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TOTAL AIRFRAME FATIGUE TEST F 104 G FINAL REPORT

Schutz

Foreign Technology Division
Wright-Patterson Air Force Base, Ohio

20 March 1975

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RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English
sin	sin
cos	cos
tg	tan
ctg	cot
sec	sec
cosec	csc
sh	sinh
ch	cosh
th	tanh
cth	coth
sch	sech
csch	csch
arc sin	$\sin^{-1}$
arc cos	$\cos^{-1}$
arc tg	$\tan^{-1}$
arc ctg	$\cot^{-1}$
arc sec	$\sec^{-1}$
arc cosec	$\csc^{-1}$
arc sh	$\sinh^{-1}$
arc ch	$\cosh^{-1}$
arc th	$\tanh^{-1}$
arc cth	$\coth^{-1}$
arc sch	sech^{-1}
arc csch	csch^{-1}

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rot	curl
lg	log

GRAPHICS DISCLAIMER

All figures, graphics, tables, equations, etc. merged into this translation were extracted from the best quality copy available.

U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

GREEK ALPHABET

Alpha	Α	α	*α*		Nu	Ν	ν	
Beta	Β	β			Xi	Ξ	ξ	
Gamma	Γ	γ			Omicron	Ο	ο	
Delta	Δ	δ			Pi	Π	π	
Epsilon	Ε	ε	*ε*		Rho	Ρ	ρ	ϱ
Zeta	Ζ	ζ			Sigma	Σ	σ	ς
Eta	Η	η			Tau	Τ	τ	
Theta	Θ	θ	ϑ		Upsilon	Υ	υ	
Iota	Ι	ι			Phi	Φ	φ	ϕ
Kappa	Κ	ϰ	κ	*κ*	Chi	Χ	χ	
Lambda	Λ	λ			Psi	Ψ	ψ	
Mu	Μ	μ			Omega	Ω	ω	

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TOTAL AIRFRAME FATIGUE TEST F 104 G FINAL REPORT*

Schütz

ABSTRACT. This final report contains the most important information and data on the experimental configuration, experimental sequence, and the results of the F 104 G total airframe fatigue experiment. Details are contained in 31 additional partial reports. In addition, the tables of Appendix B contain all the damage information which occurred on the structure during the experiments. This report can be used as a means of orientation for the information contained in the partial reports because of the cross references in the text and the tables. This final report also contains an evaluation of the most important results (damage) and contains recommendations for their elimination, as well as modifications already made.

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*Report No. TF 81/20. IABG (Industrial Facilities Operations Corporation), Ottobrunn. Main Division for Strength of Materials, Construction and Materials. Customer: Federal Ministry for Military Science and Appropriations. Contract No. T/L 115 90 115/94 407; T/L 115 10 073/94 407. IABG Task 142 1024; 142 2135.

1. General Specifications

The following deadlines and events characterized the sequence of the F 104 G total airframe fatigue experiment:

— beginning of the fatigue experiment in February, 1969;

— fracture of the right main wing in April, 1971, at 6407 total test hours, corresponding to 5997 TCTP test hours;

— continuation of the experiment with a right replacement wing up to 8687 total test hours, corresponding to 6934 TCTP test hours for the left support member, which was reached in February, 1972;

— change of the left main wing and of one troop wing with 1342 hours of use, corresponding to the retrofit program in the time period between February, 1972, to July, 1972;

— renewed start of the fatigue experiment in September, 1972;

— end of the experiment in July 1973 at 14,869 total test hours, corresponding to 6182 TCTP test hours for the retrofit main wing and 14,459 TCTP test hours for the fuselage structure (14,869 total test hours).

In addition to these major milestones, the test sequence was also interrupted by extensive repair and exchange activity, such as for example, many instances of exchange of the wing-fuselage connection fittings, reinforcement of the rear spars, etc., which took many weeks.

All of the decisions concerning the most important measures and modifications within the overall sequence were made with the permission of the customer, the BMVg T IV 8 (formally), the BWB LG IV 2, as well as the BWB-ML, MBB-UF, and the LBF. The participants were informed by the IABG about all important events and damage in the form of short information bulletins.

The concluding documentation for the F 104 G total airframe fatigue experiments was published in the form of 32 partial reports (see Table A1), which can be grouped as follows:

— 6 partial reports which contain information on the preliminary investigations, such as, for example, the influence of flap deflections, investigations of the introduction of loads, etc.;

— 7 partial reports, which describe the test configuration, the loads, the loading program, the measurement points, etc.;

— 8 partial reports which treat the results of the stress measurements, lifetime estimations, as well as related measures (probe rod experiments, inspection methods), etc.;

— 11 partial reports in which the structural damage experienced during the fatigue experiment is described in detail.

The final report presented here gives the most important details in summary form, and this is shown in the following chapters for each of the individual areas.

2. Purpose of the Experiment

A complex method of construction comes about in high performance aircraft such as the F 104 G when high strength materials are used in conjunction with the requirement for a high measure of safety for the supporting structural parts. This places relatively high requirements on the fatigue resistance.

Within the framework of the total airframe fatigue experiment F 104 G, we were able to establish fatigue strength for the required or planned lifetime for the primary structure, that is, the wings and the fuselage, in particular the central part of the fuselage for conditions close to the loads experienced during operation.

The total airframe fatigue experiment F 104 G covered the following points which determined the reliability, the operational safety, and the capacity for operation of the structure:

— determination of the fatigue-critical weak points.

Experience up to the present has shown that computations alone or simplified tests carried out by the manufacturer are not sufficient for finding fatigue-critical points. This is especially true for structures having a complex configuration, for discontinuities and segments within the structure, and for points where forces are introduced and where there are abrupt transitions in the cross section. This experience has been confirmed by the experiment described here, which has now been brought to a conclusion. During the total airframe fatigue experiment, we were able to localize sixteen different structural components or regions on the fuselage which can be considered to be especially critical for fatigue. Sixteen such points were also found on the main wing.

— lifetime of the primary structure.

In order to determine the minimum lifetime and in order to define the beginning of an inspection of main structure components, such as for example, of the wing, we used the experimental results from the total airframe fatigue experiment as a base in conjunction with statistical evaluations.

— crack propagation behavior and residual strength.

In order to specify suitable inspection intervals, it is necessary to ascertain the crack propagation behavior and the residual strength of components with beginning cracks. Within the framework of the total airframe fatigue experiment, we fixed the advancing propagation of the individual cracks at several points, in order to avoid catastrophic failure in true aircraft.

— demonstration of fail-safe properties.

The total airframe fatigue experiment showed that the fuselage structure essentially has the fail-safe properties, i.e., that if one supporting element fails, the strength of the structure does not drop below a certain minimum value before the fatigue crack was found.

The wing assembly and especially the lower shell does not have any fail-safe properties over extensive regions. The experiment showed that, when there is a fatigue surface of 3 — 4% of the supporting cross section, a force fracture occurs which leads to a fatal failure.

— testing of inspection methods.

Since the crack magnitudes considered to be critical differ widely for the individual components, it is necessary to work up inspection methods which are sufficient for all of the requirements. The damage which occurred within the framework of the total airframe fatigue experiment represents a basis for testing the effectiveness of inspection methods.

— lifetime estimation for changing deployment concepts of the troop aircraft.

The strain gauges which were applied to the aircraft in order to carry out the stress analysis for all of the load cases which occurred during the test program could be used to determine the local stress collectives which occurred during the total airframe fatigue experiment. The effect on the lifetime can be investigated by carrying out comparison calculations or by simple additional experiments with sample rods, in conjunction with a comparative damage accumulation calculation, in the case where the operational mission changes.

— logistic measur . .

If g countermeasurement units are installed in the aircraft, as a result of the equivalent damage recorded based on g counters, it is possible to determine the planned replacement point in time for each unit on an individual basis. From this, one obtains important information and data for material flow and replacement part procurement. Here again the material and component-specific results of the total airframe fatigue experiment are used as a basis for these investigations.

— development of methods for increasing the lifetime of endangered components.

In order to increase the lifetime of certain structural components which were found to be critical for fatigue because of the findings of the total airframe fatigue experiments or because of analytical derivations and troop experiment, we tested and performed modifications to the materials technology (exchange of materials), manufacturing technology (for example, Coinen, spherical steels) and construction methods (for example, addition of material, enlargement of transition radii).

3. Experiment Description of the Total Airframe Fatigue Experiment F 104 G

3.1. Experiment Configuration

It was the purpose of the F 104 G total airframe fatigue test to test the wing structure, wing fuselage connection structure, and the central part of the fuselage in a representative way. For this purpose, 33 hydraulic cylinders with the corresponding loading frames and load introduction systems were used to introduce forces at the individual regions of the structure. Figure 1 shows an overall view of this arrangement and shows the position of the airframe in the test building.

