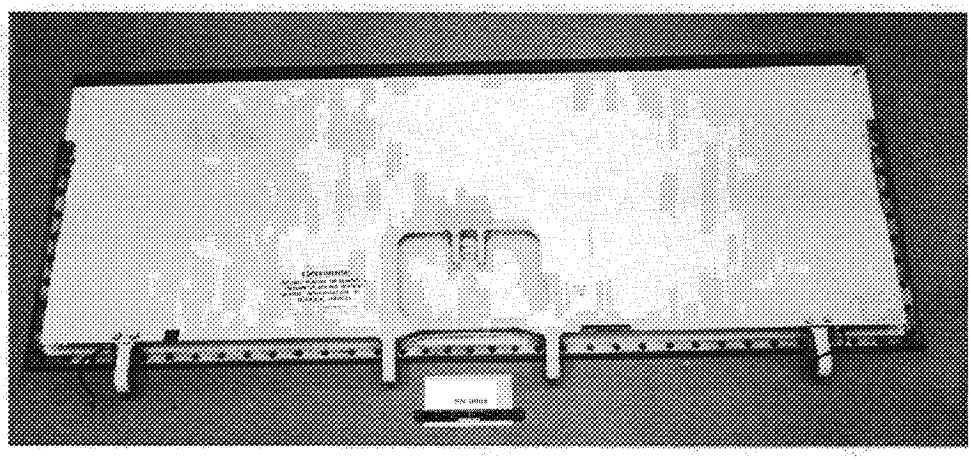
NASA Contractor Report 172600

737 GRAPHITE COMPOSITE FLIGHT SPOILER FLIGHT SERVICE EVALUATION

Randy L. Coggeshall



EIGHTH REPORT
MAY 1981 THROUGH DECEMBER 1984

Prepared under Contract NAS 1-11668 by
BOEING COMMERCIAL AIRPLANE COMPANY
July 1985

National Aeronautics and
Space Administration
Langley Research Center
Hampton, VA 23665

FOREWORD

This is the eighth progress report on the service evaluation of graphite-epoxy flight spoilers for 737 aircraft. This effort has been conducted as a portion of NASA Contract NAS1-11668, " A Study of the Effects of Long-Term Ground and Flight Environment Exposure on the Behavior of Graphite-Epoxy Spoilers." The program is structured to gather and evaluate actual commercial service experience on a large number of graphite-epoxy spoilers and test specimens in a wide range of operating environments. Two additional reports will be prepared and submitted, one after the 12-year service evaluation tests are completed and one at the completion of the flight service period, which is programmed to provide 15 years of flight service.

Tabular flight service data is included in three appendices. Appendix A summarizes the spoiler program data. Appendices B and C are status reports of the flight service data generated under NASA contracts NAS1-14952, "Boeing/NASA 727 Graphite Composite Elevator," and NAS1-15025, "Boeing/NASA 737 Graphite Composite Stabilizer."

The program is administered by Langley Research Center, National Aeronautics and Space Administration. H. Benson Dexter, Materials Division, is the technical monitor and is responsible for test and evaluation of ground-based environmental exposure specimens for the program.

The program is being conducted at the Boeing Commercial Airplane Company under the direction of Robert D. Wilson, program manager. Randy L. Coggeshall, Advanced Structures Group, is the program technical leader.

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737 GRAPHITE COMPOSITE FLIGHT SPOILER FLIGHT SERVICE EVALUATION

Randy L. Coggeshall
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PROGRAM SUMMARY AND STATUS

The eighth flight service report is submitted in accordance with the requirements of Contract NAS1-11668 and covers the service evaluation portion of this NASA contract from May 1, 1981, through December 31, 1984. Segments of the data contained herein have appeared in previous documentation (refs. 1 through 9).

A primary objective of this program is to produce 114 graphite-epoxy 737 flight spoilers for testing and service evaluation deployment. One spoiler of each of the three different graphite-epoxy material systems used has been laboratory tested for stiffness and strength in partial fulfillment of FAA certification requirements. Four spoilers were initially installed on each of 27 aircraft representing five major airlines operating in different environmental circumstances. Since that time, some aircraft have been sold by the initial operator, and some spoilers have been redeployed within the fleet due to normal maintenance schedules. These installed spoilers (units) will be monitored under actual load and environmental conditions for 15 years. Selected units are removed periodically to evaluate any material property changes as a function of time. Six environmental exposure racks have been fabricated and positioned at major airport terminals of the participating airlines in various parts of the world and at NASA-Langley Research Center to gather ground-based environmental data to support the flight data gathered from the spoilers. Material coupons have been tested after 1, 3, 5, 7, and 10 years of outdoor ground-based exposure.

Significant events that have occurred during this period include:

- Completion of the eighth inspection of those spoilers in service
- Continuation of the nondestructive inspection (NDI) sampling program and static testing of spoilers from the flight service program
- Continuation of the skin laminate moisture absorption study
- Completion of outdoor ground-based exposure program
- Discontinuation of the spoiler repair program by Boeing

As of December 31, 1984, 2,092,155 spoiler flight-hours and 2,954,814 spoiler landings have been accumulated by the fleet. The high-time spoiler had accumulated 31,265 flight-hours on Frontier Airlines 737 N7386F. Seventy-three spoilers have accumulated more than 16,000 flight-hours since the beginning of the flight service program, and 22 spoilers have had uninterrupted service since their original installation.

Laboratory testing of spoilers, returned from 7, 8, 9, and 10 years of flight service, continues to demonstrate that the spoilers retain a high percentage of their unexposed strength. Several units were tested with service-induced damages. These damages included exfoliation corrosion in the spar and skin delaminations. Even with corrosion damage the units had residual strengths that fell above design limit load. Results of these tests will be used to establish defect limitations.

Maintenance damage and related repair activities have continued at a modest level. Thirteen spoilers were removed during this reporting period. These spoilers will be retired from service unless repairs are conducted by the airline. Airlines continue to exhibit enthusiasm for and confidence in the program. Several of the airlines have reported significantly reduced maintenance with the graphite-epoxy units when compared with the production aluminum-skinned units.

As a result of a contract modification, repair activities by Boeing have been suspended, although several airlines will continue to perform repairs at their own maintenance bases. There will be no further inspection trips by Boeing personnel. Residual strength tests will be conducted after 12 and 15 years of service and reports will be issued to document the results.

PROGRAM SCOPE

The service evaluation program was established to place the 737 graphite-epoxy flight spoilers into a commercial service environment containing as many climatic variables as possible. The five actively participating airlines have 22 aircraft currently committed to the program.

Currently participating airlines are:

- Air New Zealand, Ltd.–four aircraft
- Deutsche Lufthansa Airlines–five aircraft
- Piedmont Airlines–eight aircraft
- VASP Airlines–four aircraft
- Frontier Airlines–one aircraft

The geographic scope of the service evaluation program continues as shown in Figure 1.

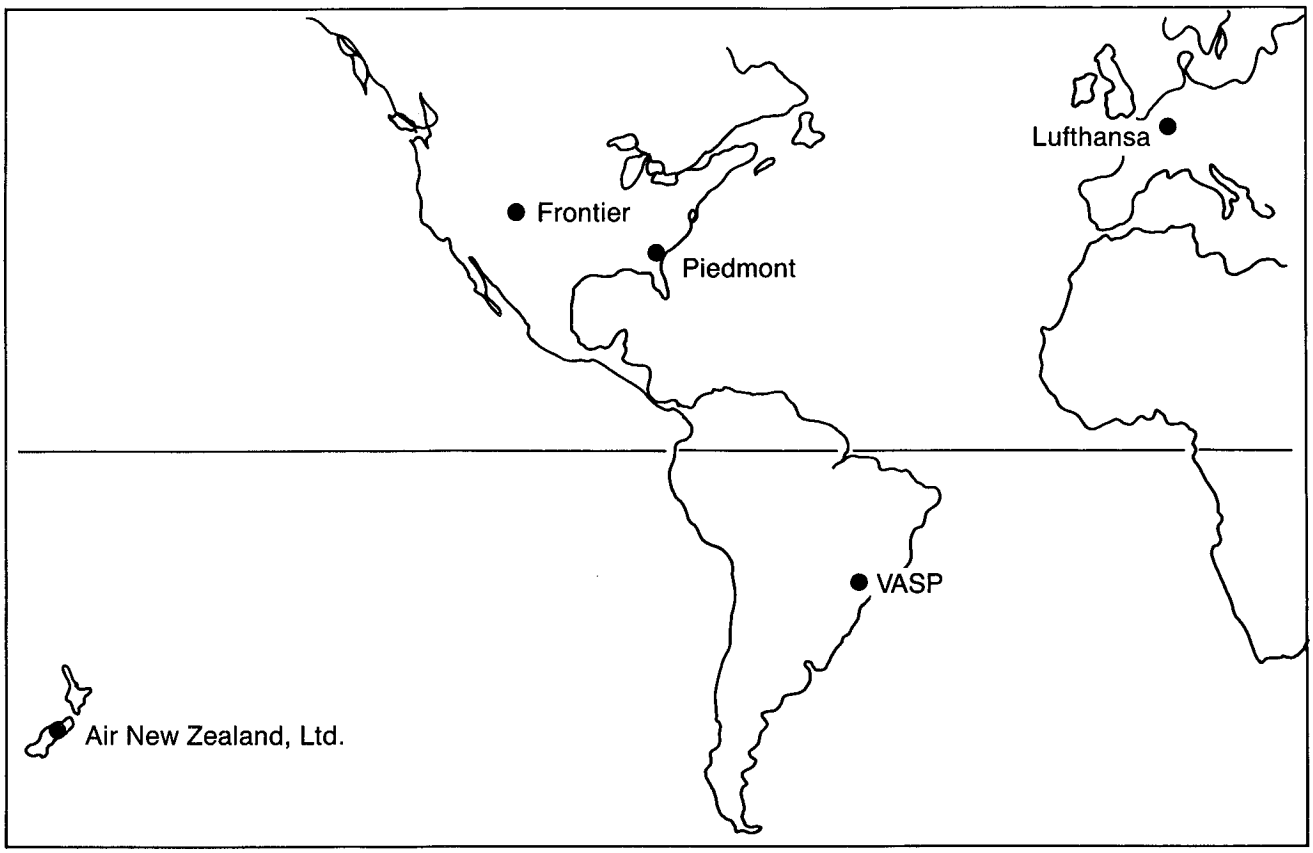

Figure 1. Geographic Deployment of Currently Participating Airlines

FLIGHT EXPERIENCE

The graphite-epoxy 737 flight spoiler flight service evaluation program, in operation since July 18, 1973, has achieved an exceptional level of commercial service exposure. The program has generated over 2 million flight-hours of service and over 2-3/4 million landings in over 11 years of operation and is adding flight experience at the rate of nearly 11,000 hours a month.

Total flight experience to December 31, 1984, is summarized in Table 1 by type of graphite-epoxy material. Table 2 summarizes the same data by airline. VASP and Frontier data include only flight experience since acquisition of their respective aircraft from PSA. A total of 73 spoilers have accumulated over 16,000 flight-hours each. Their distribution, by airline and by skin material system, is shown in Table 3.

A Fortran program called PSPOIL was established to periodically update the service history of the spoiler fleet. The computerized approach saves time and improves accuracy of the data. The program provides all of the data shown in the three tables plus installation and removal dates and the current status of spoilers (i.e., flying, out for repair, destroyed in test), Appendix A.

Spoiler material type	Net hours	Net landings
Union Carbide T300/2544	704,843	973,051
Narmco T300/5209	716,325	979,056
Hercules AS/3501	670,987	1,002,707
Total	2,092,155	2,954,814

Table 1. Flight Spoiler Service Experience by Type of Material (as of 12-31-84)

Airline	Number of aircraft in evaluation	Number of spoilers in evaluation	Total spoiler hours since installation	Total spoiler landings since installation
PSA	0	0	29,747	51,521
Aloha	0	0	174,791	444,994
New Zealand	4	12	279,073	378,469
Lufthansa	5	13	465,845	576,920
Piedmont	8	23	741,144	1,055,476
VASP	4	8	311,807	351,009
Frontier	1	1	89,748	96,425
Total	22	57	2,092,155	2,954,814

*Total placed in service is 111 spoilers, with 54 spoilers either inactive, retired, or tested

Table 2. Flight Spoiler Service Experience by Airline (as of 12-31-84)

Part number	Airline					Total
	VP	LH	PI	Frontier	NZ	
-1 (T300/2544)	5	4	12	0	3	24
-2 (T300/5209)	3	6	6	2	8	25
-3 (AS/3501)	3	8	9	0	4	24
Total	11	18	27	2	15	73

Table 3. Distribution of Spoilers With 16,000 or More Flight-Hours

SCHEDULED SPOILER REMOVALS AND EVALUATION

During this reporting period, 14 spoilers (three seventh year, four eighth year, four ninth year, and three tenth year) were removed from the flight service program for evaluation and test. All 14 removed spoilers were reinspected using through-transmission ultrasonic C-scan, and the results were compared to the records made at the time of original fabrication. Ten units were considered damage free following nondestructive inspection, but four of the 14 had service-induced damage that Boeing would normally repair before returning the spoilers to service.

Boeing has, in the past, followed a policy of refurbishing any graphite-epoxy spoiler returned to the plant for any reason, including test and evaluation. Many of the discrepancies or defects described in subsequent paragraphs represent normal or less than normal wear and tear on an aircraft component after 10 years of service. Only four of the conditions described would be likely to receive repair attention at the next maintenance break. Several would receive only a seal-and-monitor disposition, and some of those would not deteriorate to a state requiring repair during the life of the part.

The removed units were selected for destructive test to measure residual static strength following the specified calendar period of exposure. The units selected for test had deficiencies as described in the previous paragraph. Similar conditions can and do occur during a normal maintenance cycle. It was considered important to verify by test that no significant strength reduction had occurred.

Following selection for test, the units were photographed. Figures 2 and 3 show the upper and lower surfaces of spoiler S/N 0008 after 7 years of service, respectively. The damage on this unit is shown in Figures 4 and 5. Figure 4 shows an exfoliation corrosion blister at one spar to center hinge fitting splice, and Figure 5 shows a similar but less severe exfoliation corrosion blister at the opposite side.

Figures 6 and 7 are photographs of the upper and lower surfaces, respectively, of spoiler S/N 0118 after 7 years of service. The upper surface shows evidence of paint erosion although no damage to the graphite skin was apparent. Figures 8 through 10 show the damage found on this unit. Figure 8 shows earlier minor doubler corrosion that had been dressed down and repainted by the airline. This condition was also found on the opposite side. An edge delamination on the corner of the panel is also shown. These two defects are shown on Figure 9. The initial stages of exfoliation corrosion at one spar to center hinge fitting splice are shown on Figure 10.

The upper and lower surfaces of spoiler S/N 0033 after 8 years of service are shown, respectively, on Figures 11 and 12. Each doubler had been dressed down and sealed after minor corrosion. The panel was removed prior to repainting. These defects are shown on Figures 13 and 14. Figures 15 and 16 show exfoliation corrosion located at both spar to center hinge fitting splices.

Figures 17 and 18 show the upper and lower surfaces of spoiler S/N 0051 after 8 years of service. This unit was relatively clear of damage. The only detectable damage was some minor doubler corrosion as shown in Figure 19.

