strength and/or stiffness. The losses, however, were not sufficiently consistent to indicate a definite trend. Additional data, taken over longer service periods, are required before any conclusion can be drawn. These should be forthcoming as the program continues.

## 3. EXPOSURE COUPONS

Coupons for environmental testing are located on exposure racks in five areas in the continental United States, Canada, and Alaska. Their specific locations are noted in Table 4. The test coupons are made from the same materials, and with the same ply layups as the external surfaces of the composite components. A description of the coupons and the exposure racks is given in Reference 1.

After a year's exposure, one-fifth of the specimens (76) were removed from each of the five racks and sent to NASA-Langley Research Center for testing. Tension, compression, and short beam shear tests were performed, and the results were compared with tests performed on unexposed specimens. Table 4, which was taken from Reference 2, summarizes the coupon tests by comparing the results with those of the baseline (unexposed) coupons. The data shown are based on average test values.

Examination of Table 4 reveals no strength loss in the graphite specimens. The reduction of 3% (two tension and one short beam shear) is well within normal scatter.

The Kevlar specimens show no significant reduction in tensile strength, but there is a definite loss in the matrix-dominated compression and short beam shear strengths. Two facts are noticeable. The first is that the baggage door specimens show strength losses in all of the environments, with the maximum loss being in the specimens exposed to cold climates. The other is that the fairings and litter door coupons exhibit significant strength losses only after being exposed to a cold climate.

Several qualitative theories have been advanced concerning loss of strength of Kevlar/epoxy after prolonged environmental exposure. They will not be put forth here except to state that they all are concerned with the fact that the Kevlar fiber absorbs moisture, and also that the fibers do not adhere to the matrix as well as one would desire. Under prolonged cold-wet exposure, there

TABLE 4. EFFECT OF ONE YEAR OF GROUND-BASED EXPOSURE ON STRENGTH OF COUPONS OF COMPOSITE MATERIALS USED TO FABRICATE 206L COMPONENTS

| Component | Materials and Fiber Orientation | Exposure Location | Strength Retention Ratio[1] | | |
|---|---|---|---|---|---|
| | | | SBS[2] | Comp | Ten |
| Litter door | Kevlar-49/epoxy Style 281 cloth 0/45/0 | Cameron, LA | 0.98 | 1.01 | 1.02 |
| | | Oil platform | 0.95 | 0.99 | 1.00 |
| | | Hampton, VA | 1.02 | 0.97 | 1.05 |
| | | Toronto, Canada | 0.96 | 1.00 | 1.04 |
| | | Ft. Greeley, AK | 0.93 | 0.90 | 1.03 |
| Baggage door | Kevlar-49/epoxy Style 120 cloth 0/90/±45 | Cameron, LA | 0.93 | 0.94 | 1.03 |
| | | Oil platform | 0.90 | 0.93 | 0.99 |
| | | Hampton, VA | 0.97 | 0.89 | 1.00 |
| | | Toronto, Canada | 0.95 | 0.89 | 1.04 |
| | | Ft. Greeley, AK | 0.88 | 0.85 | 1.02 |
| Fwd fairing | Kevlar-49/epoxy Style 281 cloth 0/90 | Cameron, LA | 0.98 | 0.98 | 1.00 |
| | | Oil platform | 0.98 | 0.98 | 1.00 |
| | | Hampton, VA | 1.02 | 1.05 | 1.05 |
| | | Toronto, Canada | 1.04 | 0.96 | 1.04 |
| | | Ft. Greeley, AK | 0.93 | 0.94 | 1.03 |
| Vertical fin | T300/epoxy 0/±45/0 | Cameron, LA | 1.01 | 1.03 | 0.97 |
| | | Oil platform | 1.02 | 1.00 | 0.97 |
| | | Hampton, VA | 1.02 | 1.01 | 1.01 |
| | | Toronto, Canada | 1.00 | 1.01 | 1.08 |
| | | Ft. Greeley, AK | 0.97 | 1.02 | 1.00 |

[1]Strength retention ratio = $\frac{\text{strength (exposed)}}{\text{strength (baseline)}}$

[2]Short beam shear

will be a tendency to weaken the bond between the fiber and the matrix. Some resin systems will adhere to the matrix better than others, but few, if any, have as good a bond as does graphite or fiberglass.

Each of the three Kevlar/epoxy components used a different resin system. The forward fairing used CE 306[1] resin, and the litter door used F560[2] resin. The baggage door used a Brunswick resin system whose formulation, and therefore its properties, are proprietary.

Although no definite conclusions can be drawn from only a year's exposure, it appears that Kevlar/epoxy may be sensitive to long-term exposure to a cold, wet environment. This trend will be closely watched as the program continues.