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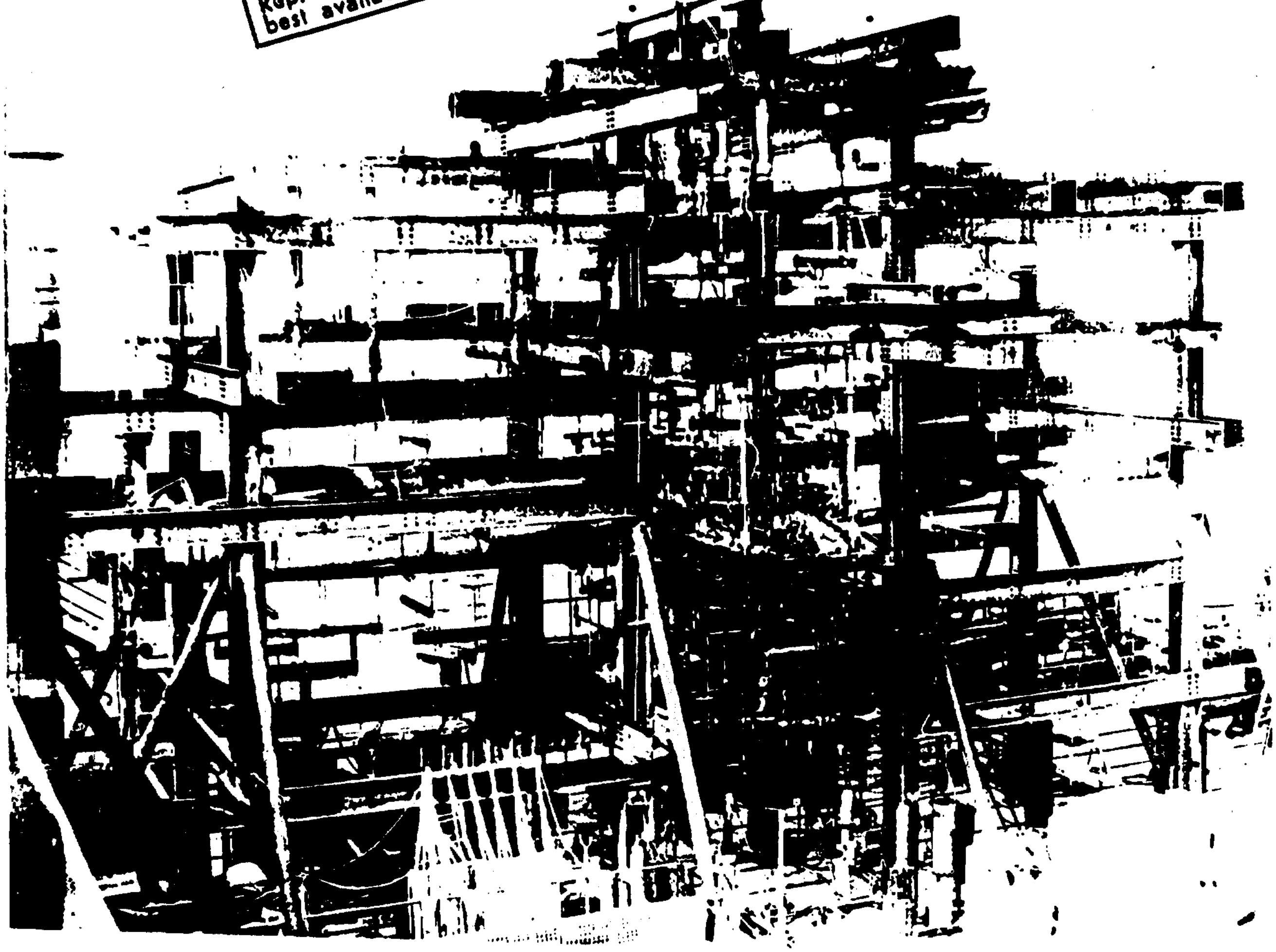

Figure 1. Overview of experimental configuration.

An original airframe was used for the test, taken from the production line.

In detail, we have the following specifications:

Type	F 104 G
Year of manufacture	1965
Manufacturer	Firm Fairey S. A. (Belgium)

Serial numbers of the most important components:

Fuselage	Serial No. 113-5
Original wing (left and right)	Serial No. 7210
Left replacement wing	Serial No. 2003
Right replacement wing	Serial No. 7020
Left retrofit wing	Serial No. 7210
Right retrofit wing	Serial No. 8166

The airframe is completely equipped according to the purpose of the experiment. The structural components not being investigated, the propulsion systems in addition to auxiliary units, the equipment, weapons, and payloads were simulated by weights or by dummies for a certain weight configuration.

The loads were applied in the form of a flight by flight program. For each of the 143 different load cases which occurred during the program, we selected the load cylinders using an electro-servo hydraulic control unit.

In conformance with the technology at the time, a punched tape was used as an information carrier for each loading case within a flight and in a sequence during the individual flights. Each load combination was stored on it. Using a cross track distributor and the corresponding control units, the hydraulic cylinders were each controlled individually. Figure 2 gives an overview of the installation.

In addition to numerous safety devices which protect the test configuration and the test object against damage, considerable amounts of equipment were used to check the test installation and to determine the strains of the test airframe.

Additional details on the structure and design of the experimental frame, the control and measurement installation, the safety installations, as well as the interactions of the individual systems can be taken from the following IABG reports:

Figure 2. Crossbar distribution panel (right) and voltage divider (left) in the supplied experimental configuration for the total airframe fatigue experiment.*

— TF-B-81/18 Total Airframe Fatigue Experiment F 104 G, Test Configuration

3.2. Experiment Loads

In addition to the symmetric maneuver and gust loads, we simulated the takeoff/landing/load change and the rolling on the ground (taxiing) within the framework of this total airframe fatigue experiment. The total number of 143 load changes can be briefly described as follows:

— three configurations (clean 2%, tip tank 92%, tip tank and pylon tank 6% of total frequency);

— two pressure point positions
22% for Ma 0.68 and 0.9
45% for Ma 1.45 and Ma 0.68 with flaps/slats (15°/15°)

— ten weight distributions

— maneuver load multiple between -2.5 g and + 6.9g

Table 1 gives a summary of the load cases used.

Details on the experimental loads including the comparisons between the intersection loads obtained by computation and by experiment can be taken from the following partial report for the individual components of the structure:

— TF-B-81/9 Total Airframe Fatigue Experiment F 104 G, Experimental Loads, Part A to C.

*Translator's Note: Figure missing on page 45 of German text.

TABLE 1

SUMMARY OF LOAD CASES

Load Case	Load Case Designation	Configuration	Mach	Flight Weight lbs.	Load Multiple n	Frequency of Load Cases per 1000 fl.hrs. MFG	TCTP
1	PQT 5/1/1.5				1.49	302	417
2	PQT 5/1/2.0				2.00	206	248
3	PQT 5/1/3.0				2.95	51	87
4	PQT 5/1/4.0				4.00	22	22
5	PST 5/1/1.5				1.49	7473	6605
6	PST 5/1/2.0			22 700	2.00	391	465
7	PST 5/1/3.0				2,95	537	744
8	PST 5/1/4.0				4.00	86	241
9	NST 5/1/0.3				0.33	8142	7728
10	NST 5/1/0.0				0.05	324	324
11	NST 5/1/1.0				1.03	3	3
12	PQT 6/1/1.5				1.50	419	581
13	PQT 6/1/2.0				2.03	286	344
14	PQT 6/1/3.0				3.00	71	120
15	PQT 6/1/4.0				3.95	30	30
16	PST 6/1/1.5	Tiptank	0,68		1.50	10770	9583
17	PST 6/1/2.0		C.P=		2.03	587	691
18	PST 6/1/3.0		22%	21 300	3.00	765	1054
19	PST 6/1/4.0				3.95	126	341
20	PST 6/1/5.0				4.97	25	52
21	NST 6/1/0.5				0,50	11793	11263
22	NST 6/1/0.0				-0.03	474	452
23	NST 6/1/1.0				-0.99	4	4
24	NST 6/1/2.5				-2.51	2	2
25	PQT 7/1/1.5				1.49	419	581
26	PQT 7/1/2.0				1.98	286	344
27	PQT 7/1/3.0				3.02	71	120
28	PQT 7/1/4.0				4.04	30	30
29	PST 7/1/1.5				1.49	10754	9566
30	PST 7/1/2.0			19 900	1.98	586	690
31	PST 7/1/3.0				3.02	766	1055
32	PST 7/1/4.0				4.04	125	340
33	PST 7/1/5.0				5.00	25	51
34	NST 7/1/0.6				0,57	11775	11244
35	NST 7/1/0.0			19 900	0.01	475	452
36	NST 7/1/2.0				-1.03	4	4
37	NST 7/1/2.5				-2.51	2	2
38	PQT 8/1/1.5				1.51	419	581
39	PQT 8/1/2.0				1.90	286	344
40	PQT 8/1/3.0				3.08	71	120
41	PQT 8/1/4.0			18 500	4.15	30	30
42	PST 8/1/1.5				1.51	10785	9598
43	PST 8/1/2.0				1.99	588	692
44	PST 8/1/3.0				3.08	766	1055
45	PST 8/1/4.0				4.15	126	341
46	PST 8/1/5.0				5.10	25	52