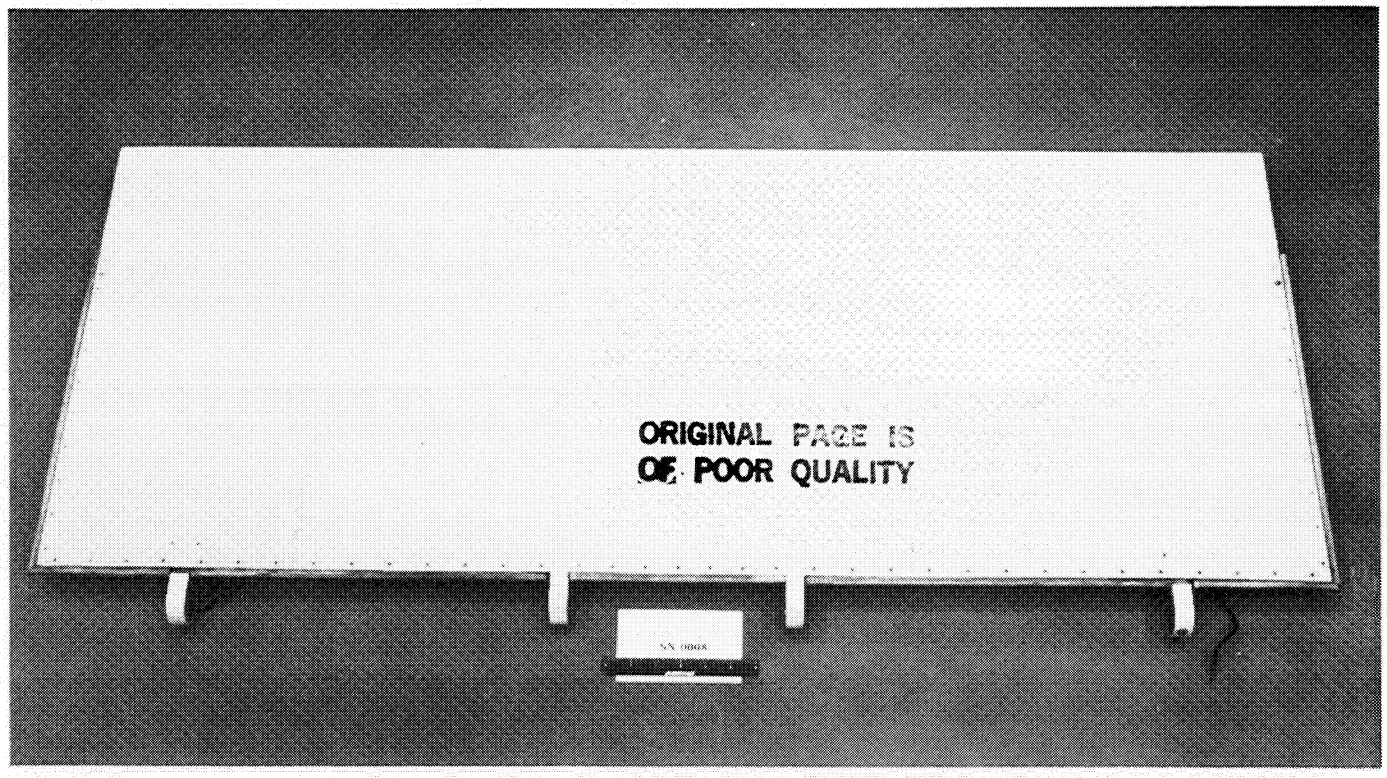

Figure 2. Upper Surface of Spoiler S/N 0008 After 7 Years of Service

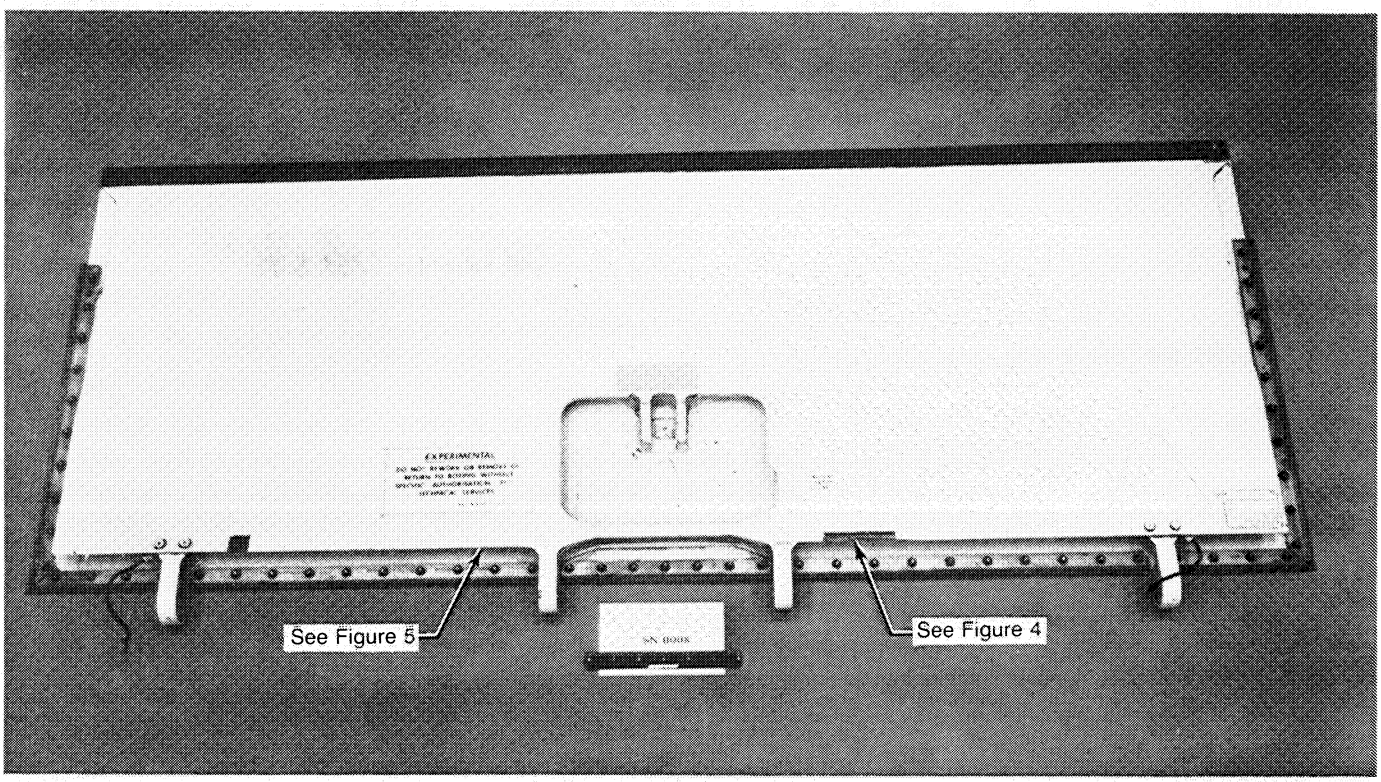

Figure 3. Lower Surface of Spoiler S/N 0008 After 7 Years of Service

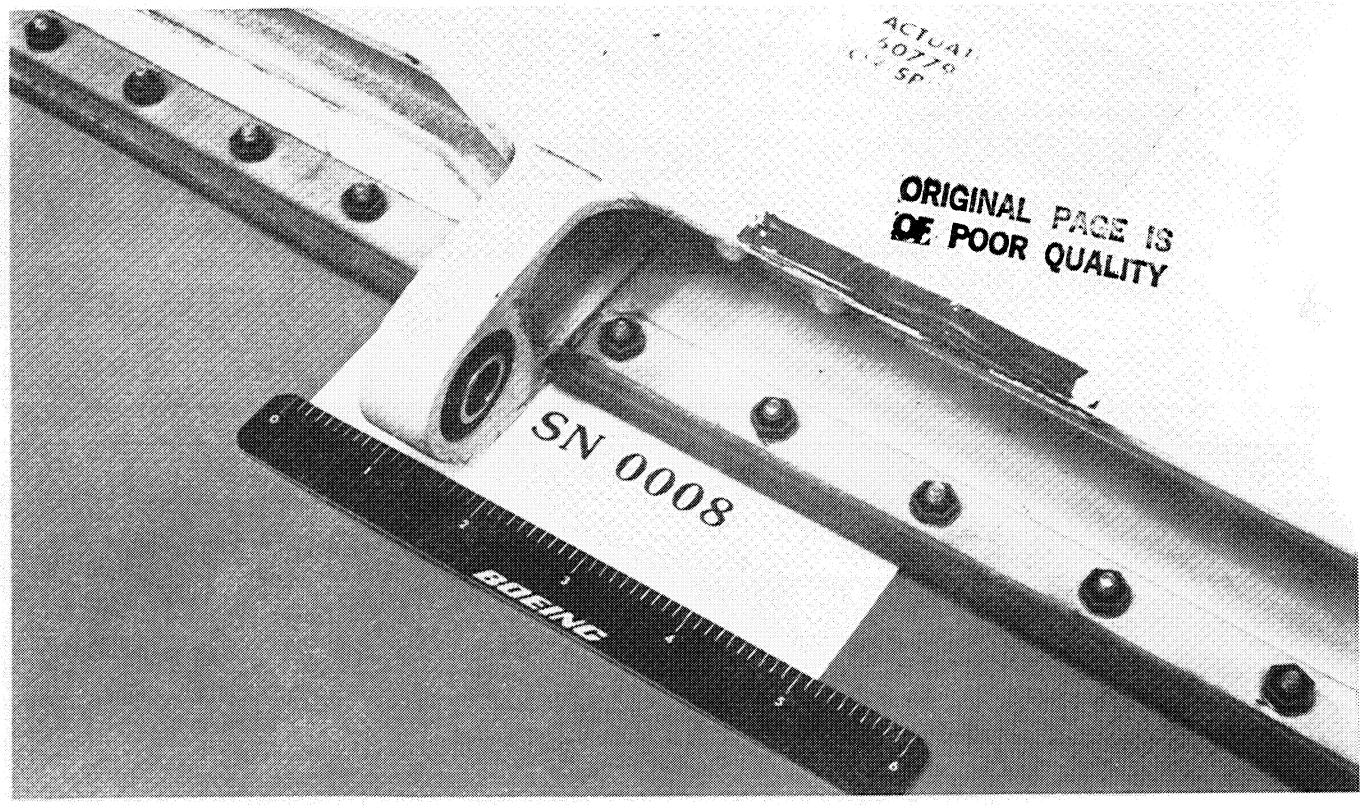

Figure 4. Hinge Detail of Spoiler S/N 0008 After 7 Years of Service

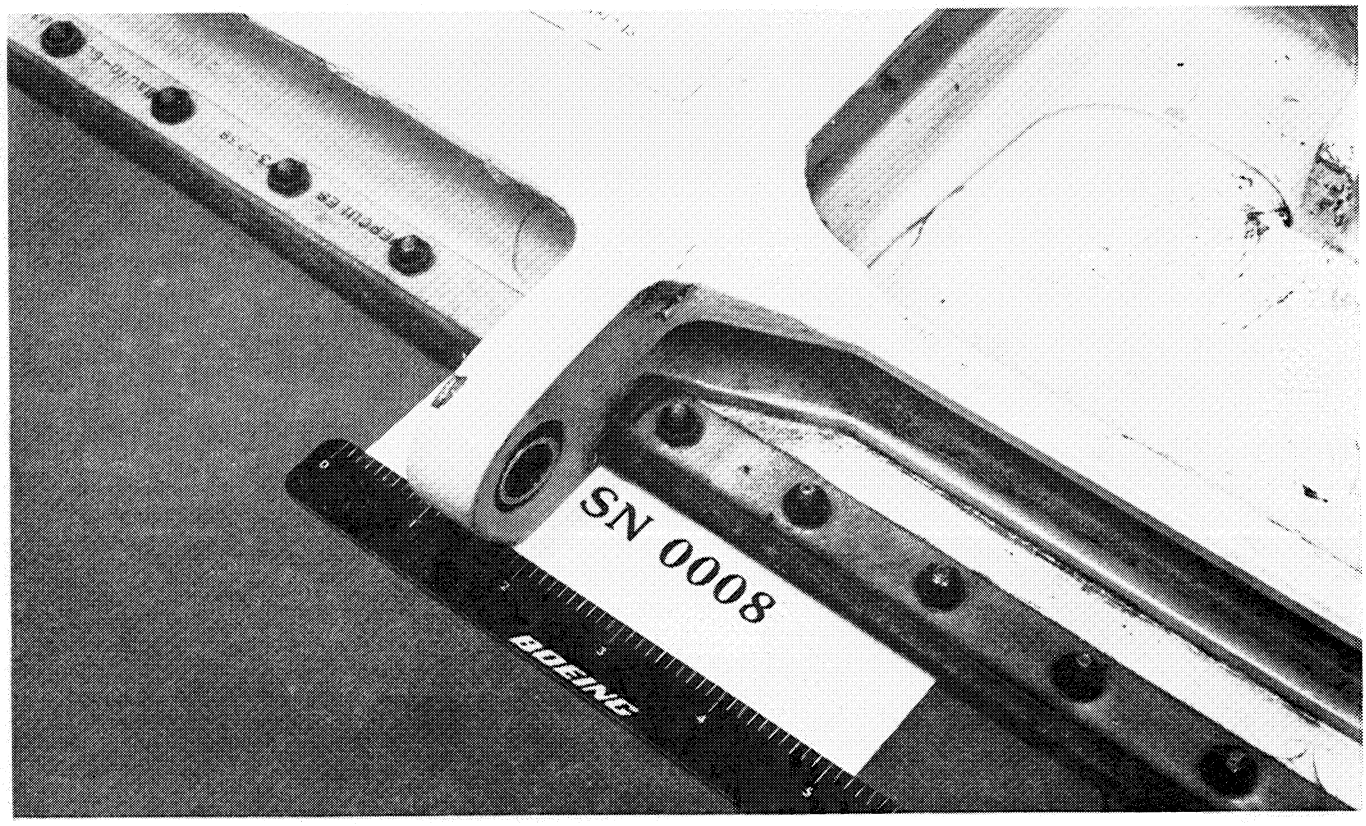

Figure 5. Hinge Detail of Spoiler S/N 0008 After 7 Years of Service

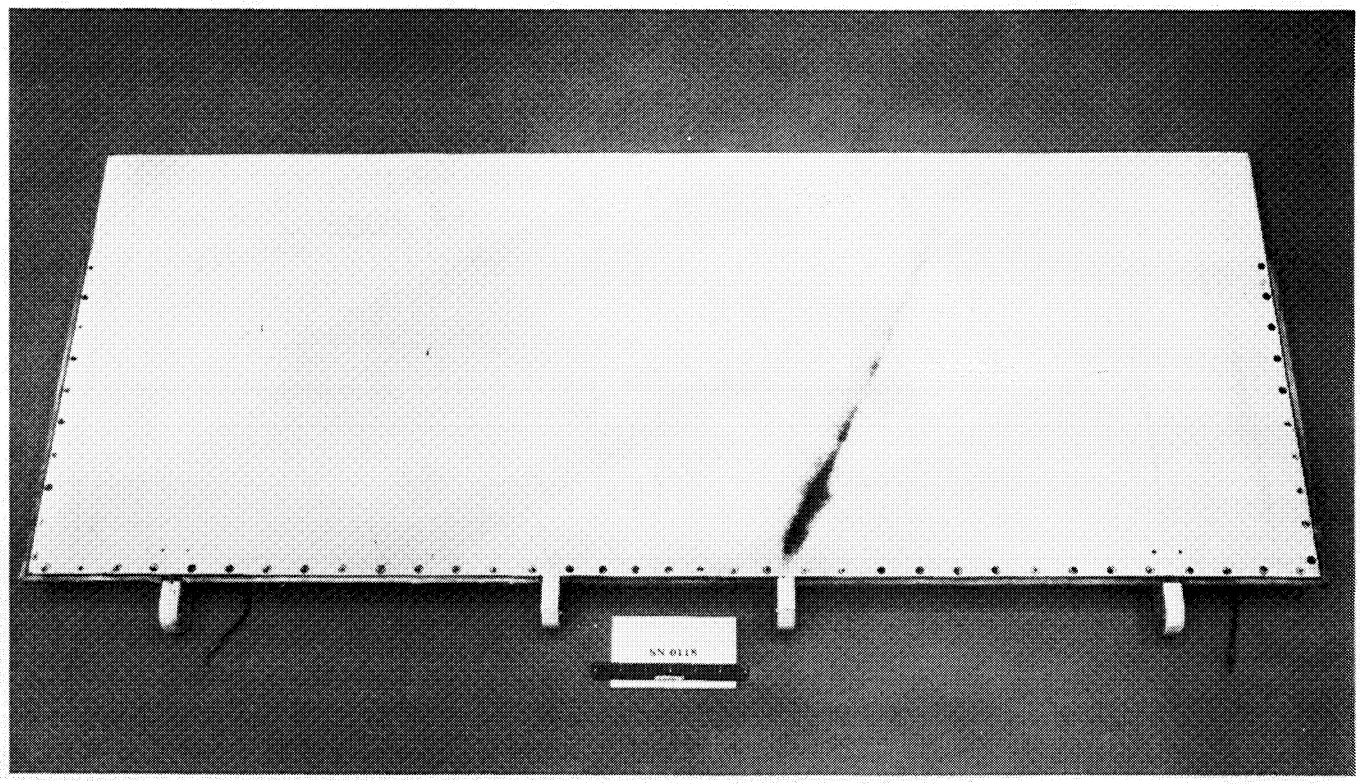

Figure 6. Upper Surface of Spoiler S/N 0118 After 7 Years of Service

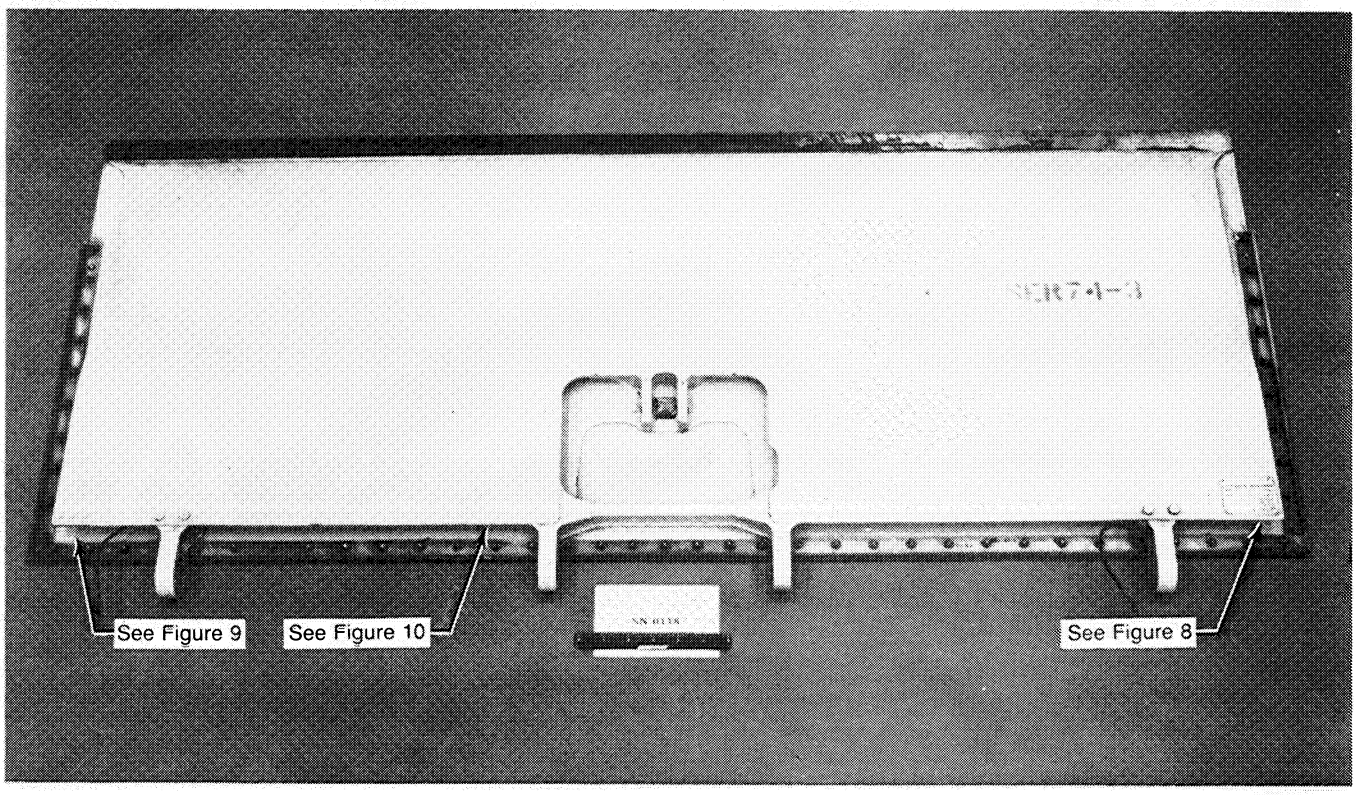

Figure 7. Lower Surface of Spoiler S/N 0118 After 7 Years of Service

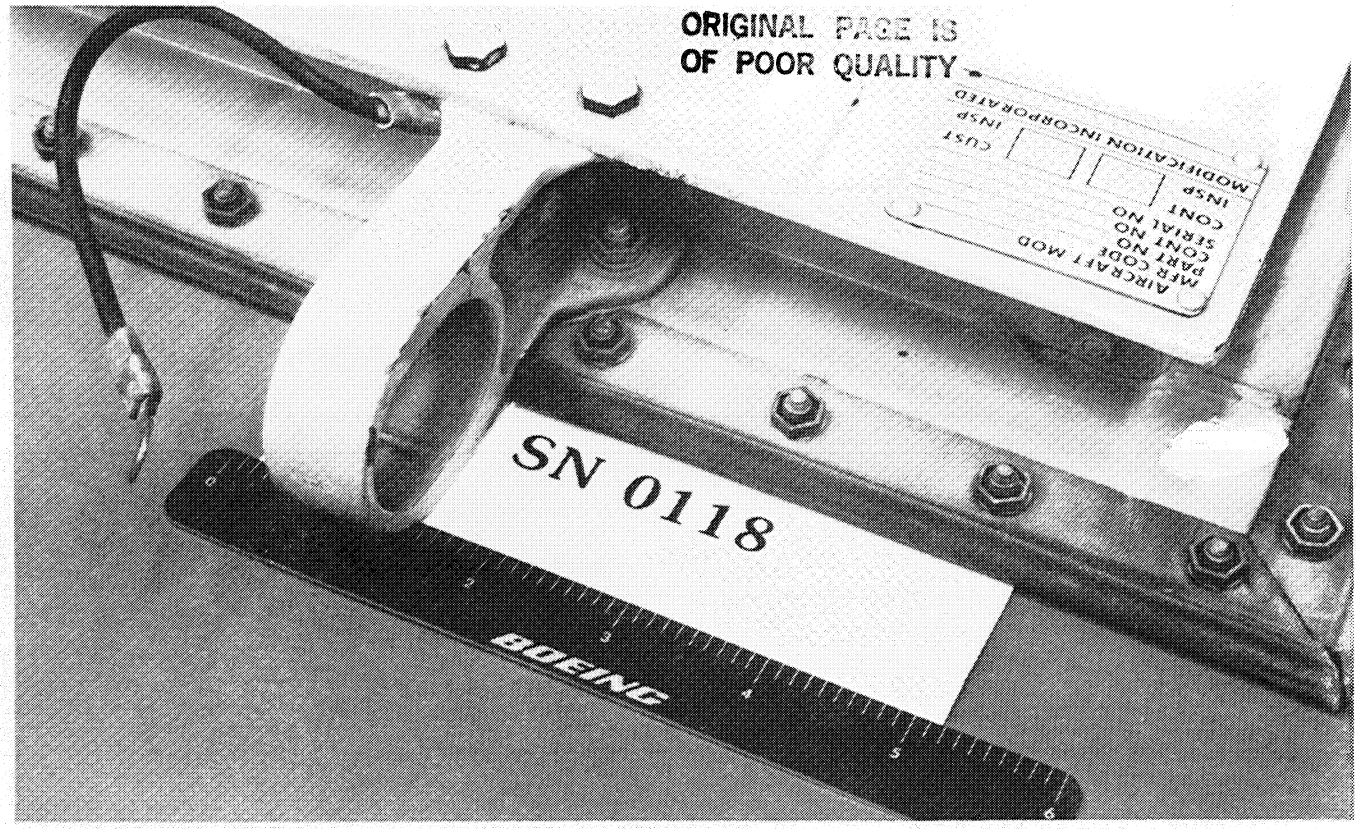

Figure 8. Corner Detail of Spoiler S/N 0118 After 7 Years of Service

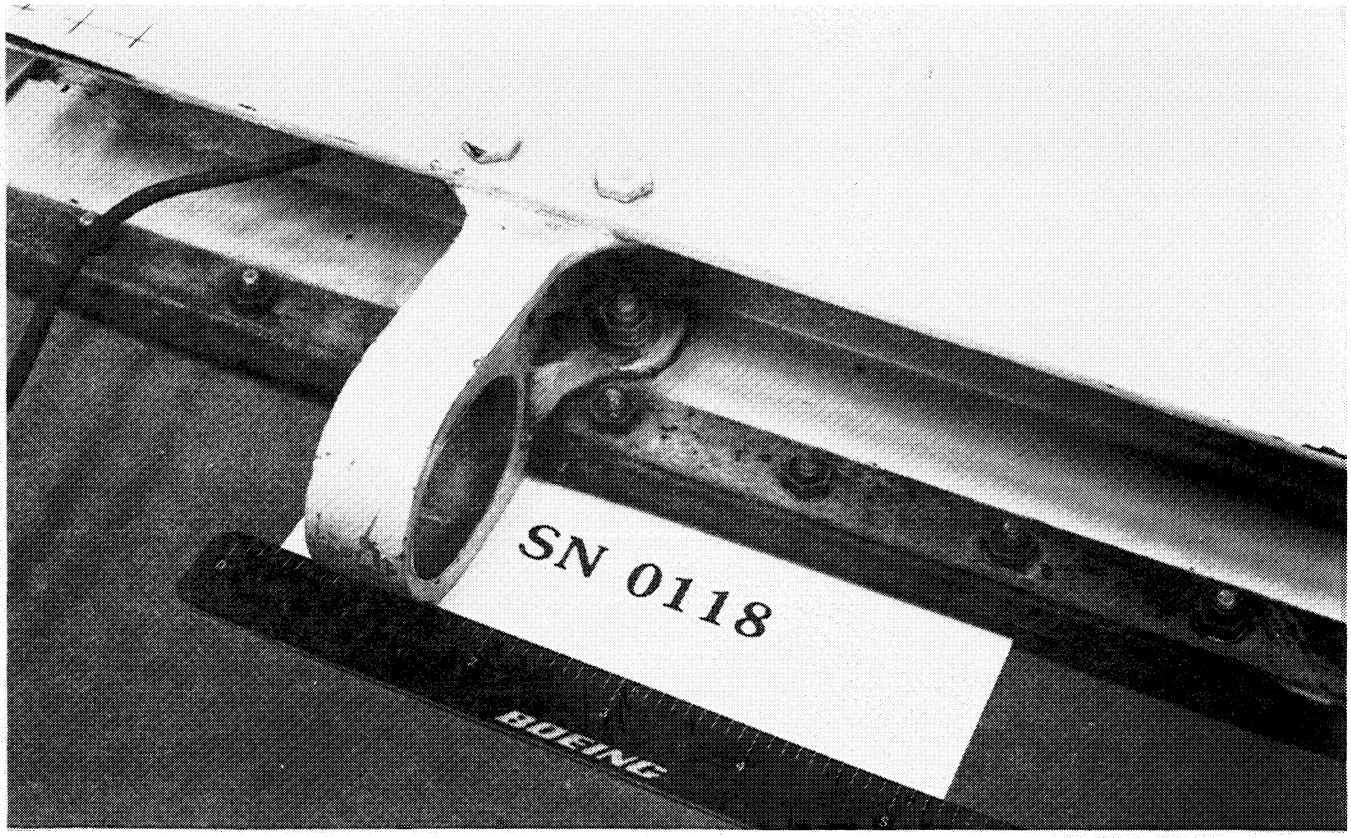

Figure 9. Corner Detail of Spoiler S/N 0118 After 7 Years of Service

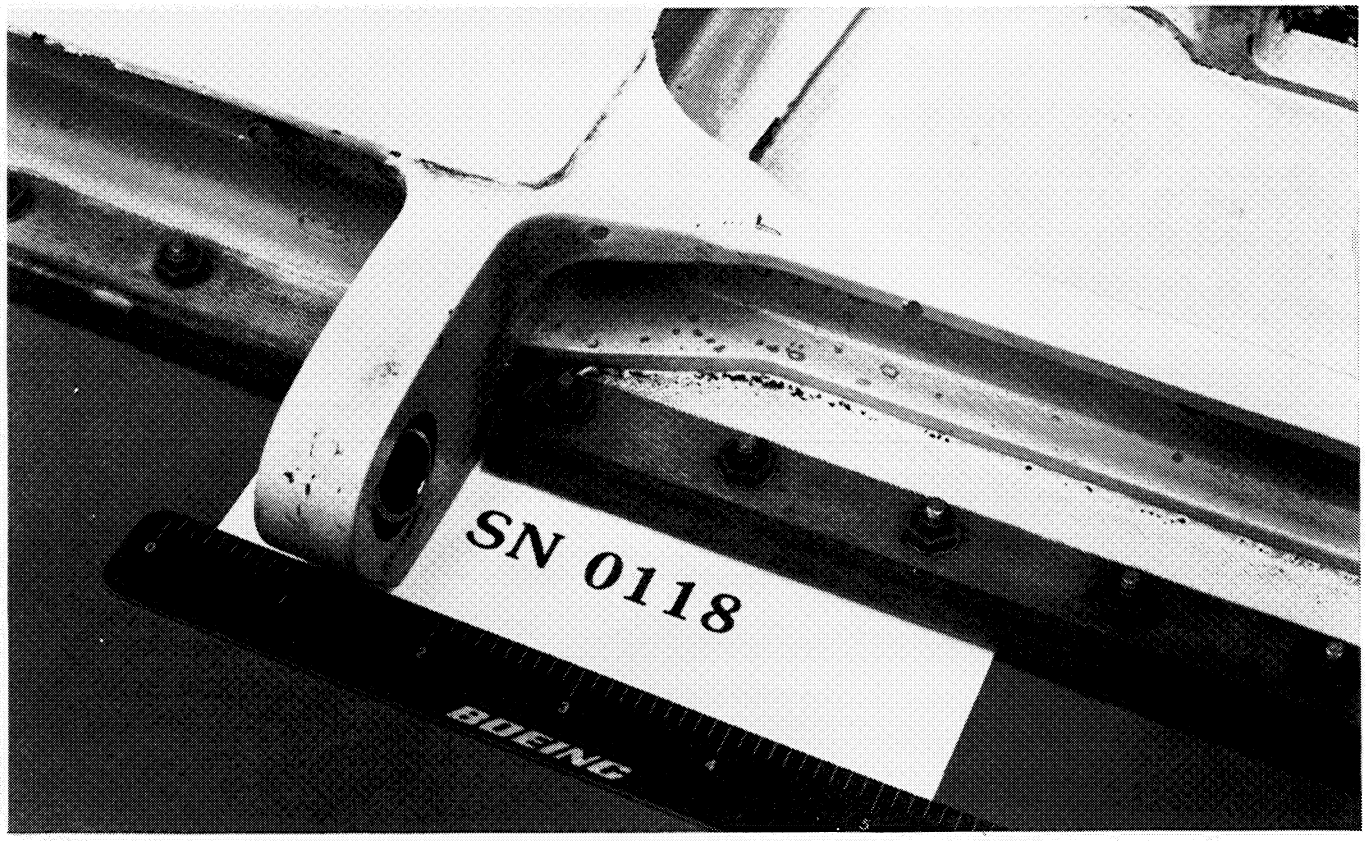

Figure 10. Hinge Detail of Spoiler S/N 0118 After 7 Years of Service

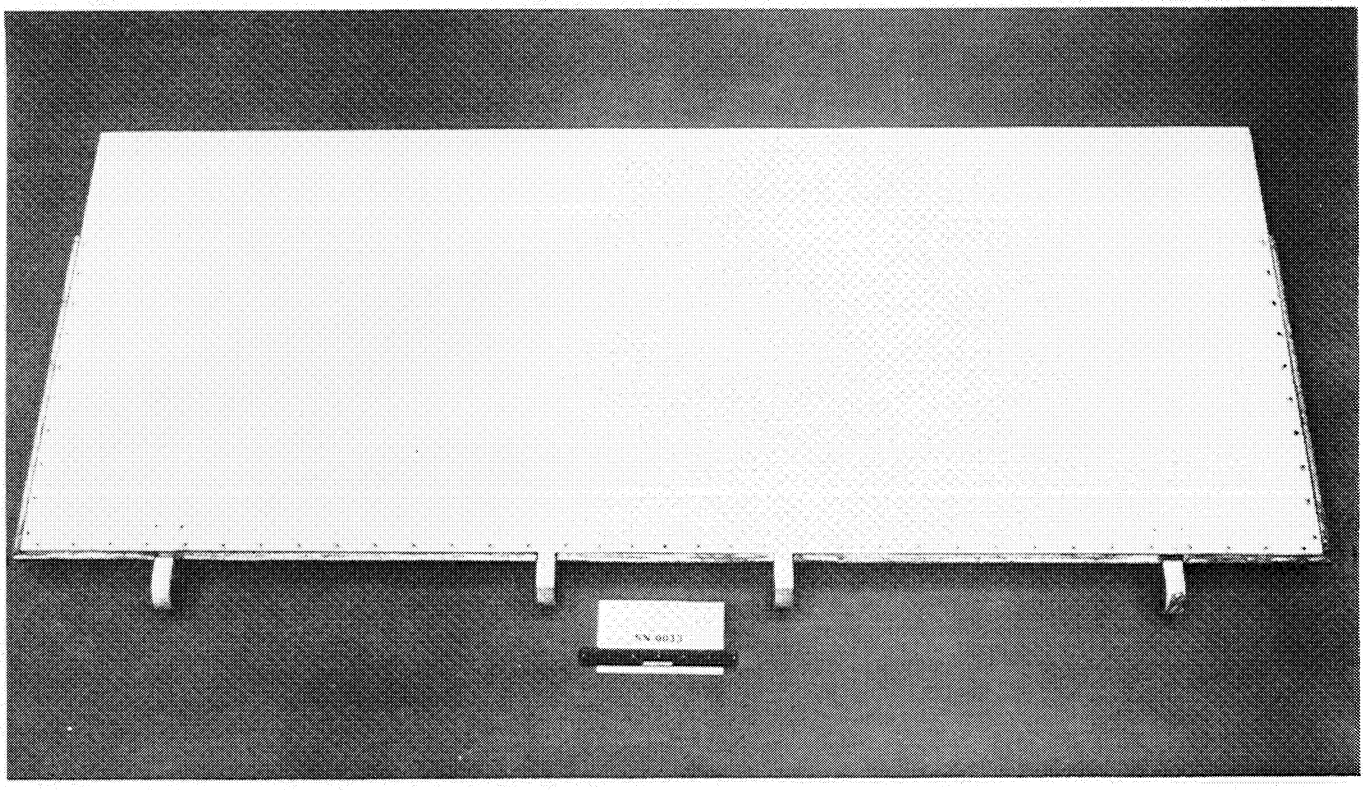

Figure 11. Upper Surface of Spoiler S/N 0033 After 8 Years of Service

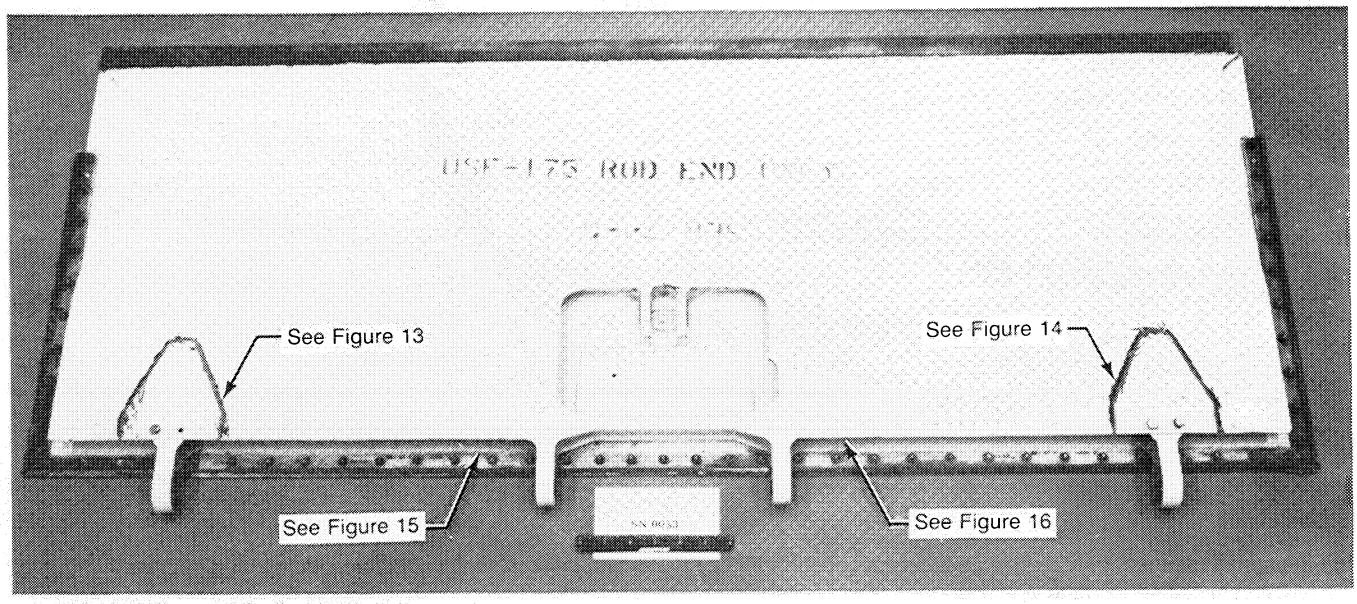

Figure 12. Lower Surface of Spoiler S/N 0033 After 8 Years of Service

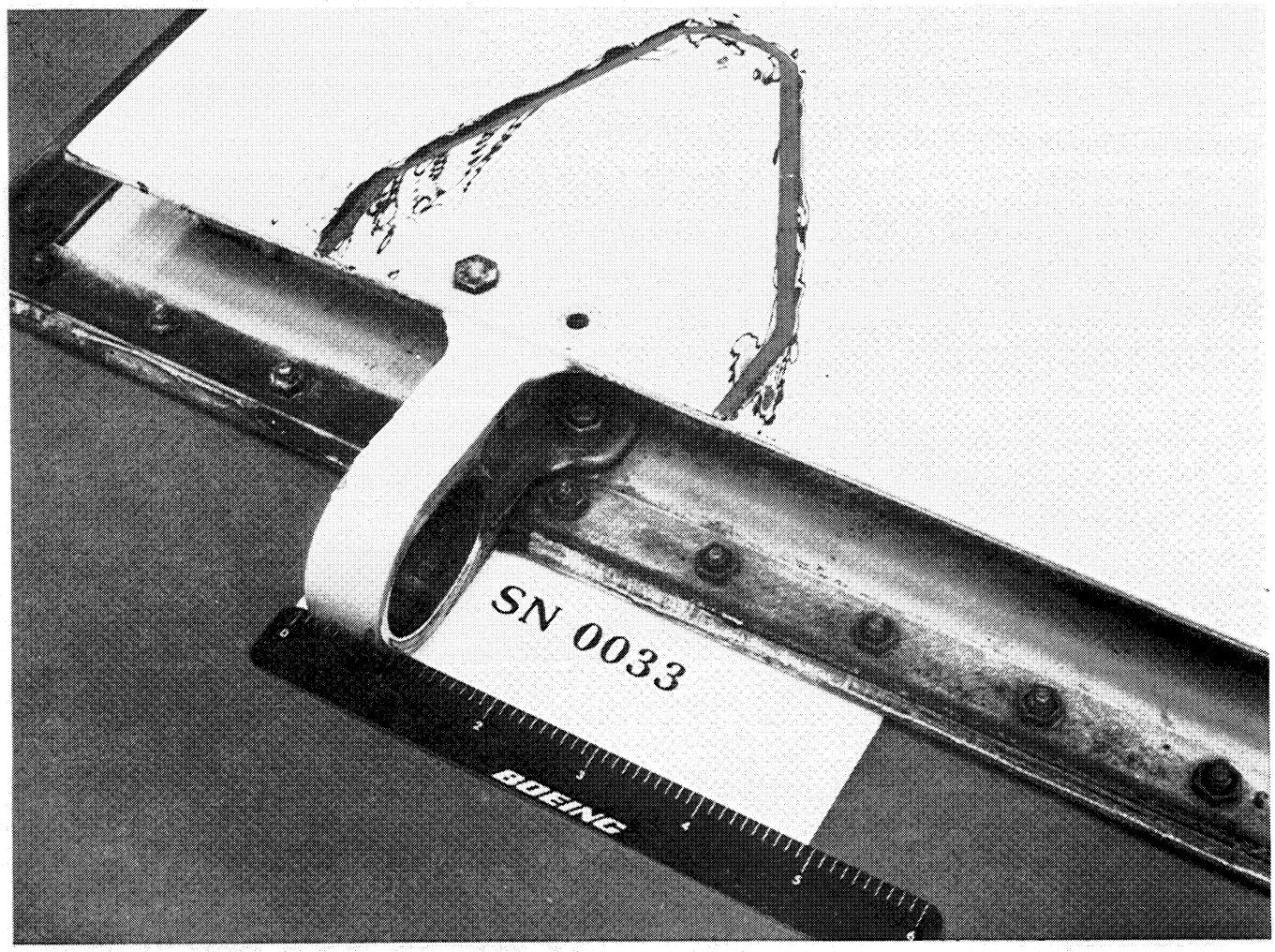

Figure 13. Corner Detail of Spoiler S/N 0033 After 8 Years of Service

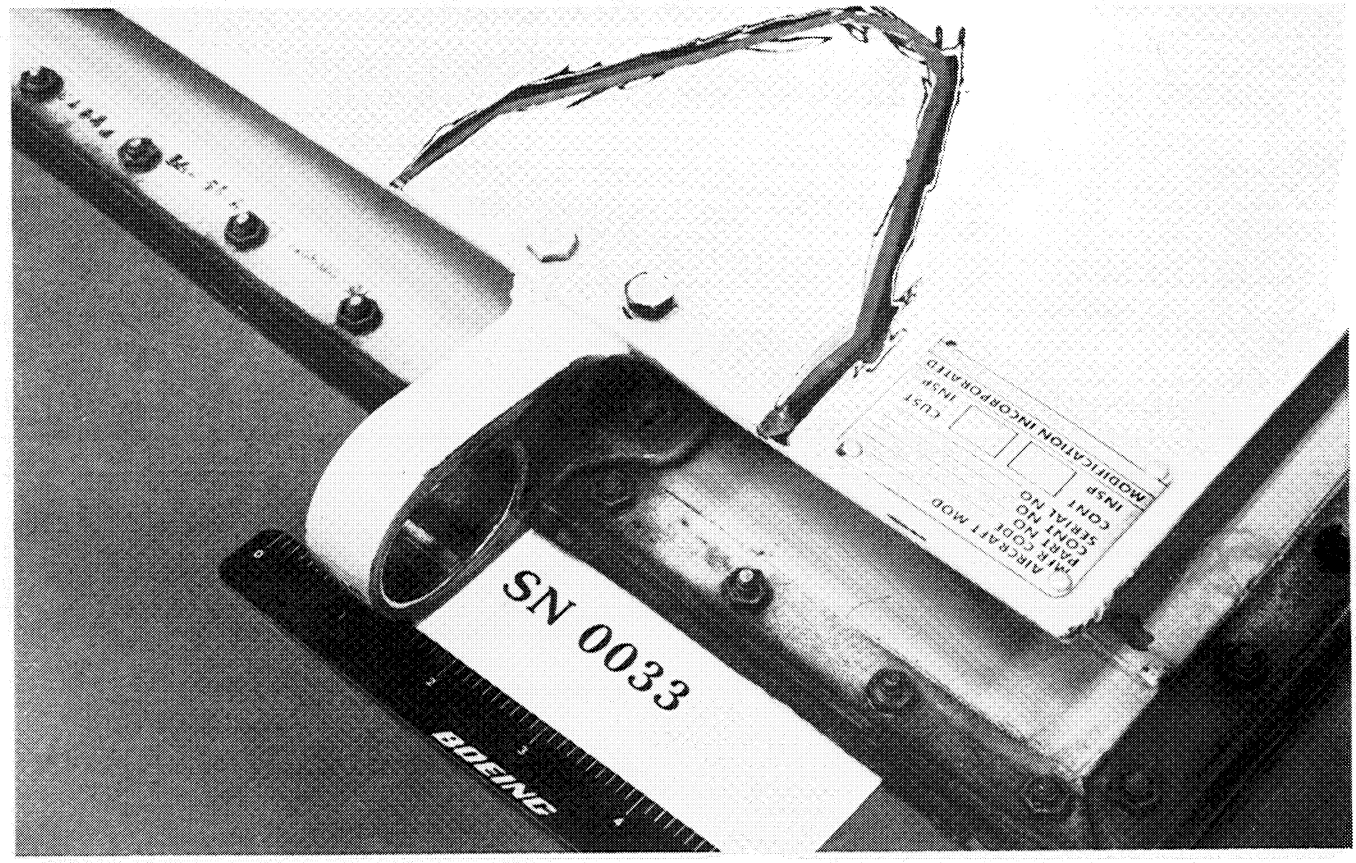

Figure 14 Corner Detail of Spoiler S/N 0033 After 8 Years of Service

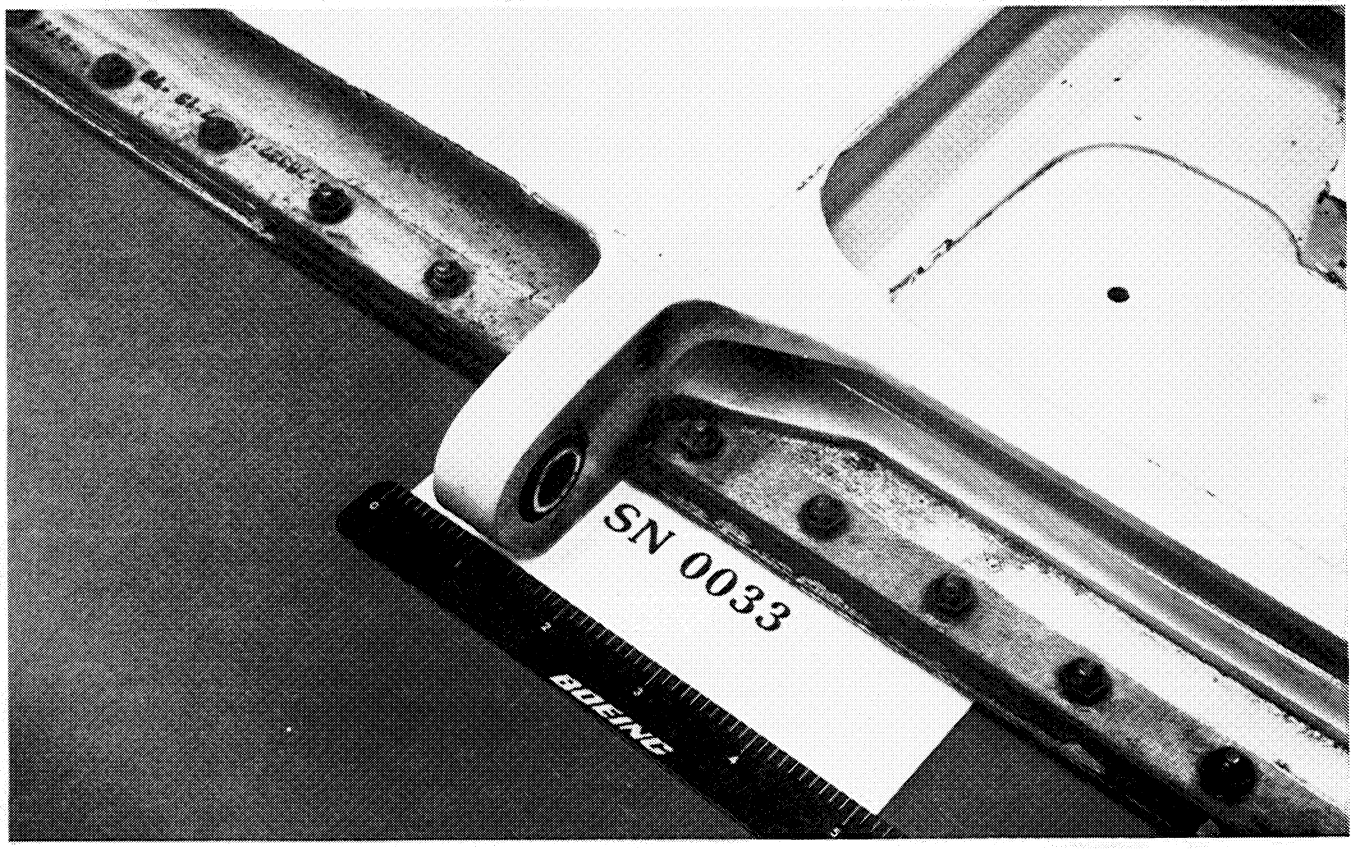

Figure 15. Hinge Detail of Spoiler S/N 0033 After 8 Years of Service

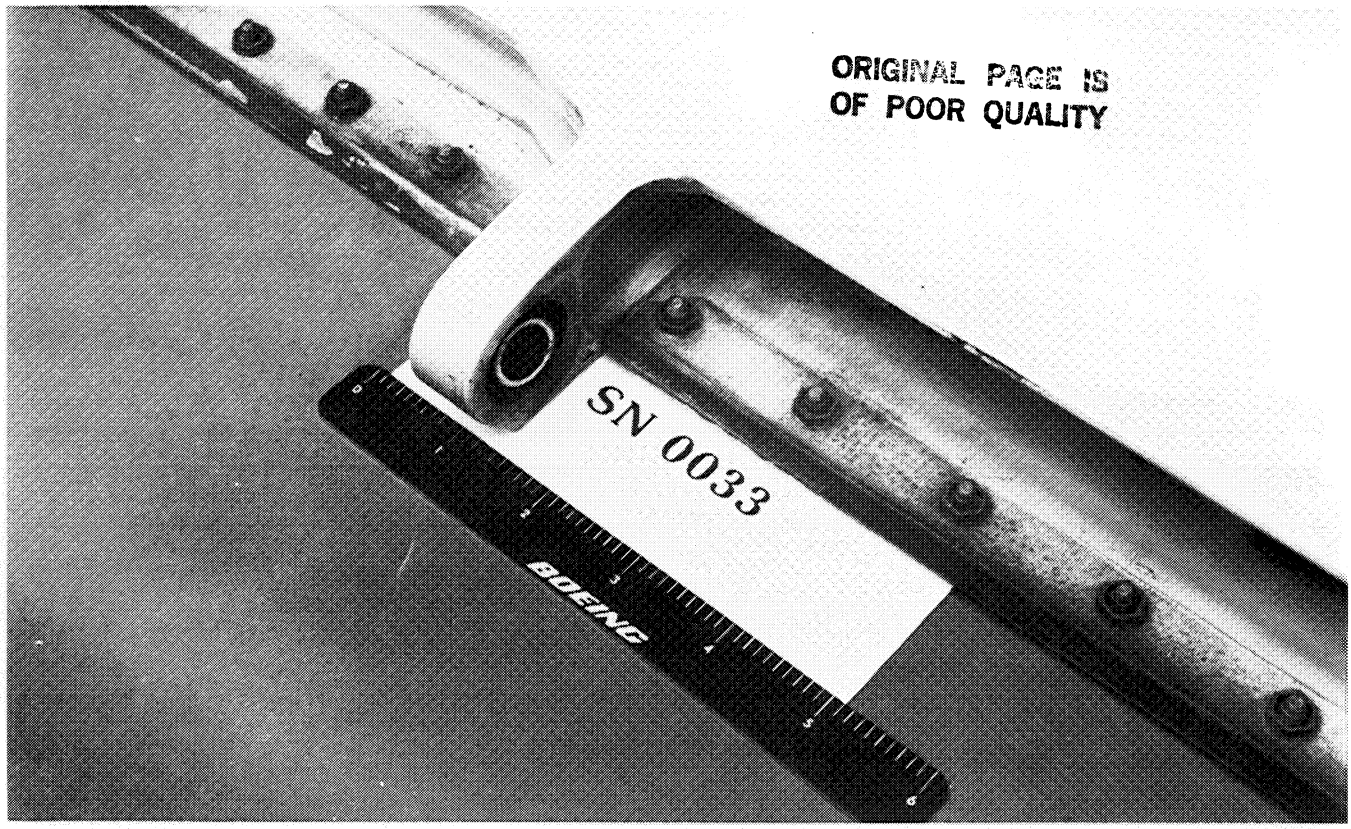

Figure 16. Hinge Detail of Spoiler S/N 0033 After 8 Years of Service

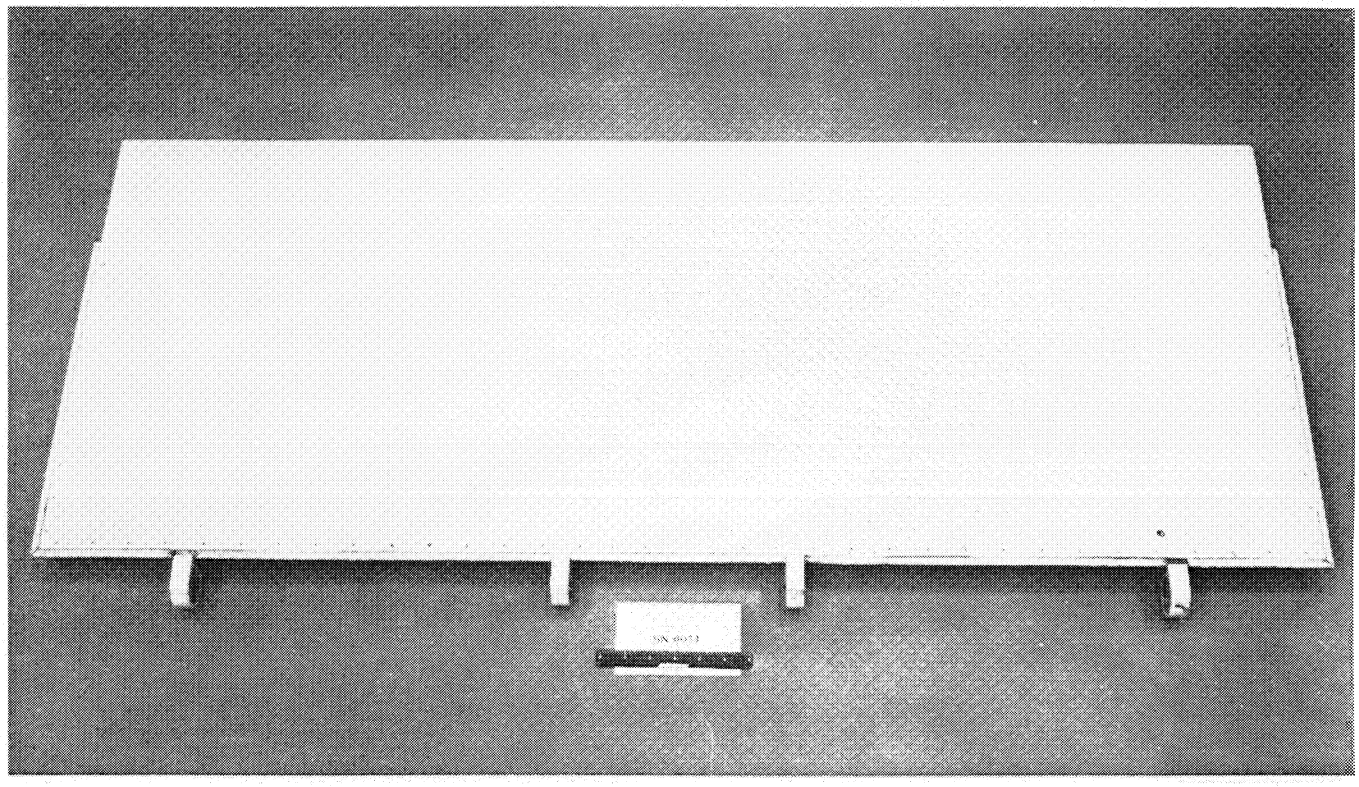

Figure 17. Upper Surface of Spoiler S/N 0051 After 8 Years of Service

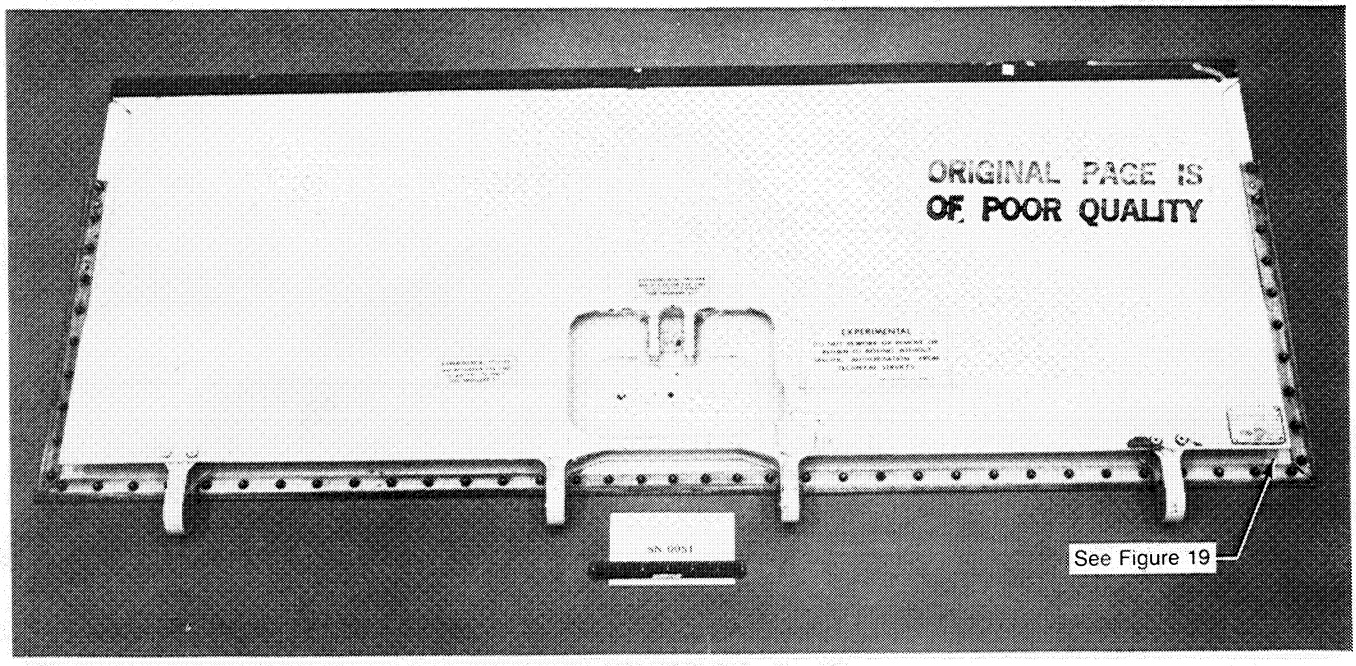

Figure 18. Lower Surface of Spoiler S/N 0051 After 8 Years of Service

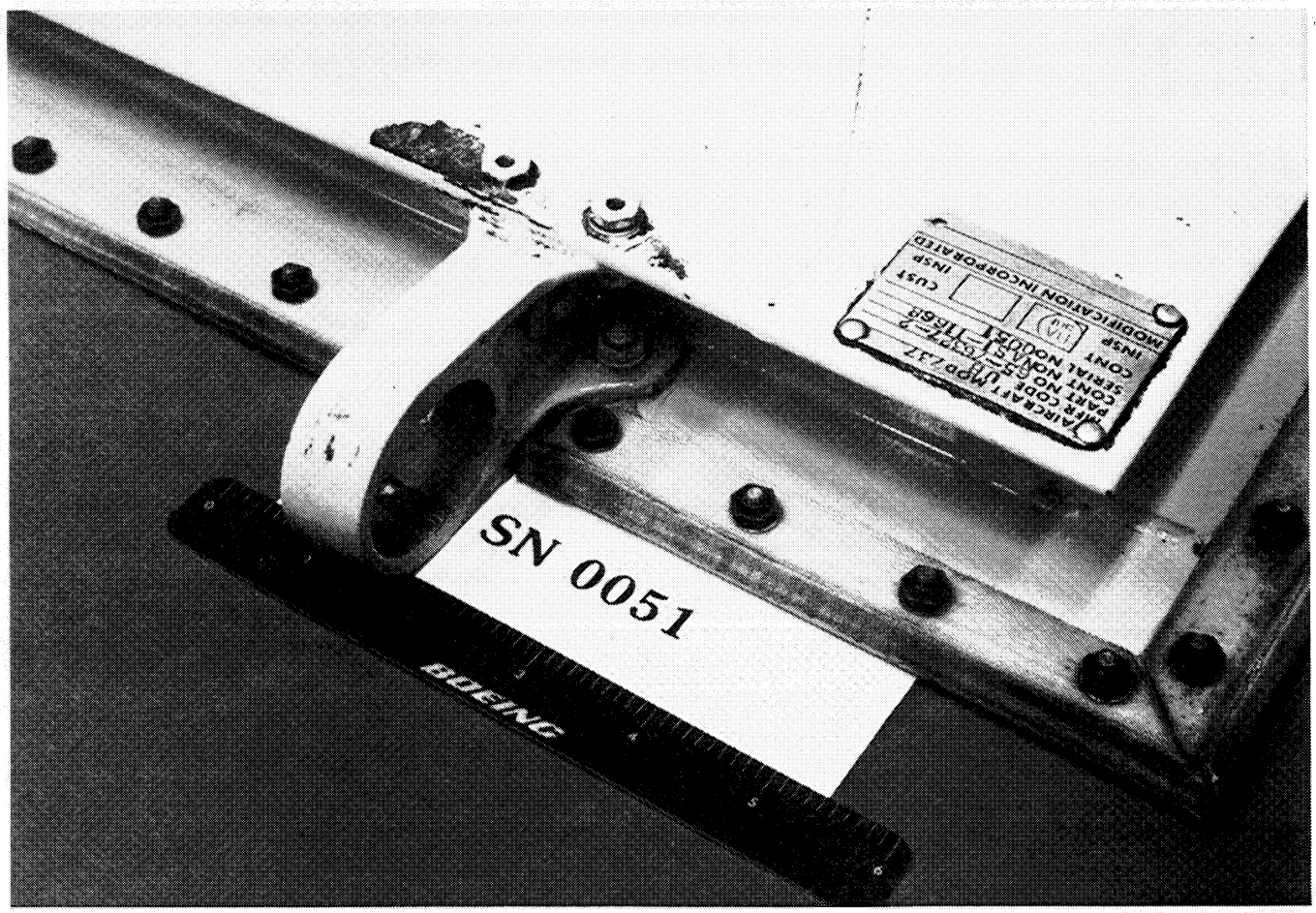

Figure 19. Corner Detail of Spoiler S/N 0051 After 8 Years of Service

Spoiler S/N 0082 with 8 years of service was returned with significant damage. Figures 20 and 21 show the upper and lower surfaces, respectively. A massive blister had developed over one spar to center hinge fitting splice as shown on Figure 22.

The upper and lower surfaces of spoiler S/N 0085 after 8 years of service are shown on Figures 23 and 24, respectively. There was no noted damage on this spoiler.

The upper and lower surfaces of spoiler S/N 0029 after 8 years of service are shown on Figures 25 and 26, respectively. Flap track rubbing on the lower surface was covered with a thick application of teflon paint. The only major damage is a blister over the center hinge fitting. A closeup of this is shown on Figure 27. This was the second blister at this location. The first blister was repaired previously.

Spoiler S/N 0038 after 9 years of service is shown on Figures 28 through 31. Corrosion was evident on both lower skin aluminum doublers and on the doubler in the center hige fitting. One doubler had delaminated as shown on Figure 29. This photograph was taken after the spoiler had been tested to failure.

Photographs of spoiler S/N 0064 after 9 years of service are shown on Figures 32 through 35. This spoiler had evidence of mechanical impact damage on the lower surface as shown on Figure 34. A blister was evident over the center hinge fitting as shown on Figure 35.

The upper surface of spoiler S/N 0102 after 9 years of service is shown on Figure 36. There is no photograph available of the lower surface. The general condition of this panel was good with the exception of some paint wear on the lower surface due to flap rubbing.

The overall view and detailed photographs of spoiler S/N 0018 after 10 years of service are shown on Figures 37 through 40. The general condition of this unit was good with the exception of a small delamination on a lower surface corner. A minor edge delamination has started at one spar to center hinge fitting location.

Spoiler S/N 0044 with 10years of service was returned with a delamination over the center hinge fitting. This is shown in an overall view on Figure 41 and in detail on Figure 42. The outer ply has been removed in a strip in the chordwise direction. The delamination area has been sanded down, removing the paint for better clarity. The lower surface overall view is shown on Figure 43. A small mechanical impact in the upper surface is shown on Figure 44. This impact was most likely caused after the panel was removed from the aircraft.

The overall views of spoiler S/N 0108 after 10 years of service are shown on Figures 45 and 46. Some interference rubbing with the flaps on the lower surface has been treated. A substantial blister on one spar to center hinge fitting location is shown on Figure 47. This blister has progressed to the point where corrosion products are visible. This blister is one of the most severe found in the program. A minor corner delamination was also found on the forward lower surface. This delamination is shown on Figure 48.