---

[1]Manufactured by Ferro Corp., Culver City, CA

[2]Manufactured by Hexcel Corp., Dublin, CA

# 4. MAINTENANCE AND SERVICE PROBLEMS

Since one facet of this program is to monitor the serviceability of composite structures, it will be of interest to discuss some of the "incidents" that have occurred during approximately 27,500 flight hours. It should be noted that although these happened to helicopters, it is probable that similar "incidents" can happen to fixed-wing aircraft in the light plane category. In many respects, the maintenance of light planes is similar to light helicopters, so it may be assumed that their maintenance problems would be about the same.

## 4.1 MAINTENANCE INSTRUCTIONS

The kit for each component contains an FAA-approved Service Instruction Manual (SI). In addition to detailed installation instructions, the SI contains repair procedures for the repairable portions of each component.

Recognizing that many of the small operators have had little or no experience working with Kevlar, and that Kevlar is not readily available at most private facilities, all standard Kevlar repairs are made with fiberglass fabric using wet layup techniques. The graphite fin, however, poses a different problem. The fin is made from a prepreg, unwoven laminate oriented [0/±45/0] along the upper and lower structural axes, becoming isotropic in the area of the fin-to-fuselage intersection. A fiberglass fabric repair would not work well for this construction, nor would it be practical to ask the operators to lay up a unidirectional laminate in the field and try to match the existing laminate with the repair. Accordingly, it was decided that the fin repairs be made with titanium sheet. It was recognized that untreated titanium does not adhere well to other surfaces, including graphite/epoxy. Therefore, when a fin structural repair is required, Bell will treat a piece of titanium for use in the repair. Although this is not an efficient long-range procedure, it was adopted for this program.

When damage is incurred whose repair is not covered by the SI, Bell will send a representative to aid the operator; or in some cases, the component is returned to Bell for rework.

## 4.2 PROBLEMS ENCOUNTERED IN SERVICE

During the course of over 27,500 flight hours, it is inevitable that some problems would be encountered. Most of the problems were minor in nature, and consisted of such mishaps as locally dented or cracked skins that occurred during ground handling operations. These were repaired by the operators, and often without informing Bell. Some of the more significant incidents that have come to Bell's attention are discussed below.

The vertical fin structure was pierced when a helicopter was blown into a sharp object during a windstorm. The accident occurred on an oil rig in the Gulf of Mexico. Figure 6 shows that the damage was about 3 inches in diameter and extended into the honeycomb core, but not to the opposite skin.