TABLE 1 (Continued)

Load Case	Load Case Designation	Configuration	Mach	Flight Weight lbs.	Load Multiple n	Frequency of Load Cases per 1000 fl.hrs. MFG	TCTP
47	NST 8/1/0.3				0,33	11811	11281
48	NST 8/1/0.0				0,06	474	452
49	NST 8/1/1.0				-0.97	5	5
50	NST 8/1/2.7				-2.68	0	0
51	PQT10/1/1.6	Tiptank	0,68 C.P= 22%		1.59	391	540
52	PQT10/1/2.0				1.98	266	320
53	PQT10/1/3.0				3.00	66	113
54	PQT10/1/4.0				4.05	28	28
55	PST10/1/1.6			17 100	1.59	9975	8855
56	PST10/1/2.0				1.98	542	636
57	PST10/1/3.0				3.00	712	978
58	PST10/1/4.0				4.05	116	316
59	NST10/1/0.4				0.42	10900	10362
60	NST10/1/0.0				0.01	441	419
61	NST10/1/1.0				-1.01	4	4
62	PKT 5/1/2.0		0.68 C.P= 45%		1.99	334	403
63	PKT 5/1/3.0				2.97	126	229
64	PKT 5/1/4.0				4.14	80	125
65	PKT 6/1/2.0	Tiptank			2.00	462	559
66	PKT 6/1/3.0			21 300	2.94	174	295
67	PKT 6/1/4.1				4.091	112	-
67	PKT 6/1/4.4				4.37	-	185
68	PKT 6/1/5.0			21 300	5.07	40	50
69	PKT 7/1/2.0		0.68 C.P= 45%		2.01	462	559
70	PKT 7/1/3.0			19 900	2.98	174	295
71	PKT 7/1/3.9				3.925	112	-
71	PKT 7/1/4.5				4.45	-	185
72	PKT 7/1/5.1				5.10	40	50
73	PKT 8/1/2.0				2.01	462	559
74	PKT 8/1/3.0				3.01	174	295
75	PKT 8/1/4.0			18 500	3.987	112	-
75	PKT 8/1/4.3				4.29	-	185
76	PKT 8/1/4.9				4.86	40	50
77	PKT10/1/2.0				1.99	430	520
78	PKT10/1/3.0			17 100	2.98	162	286
79	PKT10/1/3.9				3.893	104	-
79	PKT10/1/4.4				4.40	-	170
80	PST 5/2/1.5				1.49	463	376
81	PST 5/2/2.0				2.06	87	127
82	PST 5/2/3.0			22 700	2.99	93	111
83	PST 5/2/4.0				4.00	17	44
84	NST 5/2/0.3				0.30	658	656
85	NST 5/2/0.5		0.9		-0.47	2	2
86	PST 6/2/1.5		C.P= 22%		1.48	1295	1051

ABLE 1 (Continued

Load Case	Load Case Designation	Configuration	Mach	Flight Weight lbs.	Load Multiple n	Frequency of Load Cases per 100 fl.hrs. MFG	TCTP
87	PST 6/2/2.0			21 300	2.02	244	356
88	PST 6/2/3.0				2.97	260	311
89	PST 6/2/4.0				4.01	47	123
90	PST 6/2/5.0				5.00	5	15
91	NST 6/2/0.4				0.36	1842	1847
92	NST 6/6/2.6			21 300	-0.56	8	8
93	NST 6/2/1.5				-1.45	1	1
94	PST 7/2/1.5				1.51	1434	1163
95	PST 7/2/2.0				2.03	271	394
96	PST 7/2/3.0				3.00	287	344
97	PST 7/2/4.0				4.00	52	137
98	PST 7/2/5.0			19 900	5.00	7	17
99	NST 7/2/0.5				0.41	2039	2043
100	NST 7/2/0.5				-0.46	8	8
101	NST 7/2/1.5			19 900	-1.54	2	2
102	NST 7/2/2.0				-2.09	2	2
103	PST 8/2/1.5				1.49	1156	938
104	PST 8/2/2.0		0.9		1.93	218	317
105	PST 8/2/3.0		C.P.=		3.02	232	278
106	PST 8/2/4.0		22%		4.05	42	110
107	PST 8/2/5.0	Tiptank		18 500	5.00	5	13
108	NST 8/2/0.2				0.19	1644	1647
109	NST 8/2/0.5				-0.47	8	8
110	NST 8/2/1.5				-1.52	1	1
111	PST10/2/1.5				1.49	1481	1201
112	PST10/2/2.0				1.97	280	406
113	PST10/2/2.9			17 100	2.89	298	356
114	PST10/2/3.9				3.88	55	141
115	NST10/2/0.3				0.23	2105	2096
116	NST10/2/0.5				-0.50	9	8
117	PSC7A/3/1.7				1.71	109	109
118	PSC7A/3/3.0		1.45	19 150	2.93	22	22
119	NSC7A/3/0.5		C.P.=		0.53	131	131
120	PSC 8/2/2.0	clean	-45%		1.99	1121	1121
121	PSC 8/2/4.5		0.9		4.51	59	59
122	PSC 8/2/6.9		C.P.=	18 500	6.87	1	1
123	NSC 8/2/0.5		22%		0.47	1174	1174
124	NSC 8/2/0.0				-0.05	7	7
125	PSP 2/1/1.5				1.48	275	275
126	PSP 2/1/2.0	Tip- and	0.68		2.08	30	30
127	PSP 2/1/3.0	Pylon-	C.P.=	25 700	3.01	16	16
128	NSP 2/1/0.4	tank	22 %		0.44	321	321

TABLE 1 (Continued)

Load Case	Load Case Designation	Configuration	Mach	Flight Weight lbs.	Load Multiple n	Frequency of Load Cases per 100 fl.hrs. MFG	TCTP
129	PSP 3/1/1.5				1.50	455	455
130	PSP 3/1/2.0				2.01	50	50
131	PSP 3/1/3.0			24 100	2.97	24	24
132	PSP 3/1/4.0				3.96	8	8
133	NSP 3/1/0.4			24 100	0.41	537	537
134	PSP 5/1/1.5				1.51	422	422
135	PSP 5/1/2.0	Tip- and	0.68		2.0	46	46
136	PSP 5/1/3.1	Pylontank	C.P.=	22 700	3.10	22	22
137	PSP 5/1/4.1		22 %		4.13	8	
138	PSP 5/1/5.1				5.16	2	
139	NSP 5/1/0.4				0.44	500	500
140	RT 4/0/0.33				0.33	11115	11115
141	RT 4/0/1.66	Tiptank		23 500	1.67	11115	11115
142	RP 1/0/0.33	Tip- and			0.33	555	555
143	RP 1/0/1.66	Pylontank	0.0	26 500	1.67	555	555
144		0.68 C.P. =22%		21 300	0.84		
145		0.68 C.P. =45%					

3.3. Experimental Program

The experimental program is based on four main missions which can be characterized as follows:

— mission 1 625 flight hours
  low-low-low
  ma = 0.68
  tip tank — configuration

— mission 2 295 flight hours
  high-high-high
  Ma = 0.9
  tip tank — configuration

— mission 3 60 flight hours
test flight
Ma = 0.9/1.45
Clean — configuration

— mission 4 20 flight hours
high-high-high and
low-low-low
Ma = 0.68
tip and pylon tank — configuration

The flight hours given above are the fractions which are contained within a partial sequence of the test program which lasted 1000 flight hours. These 1000 flight hours correspond to 803 characteristic flights and each flight consists of 203 load multiples on the average. For each flight, about 75 load changes correspond to gusts and maneuvers.

The relationship between the missions and configurations, respectively, and the load states can be found from Figure 3. Figure 4 shows the MFG total spectrum. The percentage composition of this spectrum and the initial data used can be found from Table 2. The marine aviation wing spectrum (abbreviation MFG) was simulated for up to 1000 test hours.

A change in the tactical use of the aircraft at that time led one to the conclusion that this would result in a more severe load on the airframe. Therefore, the so-called tactical combat training procedure (abbreviation TCTP) spectrum was estimated, which is also shown in Figure 4.

The order of the individual load cases within a flight is partially deterministic according to a mission and partially stochastic. The sequence of the individual flights was selected so that the mix of the program sequence was as uniform as possible.