Table 4 gives data from all of the scheduled seventh-year removals and summarizes the strength and stiffness data from the four units that were statically tested. Tables 5, 6, and 7 show similar data for the eighth, ninth, and tenth year testing, respectively. Figure

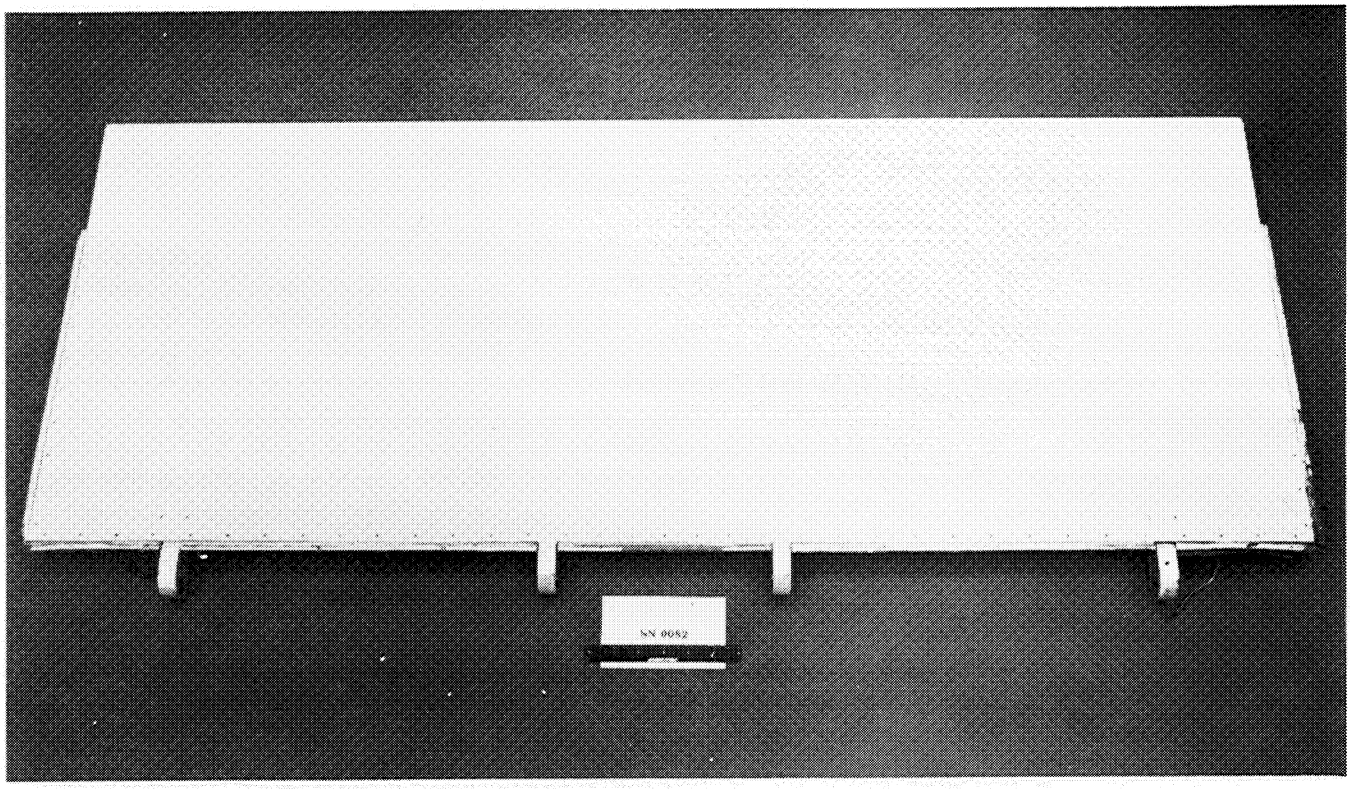

Figure 20. Upper Surface of Spoiler S/N 0082 After 8 Years of Service

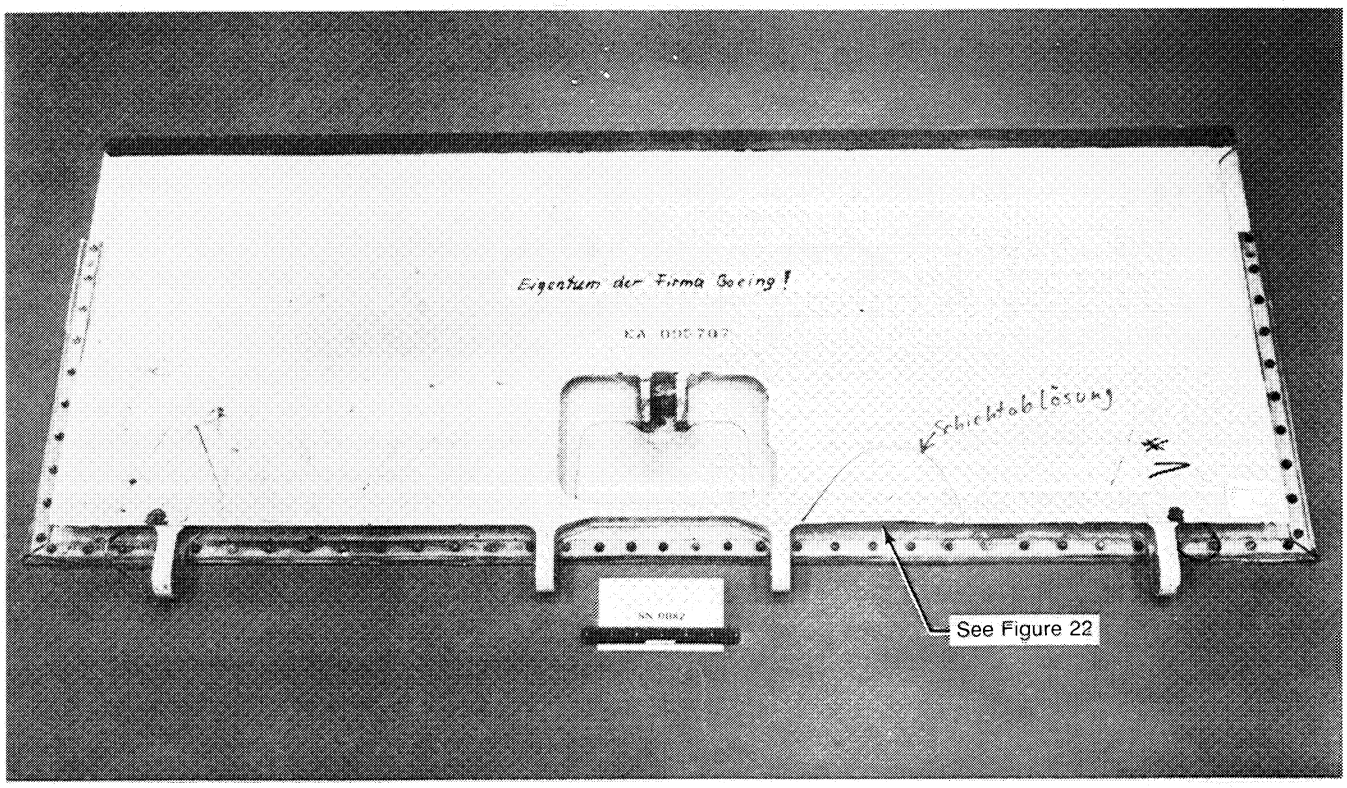

Figure 21. Lower Surface of Spoiler S/N 0082 After 8 Years of Service

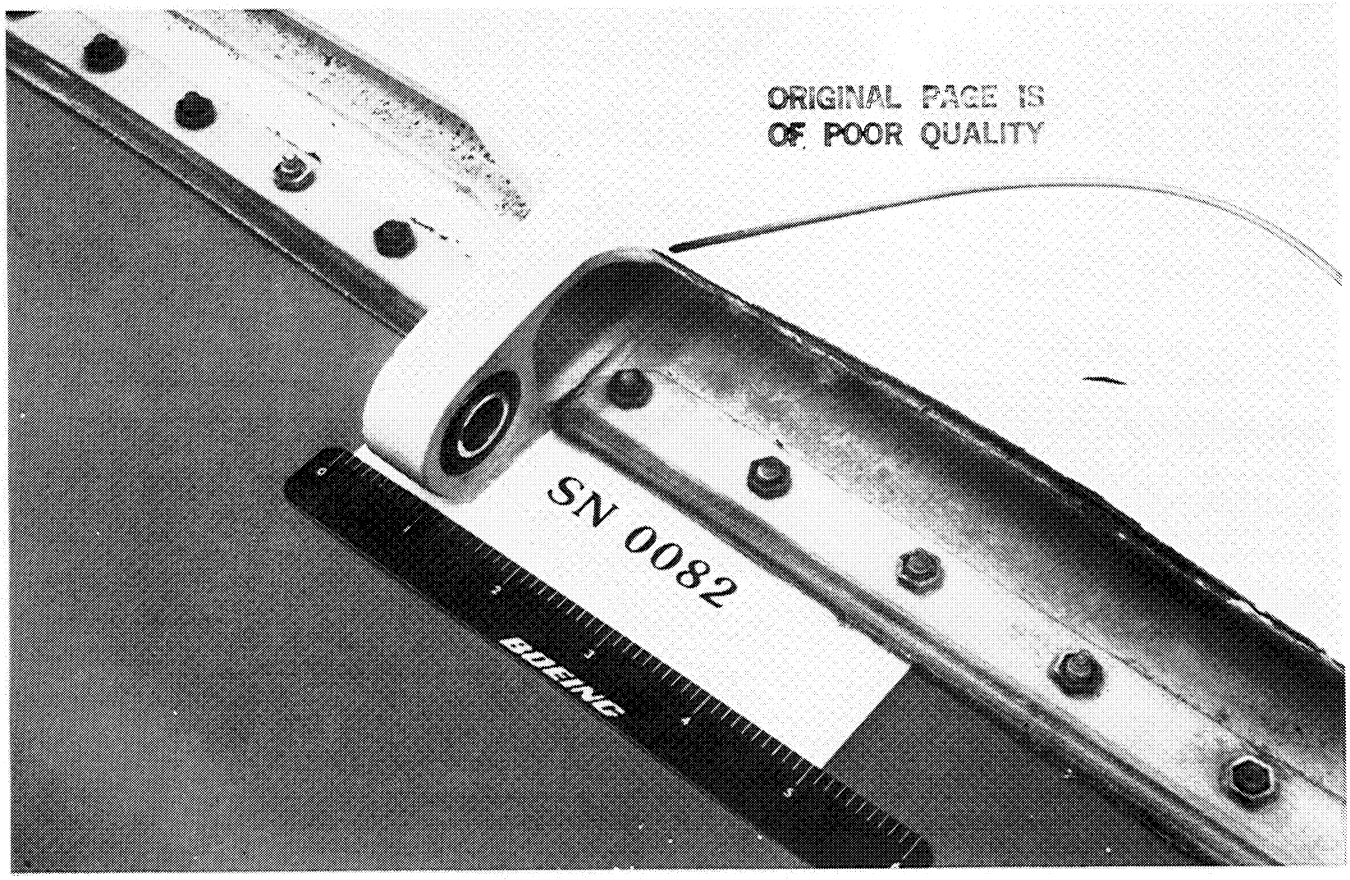

Figure 22. Hinge Detail of Spoiler S/N 0082 After 8 Years of Service

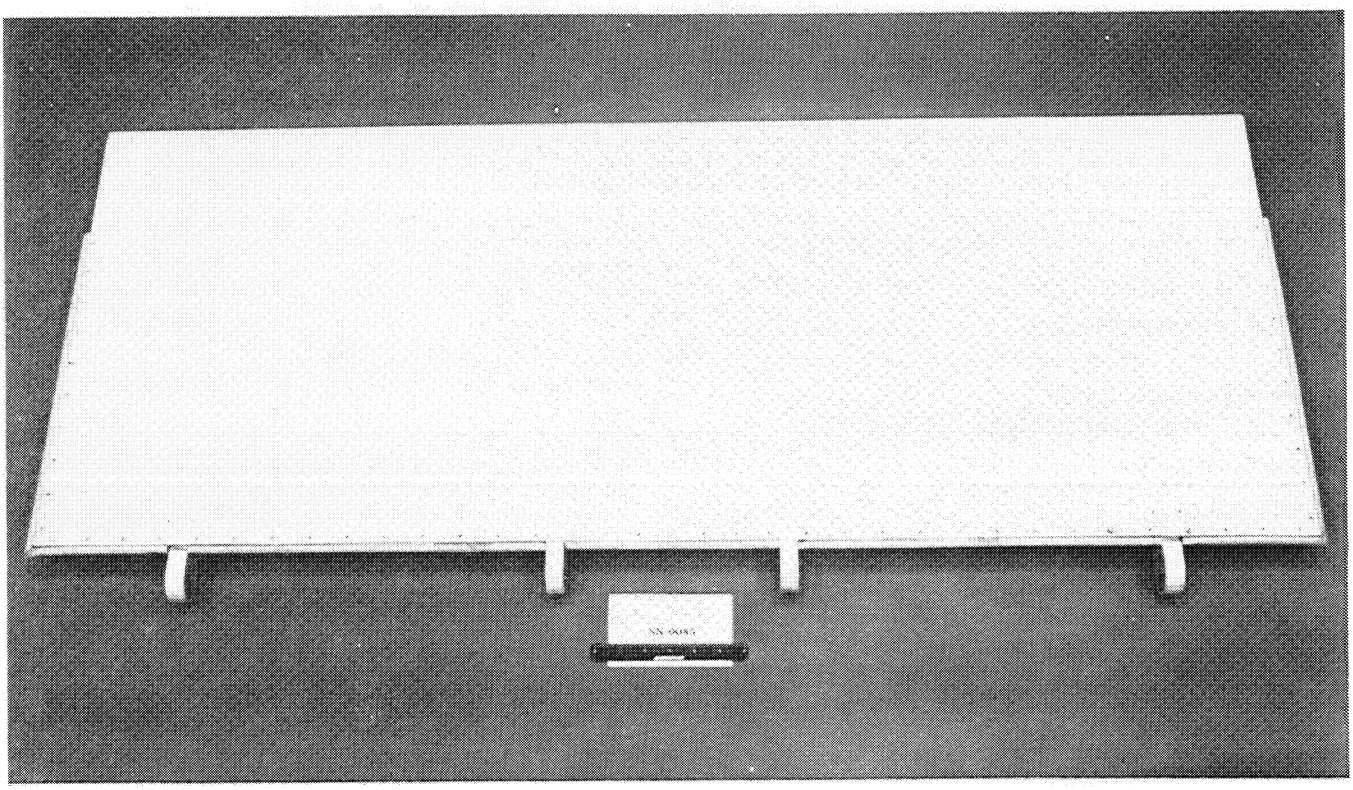

Figure 23. Upper Surface of Spoiler S/N 0085 After 8 Years of Service

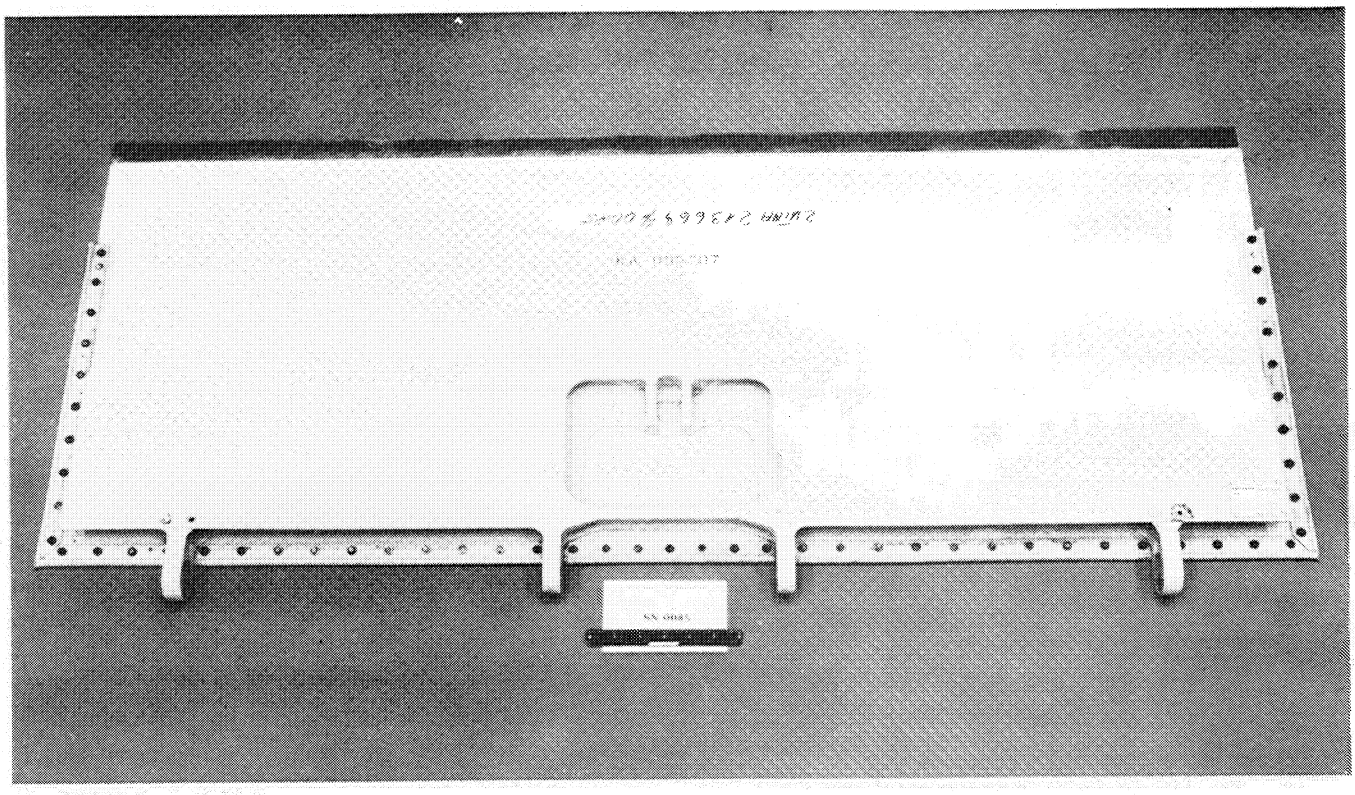

Figure 24. Lower Surface of Spoiler S/N 0085 After 8 Years of Service

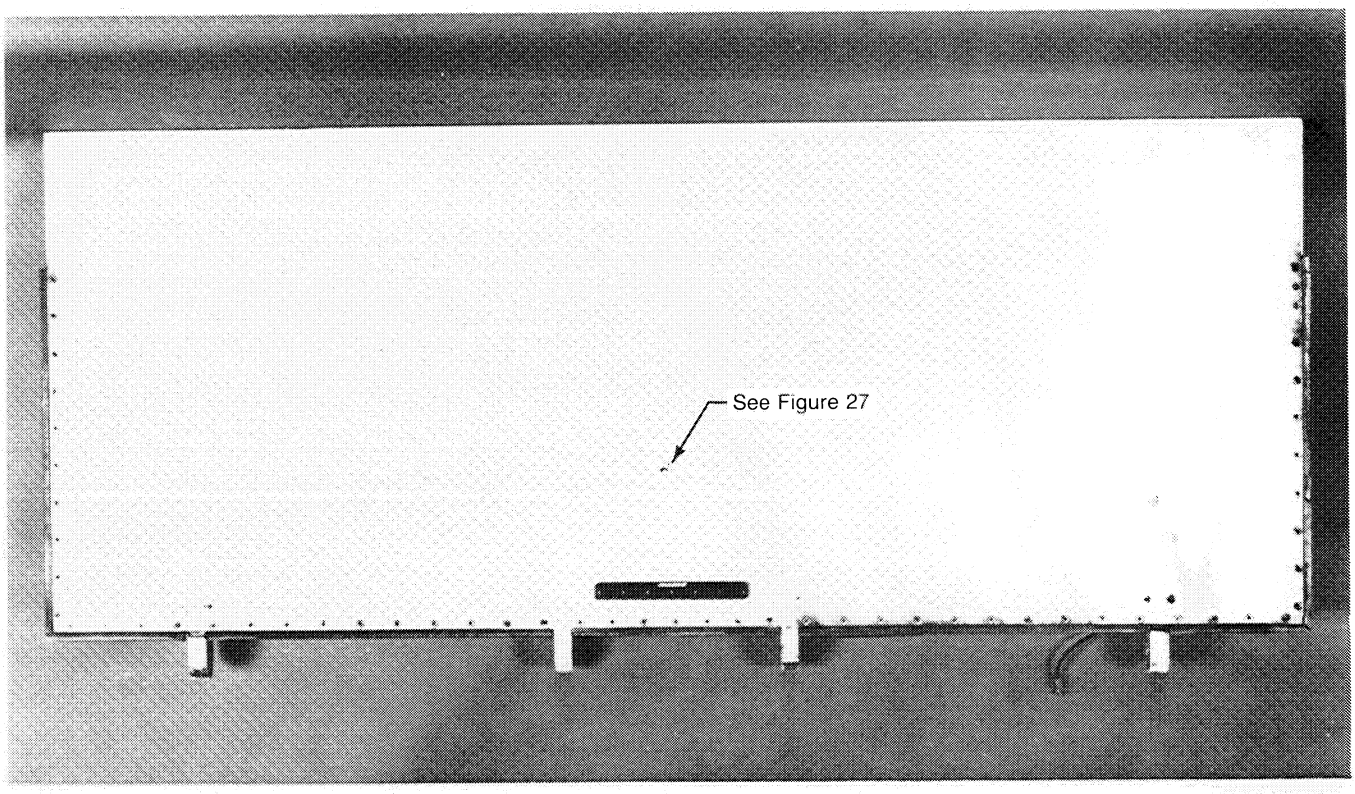

Figure 25. Upper Surface of Spoiler S/N 0029 After 9 Years of Service

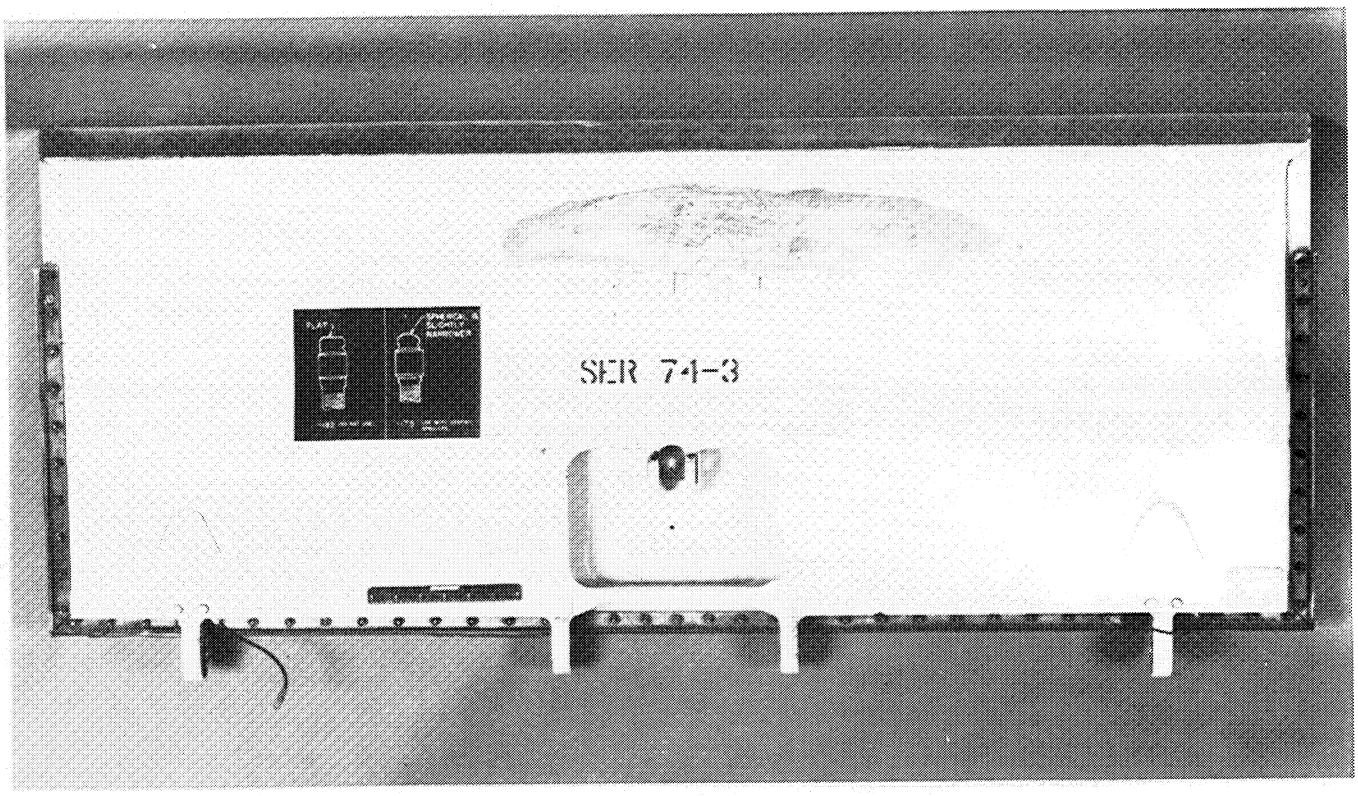

Figure 26. Lower Surface of Spoiler S/N 0029 After 9 Years of Service

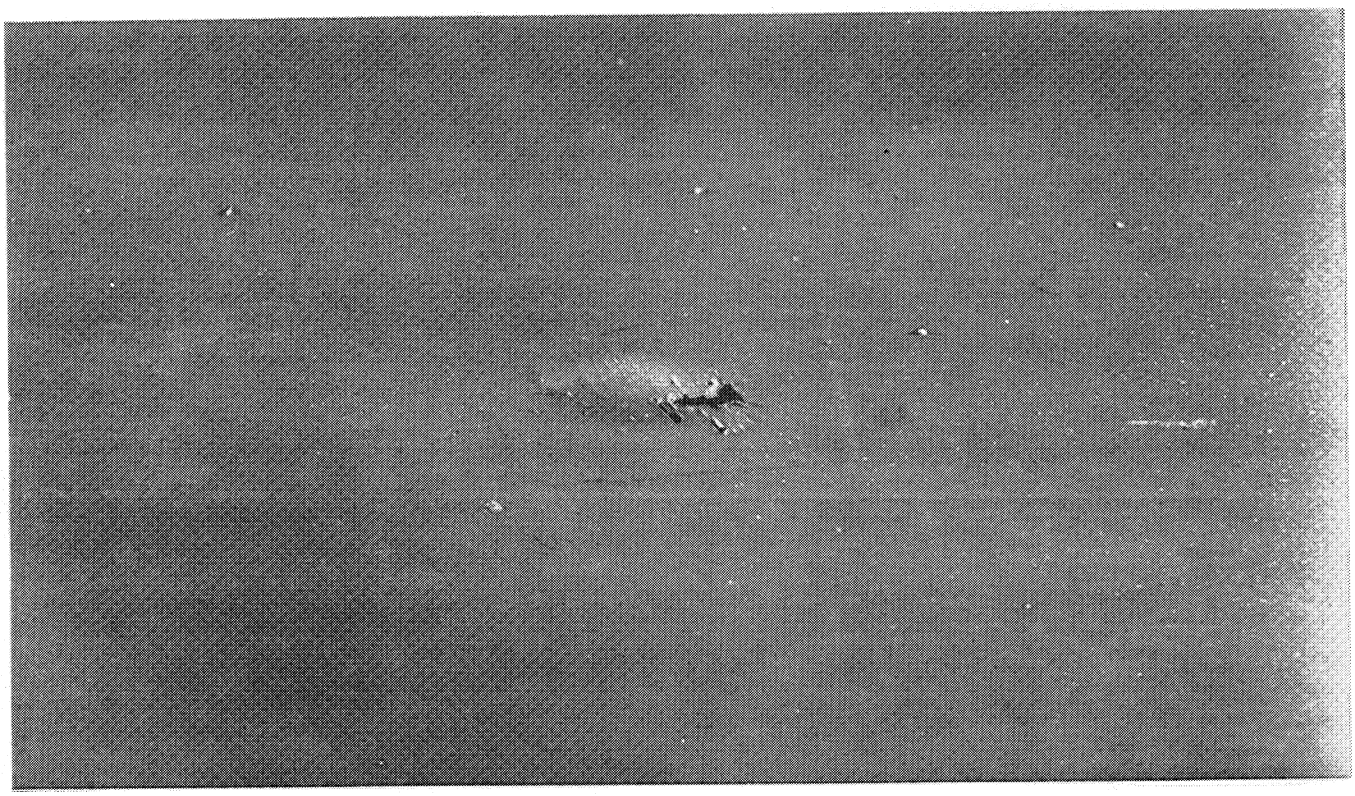

Figure 27. Blister Detail of Spoiler S/N 0029 After 9 Years of Service

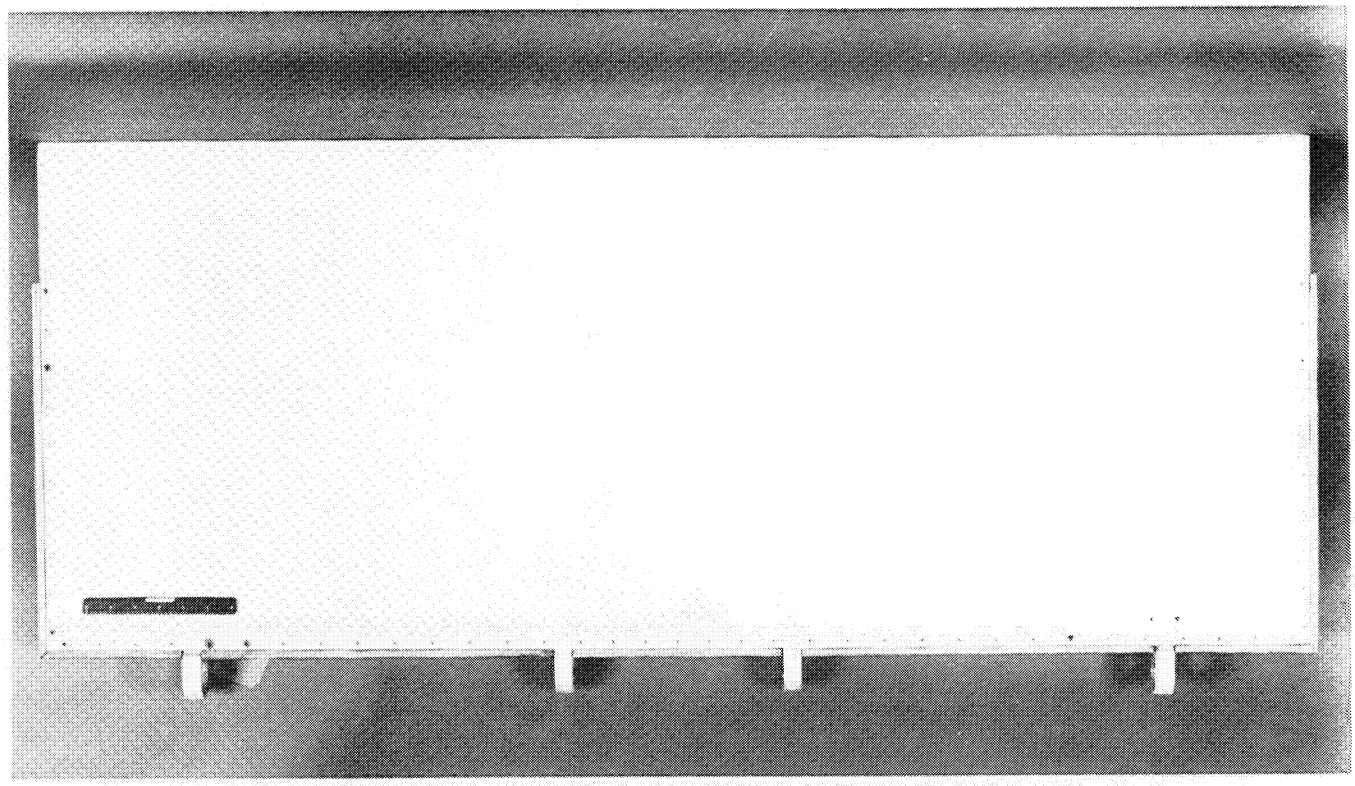

Figure 28. Upper Surface of Spoiler S/N 0038 After 9 Years of Service

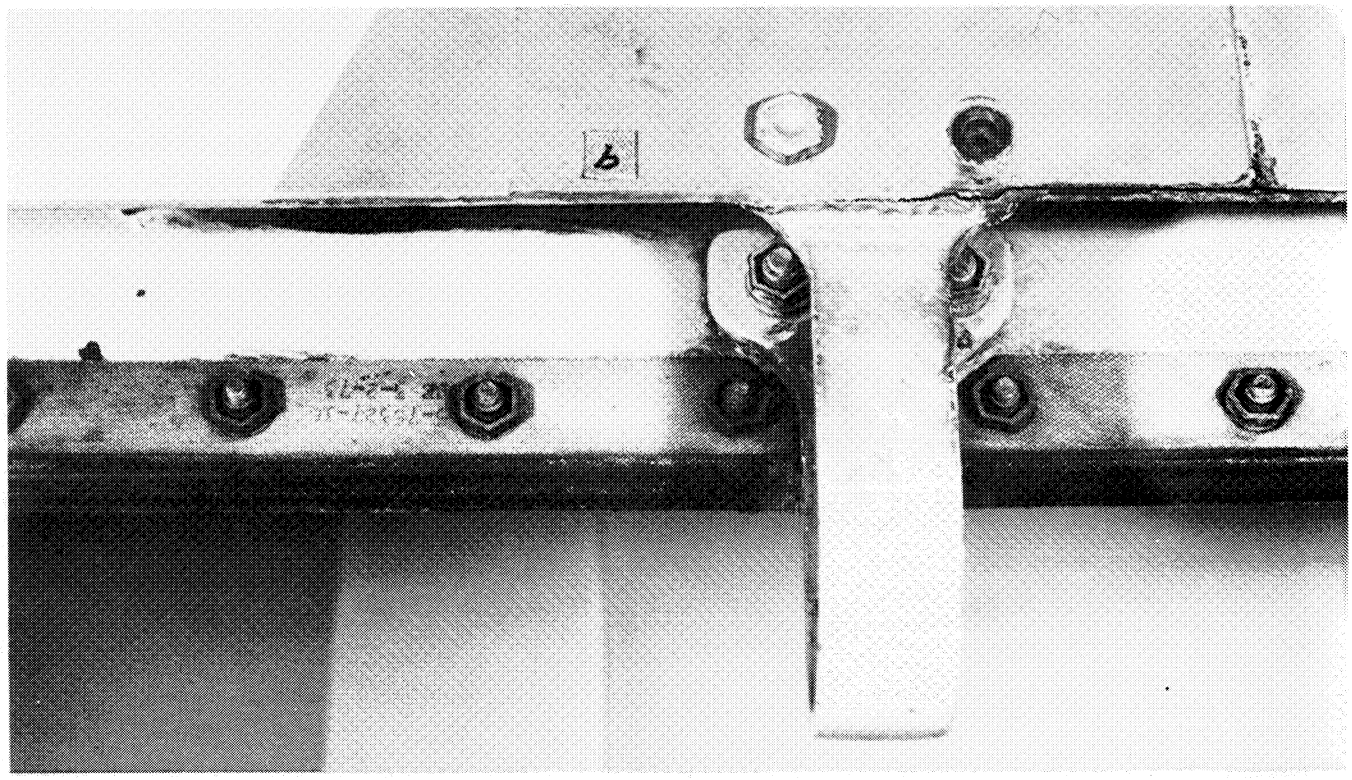

Figure 29. Outer Hinge Detail of Spoiler S/N 0038 After 9 Years of Service

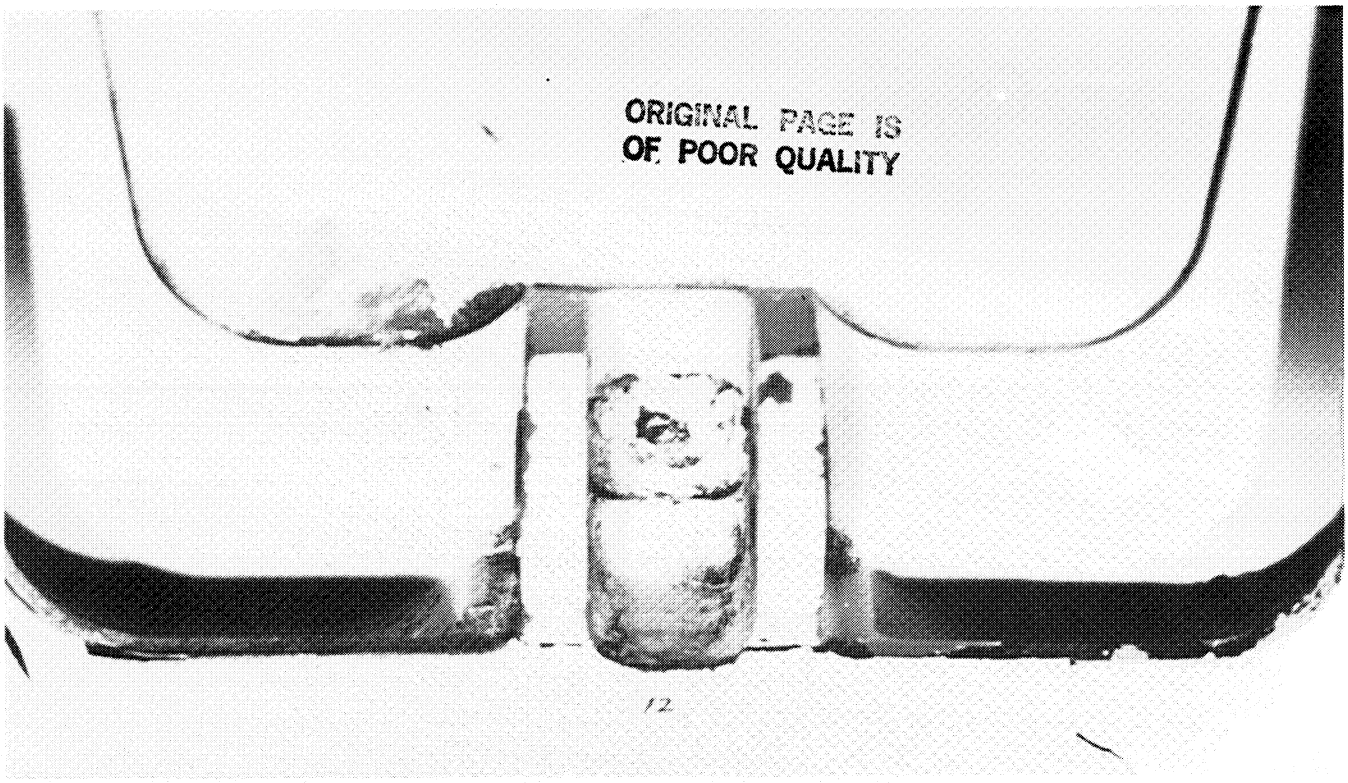

Figure 30. Center Hinge Fitting of Spoiler S/N 0038 After 9 Years of Service

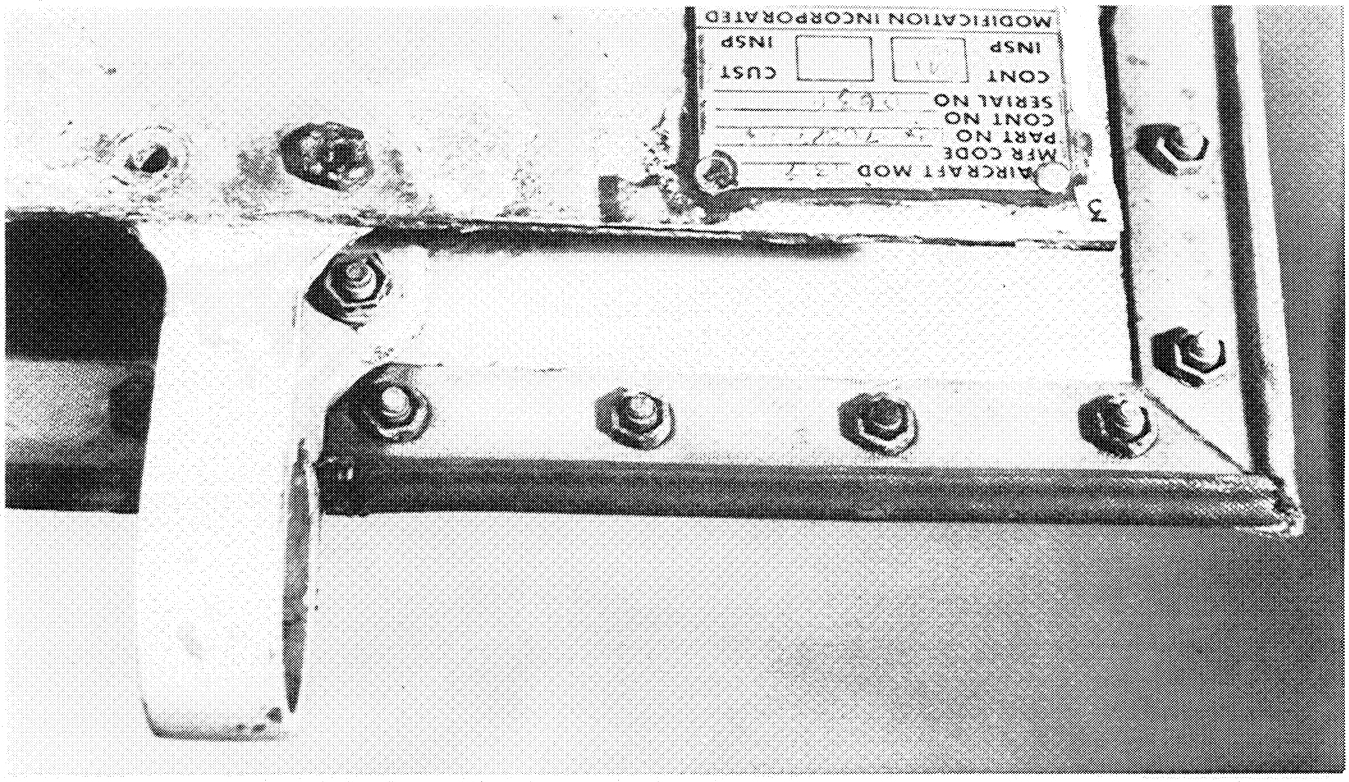

Figure 31. Corner Detail of Spoiler S/N 0038 After 9 Years of Service

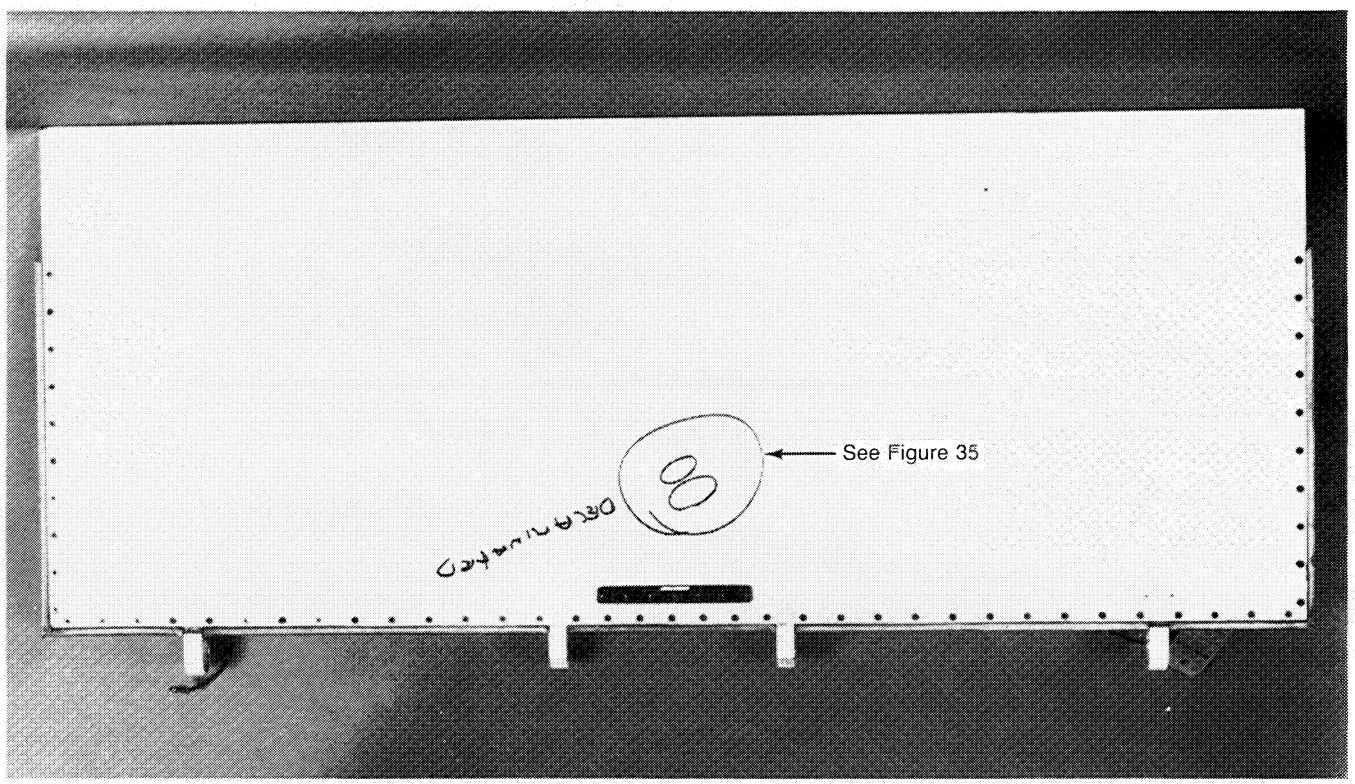

Figure 32. Upper Surface of Spoiler S/N 0064 After 9 Years of Service

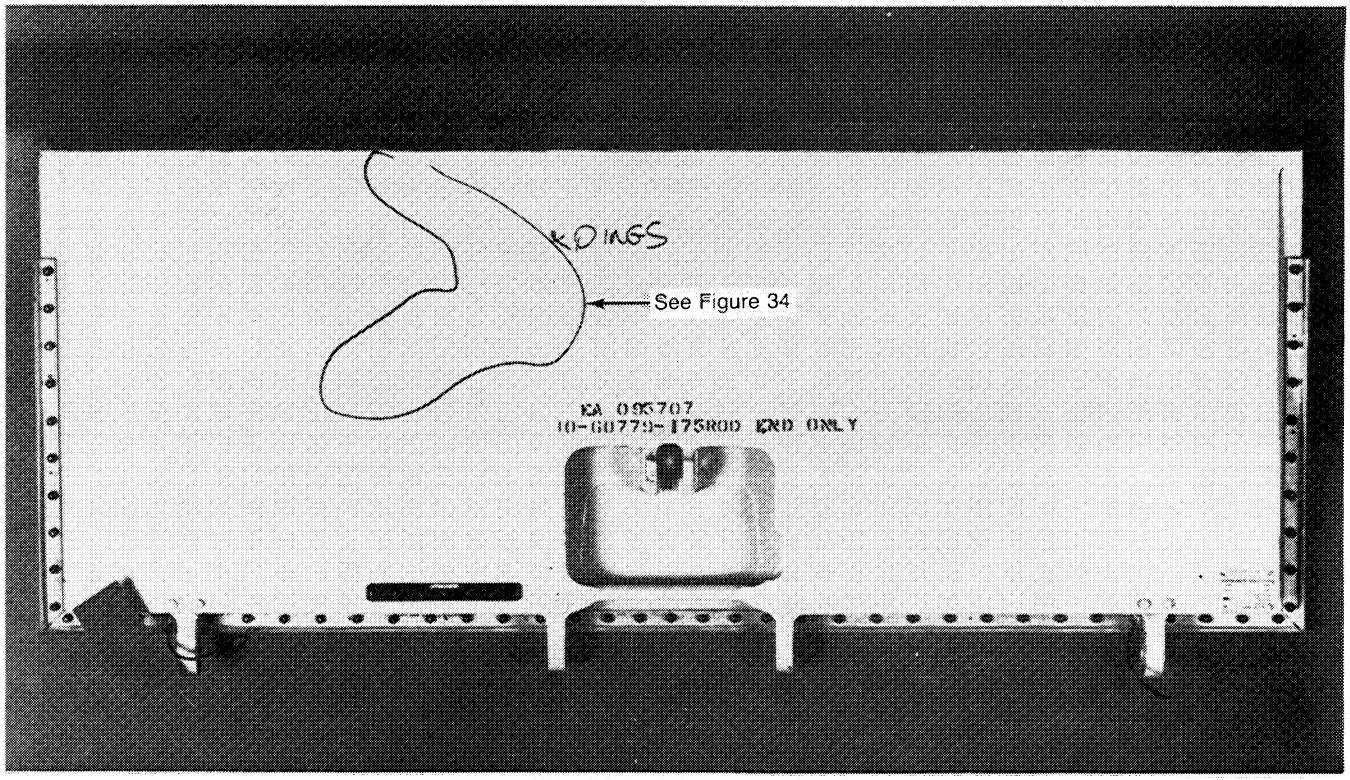

Figure 33. Lower Surface of Spoiler S/N 0064 After 9 Years of Service

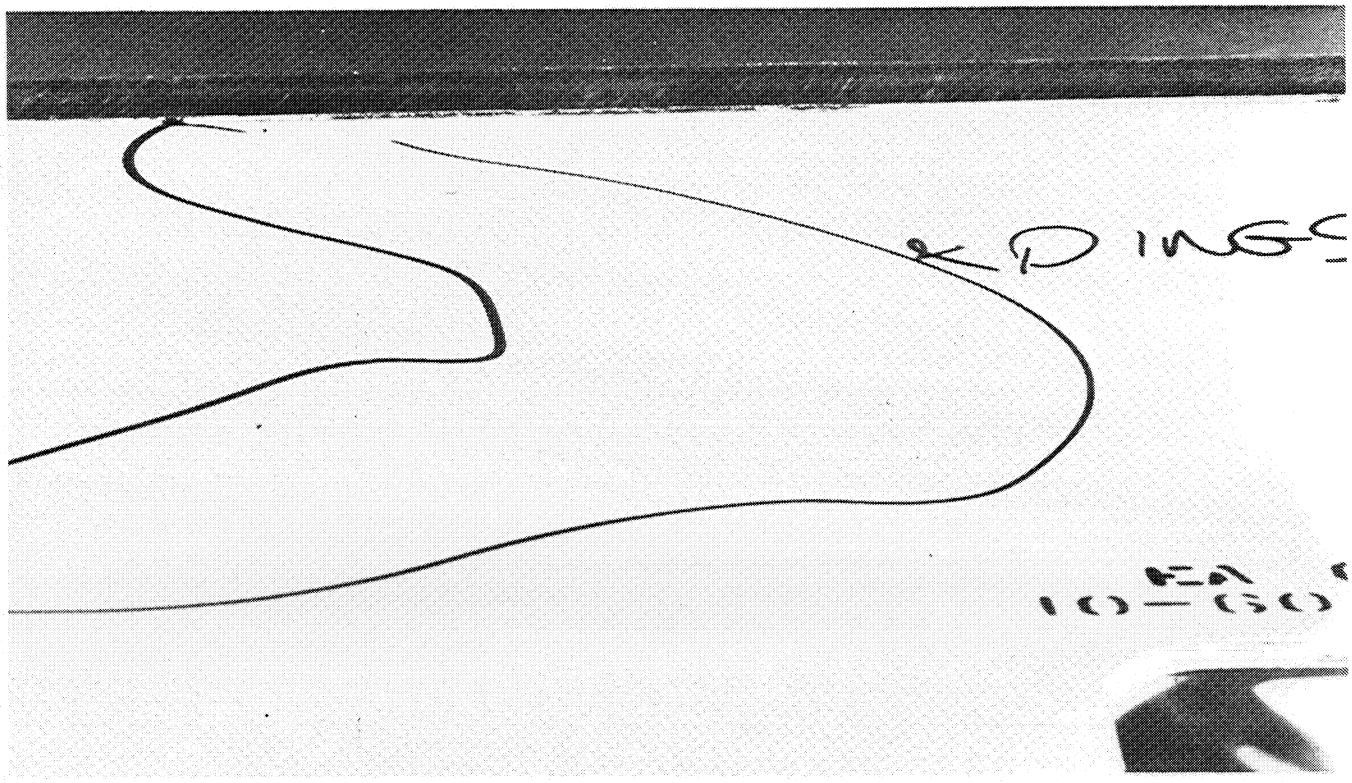

Figure 34. Surface Detail of Spoiler S/N 0064 After 9 Years of Service

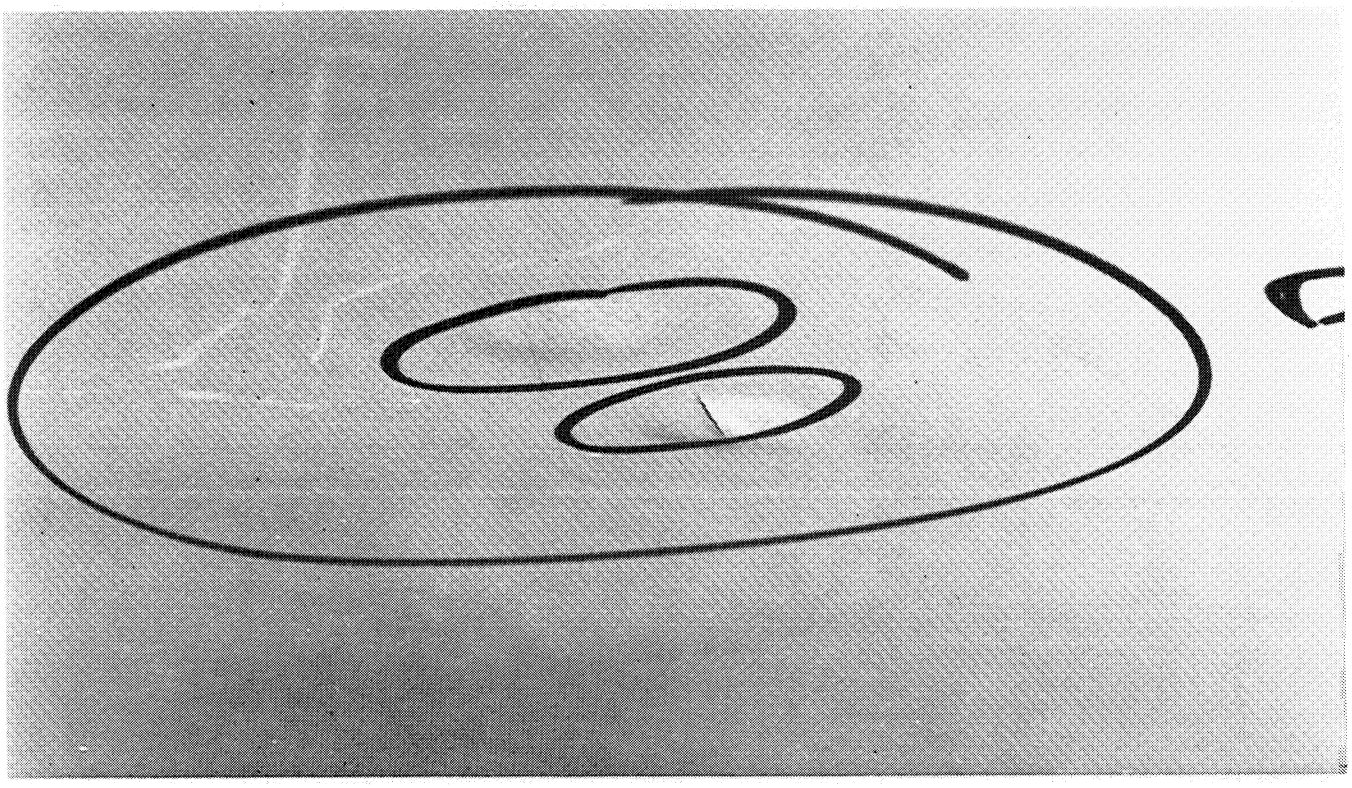

Figure 35. Surface Detail of Spoiler S/N 0064 After 9 Years of Service

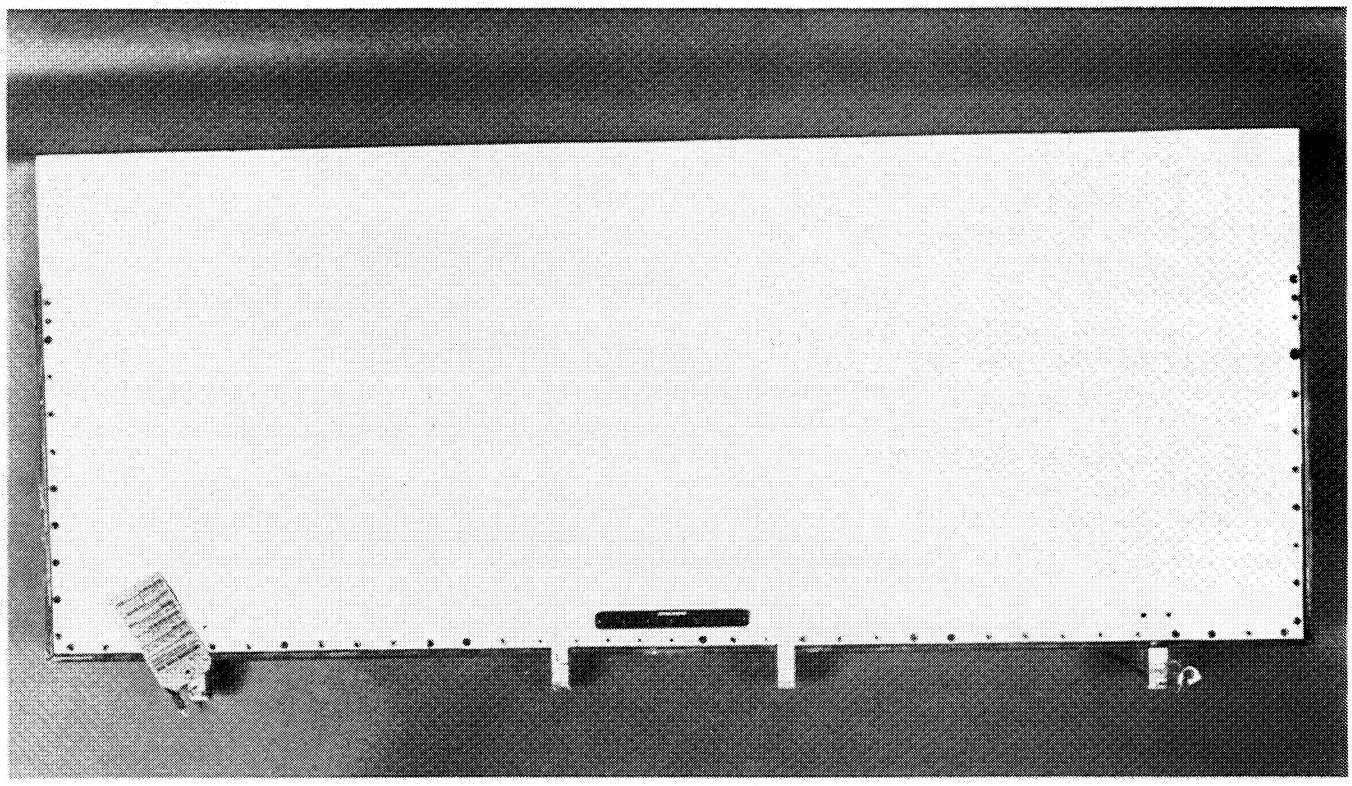

Figure 36. Upper Surface of Spoiler S/N 0102 After 9 Years of Service

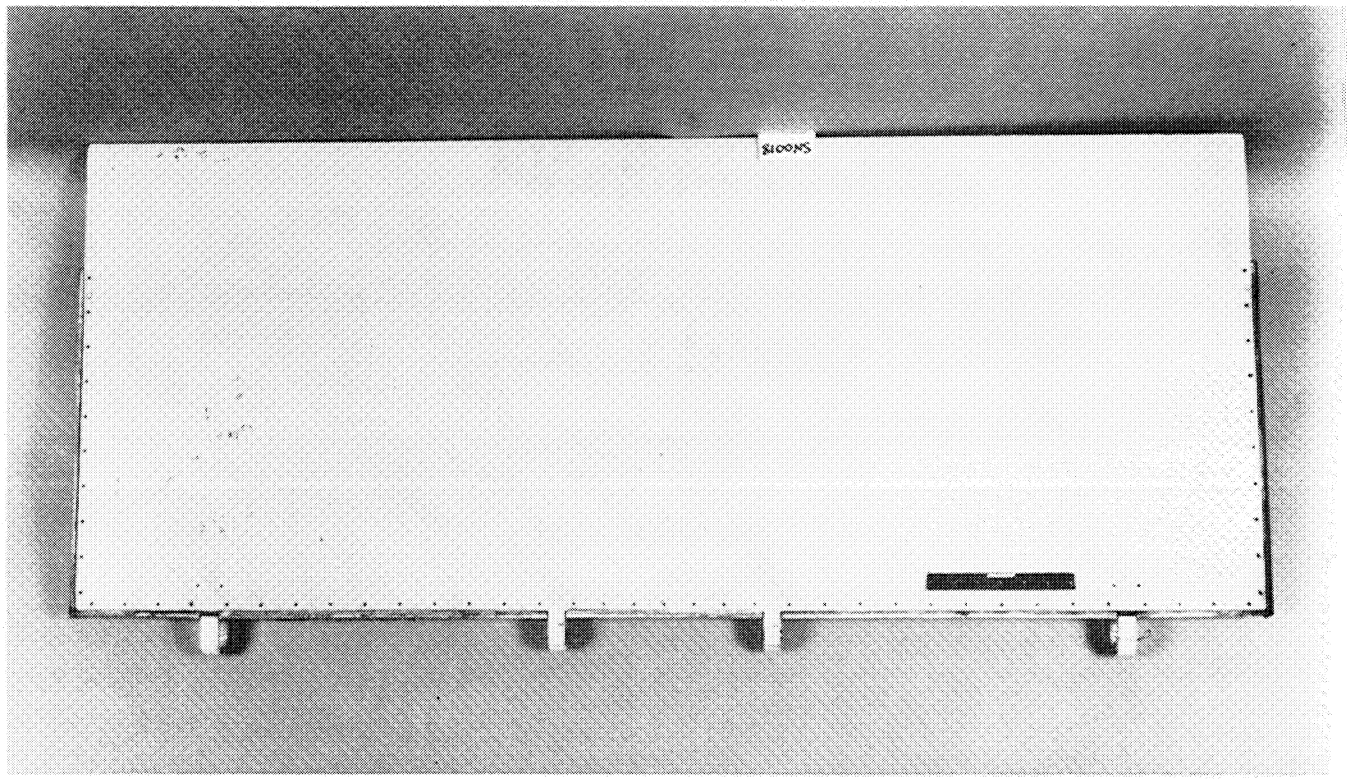

Figure 37. Upper Surface of Spoiler S/N 0018 After 10 Years of Service

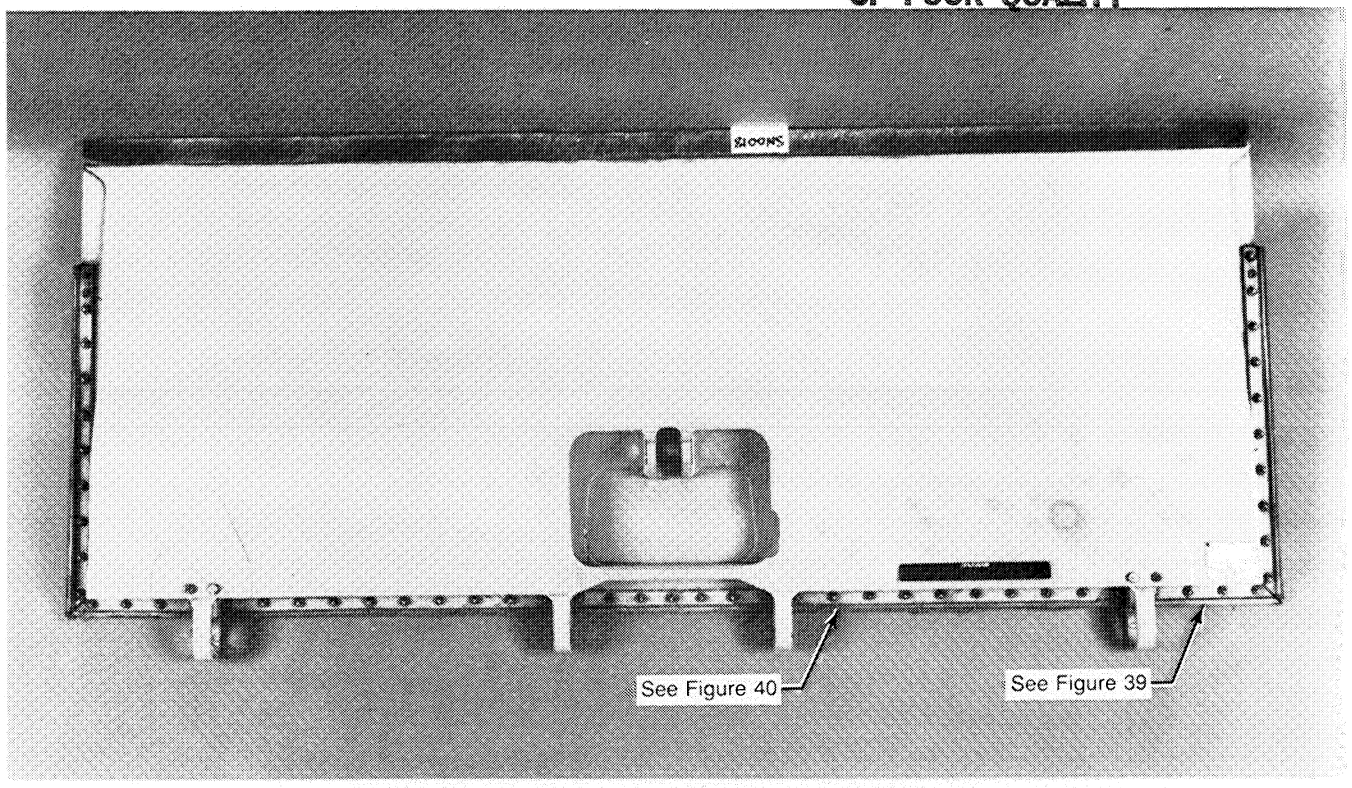

Figure 38. Lower Surface of Spoiler S/N 0018 After 10 Years of Service

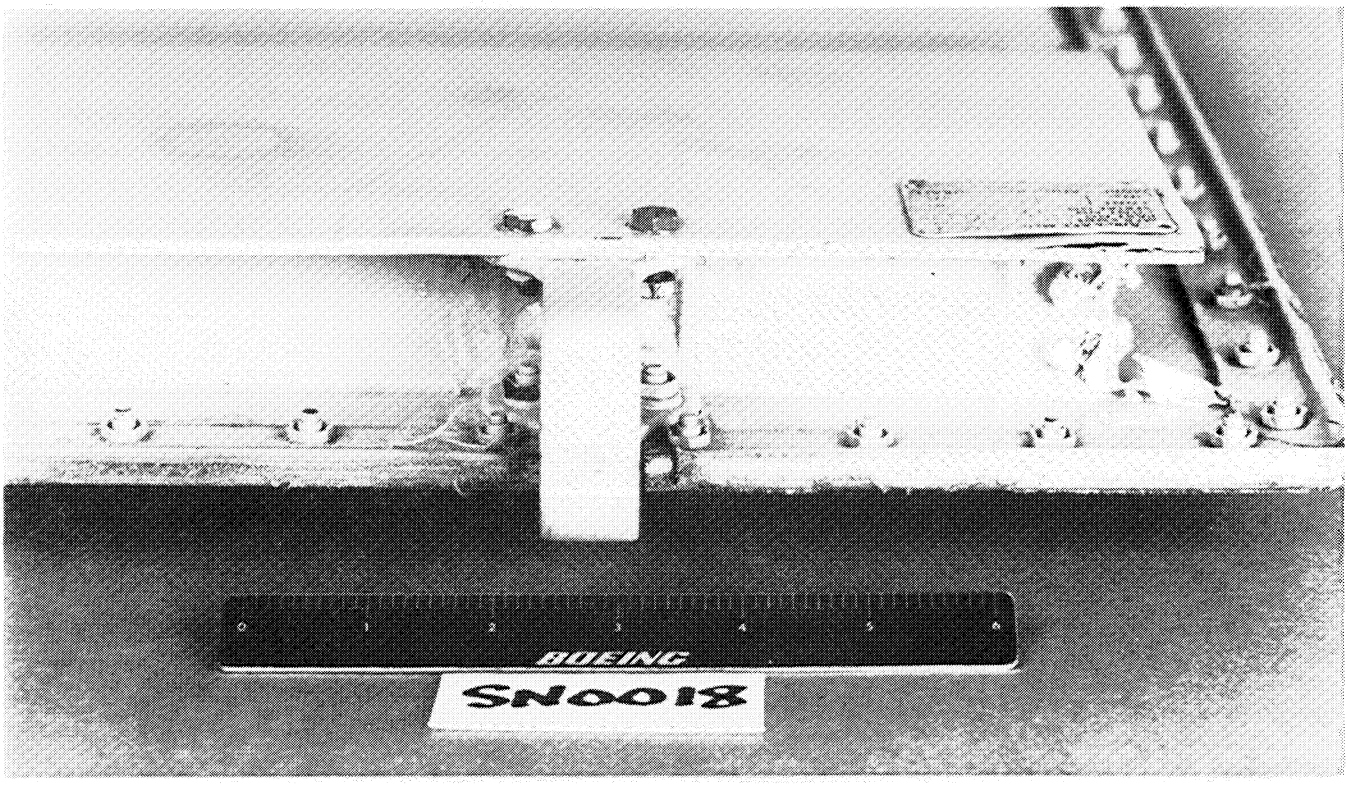

Figure 39. Corner Detail of Spoiler S/N 0018 After 10 Years of Service