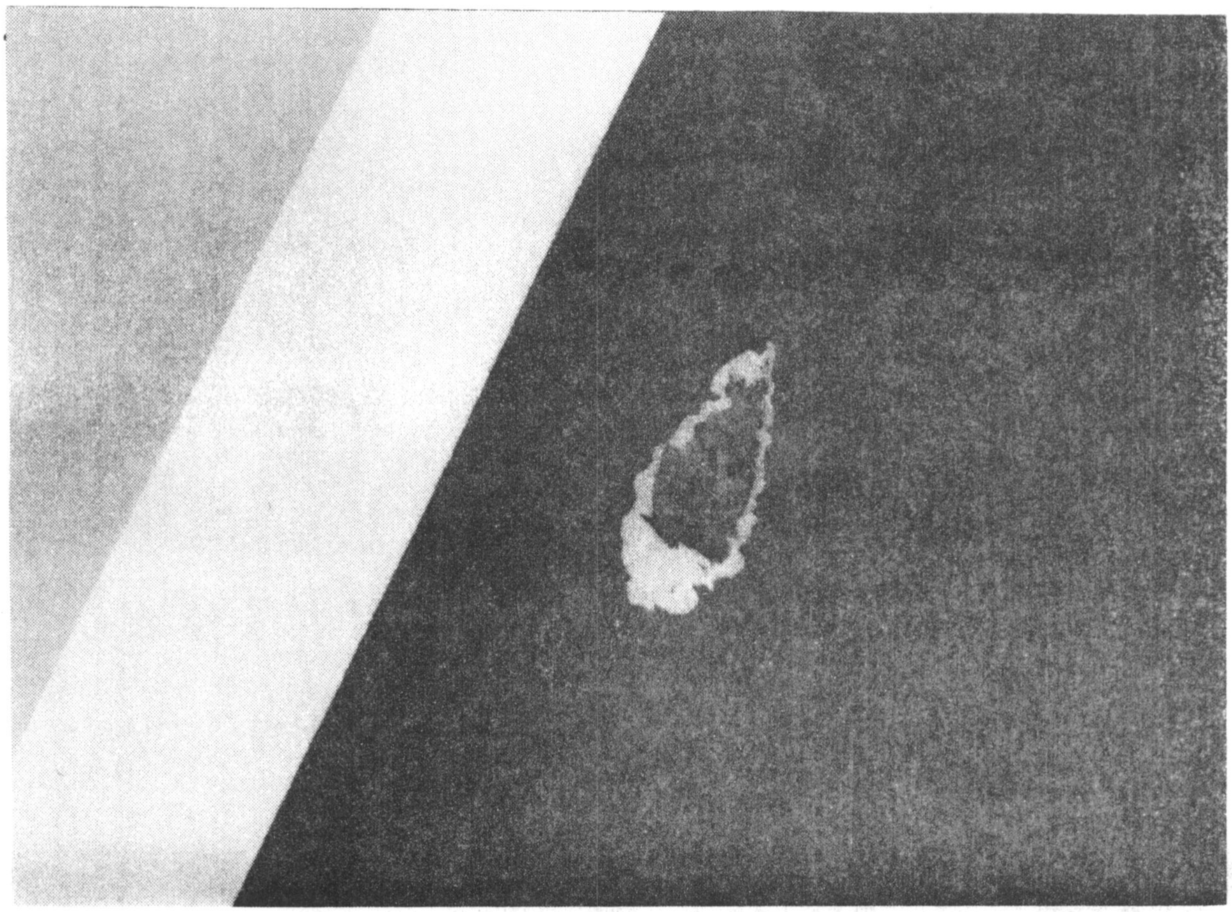

Figure 6. Damage to graphite/epoxy vertical fin when pierced by a sharp object.

The repair was made by first cleaning the hole and replacing the fibertruss core with fiberglass honeycomb core. The skins were trimmed down to the core, and a buildup of 6Al-4V titanium sheet was used to make the typical honeycomb sandwich repair. All of the bonding was done with room temperature setting EA 934[3] adhesive. Figure 7 shows the repair prior to cleanup and painting. This repair was made at Petroleum Helicopters Inc. who have the equipment to treat titanium at their facility, so it was not necessary to treat it at Bell.