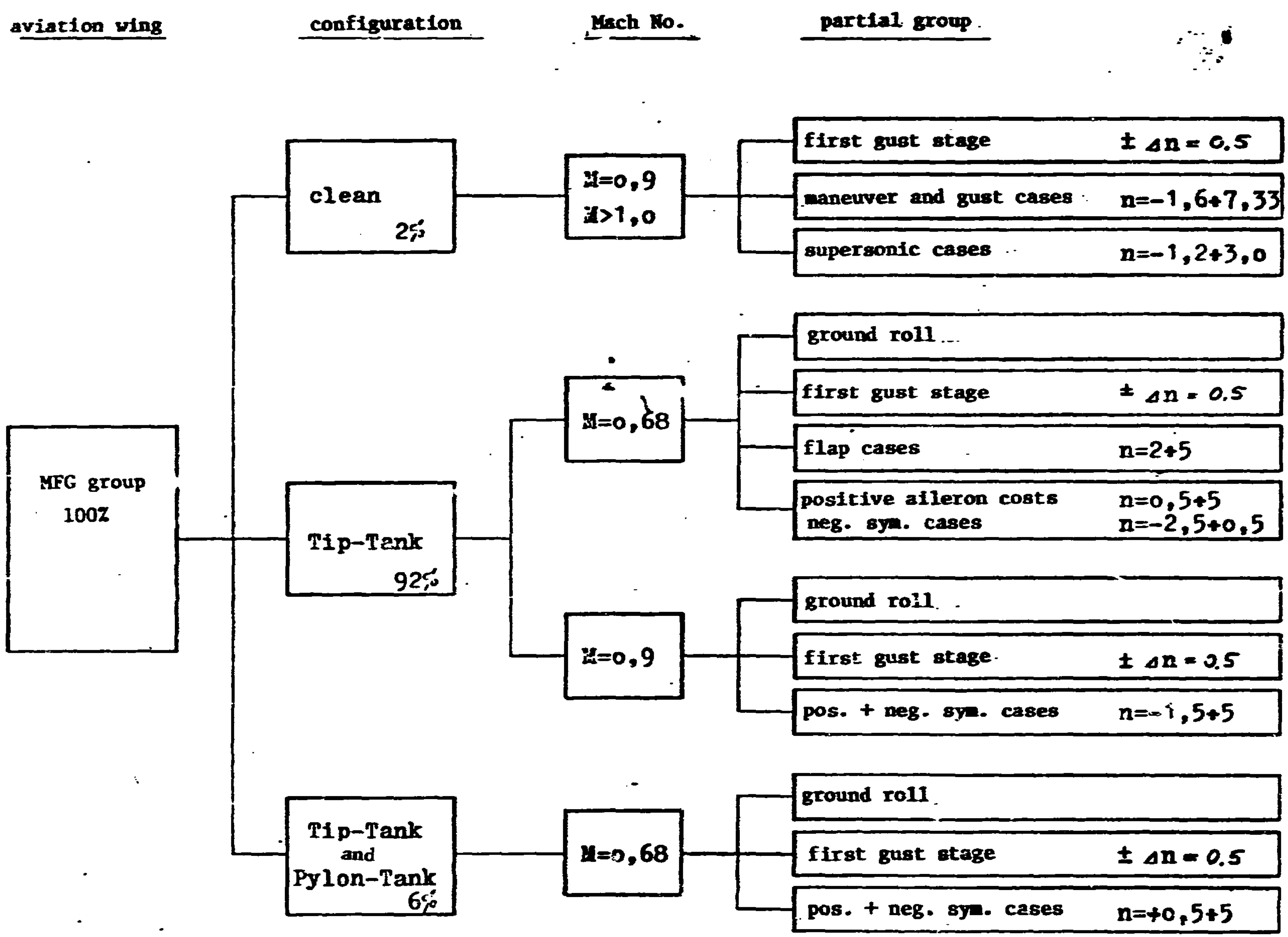

Figure 3. Structure of the MFG (Marine Aviation Wing Spectrum) group.

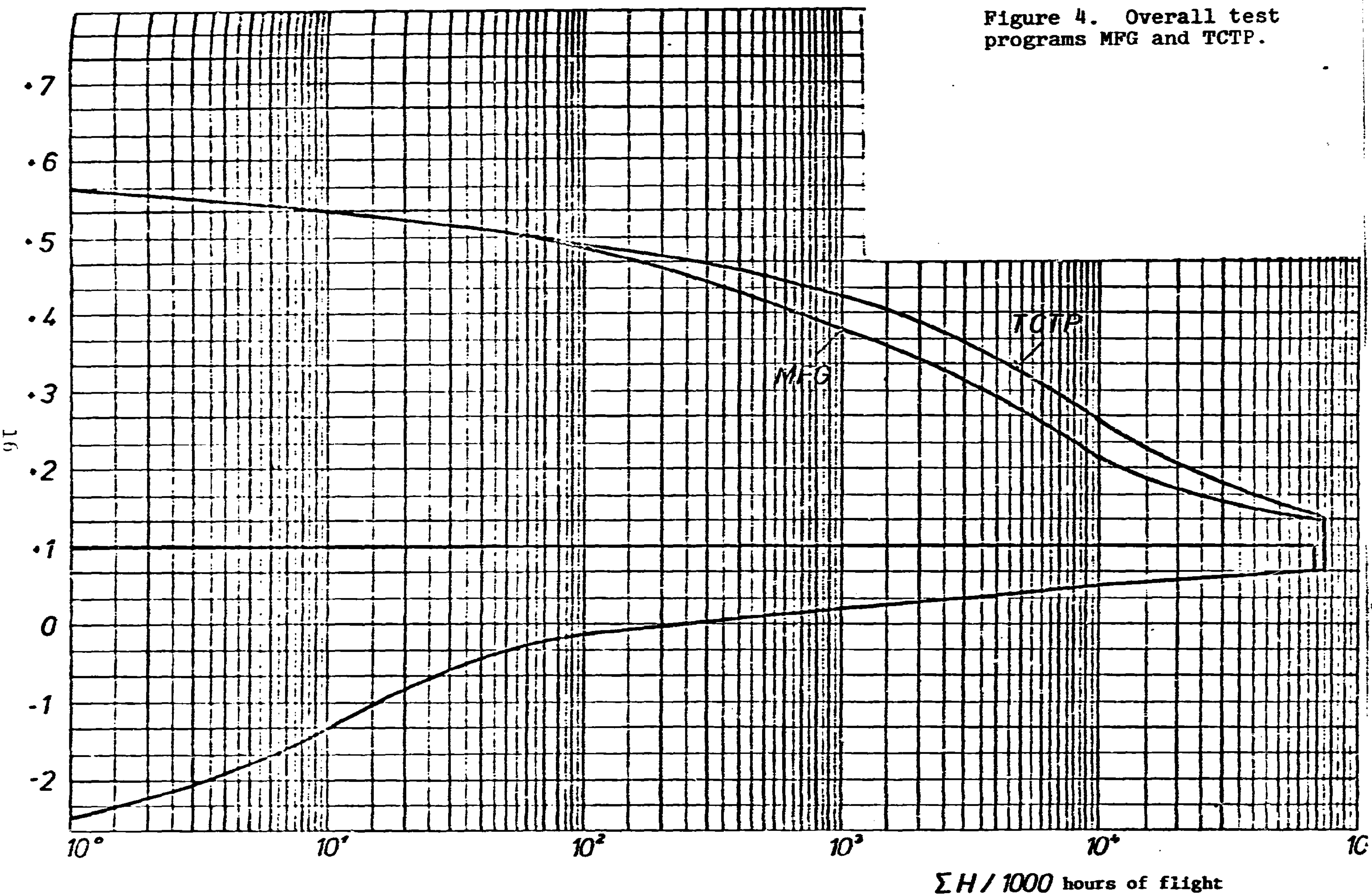

Figure 4. Overall test programs MFG and TCTP.

TABLE 2

CORRESPONDENCE OF FREQUENCY DISTRIBUTIONS AND FLIGHT MISSIONS FOR THE MARINE AVIATION WING SPECTRUM IN PERCENT OF TOTAL FLIGHT TIME

		MISSION			
		High-High-High	Low-Low-Low	High-High-High Low-Low-Low	Test Flight
		Config. T. T. Ma. 0.9 Flight time: 29.5%	Config. T. T. Ma. 0.68 Flight time: 62.5%	Config. T. T. and P. T. Ma. 0.68 Flight time: 6%	Config. CLEAN Ma. 0.9/1.45 Flight time: 2%
Frequency Distribution	Reconnaissance**	7.5		6.0	
	Air tactics***	22.0	30.0		
	Convent. bombing***		32.0		
	Test Flight***				2.0*
TOTAL		29.5	62.5	6.0	2.0

*Of this, 1.8% in the subsonic and 0.2% in the supersonic range.