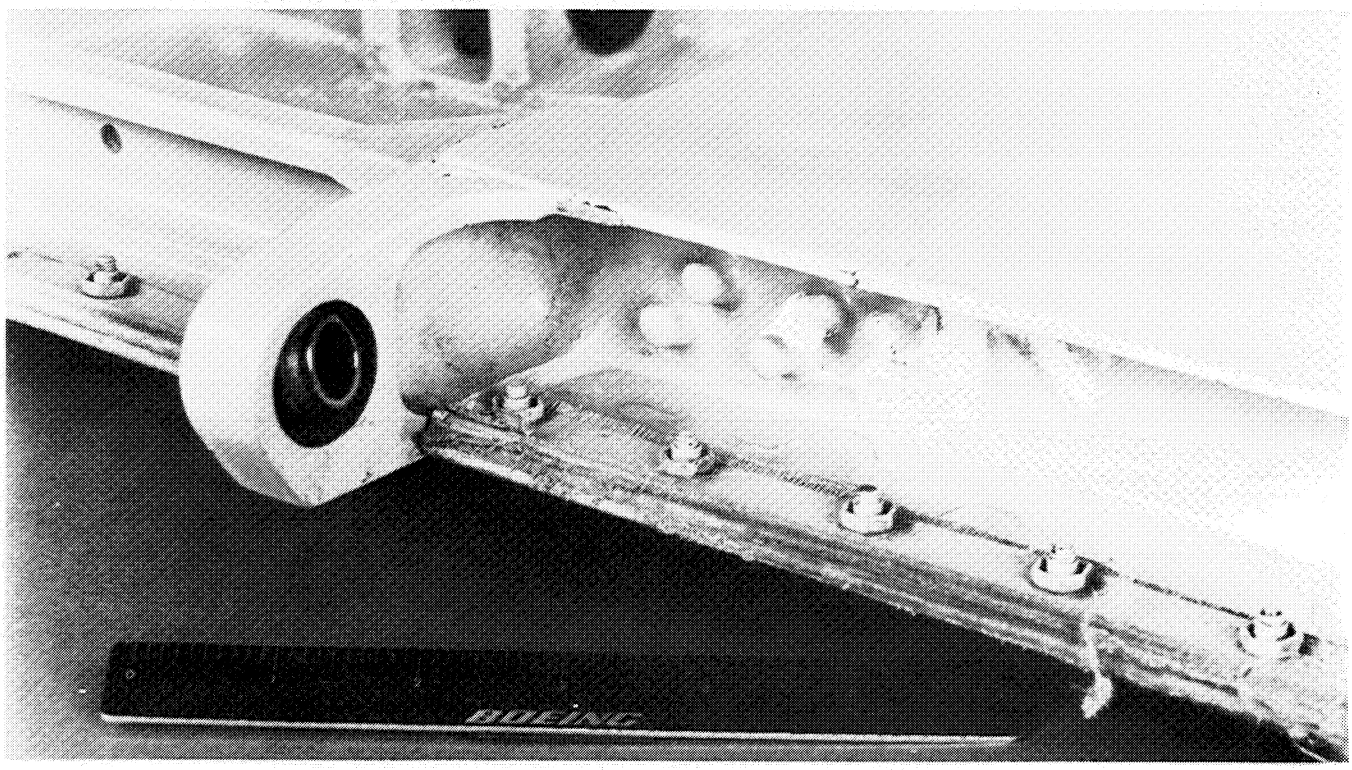

Figure 40. Hinge Detail of Spoiler S/N 0018 After 10 Years of Service

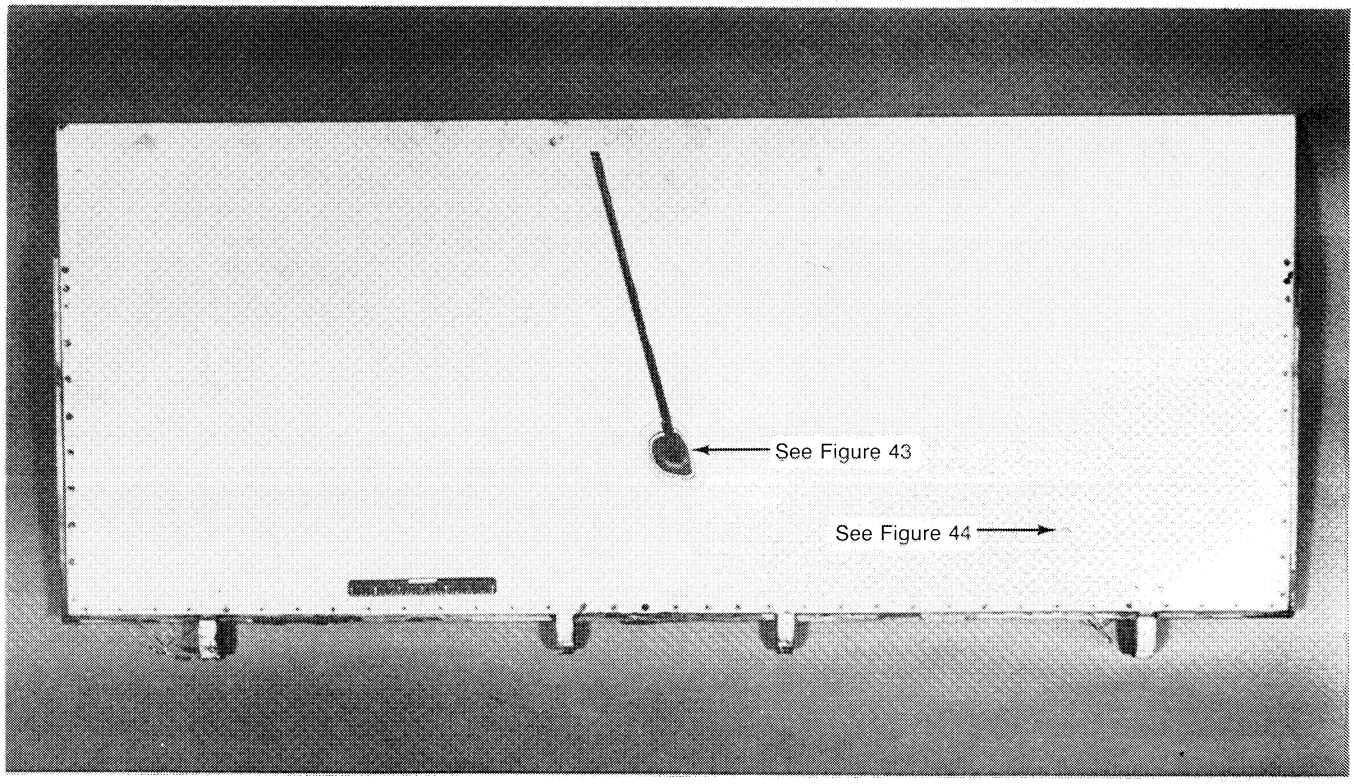

Figure 41. Upper Surface of Spoiler S/N 0044 After 10 Years of Service

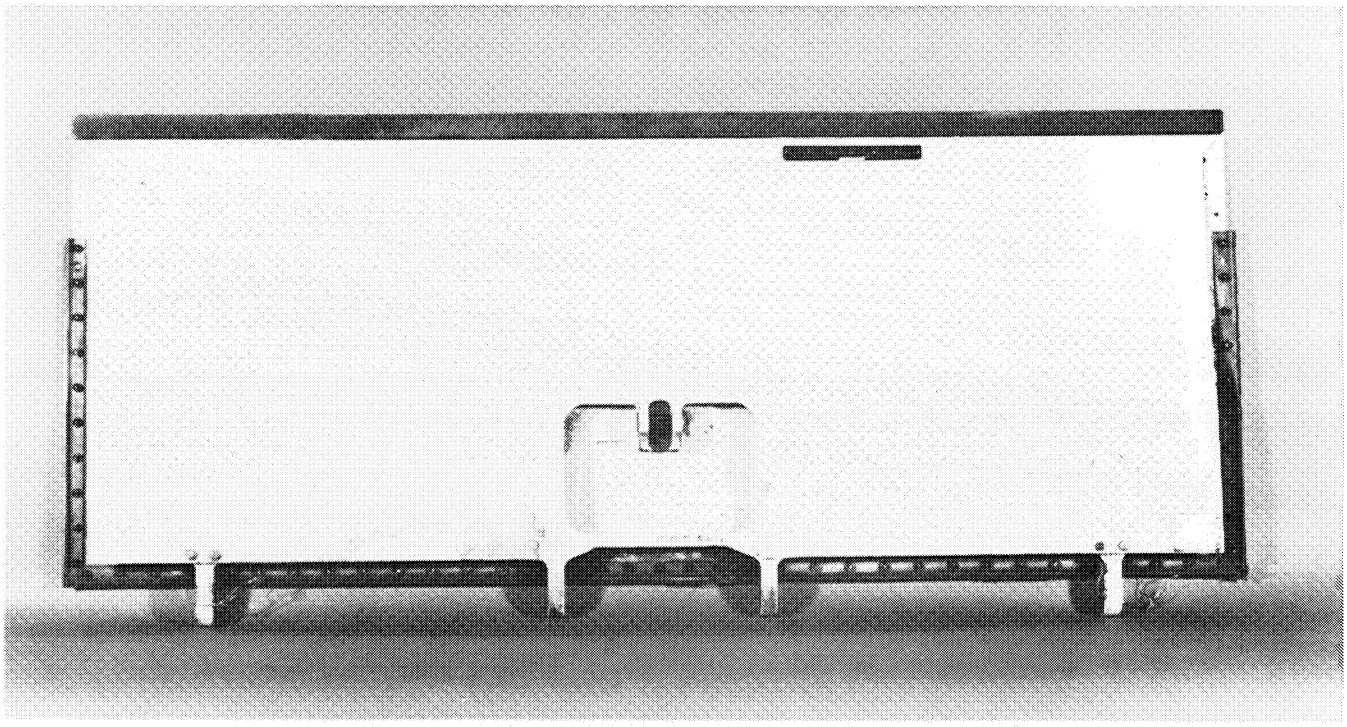

Figure 42. Lower Surface of Spoiler S/N 0044 After 10 Years of Service

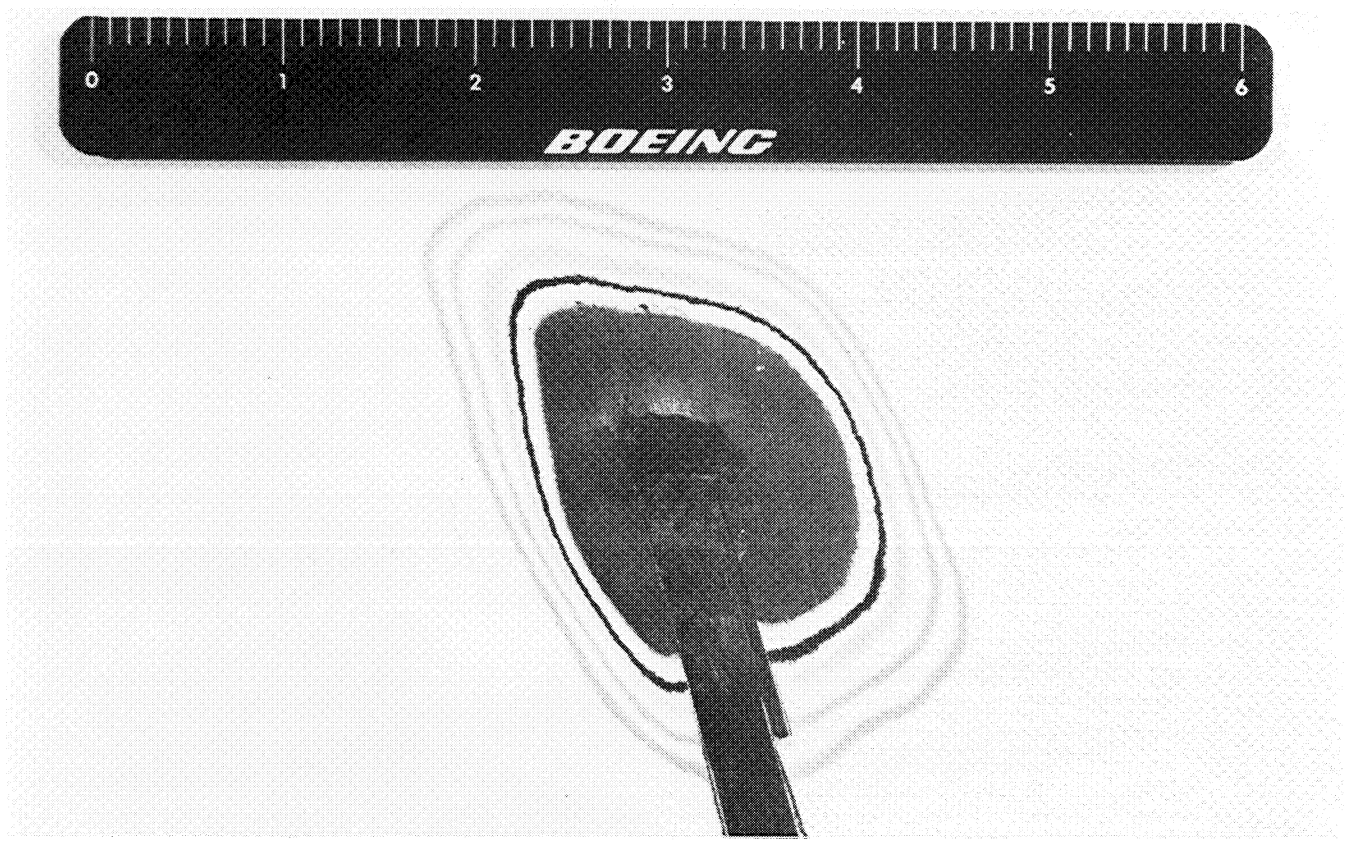

Figure 43. Blister Detail of Spoiler S/N 0044 After 10 Years of Service

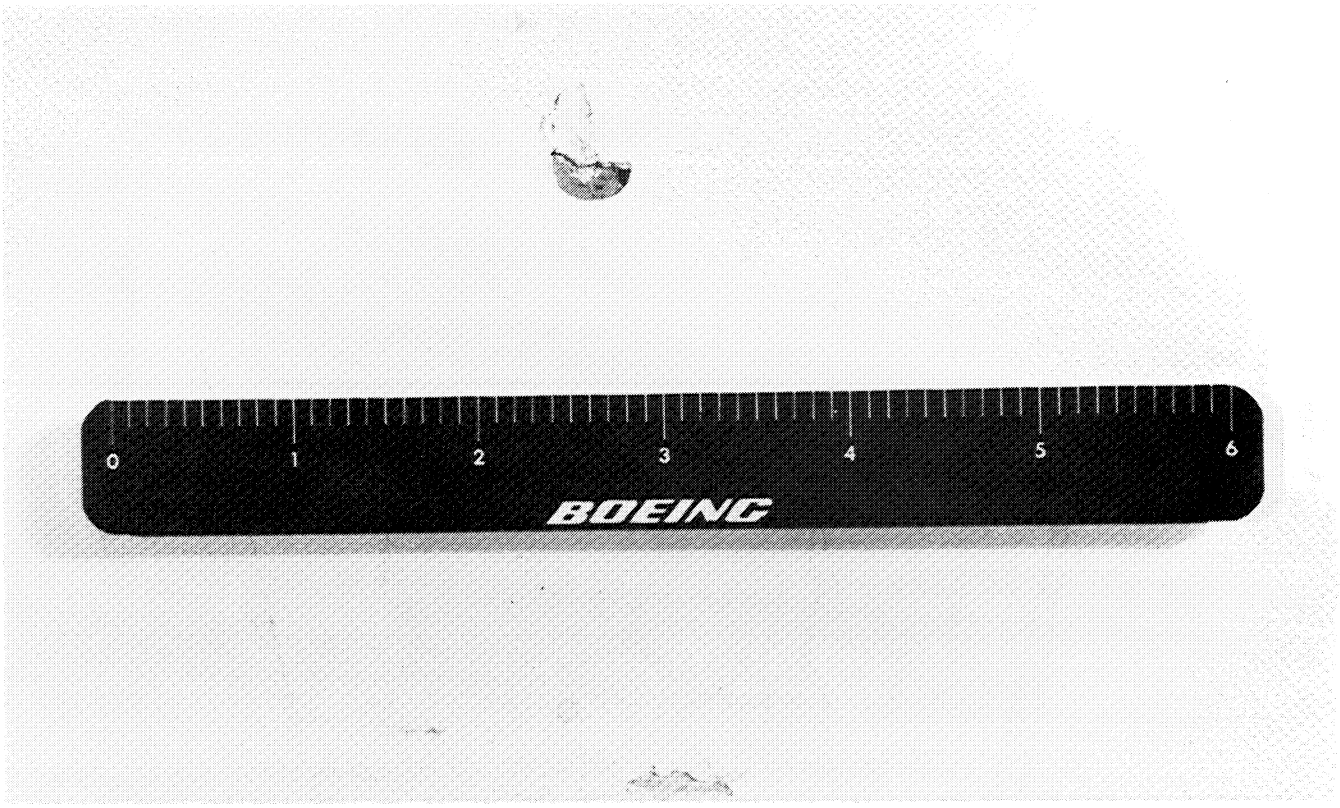

Figure 44. Surface Detail of Spoiler S/N 0044 After 10 Years of Service

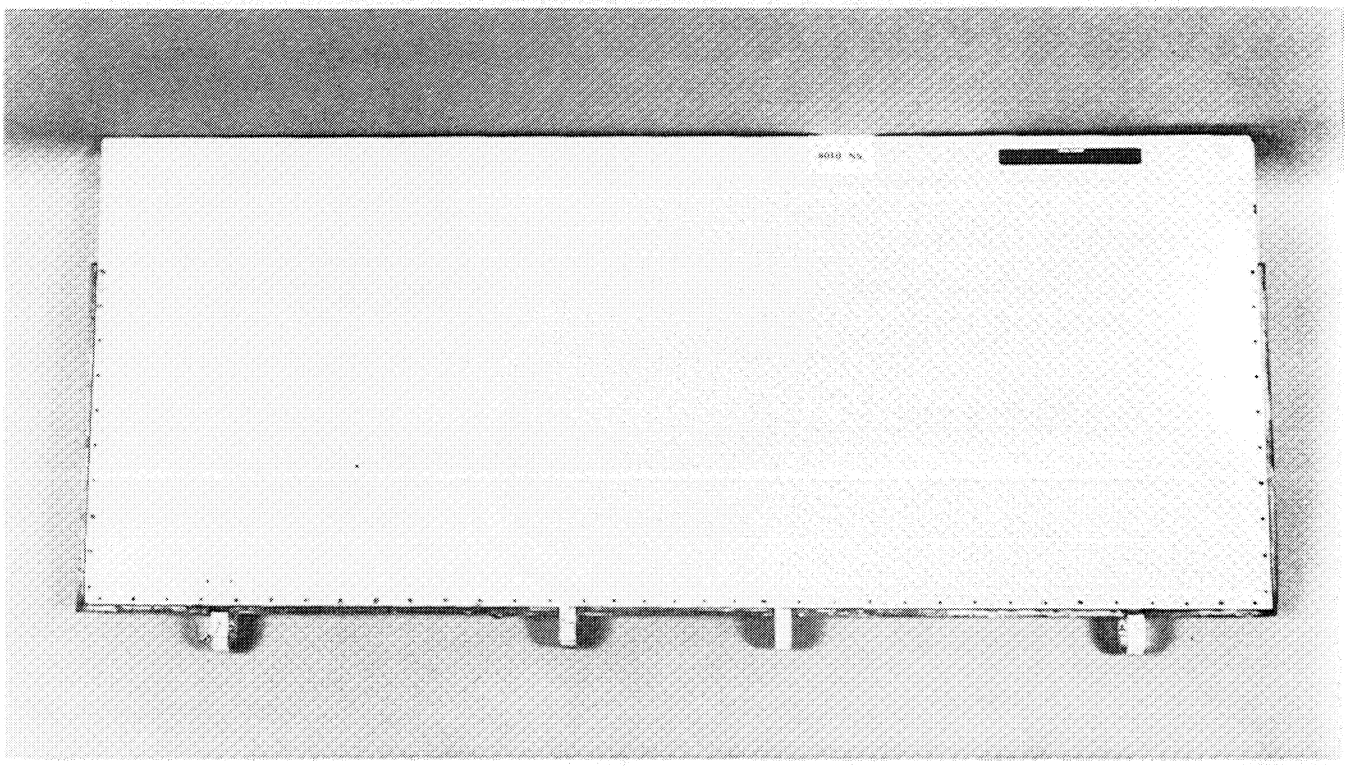

Figure 45. Upper Surface of Spoiler S/N 0108 After 10 Years of Service

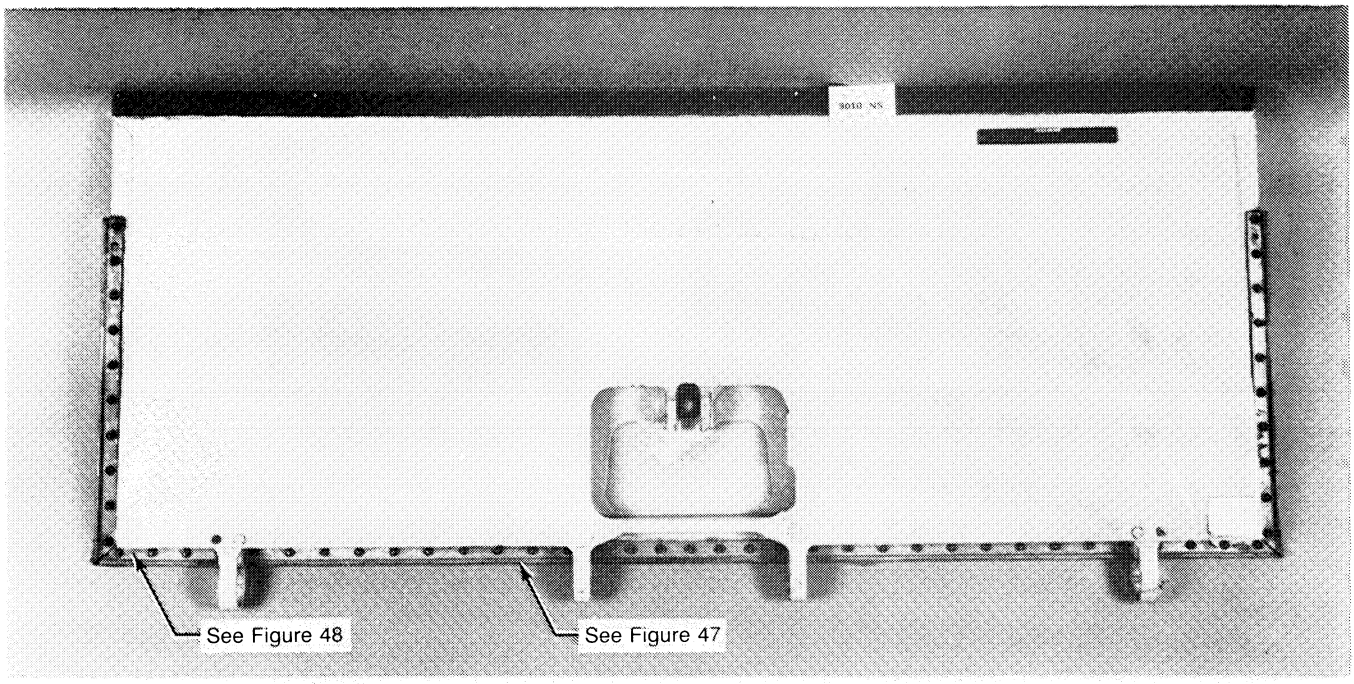

Figure 46. Lower Surface of Spoiler S/N 0108 After 10 Years of Service

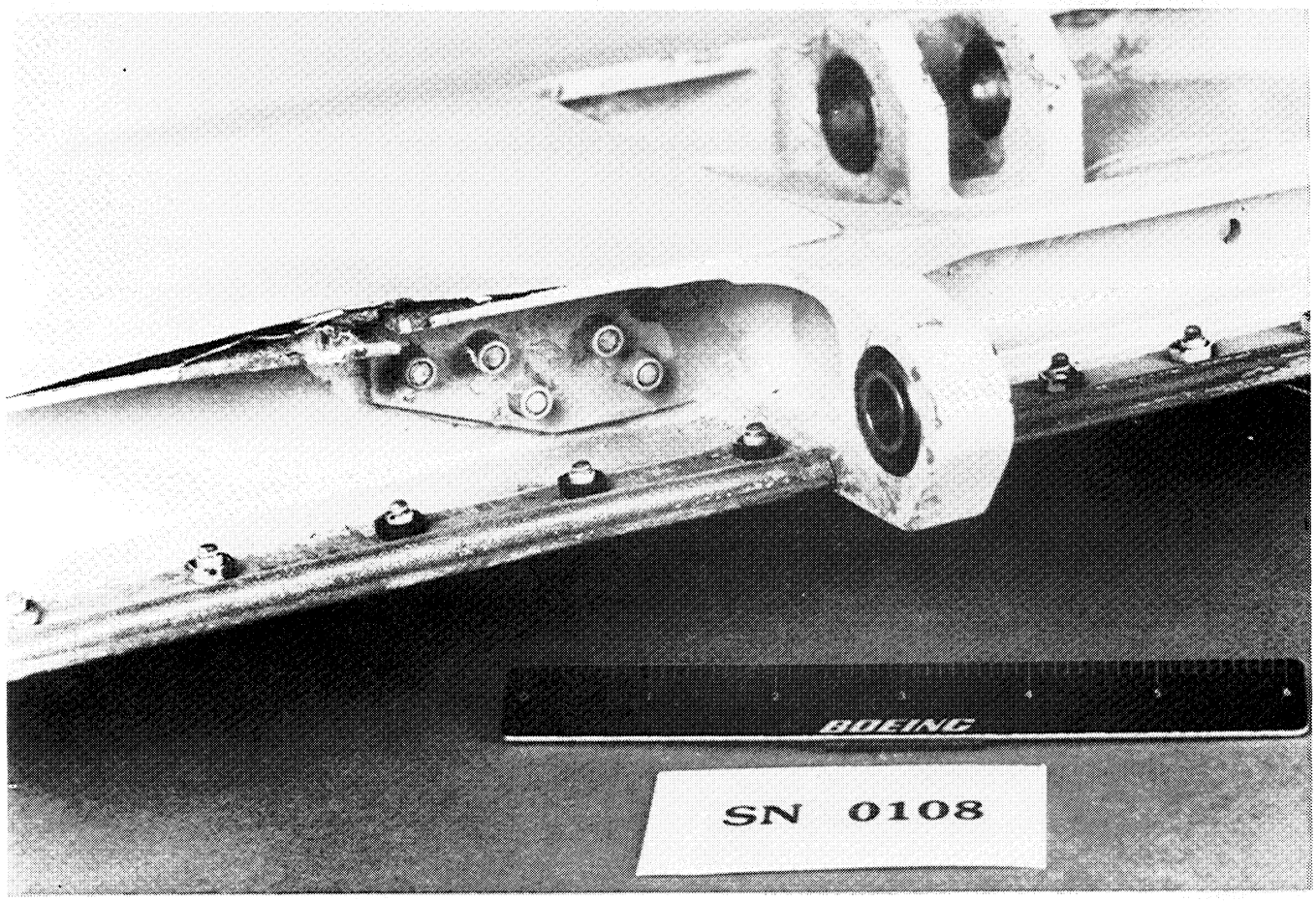

Figure 47. Hinge Detail of Spoiler S/N 0108 After 10 Years of Service

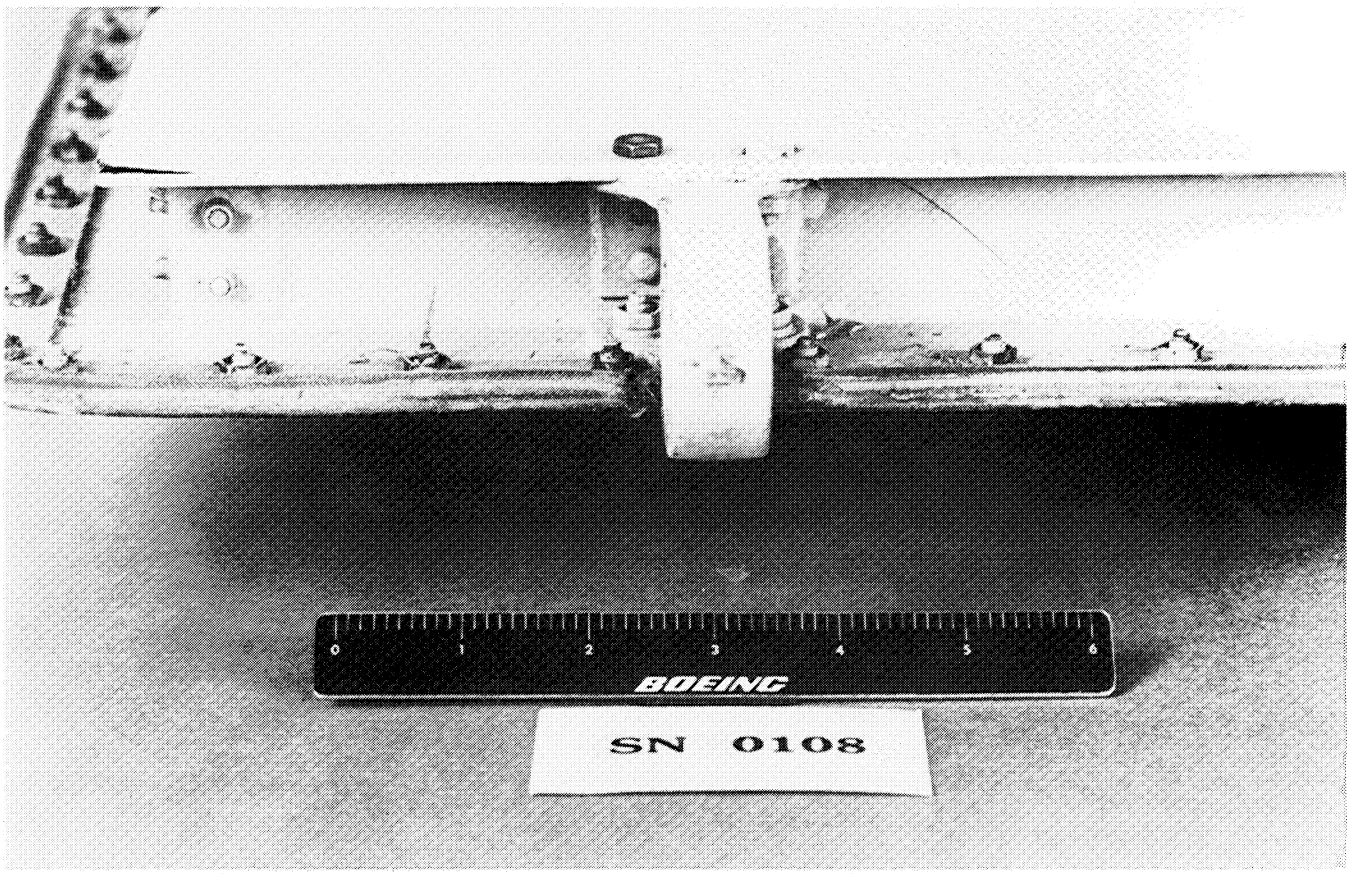

Figure 48. Corner Detail of Spoiler S/N 0108 After 10 Years of Service

Spoiler identification number	Airline	NDI Results	Failure load, % DLL	Strength change, %	Stiffness change, %	Time in service	Flight-hours	Flight-cycles
-1-0015	VASP	See text	120	-51.2	-11.1	84 months 8 days	15,544	18,008
-1-0008	Air New Zealand	See text	167	-32.1	-6	87 months 13 days	15,274	20,592
-2-0049	Aloha	See text	284	-1.7	+ 16.6	81 months 27 days	10,785	28,925
-2-0070	Piedmont	Clear	Not tested			84 months 2 days	17,726	26,355
-3-0083	Lufthansa	Clear	Not tested			78 months 10 days	16,505	25,851
-3-0118	Piedmont	See text	227	-5.4	-8.8	84 months 1 day	18,367	26,460

[1] Reported in Ref. 8.

Table 4. Summary Data From Scheduled Spoiler Removals (Seventh Year)

Spoiler identification number	Airline	NDI Results	Failure load, % DLL	Strength change, %	Stiffness change, %	Time in service	Flight-hours	Flight-cycles
-1-0033	Piedmont	See text	160	-35.0	-12.0	95 months 23 days	20,364	29,817
-2-0051	Air New Zealand	See text	210	-27.3	8.8	99 months 11 days	17,141	23,328
-3-0085	Lufthansa	See text	240	0	-36.9	93 months 29 days	18,114	28,850
-1-0038	Aloha	—	239	-2.8	6.0	90 months 15 days	12,748	34,940
-3-0082	Lufthansa	Blister	140	-41.7	-43.5	94 months 7 days	18,120	29,918

Table 5. Summary Data From Scheduled Spoiler Removals (Eighth Year)

Spoiler identification number	Airline	NDI Results	Failure load, % DLL	Strength change, %	Stiffness change, %	Time in service	Flight-hours	Flight-cycles
-1-0029	Piedmont	—	236	-4.1	+ 12.6	108 months 28 days	23,433	33,770