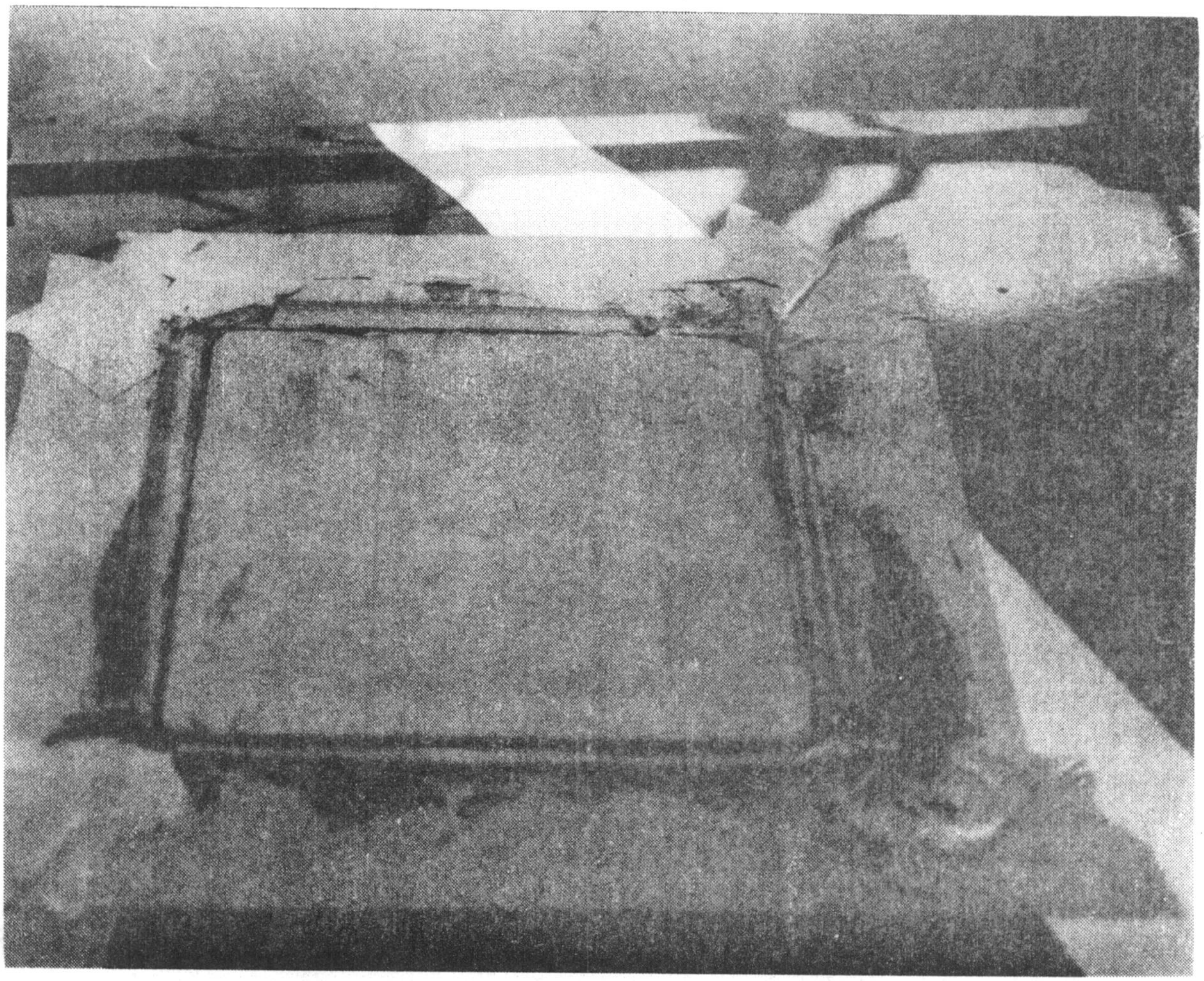

Figure 7. Repair to damaged vertical fin showing titanium repair plate prior to cleanup and painting.

[3]Manufactured by Dexter Hysol Corp., Pittsburgh, CA

One helicopter received a lightning strike while it was parked at an airfield. The light on the top of the fin was damaged and had to be replaced. The rest of the fin was visually examined, but there were no indications of damage to the composite structure. This is considered to be a validation of the lightning protection used on the fin. (This particular fin was part of the set of components that was returned from the Gulf Coast for static test after 840 flight hours.)

One operator attempted to attach an aluminum plate to the inner skin of the baggage door by means of bucked rivets. The riveting caused areas of disbonding between the inner skin and the nomex honeycomb core, and also caused some local crushing of the core. This door was returned to Bell for repair. A section of the inner skin and crushed core was removed from the door. The core was replaced, and since Bell has the facilities to work with Kevlar, Kevlar fabric prepreg was used to make the skin repair.

The above incident highlights a fact that is becoming increasingly clear as this program proceeds. The small helicopter and light plane operators are not familiar with composite materials and do not know how to work with them. In this instance, although they have been instructed to always use pulled or squeezed rivets, the information did not filter through to the men doing the work, so a failure was caused by mishandling the composite material.

Thermal buckling occurred in the outer skins of the litter doors of four helicopters parked in the Arizona desert during the summer. For all intents and purposes, these helicopters were not flown for the entire summer. Personnel at this facility said they have taken surface temperature measurements on aluminum helicopter structures with the same external paint scheme as the composite, and it is not unusual for the temperatures to reach 200° to 225°F during the summer. The coefficient of thermal expansion of the plexiglass window that is bonded to the Kevlar door structure is $4.5 \times 10^{-5}$ in/in/°F (which is about 3.5 times that of aluminum alloy), and that of Kevlar/epoxy is 0, so the loads caused by the relative thermal expansion were large enough to cause the thermal buckle shown in Figure 8. This is also evident by the fact that the bond between the door structure and the window was broken on the four doors, and the disbonds were in the corner near the buckle.