**LBF data

***F-4C flight measurement.

Figure 5 shows the sequence for a typical flight within the 803 flights. The bending moment at the root is used as a reference. Detailed data on the structure of the loading program are contained in the following IABG report:

— TF-B-81/10 Total Airframe Fatigue Experiment F 104 G Load Program

4. Results

4.1. Results of Preliminary Investigations

The influences of maneuver flaps and aileron deflection on the stress distribution in the supporting part of the wing assembly was investigated with individual components of the F 104 G in order to establish the experimental concept. The results are contained in the following reports:

— 81/01 and 81/02 Fatigue Strength Demonstration F 104 G Influence of Flap Deflection on the Stress Distribution in the Wing

— 81/07 Fatigue Experiment Demonstration F 104 G Influence of Aileron Deflections on the Stress Distribution in the Wing

After the fracture of the wing assembly, which started at WS 80.7 and occurred at the hatch, led to the loss of an aircraft and after we found damage in this region in additional operational aircraft and during fatigue experiments, we questioned the influence of the deployed landing flaps on the stress distribution in this region. It was important to clarify this question because, during the fatigue experiments, we simulated only the loads but not the deployment of the flaps. On the other hand, during deployments with the hatch, we performed the flights with a considerably higher fraction of flap operation.

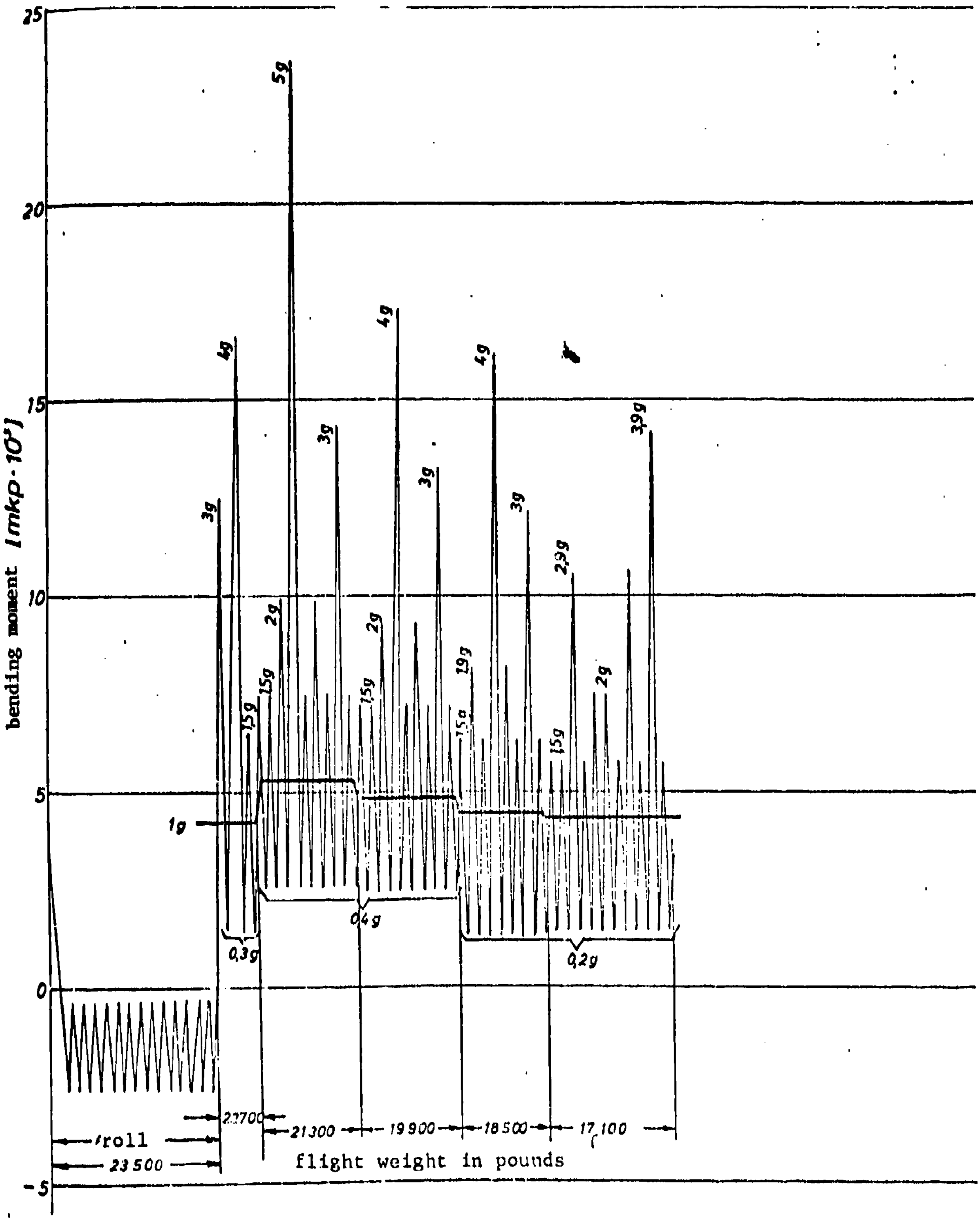

Figure 5. Bending moment variation along wing root during flight No. 25, high-high-high mission with Ma = 0.9, tip tank configuration.

The results of these additional measurements, which extend to the rear spar range and the wing root, are contained in the following report:

— TF 81/06 Total Airframe Fatigue Experiment F 104 G
Stress Analysis Flap Deflections

The result of this investigation can be summarized as follows:

— Usually one did not find a unified tendency in the change of the stress distribution when the flap was extended. Because of the small contribution of the flap cases in the TCTP collective, it is not necessary to correct the results of the total airframe fatigue experiment if the flaps are not deployed.

The measurement results obtained from the stress analysis showed that a pressure point change from the front (cp = 22%) to the back (cp = 45%), such as occurs when the flaps are operated, has a considerable negative influence on the stress distribution, in particular in the area of the wing root, and therefore also on the lifetime.

Special load introduction elements were developed to introduce the forces to the wing structure. Sometimes this led to a modification or weakening of the surrounding structure. In preliminary experiments, we were able to show that the changes made in these regions did not influence the lifetime, i.e., they do not fracture before the structure itself. The results of this investigation are contained in the following reports:

— TF 81/03 Total Airframe Fatigue Experiment F 104 G
Lifetime Improvement by Coining

— TF 81/04 Total Airframe Fatigue Experiment F 104 G
Wing Load Introduction

These results were subsequently confirmed, because no damage was found in the load introduction point during the fatigue experiment.

4.2. Stress Measurements

In order to determine the overall stress level, we determined the strains and stresses using strain gauges in all of the load bearing structures (primarily wing assemblies). After damage had occurred to an increased degree, we carried out additional instrumentation placement in order to be able to determine the local stress conditions in a better way and in order to be able to interpret them.

Before the beginning of the experiment with the retrofit wings, we carried out a small stress analysis in the region of the modified structure in order to obtain reference points on the influence of the modification. Detailed data and results of these investigations are contained in the following reports:

- TF 81/08 Total Airframe Fatigue Experiment F 104 G Arrangement of the Strain Gauges in the Fuselage and Wing, Parts A and B
- TF 81/11 Total Airframe Fatigue Experiment F 104 G Stress Analysis, Parts A and B
- TF 81/12 Total Airframe Fatigue Experiment F 104 G Stress Analysis Retrofit Wing

The stress measurements resulted in stresses along the lower shell of the wing root region (WS 48) of about +22 to 25 kg/mm^2 in the maximum load cases of the load program. The nominal stresses in the region of the pylon plane were only slightly smaller. In the region of disturbances and discontinuities, we sometimes measured considerably higher values.

An evaluation of the stress analysis of the retrofit/basic wing, mentioned in particular in the last report, showed that a stress reduction of about 15% occurs in the reinforced region of the lower wing skin of the retrofit wing at WS 47, which is a reference value.

At WS 48, this is about 20% and at the tapering in the reinforced region, it is about 30%.

In the transition range where there is thicker material, stresses occur in the unreinforced area of the retrofit wing, which are about 15% higher (because of additional bending). In the pylon fitting connection, they are about 7% lower and there are no significant differences at the pylon manifold.

4.3. Additional Investigations

It was sometimes necessary to test and develop special methods for recognizing cracks and monitoring them. In addition to the extensive breaking wire instrumentation, we also investigated the possibility of monitoring the occurrence and propagation of cracks using strain gauges. The results of such an investigation are contained in the following report:

— TF 81/05 Total Airframe Fatigue Experiment F 104 G Single Stage Experiment in a Drilled Probe Rod for Testing Crack Recognition Method Using Strain Gauges.

After the total airframe fatigue experiment had demonstrated the first structural damage, it became necessary to develop special crack test methods for the damage encountered during the fatigue experiment, as well as special methods for monitoring the operational aircraft. The first work was done within the framework of the F 104 G total airframe fatigue experiment project. The following report contains the investigation on a special eddy current crack test method:

— 81/22 Eddy Current Crack Test Method I For Main Wing F 104, Fitting 5, Bolt Hole 12

Additional special investigations required at the time were performed within the framework of separate requests. These investigations were concerned with the development of special test procedures, the production and manufacture of special equipment and the establishment of specifications for the troop personnel and their instruction.