-2-0064	Lufthansa	—	269	-6.9	+ 6.6	111 months 12 days	21,602	25,738
-3-0102	Piedmont	—	243	+ 1.3	+ 5.5	110 months 12 days	23,595	34,422

Table 6. Summary Data From Scheduled Spoiler Removals (Ninth Year)

Spoiler identification number	Airline	NDI Results	Failure load, % DLL	Strength change, %	Stiffness change, %	Time in service	Flight-hours	Flight-cycles
-1-0018	VASP		230	-23.6	+ 10.8	125 months 15 days	23,956	27,633
-2-0044	Frontier		291	+ 0.7	+ 20.4	123 months 26 days	28,337	33,767
-3-0108	VASP		188	-21.7	-2.1	121 months 2 days	23,131	26,385

Table 7. Summary Data From Scheduled Spoiler Removals (Tenth Year)

49 shows the residual static strength data accumulated to date. Each symbol represents one test of a particular spoiler dash number (i.e., type of skin material) after a predesignated period of time. Initials near the symbols indicate the airline from which the spoiler was removed. The data are shown as a residual strength ratio, where 1.0 is the original unexposed certification test value for each material system. The shaded area represents the scatter band for a total of 16 ultimate tests run on unexposed -2 units. Although limited to one production run of only one of the three types of material, the band provides some idea of the minimum scatter that could be expected. The limit and ultimate load requirements for each material system are also shown in the figure. The units with known significant damage all failed above design limit load thus meeting safe operating criteria. Figures 50 through 63 are plots of the load-deflection data for 14 spoilers reported in this document.

Figure 64 shows the test setup. Load is applied to the upper surface through an evener system and load pad scheme. The load is then reacted at the four hinge points and the actuator rod end.

Figures 65 and 66 are photographs of a typical spoilers after testing. A typical failure would be initiated through a hinge fitting splice location. Often the center hinge fitting is pushed through the upper surface upon failure.

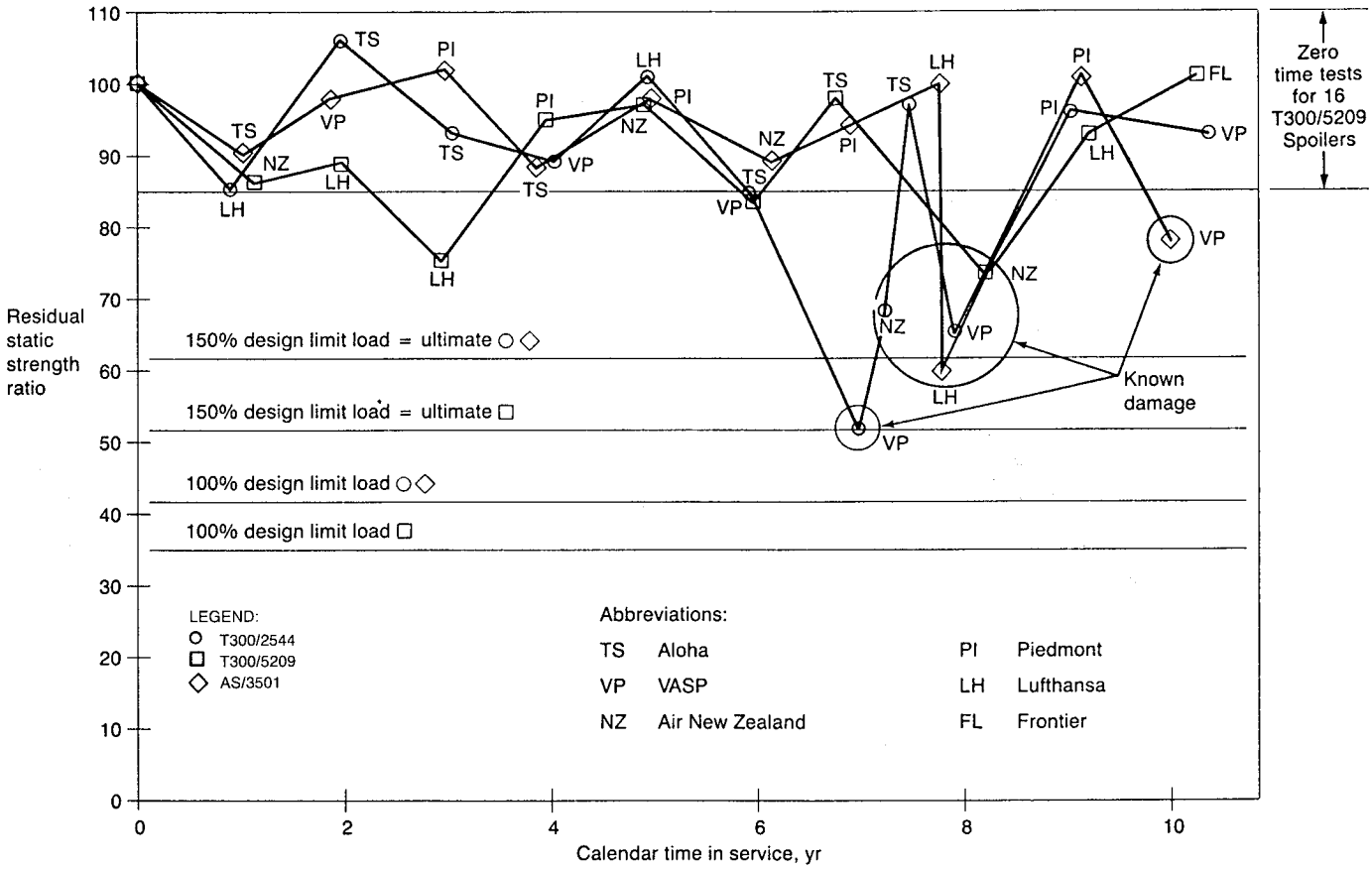

Figure 49. Summary of Residual Strength After Exposure

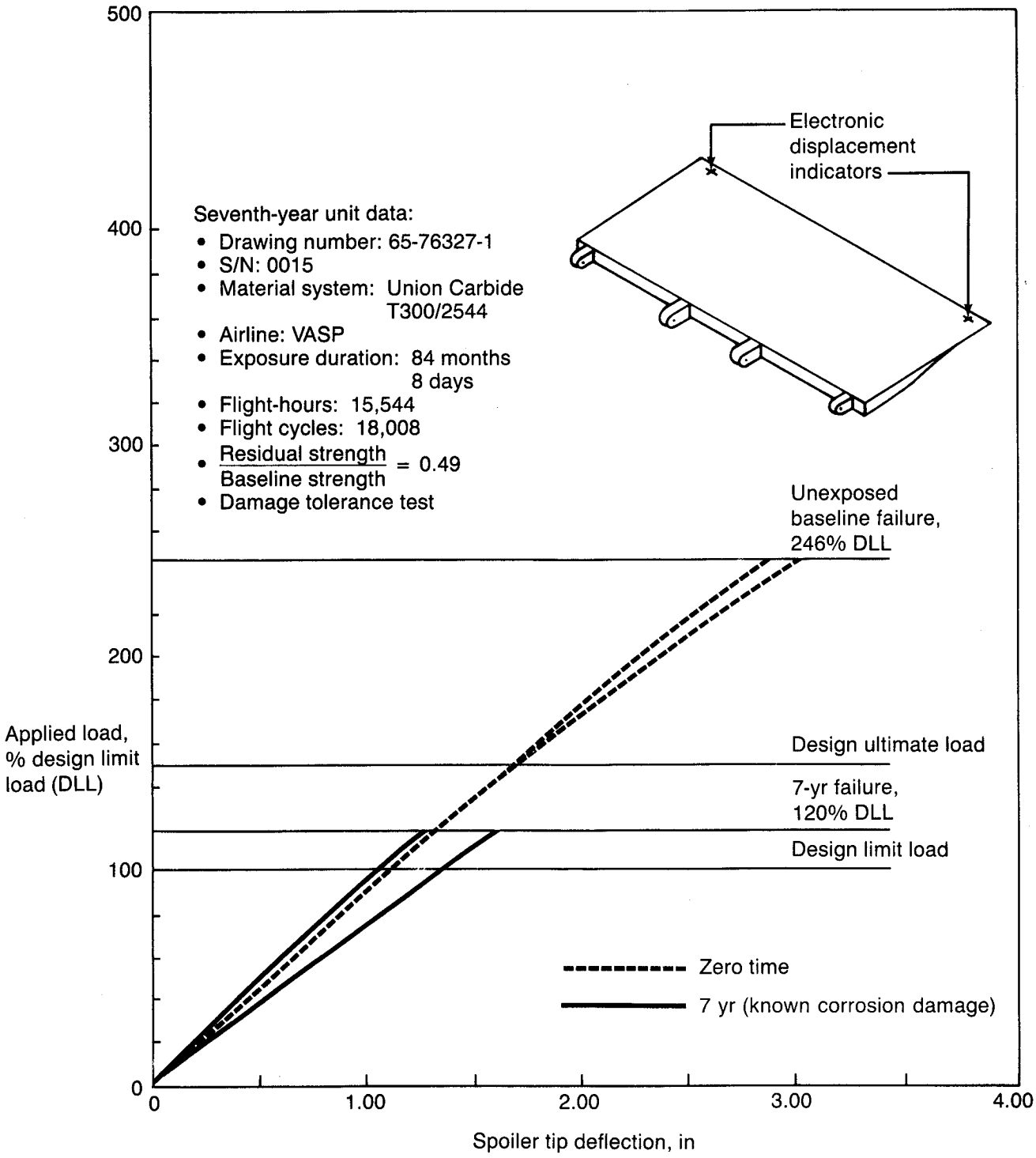

Figure 50. Residual Strength and Stiffness of Spoiler S/N 0015 After 7 Years of Service

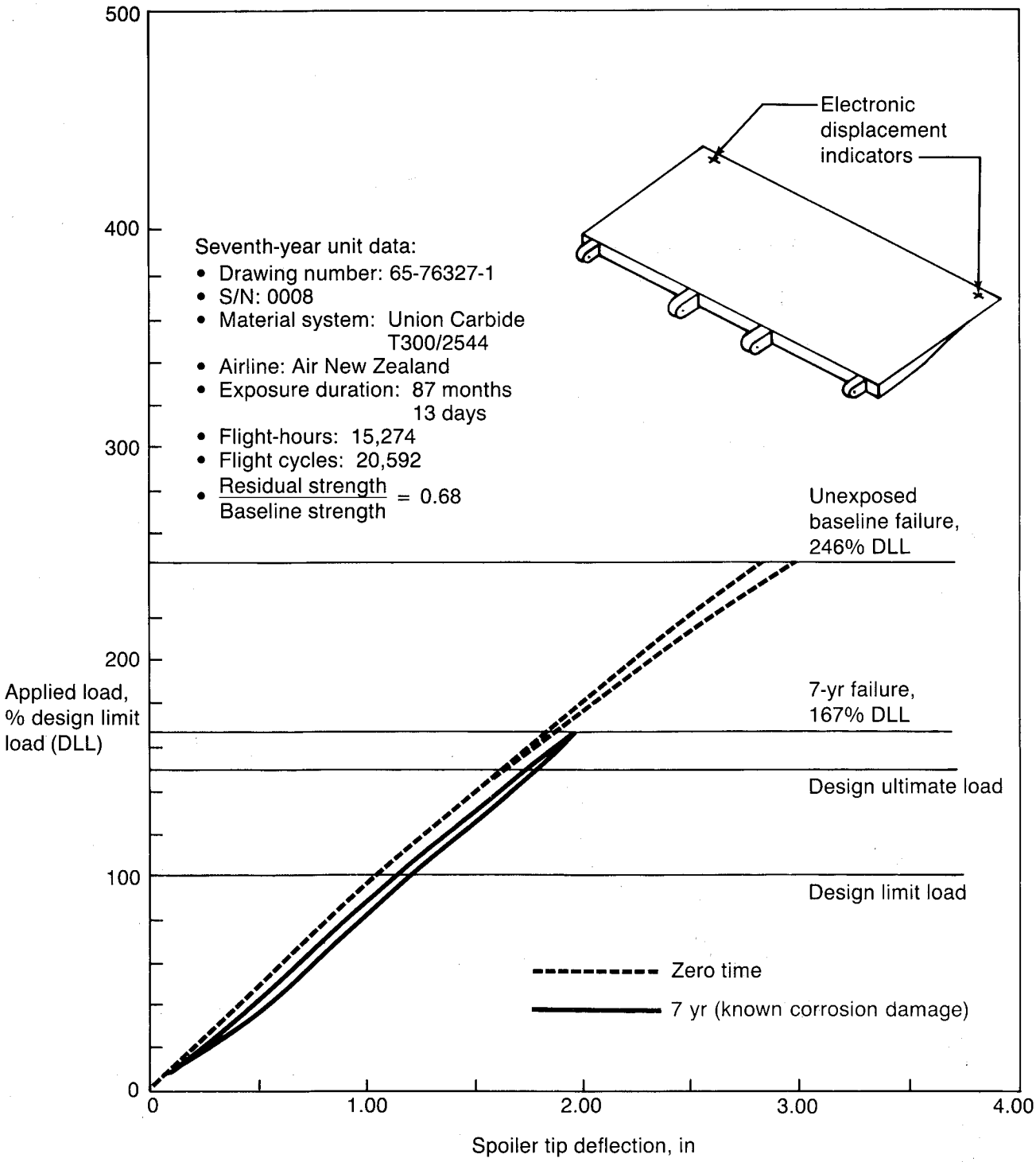

Figure 51. Residual Strength and Stiffness of Spoiler S/N 0008 After 7 Years of Service

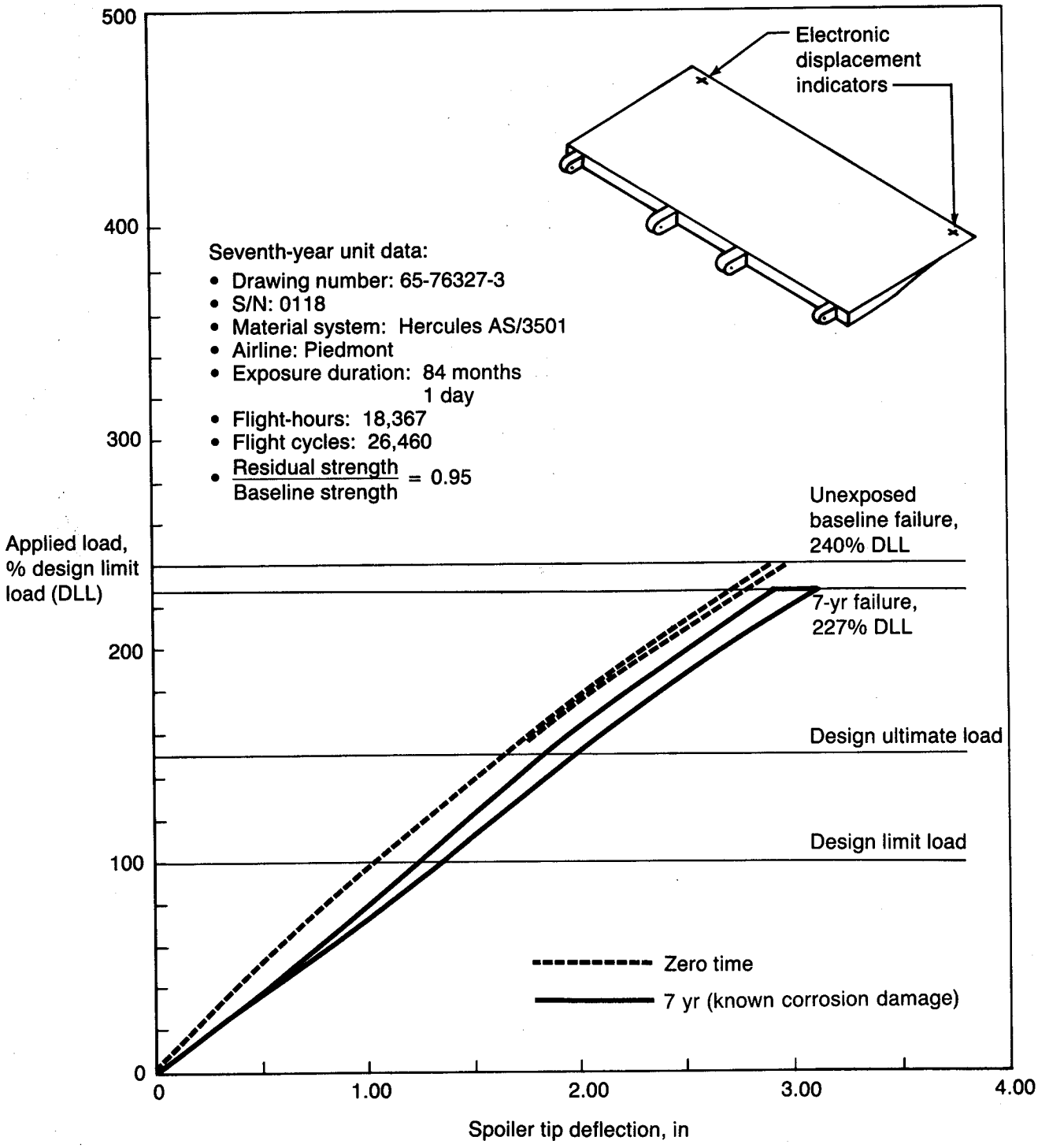

Figure 52. Residual Strength and Stiffness of Spoiler S/N 0118 After 7 Years of Service