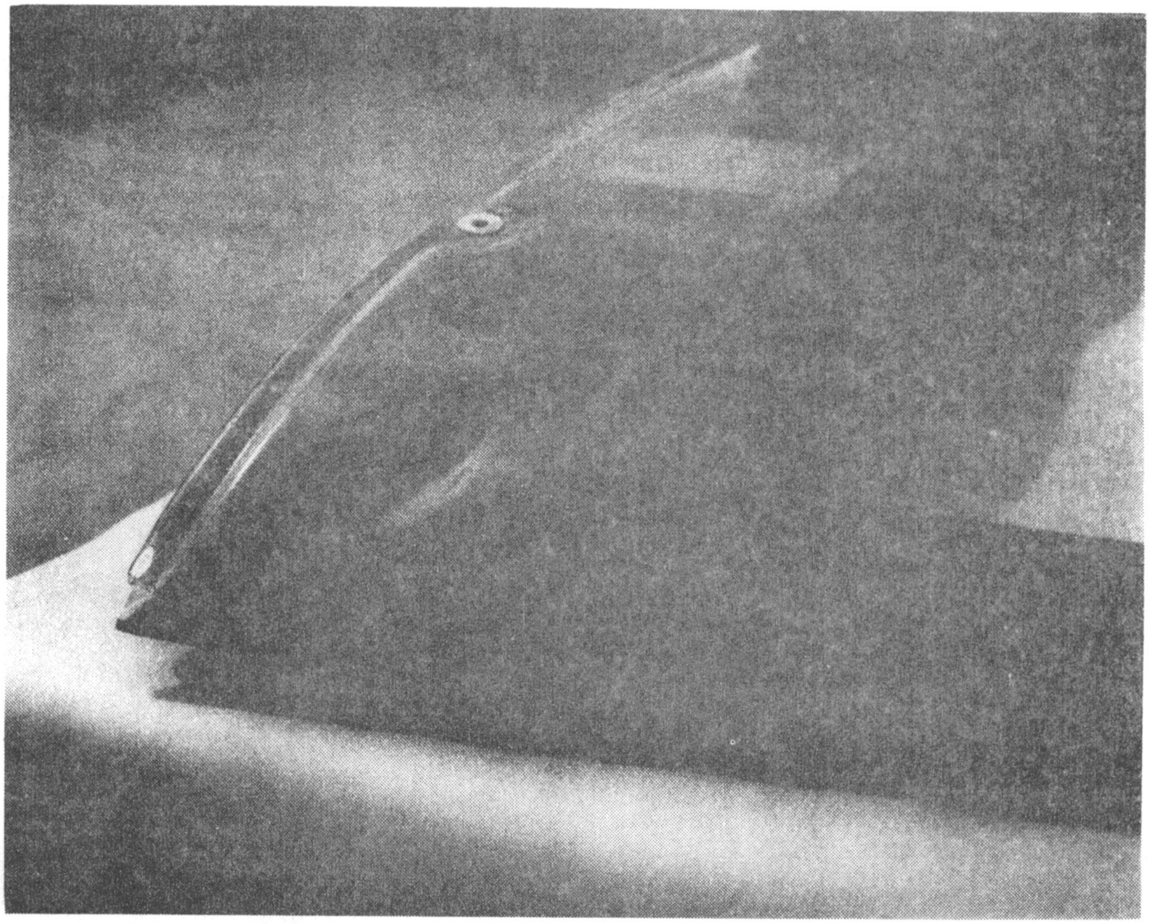

Figure 8. Thermal buckling of composite litter door after exposure to desert heat.

The four doors were returned to Bell for rework. They were clamped in the jig shown in Figure 9 and heated to 220°F for 4 minutes to eliminate the buckle. To preclude a reoccurrence of this type of failure, a rubber seal (Figure 10) was bonded between the door structure and the window to permit relative thermal expansion between the two. This design was tested to ultimate pressure before releasing it for service.