The damage which occurred relatively early, in particular at the wing connection fittings, required structural improvements of the structures in this region. The material was made thicker in order to drop the stress level, and also other alloys were selected which have better static residual strength and which are more favorable with respect to the stress crack corrosion which we found. The additional investigations of these measures were also primarily performed within the framework of additional requests.

A few investigations, such as for example, the testing of the change-over from fitting alloy 7079 T6 (old forging) to a new forging method, or to the alloy AZ 74, were carried out within the framework of the total airframe fatigue experiment. The results are contained in the following report:

— TF 81/16 Total Airframe Fatigue Experiment F 104 G
Fitting Probe Rod Experiments

4.4. Damage During the Fatigue Experiment

4.4.1. Damage summary

The structural damage which occurred within the F 104 G total airframe fatigue experiment was discussed in detail in the eleven damage reports having the numbers TF-B-81/21.1 to TF-B-81/21.11. The exact titles of the reports are given in Table A1 in Appendix A of this report. Appendix B of this report contains a summary of all the damage found on the structure. It is given in the form of a table and is structured as follows:

Table B1	Damage to the Unreinforced Basic Wings (up to 8,687 total test hours)
Table B2	Damage to the Retrofit Wings (tested between 8,687 and 14,869 total test hours)
Table B3	Damage to the Fuselage Structure (tested up to 14,869 total test hours).

In this summary, we again given the damage report in which a detailed description of the damage is given, as well as possible notes about changes, repairs, and other measures taken.

Within the framework of the F 104 G total airframe fatigue experiment, about 2420 damages and initial cracks were found, which can be classified as follows:

— wing fuselage connection fittings (basic and retrofit) about 250

— lower skin (basic and retrofit) about 720

— wing inner components (spar and ribs) about 1300

— fuselage damage about 150

4.4.2. Classification of the damage

After conclusion of the total airframe fatigue experiment, we carried out a simple global classification of all the damage which occurred. It is also given in the last column of Tables 1 — 3 in Appendix B. These categories are a measure for the significance of the individual cracks and fractures, according to the present state of knowledge.

It should be noted that such correspondences are only possible for a certain limited span of time; in the case discussed here, this is up to a minimum lifetime for the individual components given under point 5.

Category X

Damage in the form of cracks or fractures which would lead to catastrophic effects within a relatively limited time frame and which could directly influence the flight safety. The damage locations should be inspected in detail at special specified inspection intervals after certain numbers of flight hours have elapsed, and they should also be covered within the framework of disturbance announcement methods. Damaged parts must be immediately replaced.

CATEGORY X — WING DAMAGE (see also Figure 6)

Damage No.	Report No.	Wing*	Damage Location
F10, F12, F13, F14, F15, F22, F28, F42, F46, F67, F68, F64	81/21.8	B	wing connection fittings (fittings)
RF4, RF5, RF6, RF7, RF8, RF9, RF10, RF11, RF12, RF16	81/21.9	"	wing connection fittings (fittings)
F40, F44	81/21.4	B	lower wing skin pylon fitting connection
RF21, RF22	81/21.5	R	(WS 63.7 WS 66)
F1, F31	81/21.4	B**	lower wing skin, opening for the aileron servo (WS 80.7)
F 49	81/21.4	B	lower wing skin pylon manifold
RF15, RF41	81/21.5	R	(WS 73.5)

*B = basic wing, R = retrofit wing

**In the meantime, the opening has been closed.

Category X — Fuselage Damage

No damage in the category X occurred for the fuselage.

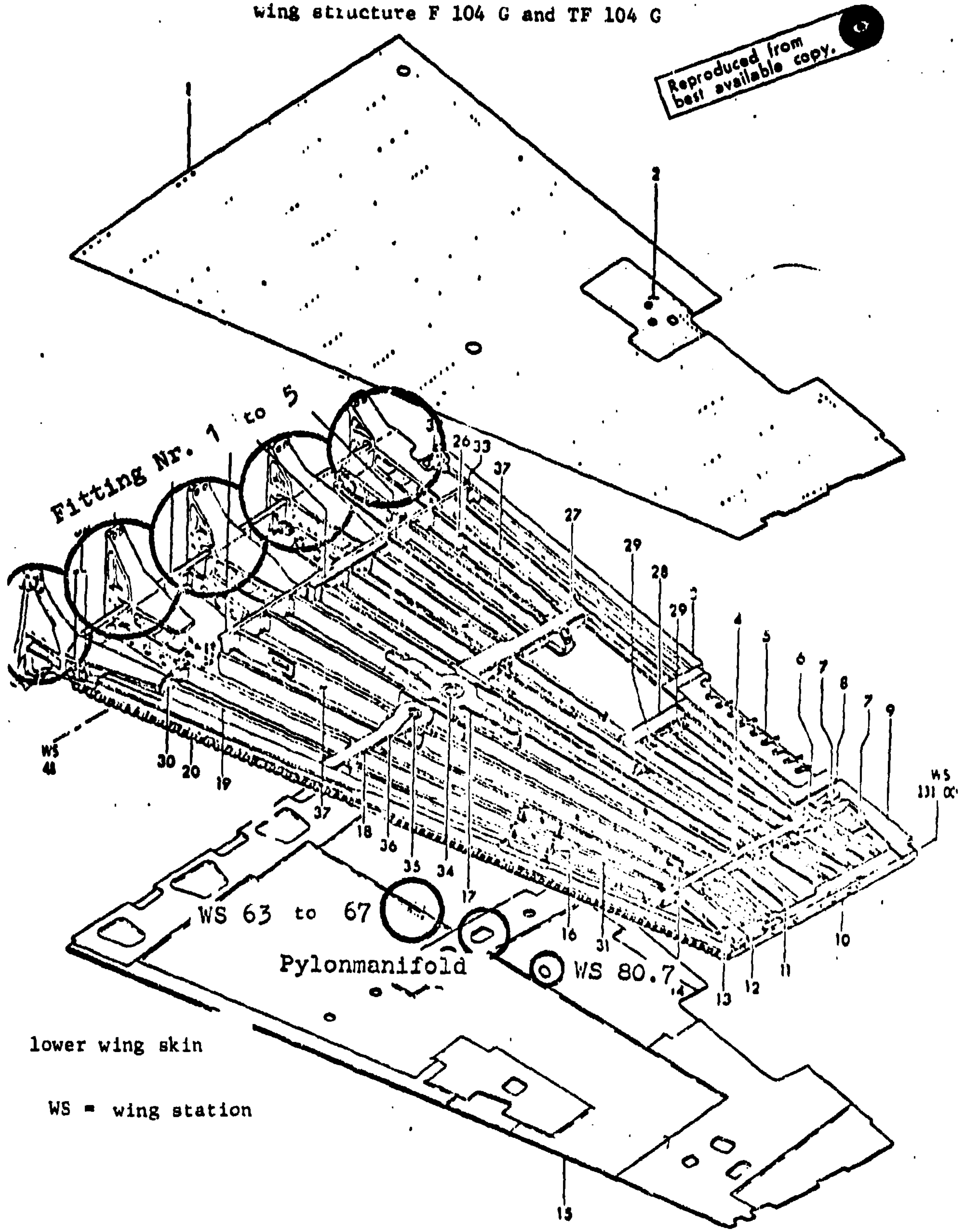

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Figure 6. Summary of wing damage of category X.

Category A

Damage which could endanger flight safety if it increased and which was determined during the total airframe fatigue test and partially in the operational aircraft. This possible type of damage should be thoroughly inspected during any change maintenance activity; the damage should be covered within the framework of the disturbance announcement procedure and should be repaired according to TO 1F-104G-3, or special instructions. A critical crack propagation between two change maintenance procedures is not required according to the present state of knowledge.

Category B

Damage which, in principle, corresponds to the damage specified as category A and which was first only determined within the framework of the total airframe fatigue test. In the case where this occurs in troop aircraft, it should be treated just as under category A as a precaution, i.e., there should be a thorough inspection during any change maintenance activity.

As can be seen from the definitions for categories A and B given above, these categories only differ by the fact that, in one case, information is available on the damage which occurred during the experiment as well as on similar troop damage.

Such a division was already established in the partial reports, for example, for the fuselage damage. Such definite statements are not possible for the wing damage, according to our present knowledge. The damage for categories A and B was therefore summarized in the following tables.