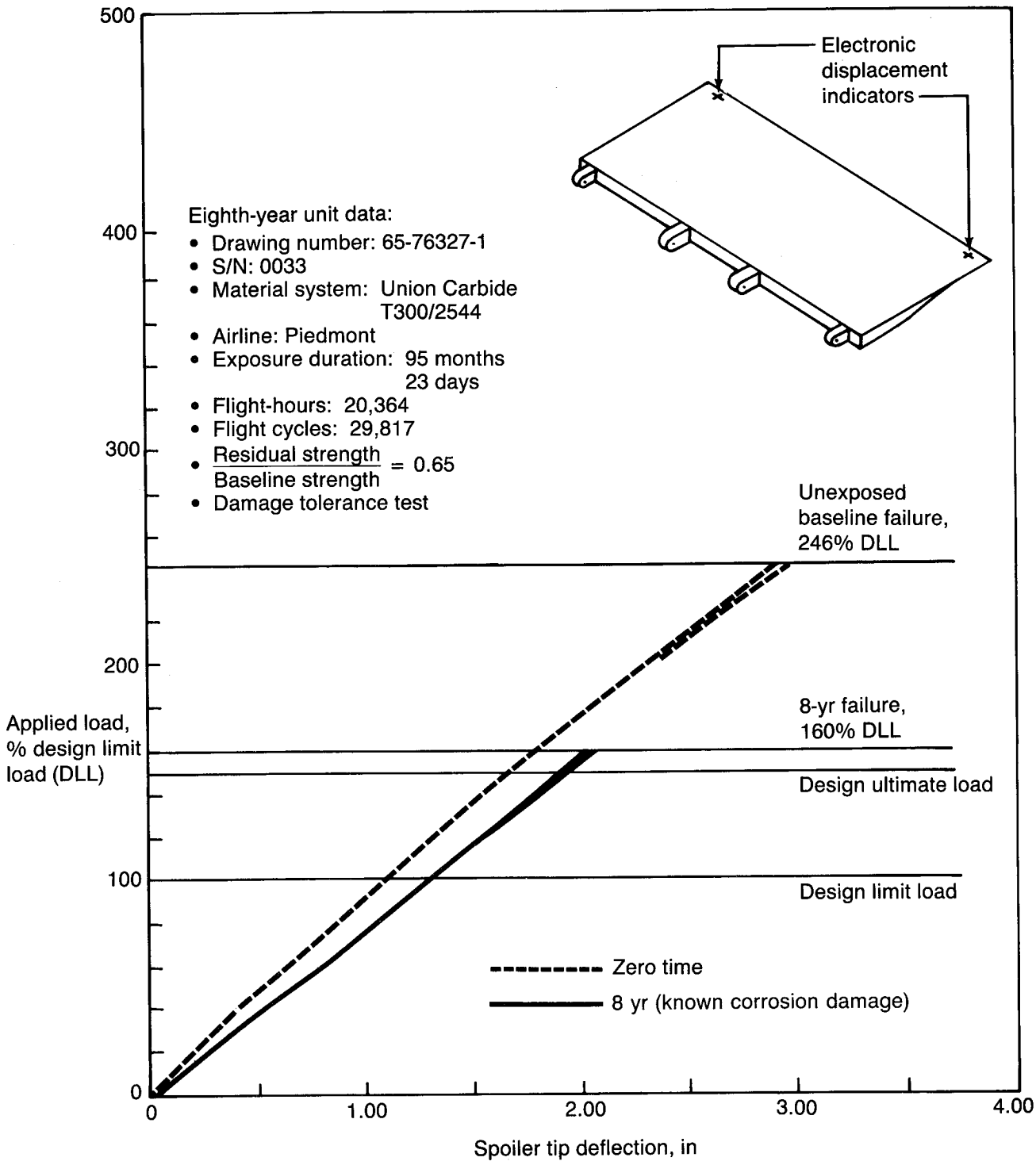

Figure 53. Residual Strength and Stiffness of Spoiler S/N 0033 After 8 Years of Service

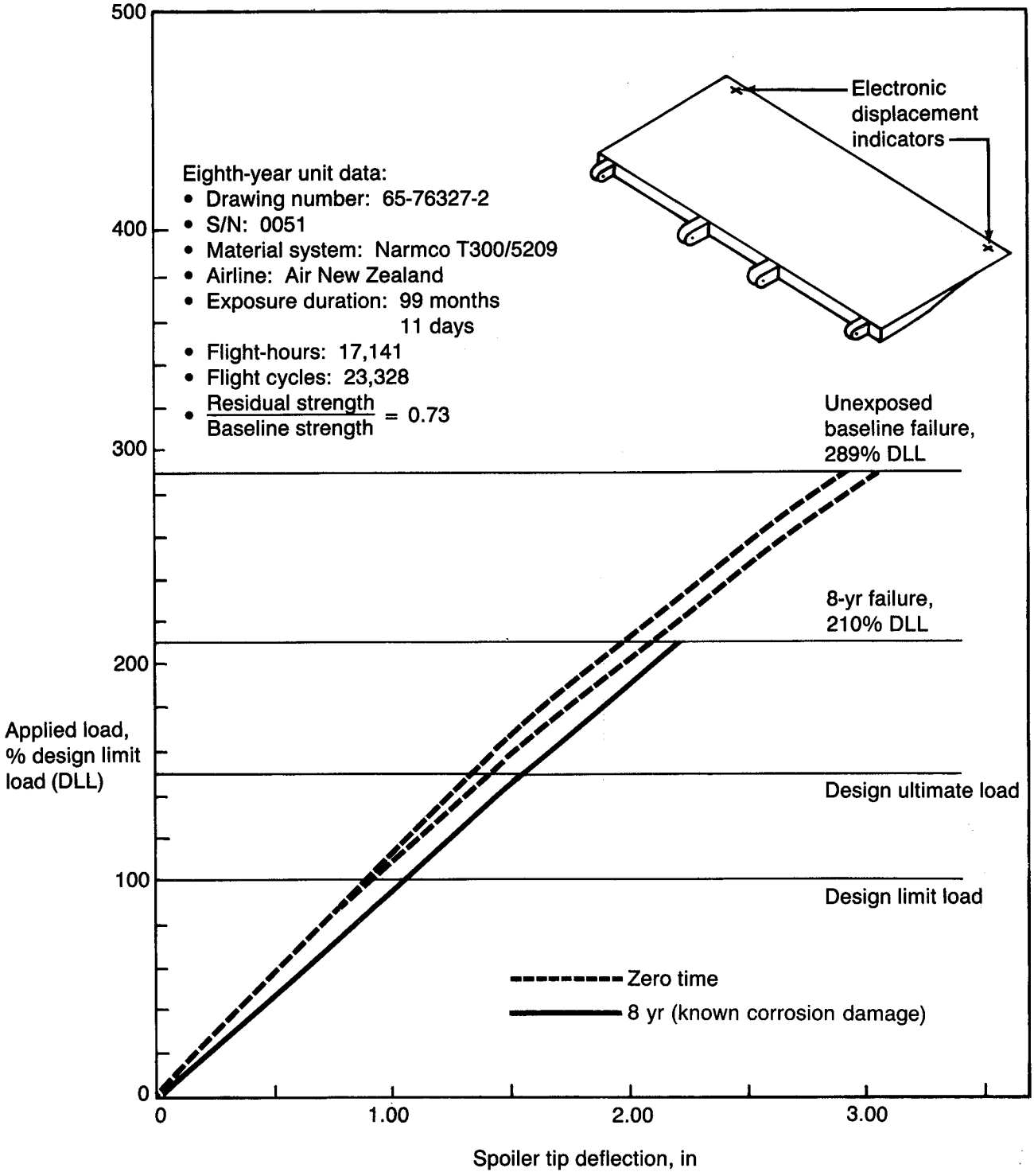

Figure 54. Residual Strength and Stiffness of Spoiler S/N 0051 After 8 Years of Service

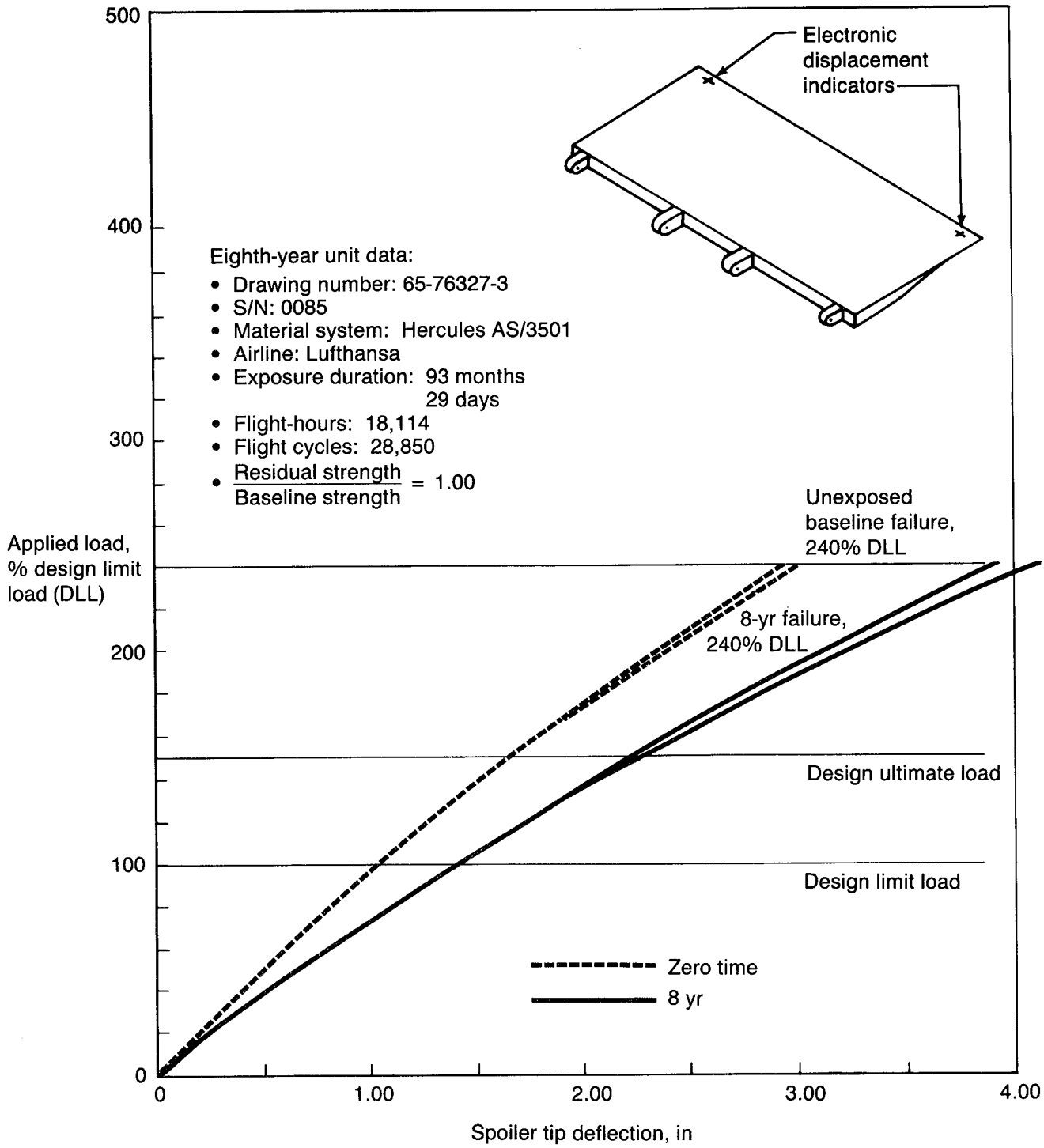

Figure 55. Residual Strength and Stiffness of Spoiler S/N 0085 After 8 Years of Service

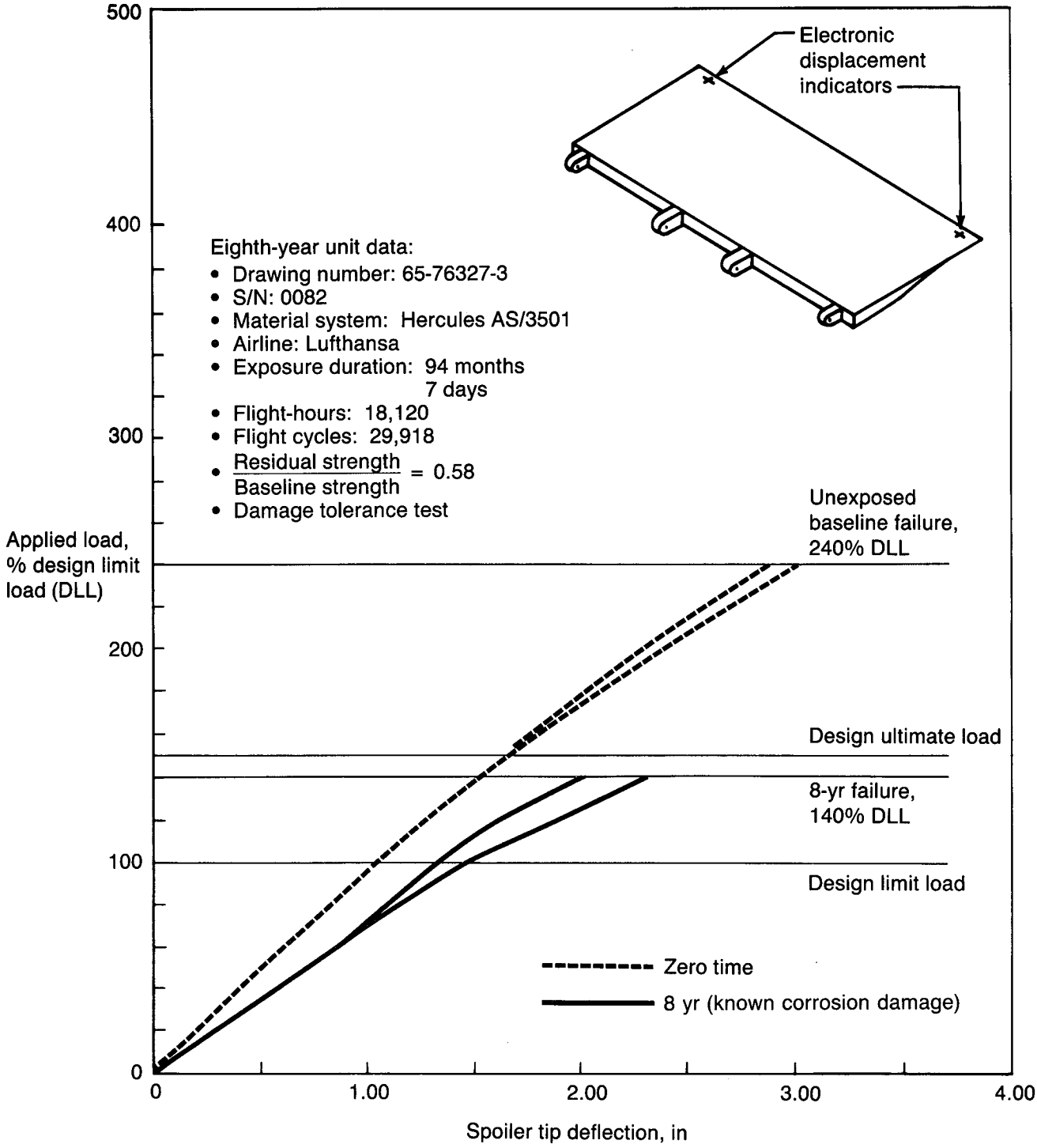

Figure 56. Residual Strength and Stiffness of Spoiler S/N 0082 After 8 Years of Service

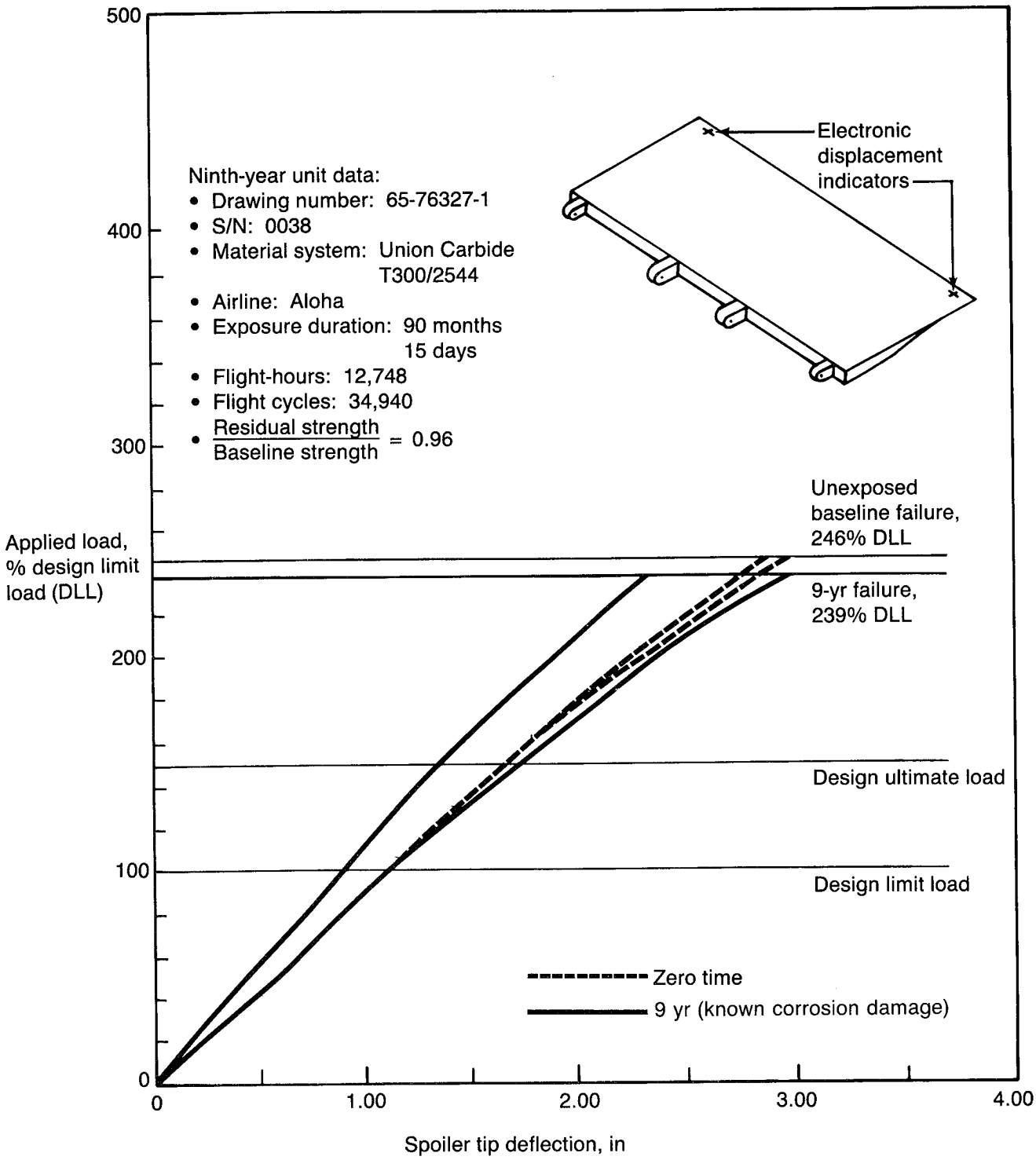

Figure 57. Residual Strength and Stiffness of Spoiler S/N 0038 After 9 Years of Service

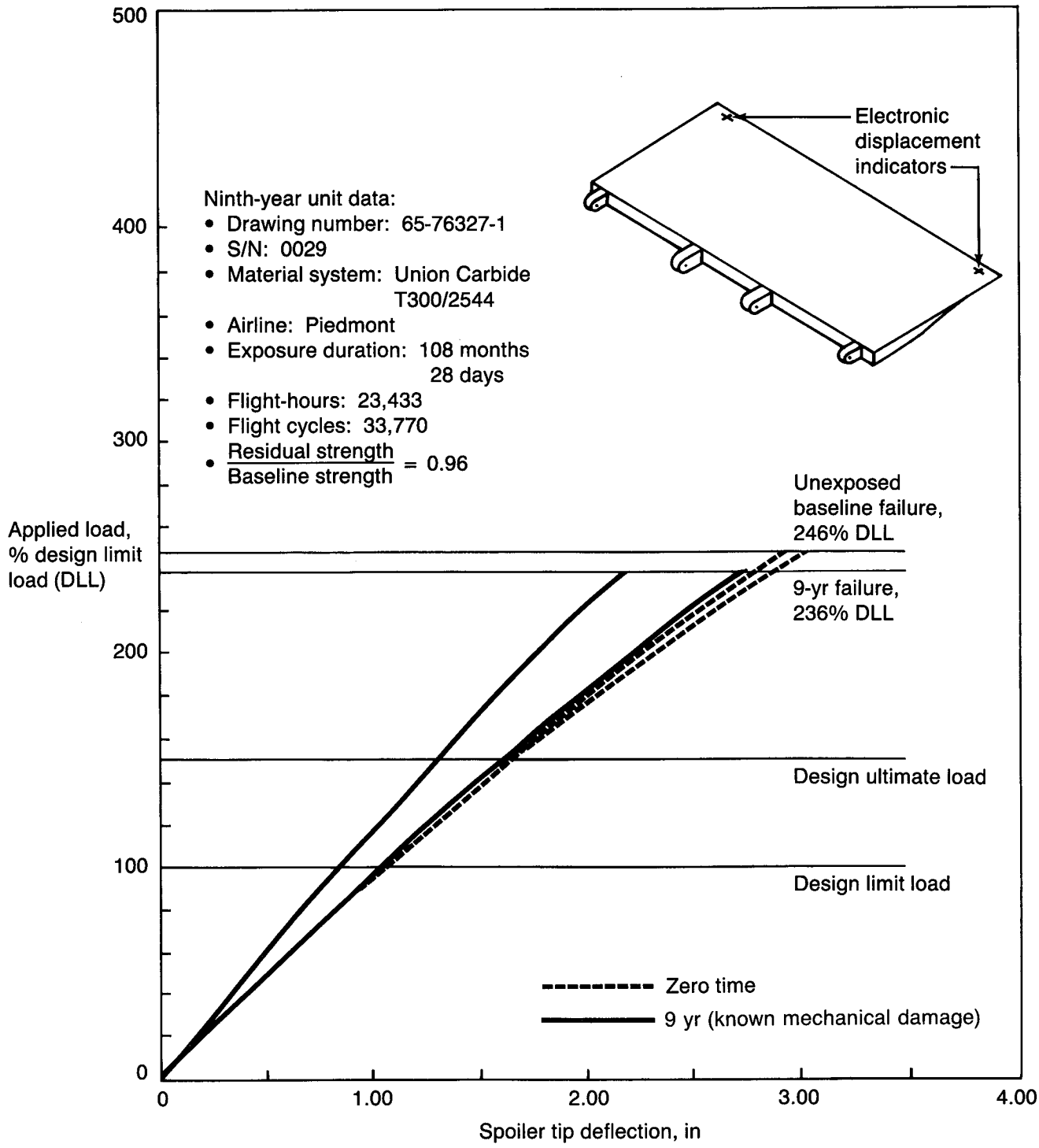

Figure 58. Residual Strength and Stiffness of Spoiler S/N 0029 After 9 Years of Service

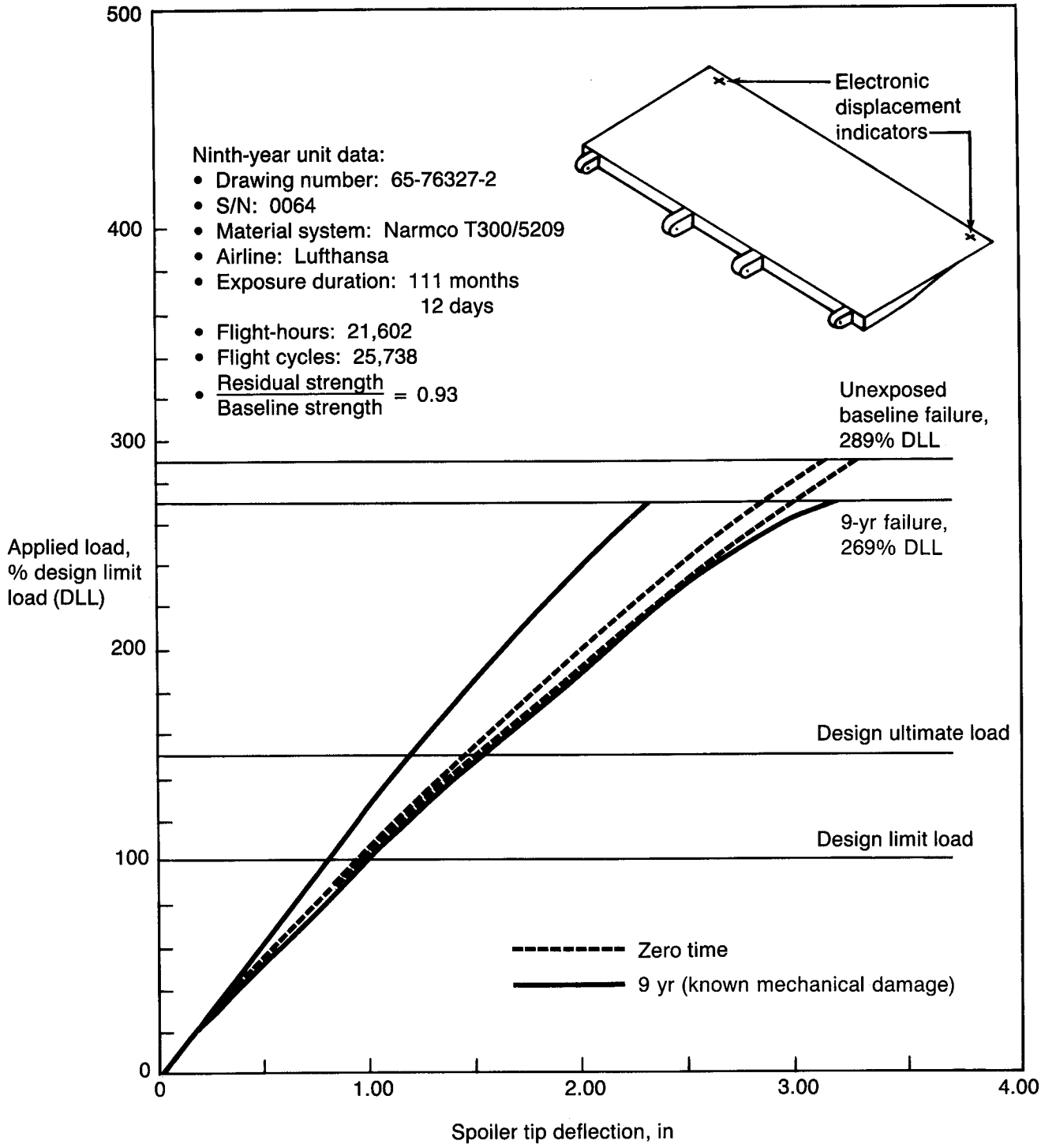

Figure 59. Residual Strength and Stiffness of Spoiler S/N 0064 After 9 Years of Service

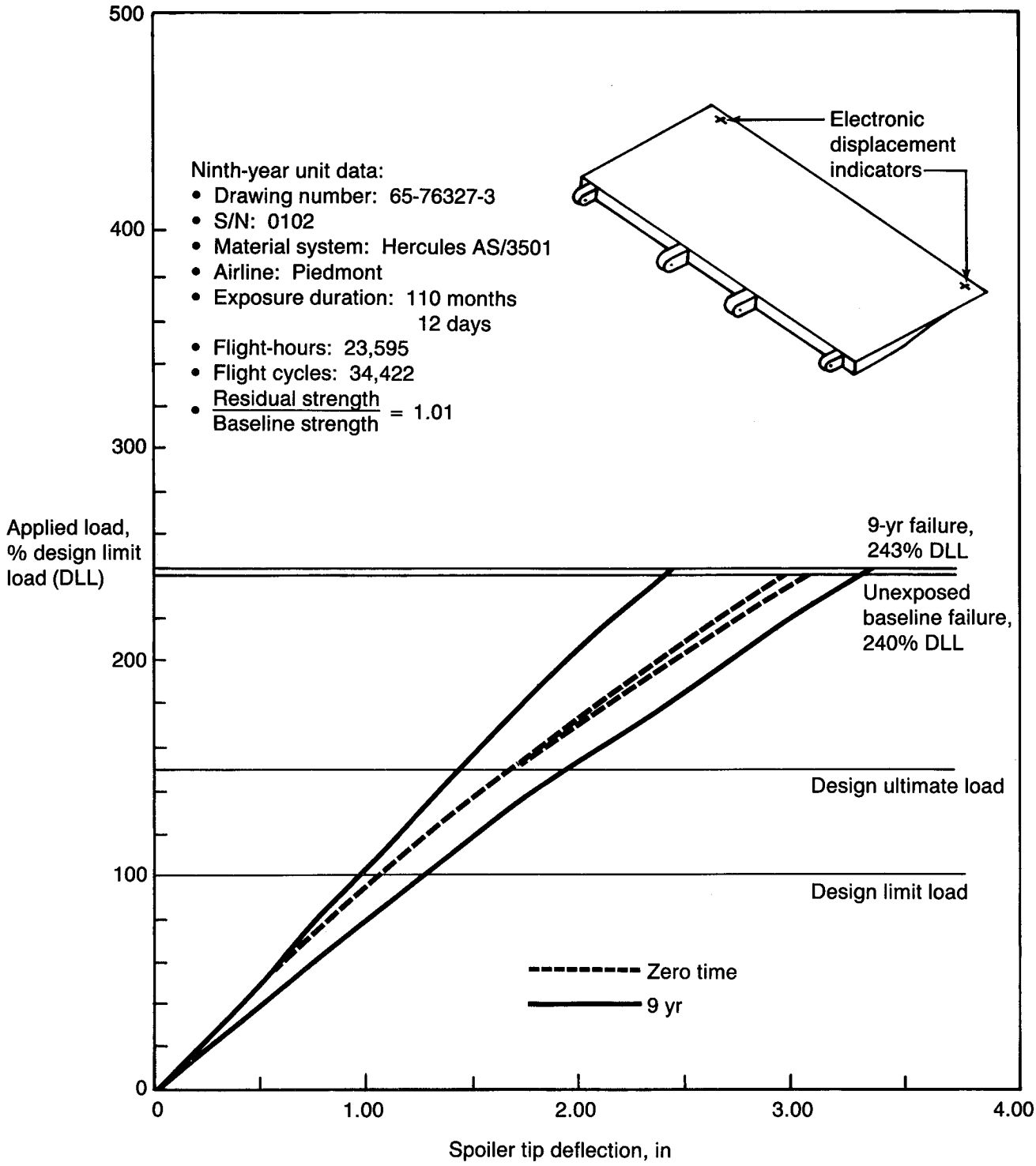

Figure 60. Residual Strength and Stiffness of Spoiler S/N 0102 After 9 Years of Service

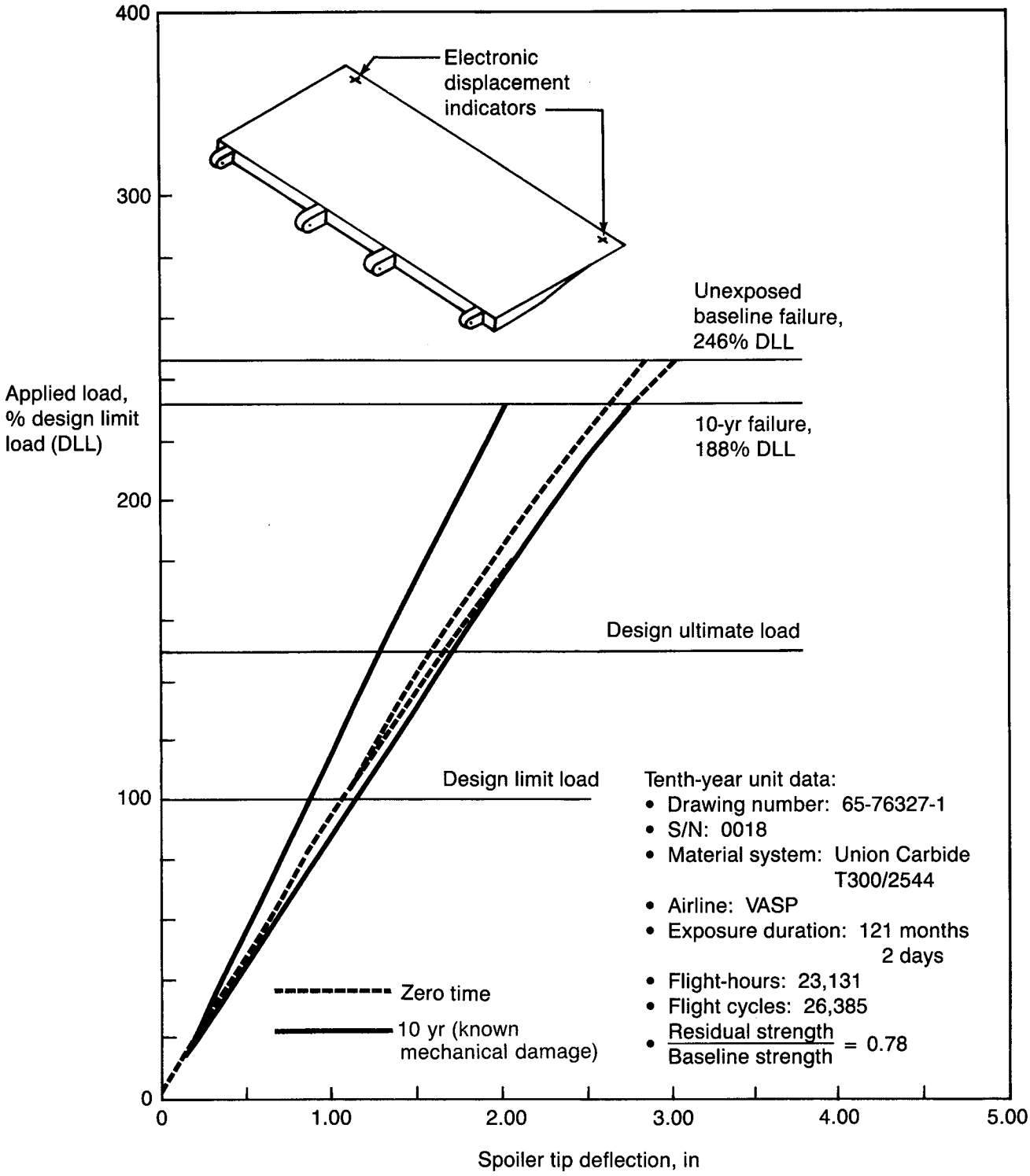

Figure 61. Residual Strength and Stiffness of Spoiler S/N 0018 After 10 Years of Service

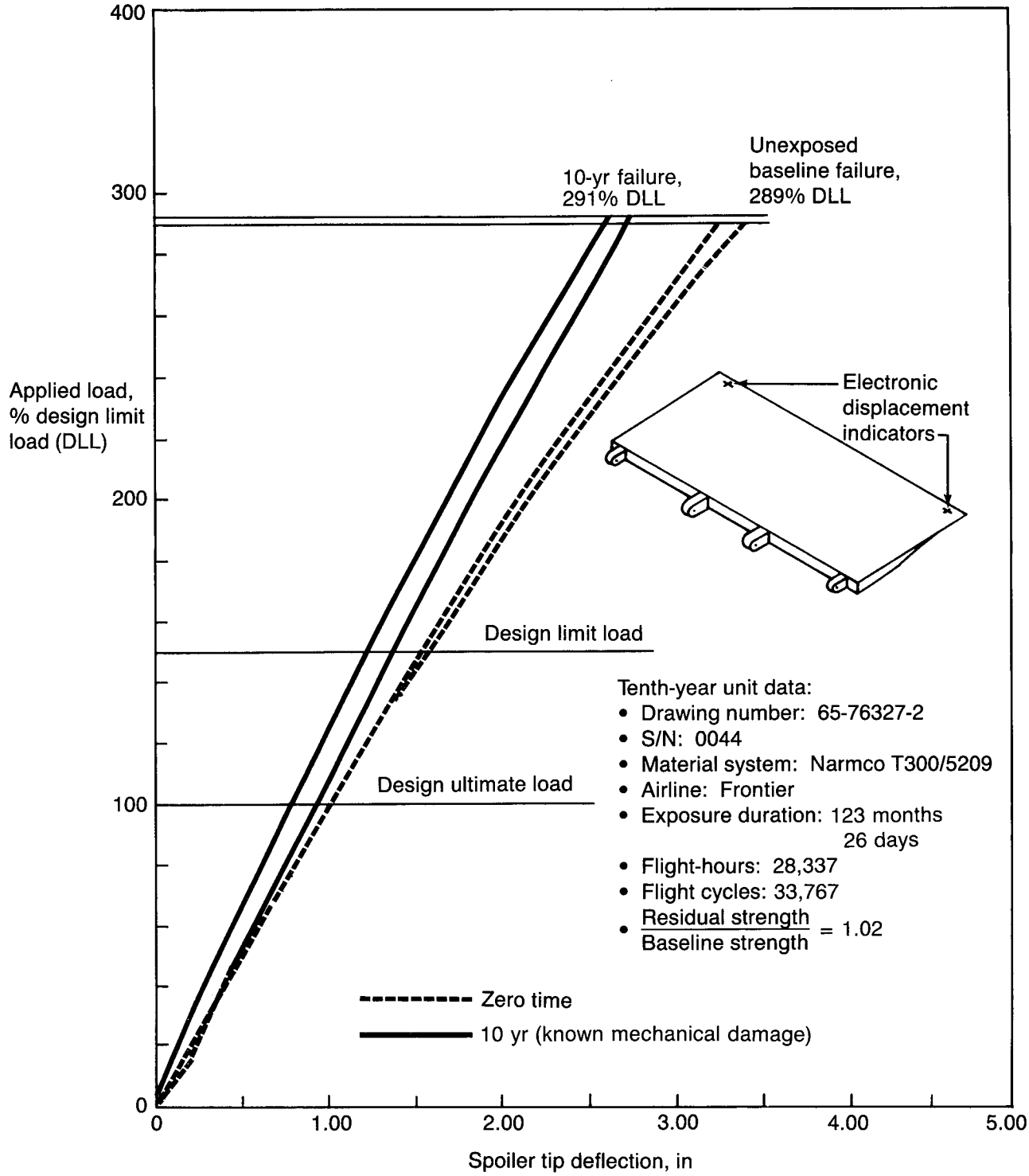

Figure 62. Residual Strength and Stiffness of Spoiler S/N 0044 After 10 Years of Service

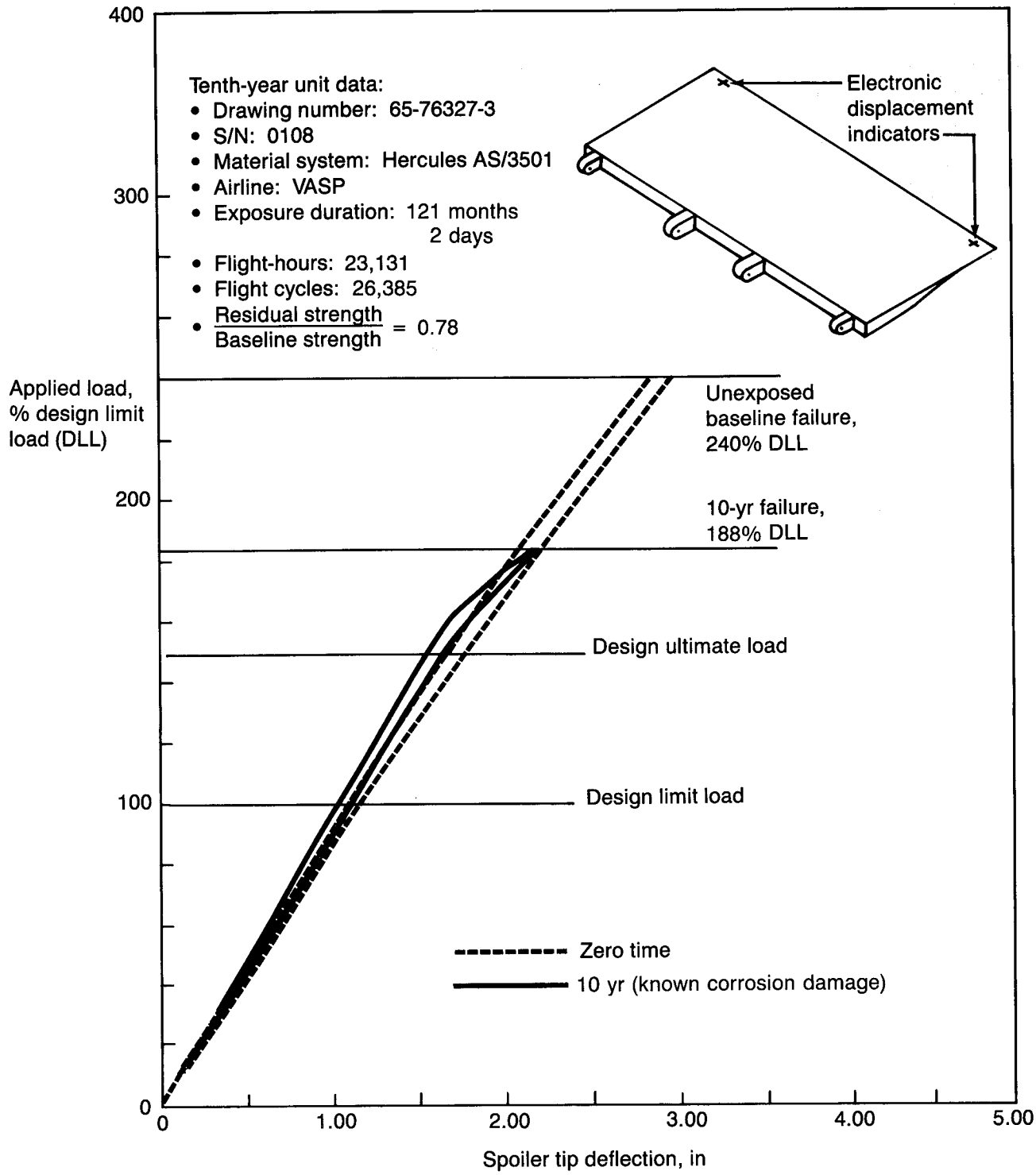

Figure 63. Residual Strength and Stiffness of Spoiler S/N 0108 After 10 Years of Service