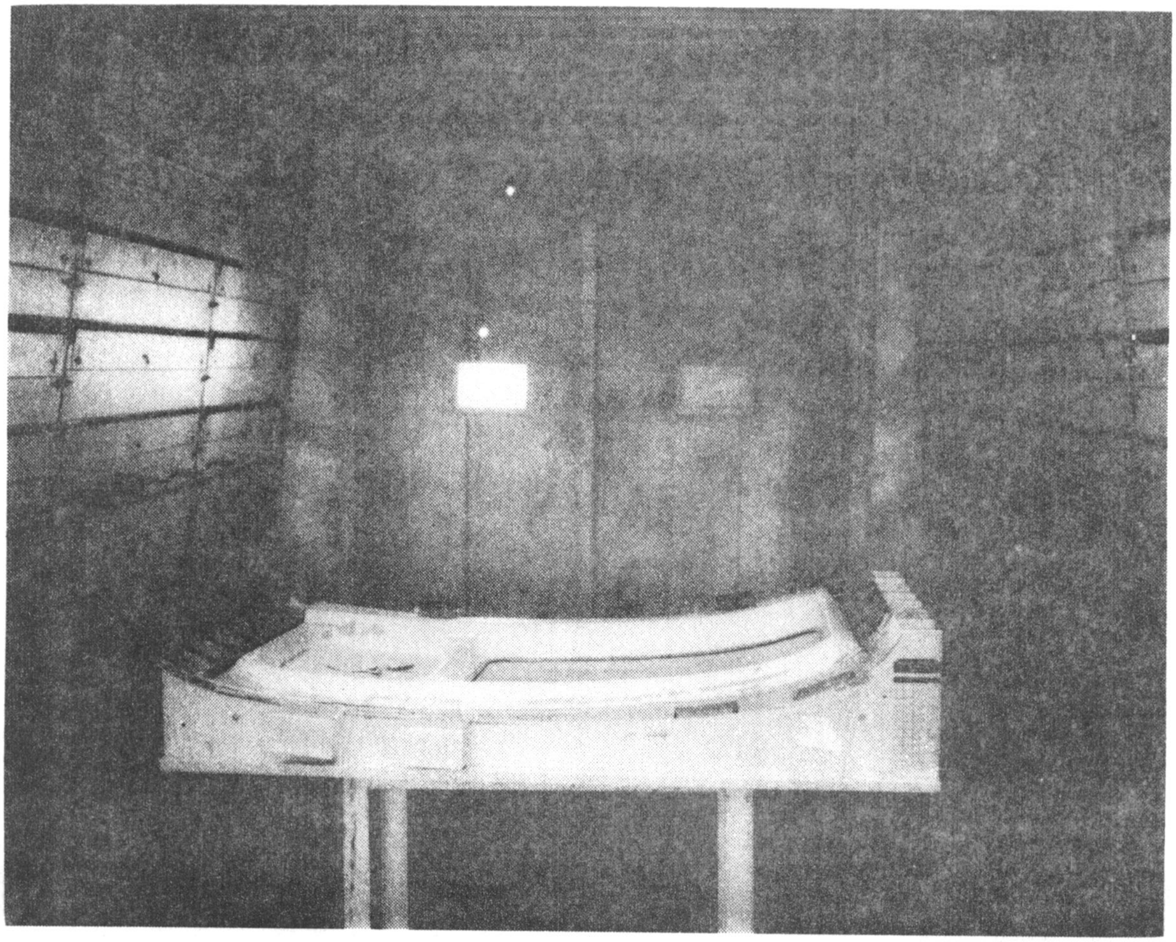

Figure 9. Buckled litter door in straightening jig.

## 4.3 POTENTIAL PROBLEMS

In the spring of 1983, two baggage door problems occurred. Although neither situation was the same, both resulted in a disbonded area between the outer skin and the nomex honeycomb core.

The Canadian Ministry of Transport reported an incident that occurred in the hangar while the helicopter was undergoing routine maintenance. A pressure vessel that is used to inflate the helicopter's floats exploded. A mechanic involuntarily jumped back, hit the inside of the open baggage door, causing it to rotate beyond its normal open position. This caused the door's outer skin