CATEGORIES A AND B — WING DAMAGES (see also Figure 7)

Damage No.	Report No.	Wing*	Damage Location
F16,F17,F44, F24,F27,F58, F65	81/21	B	Lower wing skin countersunk hole in the connection region of the fittings (WS 36 — 48)
RF23, RF 24, RF38	81/21.5	R	
F41,F44,F55, F60,F61,F65, F66	81/21.4	B	Lower wing skin countersunk hole in the interior wing region of the beam screw attachment (WS 48 — 74)
RF 33	81/21.5	R	
F19,F35,F39	81/21.10	B	Rear spar in the transition region from the Double-T to the U profile (WS 91)
RF 31	81/21.7	R	
RF13, RF14	81/21.7	R	Hinge band on the side of the wing for the landing flap connection
F 9	81/21.4	B	Lower wing skin opening for tip tank jettison arming switch (WS 117)
F 59	81/21.4	B	Lower wing skin attachment hole for the aileron servo

CATEGORIES A & B WING DAMAGES (CONTINUED)

Damage No.	Report No.	Wing*	Damage Location
F20,F30,F43	81/21.10	B	Lower wing skin, milled radius in the connection region of the rear spar and of the landing flap hinge, respectively (WS 91)
RF27, RF34	81/21.5	R	
F2,F33,F48	81/21.4	B	Top skin and cover at the opening of the aileron servo
RF2, RF18	81/21.5	R	
F3,F23,F51, F7,F29,F26, F32,F63	81/21.7	B	Connection U profile
RF3, RF17	81/21.7	R	
F37, F52, F53, F54	81/21.10	B	End rib, milled edge of flange web
RF25, RF30	81/21.7		front spar, rounding radius and hinge ring on the flap side
RF19, RF36 RF44	81/21.7	R	
RF20, RF35, RF37, RF43	81/21.7	R	hinges of the flaps
RF 40	81/21.7	R	Beams
RF29, RF32, RF39	81/21.5 81/21.7	R	Aileron servo block and connections with the lower skin

*B = basic wing; R = retrofit wing

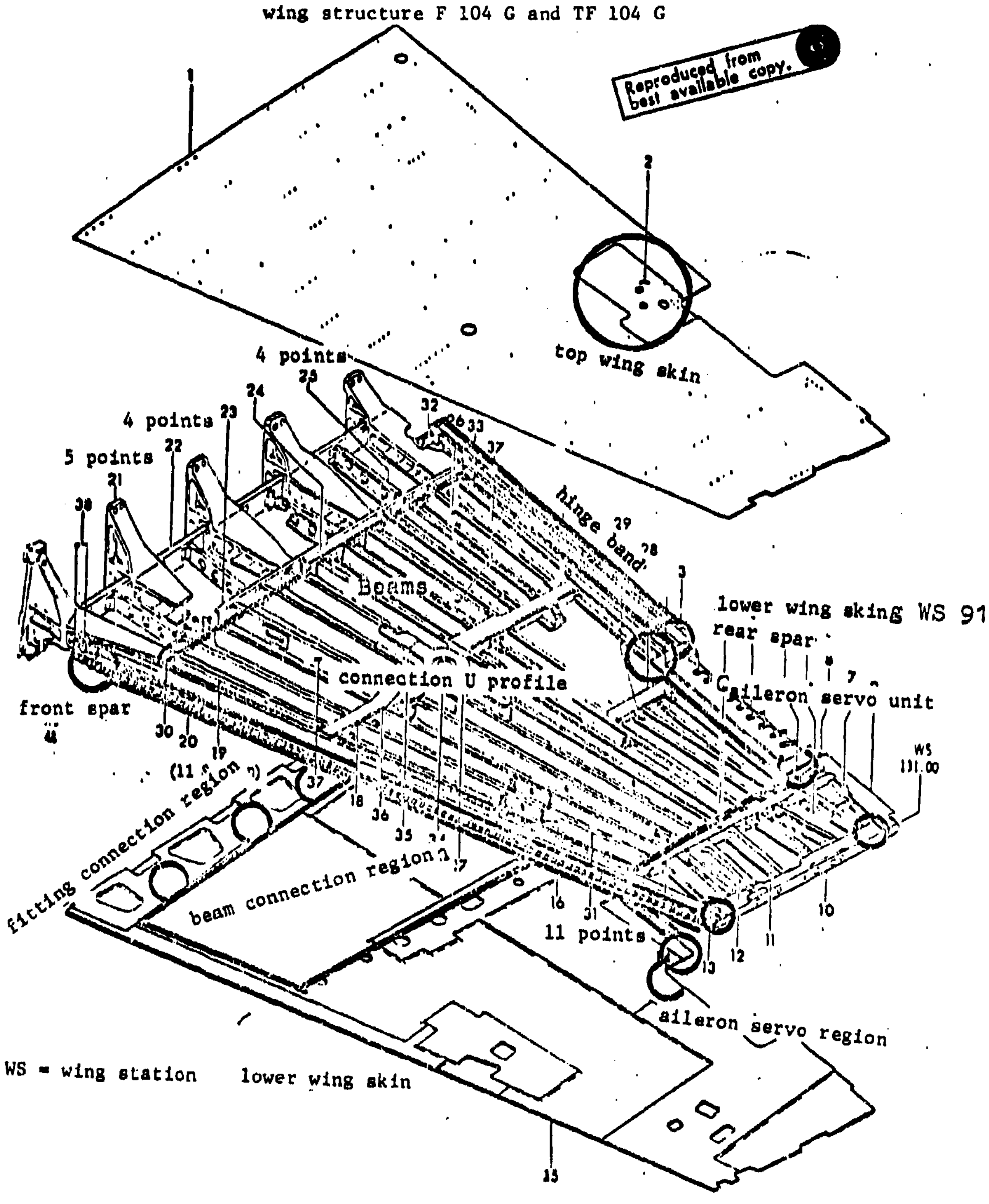


Figure 7. Wing damage summary, categories A and B.

CATEGORIES A AND B - FUSELAGE DAMAGES (see Figures 8 and 9)

Damage Number	Report Number	Damage Location	
R7, R12	81/21.3	Firewall (FS 505)	
R14, R16, R49	81/21.3 81/21.11	Angle Profile (FS 422)	
R 55	81/21.11	Upper longitudinal support (FS 422)	
R2, R6, R24	81/21.2	Hydraulic flap opening (FS 520)	
R67, R77	81/21.11	Main spar No. 5 Skin for main spar No. 5 (FS 520.5)	
R4,R5,R8,R9, R10,R11, R19,R20	81/21.3	Cracks along the rivets of the sheet metal field M13 in the span direction at the upper side of the air inlet channel	FS 444 and FS440.6 FS
R21, R25, R26, R27	81/21.3	Cracks at the bulge of the right and left landing flap actuator	FS 527 and FS 538
R22, R40, R41	81/21.3	Cracks in the sheet metal field M30 at the rivets with the main spar No. 5	FS 520

CATEGORIES A AND B — FUSELAGE DAMAGES (Continued)

Damage Number	Report Number	Damage Location	
R23, R29	81/21.3	Cracks in the upper and lower radius of the ground cooling door	FS 558 and FS546.5
R28, R30, R35	81/21.3	Cracks in the sheet metal field M31 above the hydraulic flap	FS 529 and FS 530
R32, R37, R50, R53	81/21.3 81/21.11	Cracks in the sheet metal M5 and M6 at the rivet point	FS399.6 and FS405.8
R42, R45, R59, R60, R73, R74, R75, R76	81/21.3	Cracks in the doubler below the sheet metal field M53 and in the sheet metal field M53	FS 493.3 to FS 514
R 1	81/21.1	Covers in the rear fuselage tank	
R 43	81/21.3	Cracks in the upper longitudinal support of the rear fuel container space	FS 438.4
R58, R68, R71	81/21.11	Cracks in the reinforcement for the passage for the air removal line	FS 479.5
R62, R63, R64	81/21.11	Cracks in the lower longitudinal support in the landing gear channel in the left and right profile plate	FS 444

CATEGORIES A AND B — FUSELAGE DAMAGES (continued)

Damage Number	Report Number	Damage Location	
R69, R70 R72	81/21.11	Cracks in the outer reinforcement of the basic longitudinal support for attaching the main spar Nos. 3 and 4	FS 489.5 and FS 505

Category C

Damage which occurs in regions of the total airframe fatigue experiment which is not well simulated and which, at the present time, does not appear to be critical, or for which no definite statements can be made. All the damage which does not belong to either category A or B belongs in this class.

4.4.3. Short description of the most important damage

Within the framework of the total airframe fatigue experiment F 104 G, we tested two structurally different wing types, the so-called basic wing and the retrofit wing, as well as the fuselage structure. The two wing assembly types differ most of all in the thickness of the lower skin (retrofit wing has a greater thickness in the root area), in the rear spar transition region to the aileron servo (retrofit wing is reinforced), in the fittings (retrofit with the wider flange made of AZ 74), and with respect to the surface treatment of a few components (retrofit wing is shot hardened). The basic wing, two test wings and one replacement wing in each case, were installed from the beginning of the test up to 8,687 total test hours, and the first 1000 hours were simulated according to the "Marine Aviation Wing Spectrum" (MFG test program) and the remaining test hours were simulated according to the "Tactical Combat Training Procedure (TCTP) Program." After this, the modified retrofit main wings were mounted and were tested according to the TCTP program up to 14,869 total test hours.