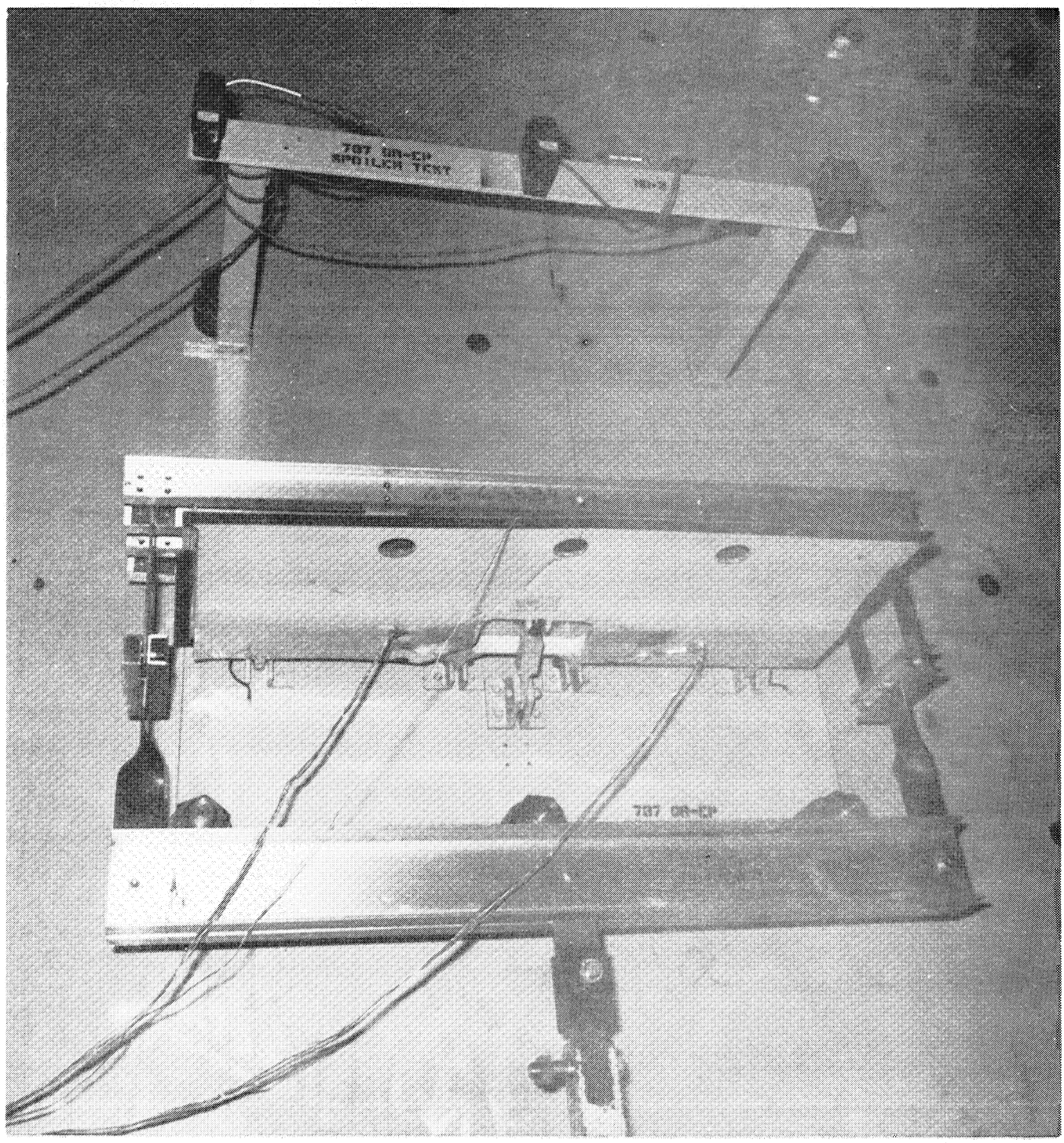

Figure 64. Spoiler Residual Strength Test Setup

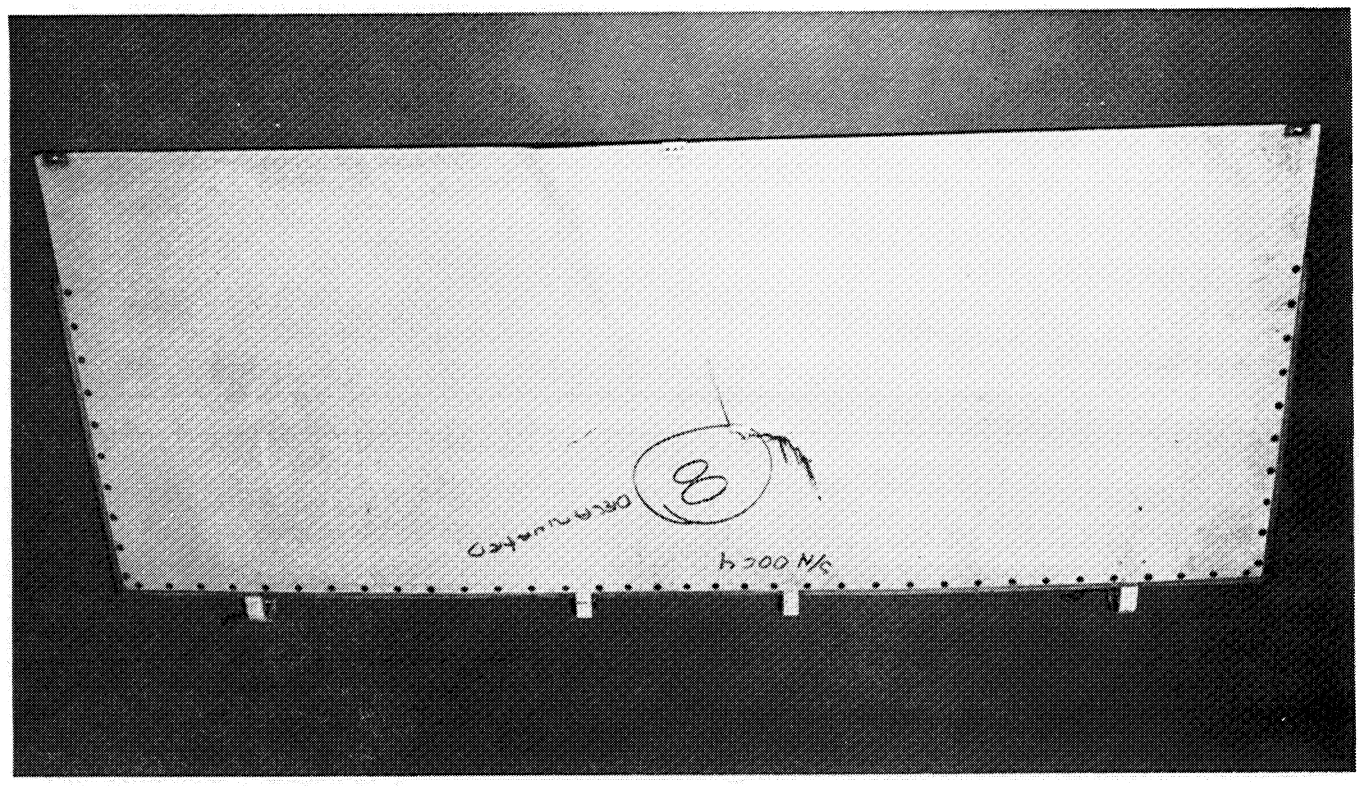

Figure 65. Upper Surface of Spoiler S/N 0064 Following Residual Strength Test

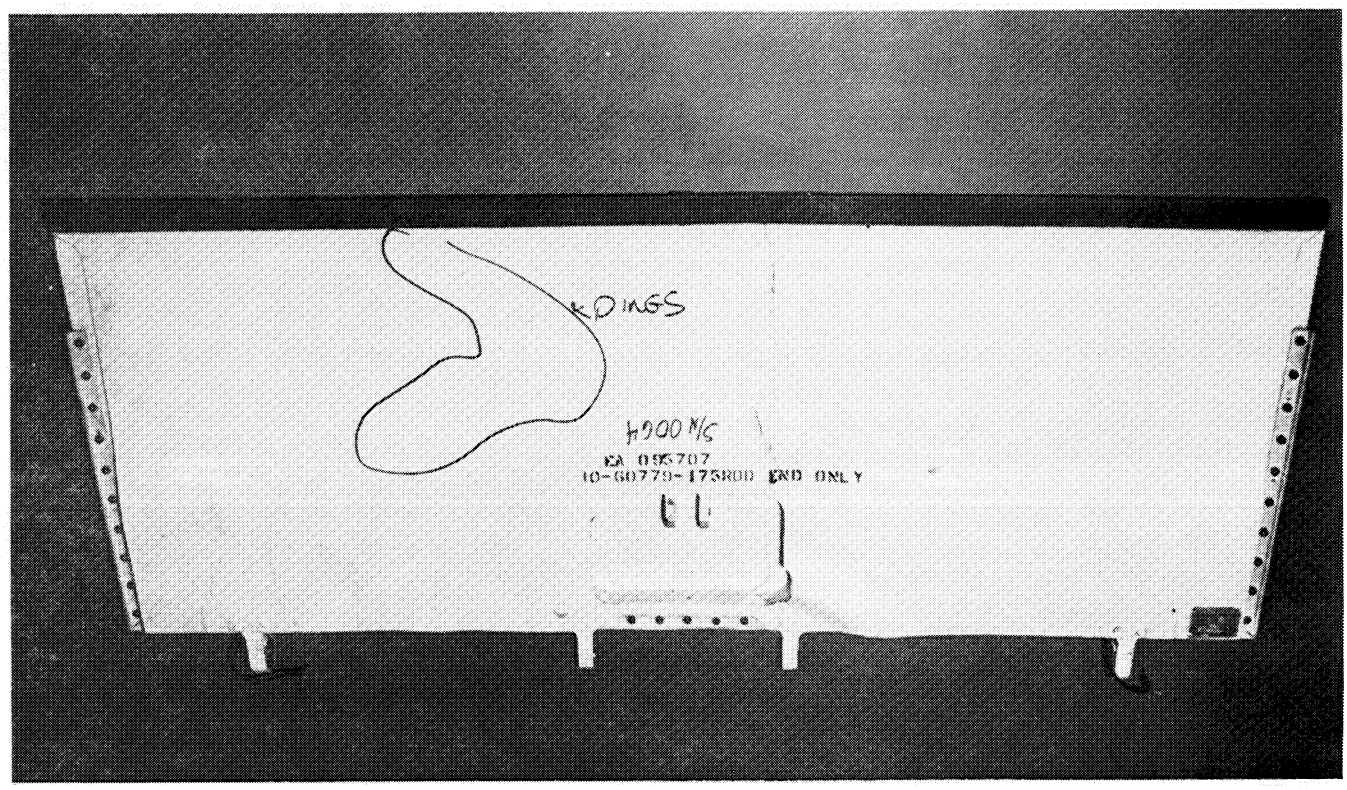

Figure 66. Lower Surface of Spoiler S/N 0064 Following Residual Strength Test

MOISTURE ABSORPTION CORE SAMPLING

As a continuation of the moisture sampling technique initiated and described in Reference 4, additional core plug samples were obtained from the spoiler panels that were static tested for residual strength. Each spoiler had three core plug samples removed. Each plug was a 2.25-in-dia cylindrical section approximately 0.4 in deep containing:

- Upper- and lower-surface paint films
- Upper and lower graphite-epoxy skins
- Two skin-to-core bonds
- The aluminum honeycomb core

All core specimens were subjected to a drying environment at 160°F. The samples were weighed in order to construct a final observed graphite-epoxy moisture content. This moisture content data is shown plotted against time on Figure 67.

The calculated moisture content was based on the observed weight changes during dryout and the following assumptions:

- The aluminum honeycomb core had no moisture
- All three polymeric materials (paint, composite matrix, and adhesive bondlines) contained the same level of moisture

Moisture content (MC) was calculated by the following formula:

$$MC = \frac{(W)(W_{DM})}{(W_{DP})(W_{DC})} \times 100$$

where:

W = observed weight loss (grams)
W_{DC} = weight of dry graphite-epoxy composite skins (grams)
W_{DP} = weight of dry polymeric components in total core plug sample (grams)
W_{DM} = weight of dry composite matrix material (grams)

The observed weight loss, W, represents the difference between the as-cut wet spoiler plug weight and the final dryout weight. Values for the paint weight (0.547g), the adhesive weight (6.653g), and the aluminum core weight (1.066g) were determined analytically or experimentally. Subtracting these values from the dry plug weight gave the weight of the dry graphite-epoxy composite skins. Using typical fiber volume fraction and densities, it was determined that 70% of the skin weight was due to the fiber, and the remaining 30% was epoxy matrix.

Use of this procedure to determine graphite-epoxy moisture content should result in a calculated value slightly higher than actual. Both the paint and the adhesive should have moisture contents higher than the epoxy matrix. This error should be relatively small.

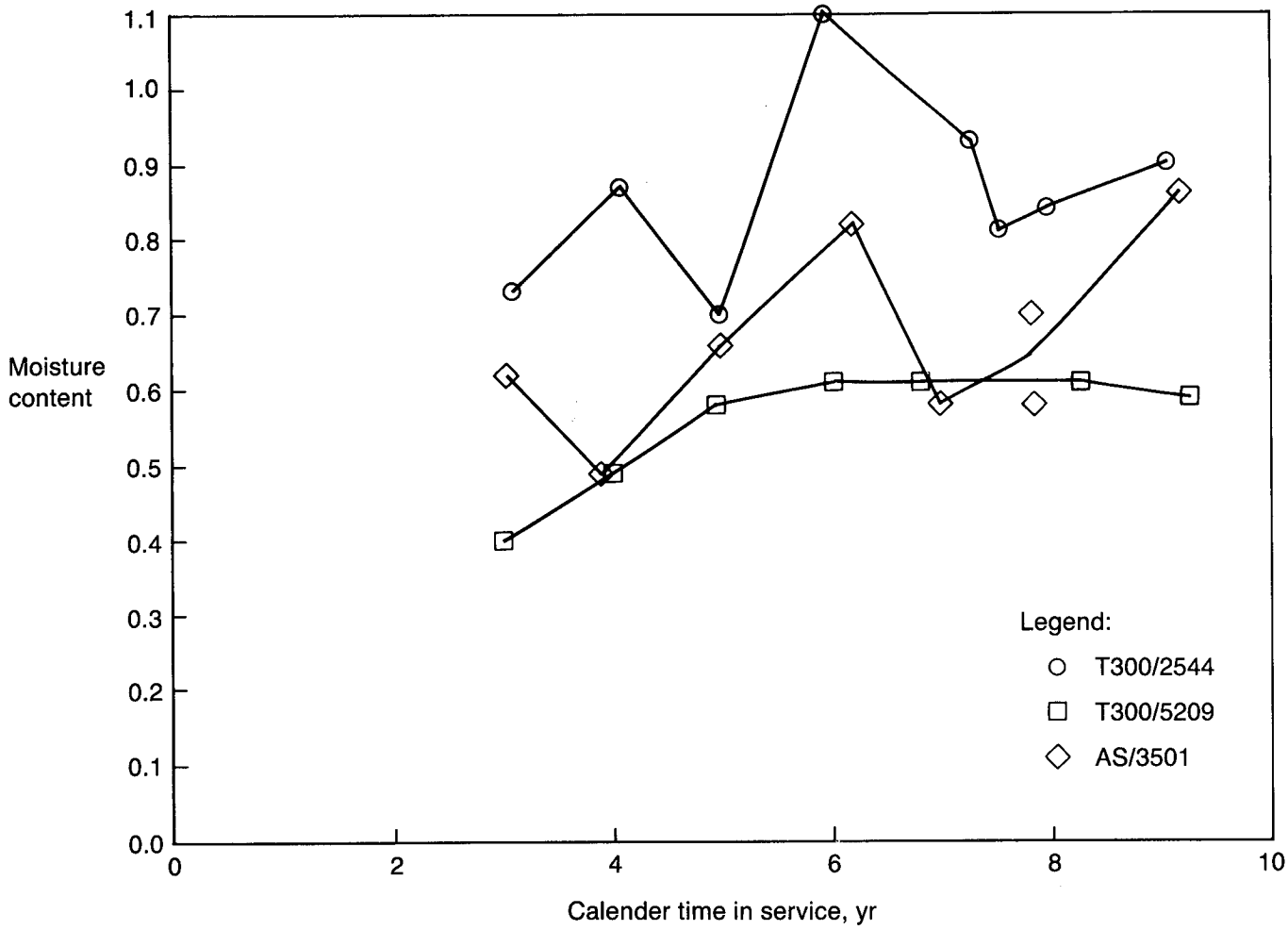

Figure 67. Moisture Weight Loss of Spoiler Core Samples

UNSCHEDULED SPOILER REMOVALS

The unscheduled removal of 15 spoilers occurred during this reporting period. Data for these spoilers are summarized in Table 8.

Tables 9 and 10 are summaries of flight-service defects observed during annual inspections and show the distribution and frequency of these defects. Table 7 includes observations (including composite skin repairs) made during the annual inspection in October 1982; Table 8 is a summary of 8 inspections made since inception of the program.

Because the rate of deterioration for several defects is slow, one incident (for example, a rod-end blister) may be recorded on more than one annual inspection trip. Tables 9 and 10 include minor defects (primarily exfoliation corrosion) that are included to show how subsequent growth, or lack of growth, can be monitored. Although policies among the airlines differ, generally only a few defects would require repair during a scheduled maintenance break. Several defects would receive only a seal-and-monitor disposition, and some would never deteriorate enough to need repair.

Without reference to the number of possible problems of a given kind, it might be concluded that these reported defects represent a marked deterioration of the spoiler fleet, but this is not so. On the contrary, executives of several airline maintenance groups said that significantly fewer problems have been experienced with the graphite-epoxy spoilers on this program than with production spoilers. In fact, maintenance was reduced by one-half to one-third, according to the airlines.

Spoiler serial number	Airline	Date removed	Reason for removal	Disposition
0009	Air New Zealand	06-25-81	Spar exfoliation corrosion	Storage
0010	Air New Zealand	06-25-81	Doubler corrosion	Storage
0038	Aloha	05-09-82	Doubler corrosion	Tested
0046	Aloha	03-21-82	Spar exfoliation corrosion	Storage
0048	Aloha	10-26-81	Spar exfoliation corrosion	Storage
0050	Air New Zealand	06-01-82	Spar exfoliation corrosion	Storage
0066	Air New Zealand	08-01-83	Spar exfoliation corrosion	ANZ stores
0069	Air New Zealand	06-16-81	Spar exfoliation corrosion	Storage
0082	Lufthansa	07-20-81	Spar exfoliation corrosion	Tested
0084	Lufthansa	04-26-83	Corner edge delamination	Storage
0091	Aloha	04-02-82	Dents — aircraft retirement	ANZ stores
0097	Aloha	10-26-81	Spar exfoliation corrosion	Storage
0106	Aloha	10-26-81	Spar exfoliation corrosion	Storage
0044	Frontier	06-25-84	Rod-end blister	Tested
0005	Air New Zealand	09-01-84	Trailing edge damage	Repaired

Table 8. Unscheduled Flight Spoiler Removals

		Number of noted defects									
	Number of spoilers	Rod-end blisters	Edge delaminations	Surface delaminations	Surface cracking	Upper-surface mechanical damage	Upper-surface natural and environmental damage	Lower-surface mechanical damage	Lower-surface natural and environmental damage	Aluminum doubler corrosion	Exfoliation corrosion damage
Frontier	2	2	0	0	0	0	0	0	0	1	2
New Zealand	9	0	0	0	0	0	0	0	0	1	7
Lufthansa	14	5	2	0	0	3	0	0	0	1	11
Aloha	0	0	0	0	0	0	0	0	0	0	0
Piedmont	25	3	2	0	0	1	0	0	0	4	23
VASP	11	4	2	0	0	3	0	1	0	4	10
Totals	61	14	6	0	0	7	0	1	0	11	53

Table 9. Spoiler Service Inspection Compilation (Seventh-Year Inspection — October 1982)

		Number of noted defects									
	Number of spoilers	Rod-end blisters	Edge delaminations	Surface delaminations	Surface cracking	Upper-surface mechanical damage	Upper-surface natural and environmental damage	Lower-surface mechanical damage	Lower-surface natural and environmental damage	Aluminum doubler corrosion	Exfoliation corrosion damage
Frontier	6	5	1	0	0	0	0	0	0	3	4
New Zealand	16	9	0	2	0	1	0	2	0	2	20
Lufthansa	24	13	5	2	0	7	0	3	0	4	24
Aloha	17	8	1	1	0	2	0	0	0	4	9
Piedmont	32	9	5	1	3	10	0	1	0	18	38
VASP	16	11	7	4	0	5	0	3	0	9	22
Totals	111	55	19	10	3	25	0	9	0	40	117

Table 10. Spoiler Service Inspection Compilation (Cumulative 8 Years)

REPAIRS

Spoilers S/N 0066 and S/N 0091 are undergoing repair at Air New Zealand. Spoiler S/N 0005 was repaired at Air New Zealand and returned to service. The unit had experienced a trailing edge delamination and the lower skin developed a blister over the damage area. The damaged lower skin and core were removed. The core was replaced and a fiberglass skin patch was bonded to the lower surface covering the damaged area. A contract modification has suspended all further repair activity by Boeing. All spoilers deemed not flightworthy will be repaired by the airlines or returned to Boeing and retired from service.

GROUND-BASED ENVIRONMENTAL SERVICE*

The 10-year ground-based environmental exposure of specimens fabricated from the three graphite-epoxy material systems used in fabricating the spoilers has been completed. Interlaminar shear, flexure, and compression specimens were subjected to continuous outdoor exposure at five airline terminals worldwide and at the NASA-Langley Research Center. The exposure locations were as follows: Hampton, Virginia; San Diego, California; Sao Paulo, Brazil; Wellington, New Zealand; Honolulu, Hawaii; and Frankfurt, Germany. Specimens were tested after 1, 3, 5, 7, and 10 years of exposure and the results are summarized herein.

The 10-year exposure test results for short-beam interlaminar shear, flexure, and compression are shown in Tables 11, 12, and 13, respectively. In addition to strength and modulus measurements, moisture content was determined for the flexure specimens after the residual strength tests were completed. The absorbed moisture content was calculated after the flexure specimens were dried in a vacuum furnace. The 10-year flexure specimens from Brazil are not yet fully dried; therefore, information on moisture content is not yet available. In addition, moisture content for the painted specimens exposed at NASA Langley was not determined because of severe paint peeling during outdoor exposure. The average moisture pickup for the six exposure locations after 1, 3, 5, 7, and 10 years of exposure is plotted in figure 69. The T300/2544 specimens absorbed about two percent moisture, the AS/3501 specimens absorbed about one percent moisture, and the T300/5209 specimens absorbed about 0.6 percent moisture during the 10-year exposure period. Since most of the specimens were not painted, the outer plies of the materials were degraded by ultraviolet radiation. Photographs are shown in figure 68 for flexure specimens with no outdoor exposure and for specimens with 10 years of outdoor exposure at NASA Langley. Scanning electron micrographs indicate that all the fibers are coated with epoxy resin for the unexposed specimens, whereas individual fibers can be seen on the 10-year exposure specimens after the surface layer of epoxy resin was leeched away by ultraviolet radiation. Close examination of the three materials indicates that the T300/2544 material is the most susceptible to the degrading effect of ultraviolet radiation. It should be noted that a coating of polyurethane aircraft paint will protect the material from ultraviolet degradation.

The average residual strength ratios for the shear, flexure, and compression specimens are plotted in figures 70, 71, and 72, respectively. These values represent a comparison of the average strength values for all six exposure sites with the average baseline strength value for that material system. A ±10% bandwidth, which represents the strength scatter in the baseline specimens, is shown on each figure. The shear strength ratios are within the scatterband except for T300-2544, which has continued to be slightly below the baseline value. For the flexure specimens, figure 71, the strength of the T300/2544 material was slightly below the scatterband after 10 years of exposure. The flexure strength for the AS/3501 material has been consistently above the baseline strength since the first year tests. These results indicate that the baseline strength may be low. To investigate this possibility, eight spare AS/3501 flexure specimens that had been stored in an office for 10 years at NASA Langley were tested. The average failure stress for these specimens was 18 percent higher than the failure stress for the baseline specimens. These results confirm that a larger number of specimens should have been tested to establish the baseline strength. For the compression specimens, figure 72, the strengths for all materials are within the scatterband or slightly below the scatterband.

*Prepared by Jane A. Hagaman, NASA-Langley Research Center

The results of this test program indicate that graphite-epoxy composite materials can withstand a variety of outdoor environments for up to 10 years of continuous exposure with no significant strength loss. It should be emphasized that these tests were conducted at room temperature and no conclusions can be drawn as to the effect of elevated temperature exposure or elevated temperature test conditions.

Table 11. Results of Ground-Based Environmental Exposure on Graphite-Epoxy Mechanical Property Test Specimens—Short-Beam Interlaminar Shear Tests

Exposure time,yr	Exposure location	Graphite-epoxy material system	Number of specimens	Average failure stress	
				MPa	ksi
0 (baseline)	LaRc	T300/5209	5	77	11.2
10	LaRC	T300/5209	3	76	11.0
10	Hawaii	T300/5209	3	74	10.7
10	New Zealand	T300/5209	3	74	10.8
10	Germany	T300/5209	3	79	11.4
10	California	T300/5209	3	78	11.3
10	LaRC* (painted specimens)	T300/5209	3	79	11.5
10	Brazil	T300/5209	3	70	10.2
0 (baseline)	LaRC	T300/2544	4	81	11.7
10	LaRC	T300/2544	3	70	10.2
10	Hawaii	T300/2544	3	69	10.0
10	New Zealand	T300/2544	3	68	9.8
10	Germany	T300/2544	3	73	10.6
10	California	T300/2544	3	66	9.5
10	LaRC* (painted specimens)	T300/2544	3	67	9.7
10	Brazil	T300/2544	3	66	9.6
0 (baseline)	LaRC	AS/3501	5	87	12.6
10	LaRC	AS/3501	2	90	13.1
10	Hawaii	AS/3501	3	83	12.1
10	New Zealand	AS/3501	3	83	12.0
10	Germany	AS/3501	3	88	12.7
10	California	AS/3501	3	83	12.1
10	LaRC* (painted specimens)	AS/3501	3	89	12.9
10	Brazil	AS/3501	3	84	12.2

*Painted specimens were fully coated with a polyurethane-based enamel over a calcium chromate primer prior to exposure at the Langley site.

Table 12. Results of Ground-Based Environmental Exposure on Graphite-Epoxy Mechanical Property Test Specimens—Flexure[a] Tests

Exposure time, yr	Exposure location	Graphite-epoxy material system	Number of specimens	Average failure stress		Average flexure modulus		Average moisture content, %
				MPa	ksi	GPa	psi (x 10^6)	
0 (baseline)	LaRC	T300/5209	5	1529	221.8	103.8	15.05	—
10	LaRC	T300/5209	3	1401	203.2	99.6	14.45	0.58
10	Hawaii	T300/5209	3	1425	206.6	101.4	14.70	0.52
10	New Zealand	T300/5209	3	1412	204.8	101.2	14.68	0.71
10	Germany	T300/5209	3	1446	209.7	103.9	15.07	0.60
10	California	T300/5209	3	1375	199.4	98.7	14.32	0.64
10	LaRC[c] (painted specimens)	T300/5209	3	1533	222.4	105.1	15.24	—
10	Brazil	T300/5209	3	1557	225.8	99.0	14.36	b
0 (baseline)	LaRC	T300/2544	5	1600	232.0	106.2	15.41	—
10	LaRC	T300/2544	3	1179	171.0	83.0	12.04	1.83
10	Hawaii	T300/2544	3	1319	191.3	84.8	12.30	1.68
10	New Zealand	T300/2544	3	1325	192.1	87.5	12.69	2.23
10	Germany	T300/2544	3	1553	225.2	96.9	14.05	1.76
10	California	T300/2544	3	1387	201.2	92.8	13.46	1.91
10	LaRC[c] (painted specimens)	T300/2544	3	1475	213.9	96.9	14.05	—
10	Brazil	T300/2544	3	1412	204.8	95.4	13.84	b
0 (baseline)	LaRC	AS/3501	5	1449	210.1	94.7	13.73	—
10	LaRC	AS/3501	3	1724	250.0	93.0	13.49	1.08
10	Hawaii	AS/3501	3	1674	242.8	89.4	12.97	1.02
10	New Zealand	AS/3501	3	1802	261.4	95.3	13.82	1.21
10	Germany	AS/3501	2	1673	242.6	93.2	13.51	1.13
10	California	AS/3501	3	1749	253.6	94.0	13.63	1.10
10	LaRC[c] (painted specimens)	AS/3501	3	1878	272.4	94.2	13.67	—
10	Brazil	AS/3501	3	1851	268.4	95.2	13.81	b

[a] Flexure specimens were fabricated from laminates with ply orientations identical to spoiler skin orientation. Specimen length is oriented in a 90-deg direction of the laminate.

[b] Specimens still in drying oven.

[c] Painted specimens were fully coated with a polyurethane-based enamel over a calcium chromate primer prior to exposure at the Langley site. Specimens not weighed for moisture content because of severe paint peeling during exposure.

Table 13. Results of Ground-Based Environmental Exposure on Graphite-Epoxy Mechanical Property Test Specimens—Compression[a] Tests

Exposure time, yr	Exposure location	Graphite-epoxy material system	Number of specimens	Average failure stress	
				MPa	ksi
0 (baseline)	LaRC	T300/5209	3	712	103.2
10	LaRC	T300/5209	3	732	106.1
10	Hawaii	T300/5209	3	705	102.3
10	New Zealand	T300/5209	3	690	100.1
10	Germany	T300/5209	3	707	102.6
10	California	T300/5209	3	658	95.5
10	LaRC[b] (painted specimens)	T300/5209	3	774	112.3
10	Brazil	T300/5209	1	731	106.0
0 (baseline)	LaRC	T300/2544	4	1029	149.2
10	LaRC	T300/2544	3	934	135.5
10	Hawaii	T300/2544	3	958	138.9
10	New Zealand	T300/2544	3	837	121.4
10	Germany	T300/2544	2	956	138.6
10	California	T300/2544	3	884	128.2
10	LaRC[b] (painted specimens)	T300/2544	3	957	138.8
10	Brazil	T300/2544	3	918	133.1
0 (baseline)	LaRC	AS/3501	5	1107	160.6
10	LaRC	AS/3501	3	1089	158.0
10	Hawaii	AS/3501	3	1005	145.8
10	New Zealand	AS/3501	3	1260	182.8
10	Germany	AS/3501	3	1065	154.4
10	California	AS/3501	3	1114	161.6
10	LaRC[b] (painted specimens)	AS/3501	2	1232	178.7
10	Brazil	AS/3501	3	1036	150.3

[a] Compression specimens were fabricated from laminates with ply orientations identical to spoiler skin ply orientation. Specimen length is oriented in the 90-deg direction of the skin laminate.

[b] Painted specimens were fully coated with a polyurethane-based enamel over a calcium chromate primer prior to exposure at the Langley site.

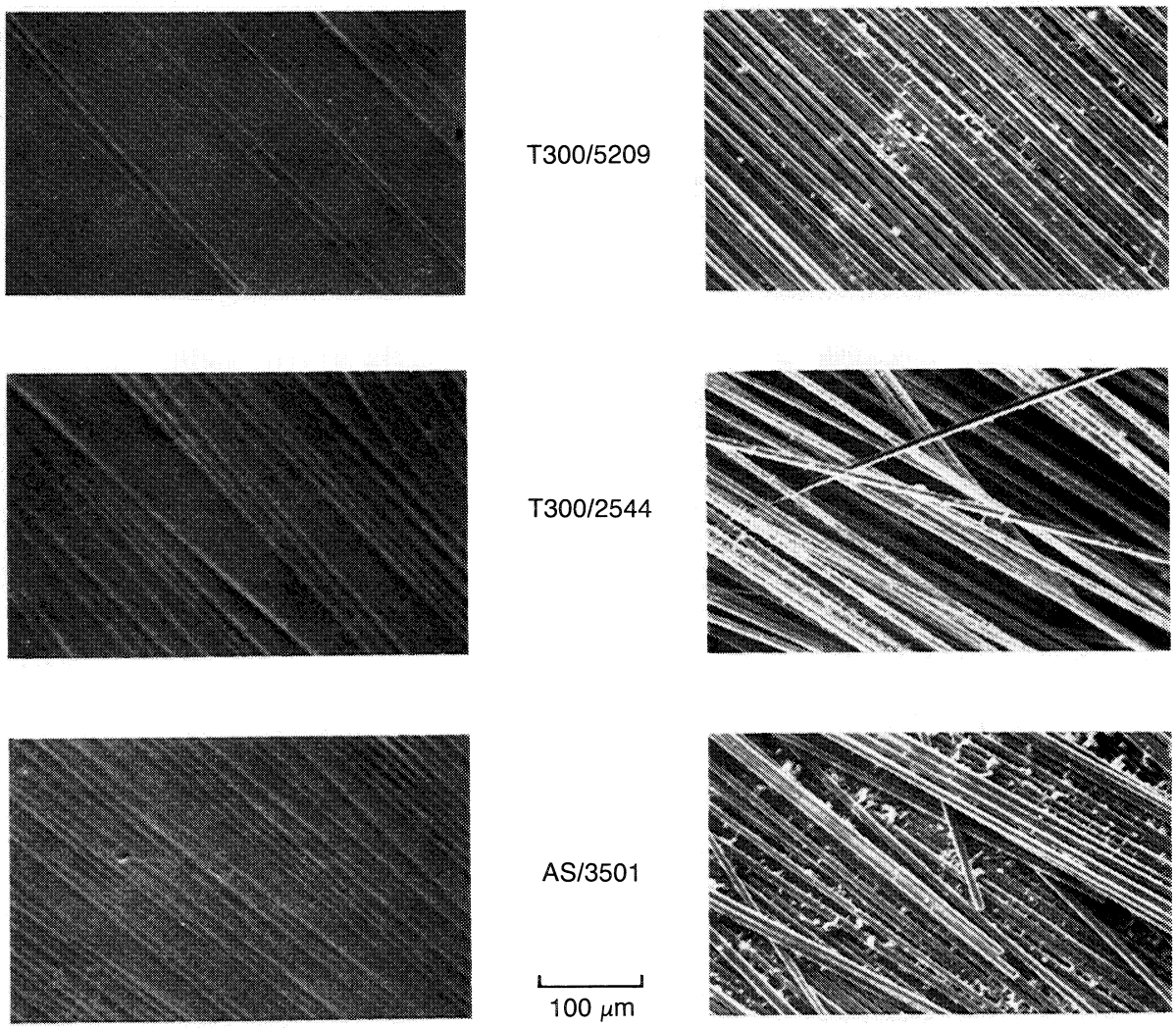

Figure 68. Ultraviolet Degradation of Unpainted Graphite-Epoxy Materials

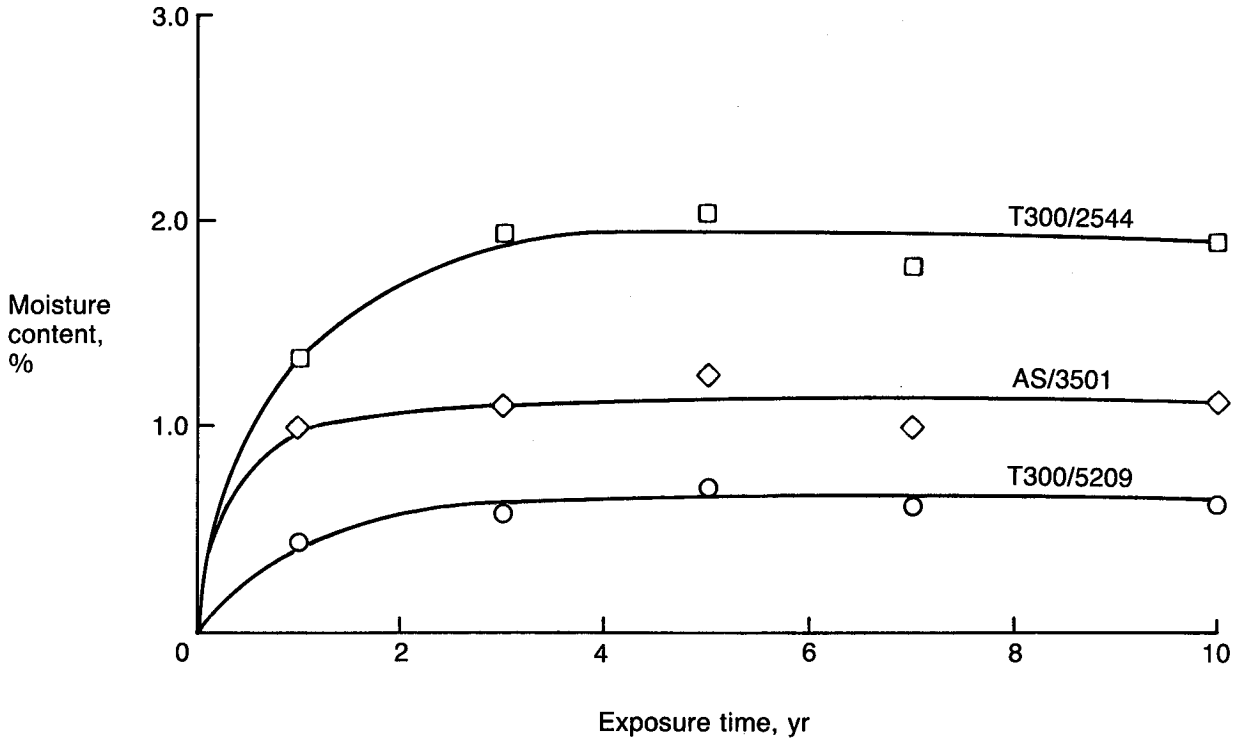

Figure 69. Average Moisture Pickup After Outdoor Exposure at Six Worldwide Locations

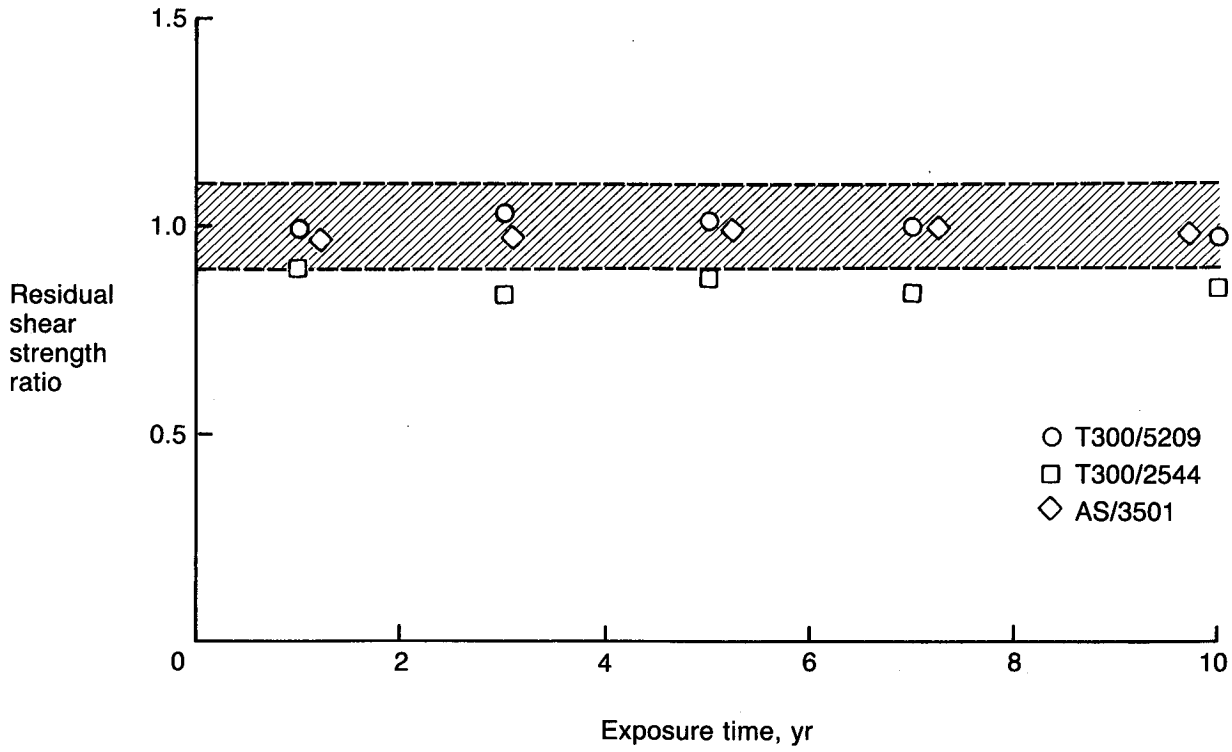

Figure 70. Average Residual Shear Strength After Outdoor Exposure at Six Worldwide Locations