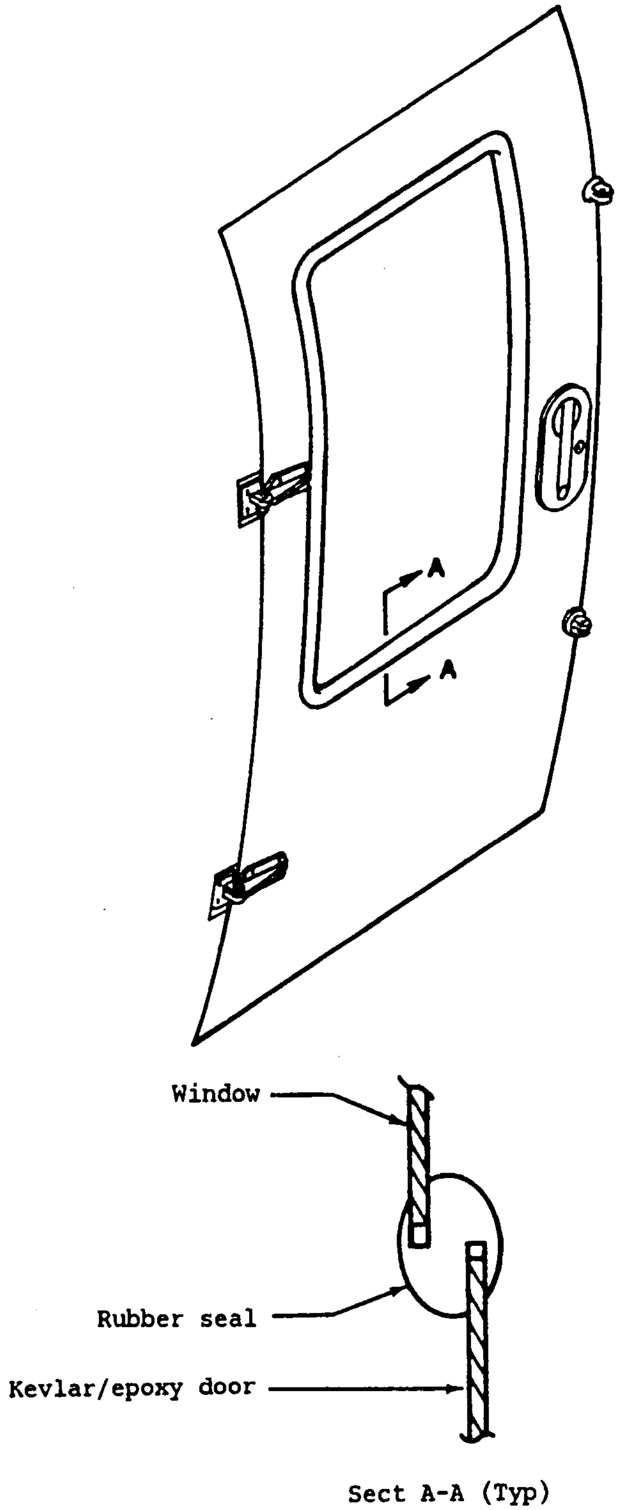


Figure 10. Installation of rubber seal to permit relative motion between window and door structure.

to impact the fuselage skin, and break the hinges. An inspection of the composite revealed the disbonded area shown in Figure 11. The bond of the core to the inner skin remained intact, and there was no evidence of damage to the fuselage structure where the door contacted it. A standard repair was made using a fiberglass wet layup, and the hinges were replaced.

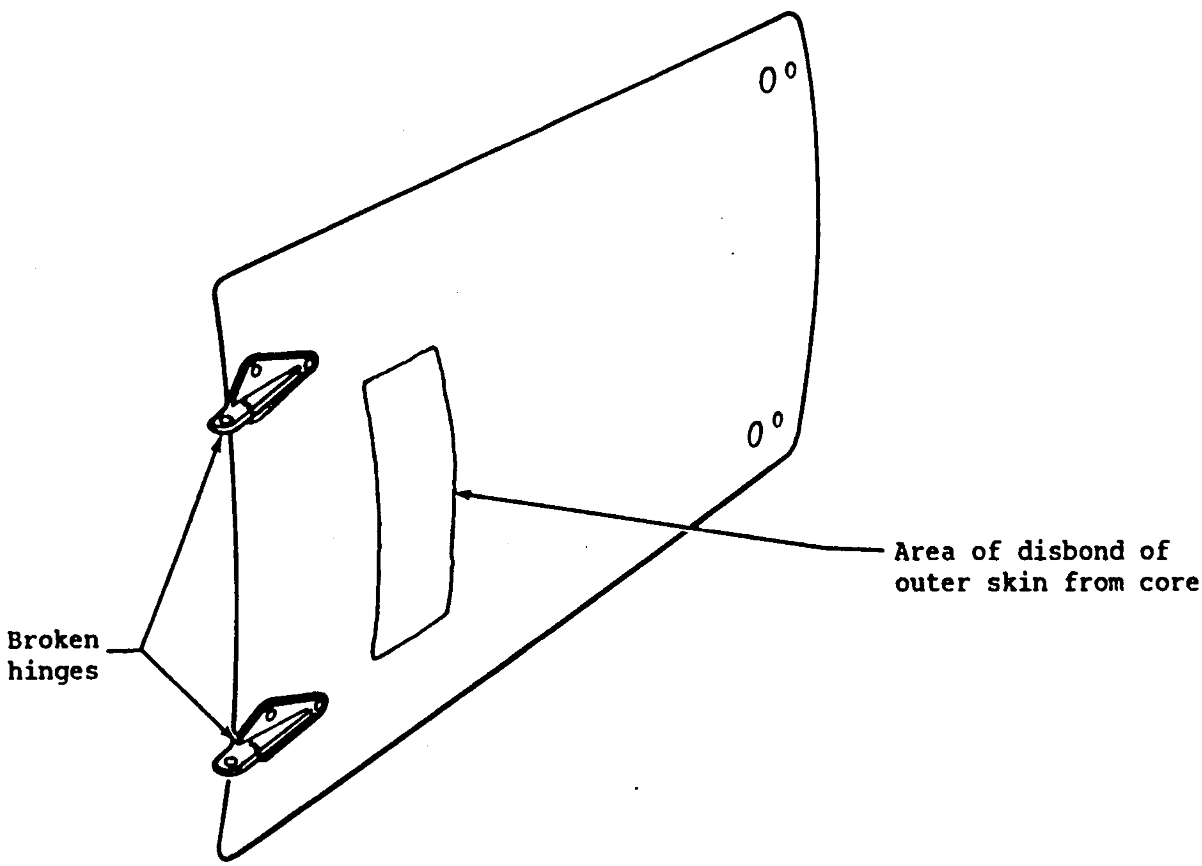


Figure 11. Failure of baggage door at Canadian Ministry of Transport resulting from a ground handling mishap.