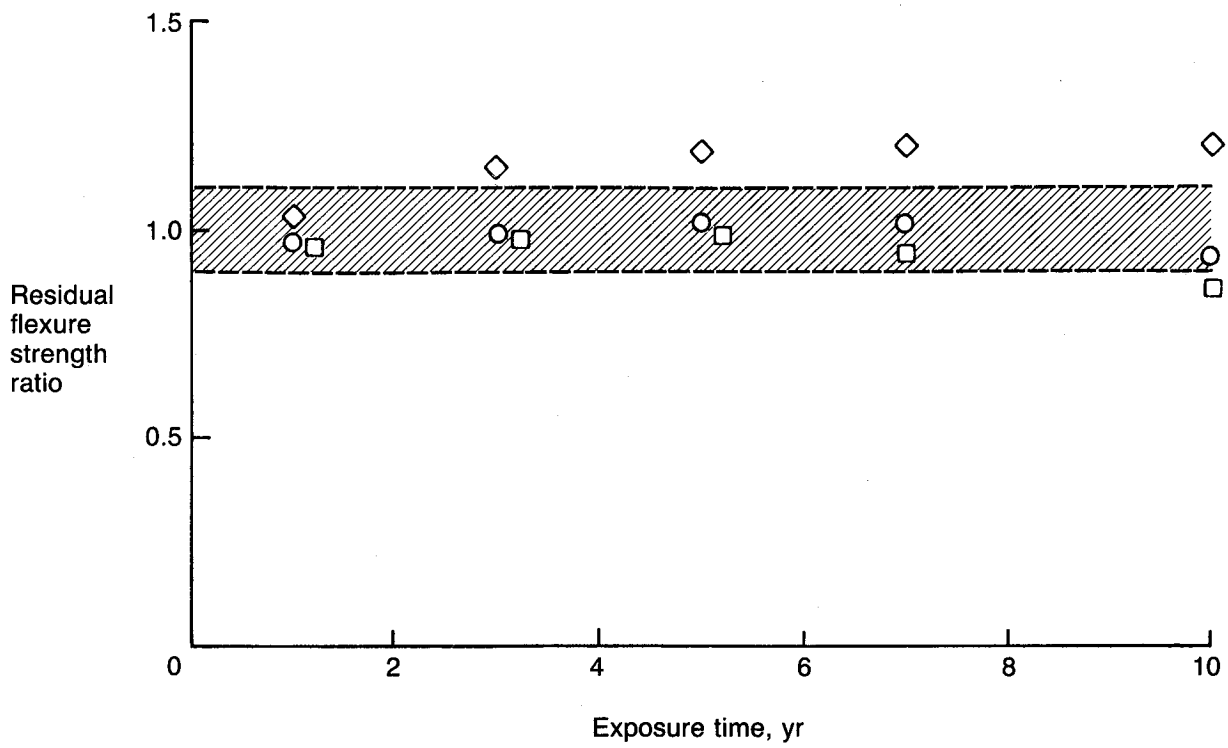

Figure 71. Average Residual Flexure Strength After Outdoor Exposure at Six Worldwide Locations

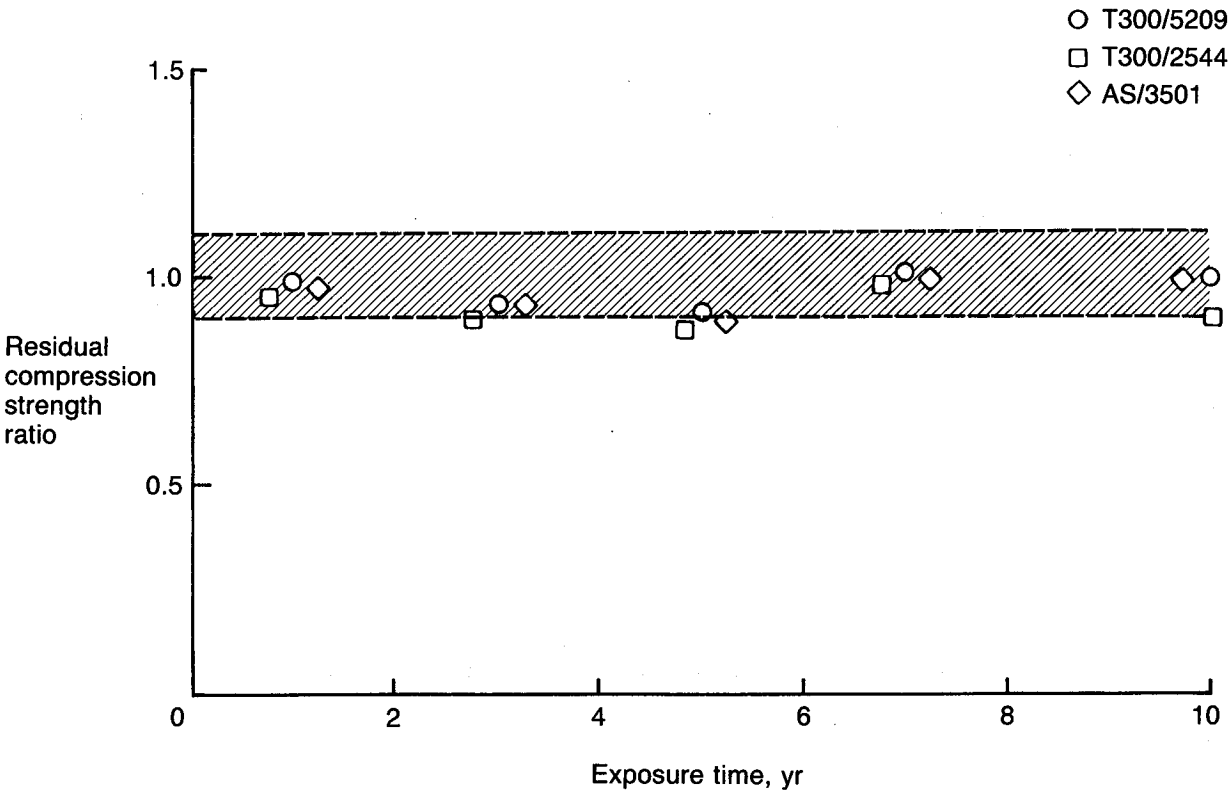

Figure 72. Average Residual Compression Strength After Outdoor Exposure at Six Worldwide Locations

CONCLUSIONS

After eleven years of service, the Boeing/NASA 737 spoiler program can be classified as an unqualified success. The participating airlines remain enthusiastic and the level of participation has been limited only by continued airplane retirements and sales.

The knowledge base created as a result of this program has been instrumental in the advancement of composite material technology. Every aspect of developing and maintaining the composite spoilers in an airline environment provided experience applicable to subsequent programs. The design, analysis, production, and certification activities presented many new challenges that were met. The service experience provided information on durability and damage tolerance and required the development of new inspection and repair methods.

The years of flight service provided a good understanding of the type and frequency of damage events occurring in a variety of service environments. Inspection and repair techniques were also developed and refined.

Several design details proved to be inadequate as time progressed. These were the details around the actuator lug at the center hinge fitting (CHF) and the center hinge fitting to spar splice. The first detail allowed disbonding of the skin to the CHF due to actuator lug interference. In the aluminum design, the detail was identical but local yielding of the aluminum skin prevented disbonding. The solution for the graphite spoilers was the installation of a modified actuator lug to eliminate the interference. The CHF-spar splice detail involved a butt splice of the spar and CHF caps with the graphite skin bonded to the caps. As a result, the load path for spanwise bending was from one cap through the adhesive to the skin and back to the other cap through adhesive. Due to a strain mismatch between the skin and cap, the adhesive layer was worked beyond its capabilities under cyclic loading. As disbonding occurred, a moisture path was created between the aluminum and graphite. Moisture acts as a catalyst for the resulting galvanic corrosion. Several important things were learned from these occurrences. Corrosion in all cases was limited to the spar cap. Excursion into the core area was prevented by the thicker adhesive layer along the skin-to-core interface. Most importantly, it was found at both of these details that the rate of damage growth was extremely slow and easily detectable before developing into a serious problem. Disbonds at the CHF-spar splice, for example, were usually detectable about two years before they would develop to a size requiring spoiler removal and repair. With proper sealing treatment, further growth can be prevented.

An ancillary project provided data on the effects of environmental exposure to graphite laminate specimens. Several hundred specimens were exposed on rooftops of airport buildings at participating airline bases. This provided a variety of exposure conditions over the 10-year duration of this project. Results of tests on returned specimens provide information on strength degradation, moisture absorption rates, and effects of ultraviolet exposure. The results show a stabilization of moisture absorption after about three years for the particular laminate geometry used. Saturation percentages are a function of material type and range from about 0.65 to 2.00 percent. Ultraviolet exposure proved to be degrading to the specimens as a function of the resin type. Most specimens were

exposed without a protective paint surface. The mechanical properties tests indicate that the specimens have withstood exposure with no significant strength loss.

A great number of damage events have been reported over the years of service. It is important to realize that while this number is large, it is also related to the level of intensity that these parts have been monitored while in service. Numerous inspection trips involving an engineering evaluation of each spoiler were conducted. In addition, detailed evaluations are made on spoilers returned for structural testing. These activities combined with the airline's scheduled maintenance activities insured that any problems or damage would be recorded in order to provide an accurate assessment of the spoilers performance.

APPENDIX A

CURRENT SPOILER FLIGHT HOURS AND LANDING DATA

CURRENT SPOILER FLIGHT HOURS AND LANDING DATA

S/N	INSTALLATION DATE	AIRLINE	INSTALLATION HOURS	INSTALLATION LANDINGS	REMOVAL DATE	CURRENT HOURS	CURRENT LANDINGS	NET HOURS	NET LANDINGS	REMARKS
0			DEMONSTRATION UNIT AT NASA LANGLEY					00	00	6
1	06-27-74	5	5681	3056	--------	32290	40495	26609	37439	2
2			CERTIFICATION STATIC TEST UNIT					00	00	4
3	07-18-73	7	8095	12842	05-17-74	9018	14379	923	1537	0
3	05-17-74	6	9018	14379	--------	34369	42826	25351	28447	2
4	07-28-73	7	8161	12965	05-17-74	9018	14379	857	1414	0
4	05-17-74	6	9018	14379	--------	34369	42826	25351	28447	2
5	07-18-73	7	8095	12842	05-17-74	9018	14379	923	1537	0
5	05-17-74	6	9018	14379	04-08-78	18112	24432	9094	10053	0
5	02-15-79	6	20212	26856	04-24-80	23294	30267	3082	3411	0
5	08-06-82	2	29534	40417	09-01-84	33223	45292	3689	4875	1
6	07-28-73	7	8161	12965	05-17-74	9018	14379	857	1414	0
6	05-17-74	6	9018	14379	--------	34369	42826	25351	28447	2
7	09-15-73	2	10861	15053	--------	33991	46309	23130	31256	2
8	09-15-73	2	10861	15053	09-27-78	21603	29443	10742	14390	0
8	08-06-79	2	23465	31977	11-06-81	27997	38179	4532	6202	1
9	09-15-73	2	10861	15053	02-04-76	16147	22112	5286	7059	0
9	09-27-78	2	21603	29443	06-25-81	27258	37151	5655	7708	1
10	09-15-73	2	10861	15053	06-25-81	27258	37151	16397	22098	1
11	08-26-73	4	11274	15681	08-21-77	20307	26924	9033	11243	0
11	03-24-78	4	21658	28554	02-27-81	28562	36655	6904	8101	1
12	08-26-73	4	11274	15681	03-04-75	14694	19964	3420	4283	0
12	06-13-75	4	15148	20528	09-18-75	15793	21324	645	796	0
12	09-18-75	4	15940	21518	07-03-78	22297	29334	6357	7816	0
12	10-19-78	4	22954	30142	05-12-80	26719	34534	3765	4392	0
12	09-02-81	4	17	6	--------	7804	9368	7787	9362	2
13	08-26-73	4	11274	15681	05-06-78	21938	28901	10664	13220	0
13	10-06-78	4	20532	25040	10-20-78	20636	25143	104	103	0
13	10-25-78	4	22987	30176	02-27-81	28562	36655	5575	6479	1
14	08-26-73	4	11274	15681	07-29-74	13329	18216	2055	2535	1
15	08-02-73	7	8651	13711	05-17-74	9399	14936	748	1225	0
15	05-17-74	6	9399	14936	05-13-75	11689	17594	2290	2658	0
15	01-31-76	6	13411	19607	04-30-81	25917	33732	12506	14125	3
16	08-02-73	7	8651	13711	05-17-74	9399	14936	748	1225	0
16	05-17-74	6	9399	14936	09-04-77	17147	23719	7748	8783	1
17	08-02-73	7	8651	13711	05-17-74	9399	14936	748	1225	0
17	05-17-74	6	9399	14936	09-21-75	12432	18474	3033	3538	0
17	01-31-76	6	13411	19607	12-09-78	20050	26978	6639	7371	0
17	03-15-80	6	23355	30689	--------	34934	44046	11579	13357	2
18	08-02-73	7	8651	13711	05-17-74	9399	14936	748	1225	0
18	05-17-74	6	9399	14936	05-13-75	11689	17594	2290	2658	0
18	01-31-76	6	13411	19607	10-03-84	34329	43357	20918	23750	1
19	10-02-73	4	11200	14884	01-01-82	29951	37516	18751	22632	0
19	02-11-82	4	29488	33283	--------	37264	40671	7776	7388	2
20	10-02-73	4	11200	14884	09-27-78	22678	29128	11478	14244	1
21	10-02-73	4	11200	14884	03-29-75	14653	19211	3453	4327	0
21	08-02-75	4	15425	20178	10-12-78	22772	29241	7347	9063	0
21	08-10-79	4	24739	31517	01-01-82	29951	37516	5212	5999	0
21	02-23-82	4	12	4	--------	7314	6590	7302	6586	2

CURRENT SPOILER FLIGHT HOURS AND LANDING DATA

S/N	INSTALLATION DATE	AIRLINE	INSTALLATION HOURS	INSTALLATION LANDINGS	REMOVAL DATE	CURRENT HOURS	CURRENT LANDINGS	NET HOURS	NET LANDINGS	REMARKS
22	10-02-73	4	11200	14884	10-12-78	22772	29241	11572	14357	0
22	08-10-79	4	24739	31517	8-10-79	24739	31517	0	0	1
23	8-18-73	1	9207	24932	4-20-78	17722	48181	8515	23249	1
24	8-18-73	1	9207	24932	7-11-74	10974	29694	1767	4762	0
24	2-25-75	1	12071	32691	3-13-80	21114	57325	9043	24634	1
25	8-18-73	1	9207	24932	8-18-75	12964	35165	3757	10233	1
26	8-18-73	1	9207	24932	2-25-75	12071	32691	2864	7759	0
26	5-16-75	1	8287	14823	11-11-76	10395	20494	2108	5671	1
27	4-23-74	5	12329	20204	5-30-77	20488	32576	8159	12372	0
27	12-13-77	5	21916	34744	-------	39763	58942	17847	24198	2
28	2-28-74	5	13747	22449	2-24-75	16387	26396	2640	3947	0
28	6-17-75	5	17201	27670	-------	41224	61276	24023	33606	2
29	4-23-74	5	12329	20204	05-20-83	35762	53974	23433	33770	1
30	2-28-74	5	13747	22449	-------	41224	61276	27477	38827	2
31	2-28-74	5	13747	22449	8-11-79	27973	43614	14226	21165	0
31	04-14-82	5	34475	52801	--------	41224	61276	6749	8475	2
32	4-23-74	5	12329	20204	1-28-75	14411	23348	2082	3144	0
32	6-3-75	5	15259	24624	-------	39763	58942	24504	34318	2
33	2-28-74	5	13747	22449	02-21-82	34111	52266	20364	29817	3
34	4-23-74	5	12329	20204	-------	39763	58942	27434	38738	2
35	6-27-74	5	5681	3056	4-18-75	7673	5964	1992	2908	0
35	8-15-75	5	8542	7300	-------	32290	40495	23748	33195	2
36	6-27-74	5	5681	3056	4-16-75	7663	5945	1982	2889	0
36	8-15-75	5	8542	7300	--------	32290	40495	23748	33195	2
37	6-27-74	5	5681	3056	-------	32290	40495	26609	37439	2
38	10-25-74	1	11340	30745	05-09-82	24088	65685	12748	34940	3
39			DOES NOT EXIST							5
40			DOES NOT EXIST							5
41			CERTIFICATION STATIC TEST UNIT					00	00	4
42	7-26-73	7	5003	8092	9-30-75	9600	16525	4597	8433	0
42	9-30-75	3	9600	16525	-------	36268	45047	26668	28522	2
43	7-25-73	7	4993	8068	9-30-75	9600	16525	4607	8457	0
43	9-30-75	3	9600	16525	6-26-80	23912	31825	14312	15300	0
43	05-10-82	2	28784	39210	--------	33801	46061	5017	6851	2
44	7-26-73	7	5003	8092	9-30-75	9600	16525	4597	8433	0
44	9-30-75	3	9600	16525	12-29-76	13201	20370	3601	3845	0
44	8-3-77	3	15025	22485	06-25-84	35164	43974	20139	21489	1
45	7-25-73	7	4993	8068	7-14-74	6895	11280	1902	3212	0
45	1-15-76	3	10064	16998	4-24-78	17369	24969	7305	7971	0
45	4-9-79	2	22504	30331	3-19-81	26488	35711	3984	5380	1
46	8-8-73	1	6447	9087	1-11-78	13058	26664	6611	17577	0
46	1-11-78	1	20014	30447	5-16-79	22540	37358	2526	6911	0
46	10-15-80	1	22118	59759	2-26-81	22613	61420	495	1661	0
46	2-26-81	1	6391	17574	03-21-82	8167	22328	1776	4754	3
47	8-8-73	1	6447	9087	1-7-76	10256	19089	3809	10002	0
47	8-16-76	3	14728	16350	1-9-78	19153	21328	4425	4978	0
47	4-24-78	3	17409	25010	4-20-81	26282	34352	8873	9342	0
47	04-08-83	2	30525	41316	--------	33701	45507	3176	4191	2
48	8-8-73	1	6447	9087	2-25-75	9103	16022	2656	6935	0
48	5-16-75	1	8287	14823	8-17-77	11473	23389	3186	8566	0
48	8-17-77	1	15912	36880	10-26-81	23575	50737	7663	13857	3
49	8-8-73	1	6447	9087	4-13-77	12050	23911	5603	14824	0
49	1-11-78	1	20014	30447	4-2-80	23688	40420	3674	9973	0
49	4-8-80	1	19905	53977	3-10-81	21413	58105	1508	4128	1
50	7-23-73	2	10539	14075	1-28-76	15771	21303	5232	7228	0
50	09-29-78	2	21534	29018	06-01-82	28962	39171	7428	10153	3

CURRENT SPOILER FLIGHT HOURS AND LANDING DATA

S/N	INSTALLATION DATE	AIRLINE	INSTALLATION		REMOVAL DATE	CURRENT		NET		REMARKS
			HOURS	LANDINGS		HOURS	LANDINGS	HOURS	LANDINGS	
51	07-23-73	2	10539	14075	10-18-77	19444	26204	8905	12129	0
51	4-3-78	2	20435	27564	04-18-82	28671	38763	8236	11199	3
52	7-23-73	2	10539	14075	2-27-75	14057	18964	3518	4889	0
52	6-8-75	2	14707	19835	11-16-78	21757	29355	7050	9520	0
52	2-28-80	2	24447	32979	-----	33701	45507	9254	12528	2
53	7-23-73	2	10539	14075	9-24-74	13138	17747	2599	3672	1
54	9-6-73	4	11152	15328	9-6-76	17899	23824	6747	8496	1
55	9-6-73	4	11152	15328	08-28-81	29501	37306	18349	21978	0
55	11-22-81	4	311	333	--------	7621	8691	7310	8358	2
56	9-6-73	4	11152	15328	08-28-81	29501	37306	18349	21978	0
56	10-05-81	4	12	3	--------	7621	8691	7609	8688	2
57	9-6-73	4	11152	15328	9-7-75	15633	20997	4481	5669	1
58	8-6-73	7	8476	13644	5-17-74	9402	15241	926	1597	0
58	5-17-74	6	9402	15241	-----	34374	43234	24972	27993	2
59	8-6-73	7	8476	13644	5-17-74	9402	15241	926	1597	0
59	5-17-74	6	9402	15241	1-14-75	10900	17164	1498	1923	0
59	1-31-76	6	13181	19621	9-1-80	24475	31957	11294	12336	1
60	8-6-73	7	8476	13644	5-17-74	9402	15241	926	1597	0
60	5-17-74	6	9402	15241	9-2-76	14715	21102	5313	5861	0
60	11-17-77	6	17529	24227	-----	34374	43234	16845	19007	2
61	8-6-73	7	8476	13644	5-17-74	9402	15241	926	1597	0
61	5-17-74	6	9402	15241	-----	34374	43234	24972	27993	2
62	10-23-73	4	11450	15759	10-27-81	30083	38179	18633	22420	0
62	02-23-82	4	12	3	--------	7314	6590	7302	6587	2
63	10-23-73	4	11450	15759	10-27-81	30083	38179	18633	22420	0
63	02-23-82	4	12	3	--------	7314	6590	7302	6587	2
64	10-23-73	4	11450	15759	10-27-81	30083	38179	18633	22420	0
64	02-05-82	4	29488	33283	04-09-82	29908	33654	420	371	0
64	04-20-82	4	1271	1408	05-26-83	3820	4355	2549	2947	1
65	10-23-73	4	11450	15759	10-27-81	30083	38179	18633	22420	0
65	02-23-82	4	12	3	--------	7314	6590	7302	6587	2
66	9-29-73	2	10787	14648	2-27-75	14184	19120	3397	4472	0
66	6-7-75	2	14602	19678	10-28-77	19605	26654	5003	6976	0
66	4-6-78	2	20556	27959	5-2-79	22584	30603	2028	2644	0
66	11-14-80	2	25702	34889	05-10-82	28784	39210	3082	4321	0
66	06-08-82	2	28959	39446	08-01-83	30925	42208	1966	2762	0
66	11-30-84	2	29041	40481	--------	29237	40744	196	263	2
67	9-29-73	2	10787	14648	9-15-78	21231	28840	10444	14192	1
68	9-29-73	2	10787	14648	6-16-80	25009	33910	14222	19262	0
68	08-04-82	2	29217	39803	07-10-84	32904	44872	3687	5069	0
68	01-12-85	2	33991	46309	--------	33991	46309	0	0	2
69	9-29-73	2	10787	14648	06-16-81	26913	36522	16126	21874	1
70	3-4-74	5	13908	22649	3-6-81	31634	49004	17726	26355	0
70	04-21-82	5	34592	53159	--------	41007	61261	6415	8102	2
71	3-4-74	5	13908	22649	3-6-78	24332	38438	10424	15789	1
72	3-4-74	5	13908	22649	3-11-79	26978	42326	13070	19677	0
72	6-28-79	5	27721	43379	-----	41007	61261	13286	17882	2
73	8-15-74	5	15070	24630	-----	41462	61965	26392	37335	2
74	3-4-74	5	13908	22649	4-27-76	19600	31548	5692	8899	0
74	8-16-76	3	14728	16350	1-9-78	19153	21328	4425	4978	0
74	4-11-79	2	22467	30441	5-2-79	22584	30603	117	162	0
74	2-23-81	2	26378	35804	-------	33801	46061	7423	10257	2
75	8-15-74	5	15070	24630	-----	41462	61965	26392	37335	2
76	8-15-74	5	15070	24630	-----	41462	61965	26392	37335	2
77	8-15-74	5	15070	24630	-----	41462	61965	26392	37335	2

CURRENT SPOILER FLIGHT HOURS AND LANDING DATA

S/N	INSTALLATION DATE	AIRLINE	INSTALLATION HOURS	INSTALLATION LANDINGS	REMOVAL DATE	CURRENT HOURS	CURRENT LANDINGS	NET HOURS	NET LANDINGS	REMARKS
78	10-17-73	1	9343	25410	10-24-74	11340	30728	1997	5318	0
78	2-25-75	1	9103	16022	1-11-78	13058	26664	3955	10642	0
78	1-11-78	1	20014	30447	4-2-80	23688	40420	3674	9973	0
78	04-08-80	1	19905	53977	11-01-82	23349	63296	3444	9319	0
78	04-08-83	2	30525	41316	--------	33701	45507	3176	4191	2
79			DOES NOT EXIST							5
80			DOES NOT EXIST							5
81			CERTIFICATION STATIC TEST UNIT					00	00	4
82	9-12-73	4	11560	16962	07-20-81	29680	46880	18120	29918	3
83	9-12-73	4	11560	16962	5-17-75	15286	22013	3726	5051	0
83	9-12-76	4	16901	26080	07-20-81	29680	46880	12779	20800	0
83	09-02-81	4	17	6	--------	7804	9368	7787	9362	2
84	9-12-73	4	11560	16962	5-17-75	15286	22013	3726	5051	0
84	12-19-75	4	16576	25672	07-20-81	29680	46880	13104	21208	0
84	08-24-81	4	11	3	04-26-83	3920	4447	3909	4444	1
85	9-12-73	4	11560	16962	9-4-75	15896	23901	4336	6939	0
85	2-12-76	4	16901	26080	07-20-81	29680	46880	12779	20800	0
85	09-02-81	4	17	6	02-02-82	1016	1117	999	1111	3
86	9-22-73	2	5587	8565	11-30-84	29041	40481	23454	31916	1
87	9-22-73	2	5587	8565	6-11-75	9516	13797	3929	5232	0
87	12-19-75	2	10647	15393	6-16-80	20322	28691	9675	13298	1
88	9-22-73	2	5587	8565	6-11-75	9516	13797	3929	5232	0
88	12-19-75	2	10647	15393	11-22-76	12556	18020	1909	2627	0
88	9-9-77	2	14149	20361	9-24-80	20796	29307	6647	8946	1
89	9-22-73	2	5587	8565	6-21-74	7272	10794	1685	2229	0
89	2-13-75	2	8771	12820	11-22-76	12556	18020	3785	5200	0
89	9-9-77	2	14149	20361	2-12-78	15100	21677	951	1316	0
89	2-14-79	2	17400	24707	06-11-81	22003	30940	4603	6233	0
89	07-21-81	2	22218	31229	--------	29237	40744	7019	9515	2
90	8-15-73	1	5623	7992	5-2-74	6788	10937	1165	2945	0
90	10-24-74	1	11334	30728	4-4-79	19300	52783	7966	22055	1
91	8-15-73	1	5623	7992	5-16-75	8287	14823	2664	6831	0
91	8-18-75	1	12964	35165	12-18-75	13572	36811	608	1646	0
91	12-18-75	1	13572	36811	12-13-78	18925	51459	5353	14648	0
91	12-12-79	1	20693	56210	2-26-81	22613	61420	1920	5210	0
91	2-26-81	1	6391	17574	04-02-82	8185	22377	1794	4803	0
91	01-12-85	2	33991	46309	--------	33991	46309	0	0	2
92	8-15-73	1	5623	7992	8-18-77	11480	23406	5857	15414	0
92	8-18-77	1	15916	36893	10-26-81	23575	50737	7659	13844	0
92	05-06-83	2	30532	41749	01-12-85	33991	46309	3459	4560	1
93	3-20-74	5	13879	22839	4-1-75	16461	26759	2582	3920	0
93	8-3-75	5	17333	28122	3-30-77	21797	34851	4464	6729	0
93	2-8-78	5	24051	38238	-----	41007	61400	16956	23162	2
94	3-20-74	5	13879	22839	4-1-75	16461	26759	2582	3920	0
94	8-3-75	5	17333	28122	-----	41007	61400	23674	33278	2
95	3-20-74	5	13879	22839	-----	41007	61400	27128	38561	2
96	3-20-74	5	13879	22839	3-20-79	26988	42537	13109	19698	1
97	12-21-77	1	16360	38058	10-26-81	23575	50737	7215	12679	3
98	9-25-73	1	9244	25150	05-12-82	24093	65702	14849	40552	0
98	05-20-83	2	25906	36352	--------	29237	40744	3331	4392	2
99	3-21-74	5	10290	15517	-----	37488	54543	27198	39026	2
100	4-11-74	5	12641	20584	-----	39959	58766	27318	38182	2
101	3-21-74	5	10290	15517	-----	37488	54543	27198	39026	2
102	3-21-74	5	10290	15517	06-08-83	33885	49939	23595	34422	1
103	4-11-74	5	12641	20584	4-17-80	28250	43515	15609	22931	1
104	9-25-73	1	9244	25150	10-25-74	11340	30745	2096	5595	1

CURRENT SPOILER FLIGHT HOURS AND LANDING DATA

S/N	INSTALLATION DATE	AIRLINE	INSTALLATION HOURS	INSTALLATION LANDINGS	REMOVAL DATE	CURRENT HOURS	CURRENT LANDINGS	NET HOURS	NET LANDINGS	REMARKS
105	9-25-73	1	9244	25150	10-17-73	9343	25410	99	260	0
105	6-7-74	1	6916	11247	5-16-75	8287	14823	1371	3576	1
106	8-15-73	1	5623	7992	8-17-77	11473	23389	5850	15397	0
106	8-17-77	1	15912	36880	10-26-81	23575	50737	7663	13857	3
107	9-25-73	1	9244	25150	8-17-77	16527	45144	7283	19994	1
108	9-1-73	7	8621	13711	5-17-74	9568	15160	947	1449	0
108	5-17-74	6	9568	15160	11-17-76	15342	21726	5774	6566	0
108	11-21-77	6	17818	24525	10-04-84	34228	42895	16410	18370	1
109	9-1-73	7	8621	13711	5-17-74	9568	15160	947	1449	0
109	5-17-74	6	9568	15160	7-29-75	12174	18313	2606	3153	1
110	9-1-73	7	8621	13711	5-17-74	9568	15160	947	1449	0
110	5-17-74	6	9568	15160	-----	34629	43355	25061	28195	2
111	9-1-73	7	8621	13711	5-17-74	9568	15160	947	1449	0
111	5-17-74	6	9568	15160	7-29-75	12174	18313	2606	3153	0
111	1-31-76	6	13369	19647	4-10-78	18669	25467	5300	5820	0
111	12-14-78	6	20304	27301	10-04-84	34228	42895	13924	15594	1
112	11-13-73	4	11587	16011	6-20-75	15179	20569	3592	4558	0
112	12-18-75	4	16309	21974	03-02-81	28405	36410	12096	14436	0
112	08-24-81	4	11	3	--------	7926	9047	7915	9044	2
113	11-13-73	4	11587	16011	03-02-81	28405	36410	16818	20399	0
113	08-24-81	4	11	3	--------	7926	9047	7915	9044	2
114	11-13-73	4	11587	16011	3-9-75	14601	19849	3014	3838	0
114	6-20-75	4	15179	20569	9-30-80	27495	35391	12316	14822	0
114	08-02-82	4	2189	2488	--------	7804	9368	5615	6880	2
115	11-13-73	4	11587	16011	11-9-76	18322	24487	6735	8476	0
115	3-26-77	4	19208	25567	03-02-81	28405	36410	9197	10843	0
115	08-24-81	4	11	3	--------	7926	9047	7915	9044	2
116	3-21-74	5	10290	15517	4-4-77	18529	28010	8239	12493	1
117	4-11-74	5	12641	20584	-------	39959	58766	27318	38182	2
118	4-11-74	5	12641	20584	5-18-76	18147	29062	5506	8478	0
118	12-17-76	5	19709	31351	11-11-81	32570	49333	12861	17982	3

Airline code (JALC)
Aloha = 1, Air New Zealand = 2, Frontier = 3, Lufthansa = 4, Piedmont = 5, VASP = 6, PSA = 7

Remarks code
O = Old data, 1 = No longer active, 2 = Currently active, 3 = Out for repair or evaluation
4 = Certification static test, 5 = Does not exist, 6 = Demo unit at NASA

Summary

AIRLINE	NET HOURS	NET LANDINGS
Aloha	174,791	444,994
Air New Zealand	279,073	378,469
Frontier	89,748	96,425
Lufthansa	465,845	576,920
Piedmont	741,144	1,055,476
VASP	311,807	351,009
PSA	29,747	51,521
Spoiler numbers		
1 through 38	704,843	973,051
41 through 78	716,325	979,056
81 through 118	670,987	1,002,707
Total	2,092,155	2,954,814

S/N	SPOILER FLIGHT HOURS AND LANDINGS HOURS	LANDINGS
1	26609	37439
2	0	0
3	26274	29984
4	26208	29861
5	16788	19876
6	26208	29861
7	23130	31256
8	15274	20592
9	10941	14767
10	16397	22098
11	15937	19344
12	21974	26649
13	16343	19802
14	2055	2535
15	15544	18008
16	8496	10008
17	21999	25491
18	23956	27633
19	26527	30020
20	11478	14244
21	23314	25975
22	11572	14357
23	8515	23249
24	10810	29396
25	3757	10233
26	4972	13430
27	26006	36570
28	26663	37553
29	23433	33770
30	27477	38827
31	20975	29640
32	26586	37462
33	20364	29817
34	27434	38738
35	25740	36103
36	25730	36084
37	26609	37439
38	12748	34940
39	0	0
40	0	0
41	0	0
42	31265	36955
43	23936	30608
44	28337	33767
45	13191	16563
46	11408	30903
47	20283	28513
48	13505	29358
49	10785	28925
50	12660	17381
51	17141	23328
52	19822	26937
53	2599	3672
54	6747	8496
55	25659	30336
56	25958	30666
57	4481	5669
58	25898	29590

S/N	SPOILER FLIGHT HOURS AND LANDINGS HOURS	LANDINGS
59	13718	15856
60	23084	26465
61	25898	29590
62	25935	29007
63	25935	29007
64	21602	25738
65	25935	29007
66	15672	21438
67	10444	14192
68	17909	24331
69	16126	21874
70	24141	34457
71	10424	15789
72	26356	37559
73	26392	37335
74	17657	24296
75	26392	37335
76	26392	37335
77	26392	37335
78	16246	39443
79	0	0
80	0	0
81	0	0
82	18120	29918
83	24292	35213
84	20739	30703
85	18114	28850
86	23454	31916
87	13604	18530
88	12485	16805
89	18043	24493
90	9131	25000
91	12339	33138
92	16975	33818
93	24002	33811
94	26256	37198
95	27128	38561
96	13109	19698
97	7215	12679
98	18180	44944
99	27198	39026
100	27318	38182
101	27198	39026
102	23595	34422
103	15609	22931
104	2096	5595
105	1470	3836
106	13513	29254
107	7283	19994
108	23131	26385
109	3553	4602
110	26008	29644
111	22777	26016
112	23603	28038
113	24733	29443
114	20945	25540
115	23847	28363
116	8239	12493
117	27318	38182
118	18367	26460

APPENDIX B

NASA/BOEING 727 GRAPHITE COMPOSITE ELEVATOR SERVICE HISTORY

Five shipsets of 727 graphite composite elevators were fabricated for Contract NAS1-14952 with the prime objective of establishing and demonstrating the structural integrity, operating-life characteristics, and manufacturing cost of composite structures.

The five shipsets (10 units) entered service with United Airlines in 1980. A summary of accumulated hours and landings is shown on Table B1.

Two separate ground handling incidents resulted in the damage and subsequent removal of two units. These units were subsequently repaired at the United Maintenance Base and are awaiting reinstallation. Lightning strikes or exits have resulted in the required repair of several units. These repairs were minor and performed with the units remaining on the aircraft.

CURRENT SPOILER FLIGHT HOURS AND LANDING DATA

S/N	INSTALLATION DATE	AIRLINE	INSTALLATION		REMOVAL DATE	CURRENT		NET		REMARKS
			HOURS	LANDINGS		HOURS	LANDINGS	HOURS	LANDINGS	
1	03-19-80	1	0	0	--------	14741	7952	14741	7952	2
2	03-19-80	1	0	0	--------	14741	7952	14741	7952	2
3	03-27-80	1	0	0	03-07-82	6201	3013	6201	3013	1
4	03-27-80	1	0	0	03-07-82	6201	3013	6201	3013	0
4	08-20-82	1	6678	3353	--------	14324	7778	7646	4425	2
5	04-25-80	1	0	0	--------	14324	7778	14324	7778	2
6	04-25-80	1	0	0	08-20-82	6678	3353	6678	3353	1
7	04-30-80	1	0	0	--------	14367	7719	14367	7719	2
8	04-30-80	1	0	0	--------	14367	7719	14367	7719	2
9	06-01-80	1	0	0	--------	13829	7510	13829	7510	2
10	06-01-80	1	0	0	--------	13829	7510	13829	7510	2

UNITED=1
REMARKS CODE
0=OLD DATA, 1=IN STORES, 2=CURRENTLY ACTIVE, 3= OUT FOR REPAIR OR EVALUATION

TOTAL NET HOURS= 126924 TOTAL NET LANDINGS= 67944

ELEVATOR FLIGHT HOURS AND LANDINGS

S/N	HOURS	LANDINGS	AIRCRAFT
1	14741	7952	N7459U
2	14741	7952	N7459U
3	6201	3013	STORES
4	13847	7438	N7461U
5	14324	7778	N7461U
6	6678	3353	STORES
7	14367	7719	N7462U
8	14367	7719	N7462U
9	13829	7510	N7466U
10	13829	7510	N7466U

APPENDIX C

NASA/BOEING 737 GRAPHITE COMPOSITE STABILIZER SERVICE HISTORY

Five shipsets of 737 graphite composite stabilizers were fabricated for Contract NAS1-15025 with the prime objective of demonstrating the feasibility of fabricating, certifying, and the entrance into service of composite primary structure.

Five shipsets (10 units) entered service with Delta Airlines and Mark Air in 1984. A summary of accumulated hours and landings is shown on Table C1.

No service difficulties have been seen.

CURRENT SPOILER FLIGHT HOURS AND LANDING DATA

S/N	INSTALLATION DATE	AIRLINE	INSTALLATION		REMOVAL DATE	CURRENT		NET		REMARKS
			HOURS	LANDINGS		HOURS	LANDINGS	HOURS	LANDINGS	
1	03-13-84	1	0	0	--------	2056	2230	2056	2230	2
2	03-13-84	1	0	0	--------	2056	2230	2056	2230	2
3	03-16-84	1	0	0	--------	1988	2154	1988	2154	2
4	03-16-84	1	0	0	--------	1988	2154	1988	2154	2
5	05-11-84	2	0	0	--------	1773	1972	1773	1972	2
6	05-11-84	2	0	0	--------	1773	1972	1773	1972	2
7	06-22-84	2	0	0	--------	1392	1516	1392	1516	2
8	06-22-84	2	0	0	--------	1392	1516	1392	1516	2
9	08-18-84	2	0	0	--------	1124	1294	1124	1294	2
10	08-18-84	2	0	0	--------	1124	1294	1124	1294	2

DELTA=1, MARKAIR=2
REMARKS CODE
0=OLD DATA, 1=NO LONGER ACTIVE, 2=CURRENTLY ACTIVE, 3= OUT FOR REPAIR OR EVALUATION

TOTAL NET HOURS= 16666 TOTAL NET LANDINGS= 18332

STABILIZER FLIGHT HOURS AND LANDINGS

S/N	HOURS	LANDINGS	AIRCRAFT
1	2056	2230	N314DL
2	2056	2230	N314DL
3	1988	2154	N307DL
4	1988	2154	N307DL
5	1773	1972	N670MA
6	1773	1972	N670MA
7	1392	1516	N671MA
8	1392	1516	N671MA
9	1124	1294	N672MA
10	1124	1294	N672MA

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15. Supplementary Notes

Use of commercial products or names of manufacturers in this report does not constitute official endorsement of such products or manufacturers, either expressed or implied, by the National Aeronautics and Space Administration.

Langley Technical Representative: H. Benson Dexter

16. Abstract

The eighth flight service report was prepared in compliance with the requirements of Contract NAS1-11668. It covers the flight service experience of 111 graphite-epoxy spoilers on 737 transport aircraft and related ground-based environmental exposure of graphite-epoxy material specimens for the period of May 1981 through December 1984. Spoilers have been installed on 28 aircraft representing seven major airlines operating throughout the world. An extended flight service evaluation program of 15 years is presently underway. As of December 1984, a total of 2,092,155 spoiler flight-hours and 2,954,814 spoiler landings had been accumulated by this fleet.

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