At about the same time, Bell was informed that there was a "soft" area on an outer skin of a baggage door of a helicopter operated by Heli-Voyageur in Quebec. An inspection of the "soft" skin revealed, by tapping, that there was a disbonded outer skin-to-core area approximately the same size, and in approximately the same location as the one shown in Figure 11. There were no damage marks on either the door or fuselage skin, and the hinges were undamaged. The maintenance chief at Heli-Voyageur said that no one reported either a hard opening or an impact with a foreign object. The cause of the disbond, therefore, remains unknown.

Although the two incidents appear to be isolated, the fact that they were both similar failures may not be just coincidence. Also, it must be recalled that the door that was returned from Island Helicopters for test failed at a low load by extensive disbonding of the outer skin to the core (Table 3 and Figure 3).

These three happenings appear to form a pattern, and while no conclusions can as yet be drawn, this structure will be closely monitored in the future.

## 5. CONCLUDING REMARKS

1. As of 1 August 1983, 34 helicopters have reported a total of 27,517 flight service hours on the four composite test components, for an average of 809.3 hours per helicopter. The high-time helicopter accumulated 2244 hours in the Gulf Coast area.

2. Three sets of components were returned to Bell for static test after approximately one year's service. The graphite/epoxy fins showed no signs of structural degradation. The tests of the Kevlar/epoxy components gave inconsistent results. The forward fairing showed no signs of structural degradation, but the two doors exhibited a slight loss in strength and/or stiffness as compared with the preservice tests.

3. After a year's exposure, one-fifth of the exposure specimens were returned to NASA-Langley Research Center for test. The graphite/epoxy specimens showed no loss of strength. The Kevlar/epoxy specimens, however, showed a loss of strength of up to 15% in the matrix-dominated (short beam shear and compression) properties. This loss of strength appears to be most prevalent in the specimens that were located in cold climates.

4. The only significant failures in the field occurred on the litter doors, and were in the form of skin buckles, which were caused by differential thermal expansion between the Kevlar/epoxy skin and the plexiglass window. The skin was repaired, and the deficiency was eliminated by inserting a rubber seal between the skin and the window to absorb the relative thermal motion.

5. Although it is too early to draw any definite conclusions, there appears to be a trend toward reduced strength and/or stiffness in the Kevlar/epoxy doors that were exposed to a cold, moist climate for long periods of time. This trend seems to be following a similar one that showed up on the exposure specimens. The effect will be closely watched as more test data is accumulated.

## 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. Baker, Donald J., "Flight Service Evaluation of Composite Components on Bell 206L and Sikorsky S-76 Helicopters," NASA Technical Memorandum 84637, AVRADCOM Technical Report TR-83-B-1, March 1983.

| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| NASA CR-172296 | | |
| 4. Title and Subtitle<br>Flight Service Evaluation of Composite Components on the Bell Helicopter 206L: First Annual Flight Service Report | | 5. Report Date<br>March 1984<br>6. Performing Organization Code |
| 7. Author(s)<br>H. Zinberg | | 8. Performing Organization Report No. |
| 9. Performing Organization Name and Address<br>Bell Helicopter Textron, Inc.<br>P. O. Box 482<br>Fort Worth, Texas 76101 | | 10. Work Unit No.<br>11. Contract or Grant No.<br>NAS 1-15279 |
| 12. Sponsoring Agency Name and Address<br>National Aeronautics and Space Administration<br>Washington, D. C. 20546 | | 13. Type of Report and Period Covered<br>Contractor Report<br>14. Sponsoring Agency Code |

15. Supplementary Notes

Langley Technical Monitor: D. J. Baker
Technical Summary Report

16. Abstract

This is the first annual report on the flight service components for the Bell Model 206L JetRanger helicopter. The components have been placed in service in the Continental United States, Canada, and Alaska. The report covers the period from 1 February 1982 to 1 August 1983. The status of 34 sets of components is discussed in this report. Approximately 27,500 flight hours were accumulated on the components as of 1 August 1983. Three sets of components and one-fifth of the exposure coupons were returned and tested. The results are given. The overall behavior of the components and associated problems are discussed.

| 17. Key Words (Suggested by Author(s)) | 18. Distribution Statement |
|---|---|
| Flight Service, Advanced Components, Composite Specimens, Environmental Exposure, Kevlar, Graphite | Unclassified - Unlimited<br>Subject Category 24 |

| 19. Security Classif. (of this report) | 20. Security Classif. (of this page) | 21. No. of Pages | 22. Price |
|---|---|---|---|
| Unclassified | Unclassified | 29 | |

N-305

For sale by the National Technical Information Service, Springfield, Virginia 22161