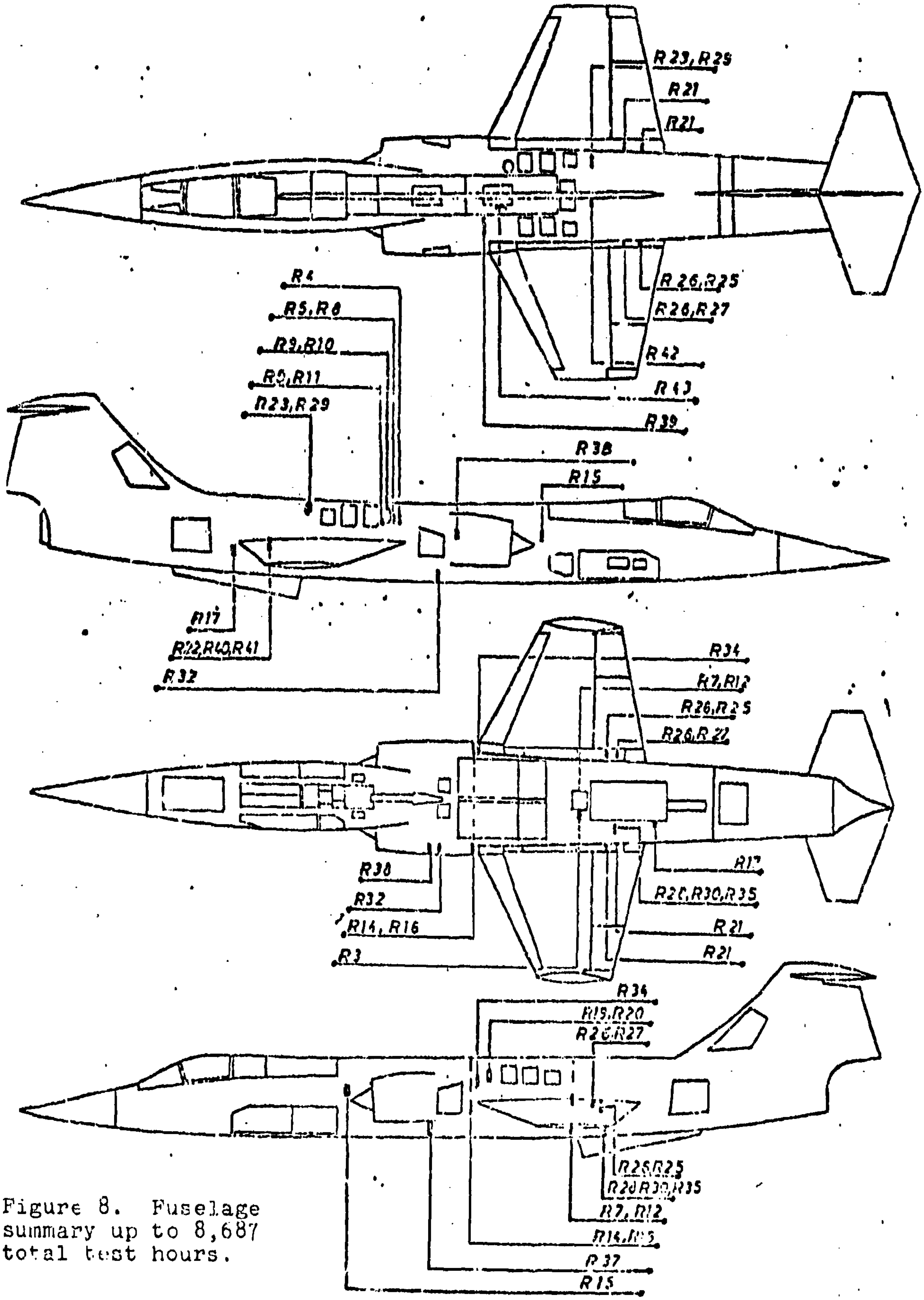


Figure 8. Fuselage summary up to 8,687 total test hours.

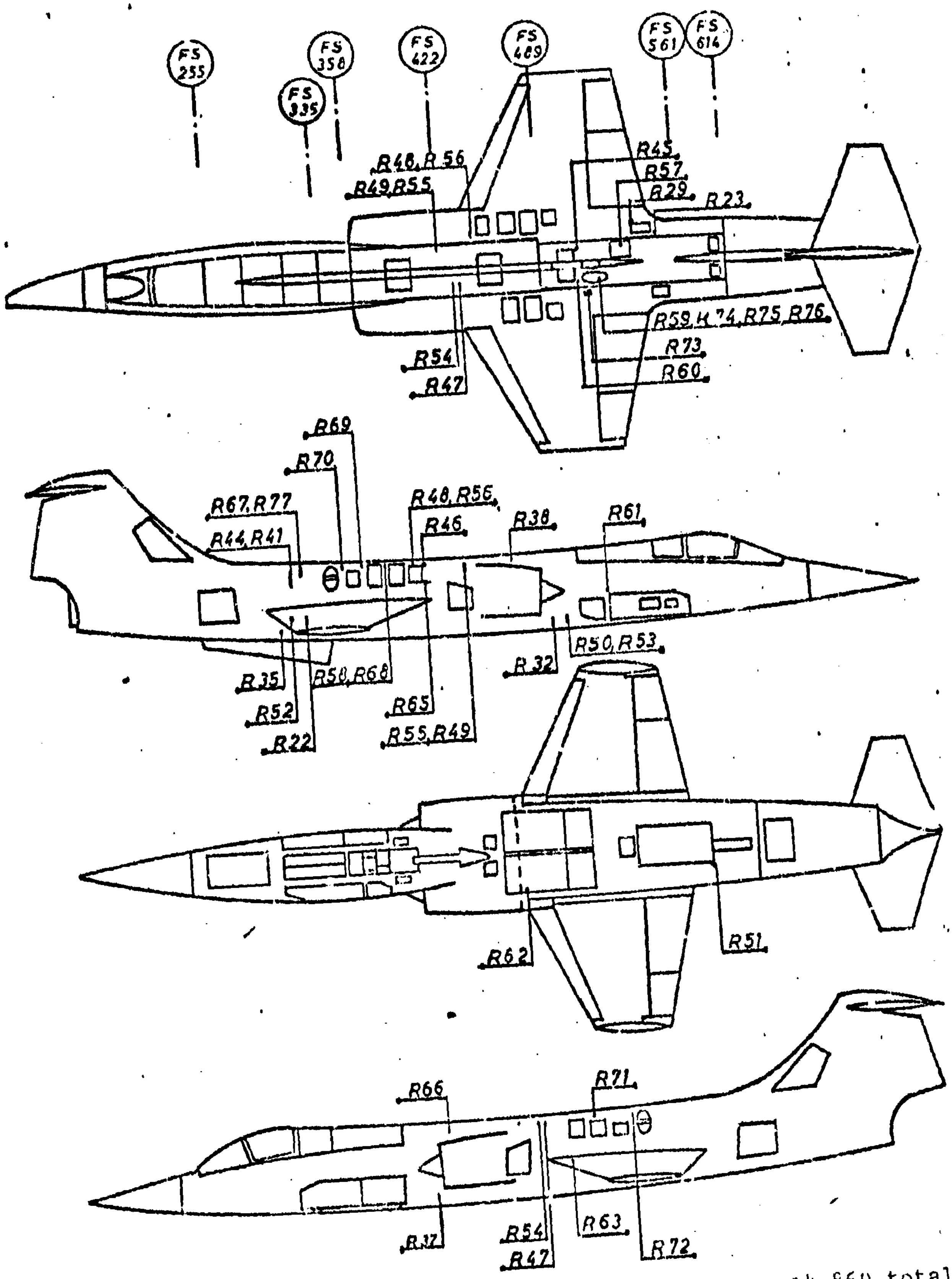


Figure 9. Fuselage damage summary between 8,687 to 14,869 total test hours.

Overall, there were a few regions which were extremely critical for fatigue in the test structure, which are given in the following in the chronological order of their appearance:

— lower wing skin WS 80.7 opening for the aileron servo in the right basic wing

The damage was first established after about a calculated 1156 TCTP component test hours and propagated along a length of 10 mm (see Figure 10) up to 1,263 TCTP component test hours. A crack at a similar position in a troop aircraft stationed in the USA led to total damage. The openings mentioned have, in the meantime, been found to be superfluous because of construction changes and all lower wing skins are now being closed in succession, or these openings are no longer made in new surfaces.

— wing connection fittings (fittings)

During the total airframe fatigue test with the basic wing, in addition to a large number of fatigue cracks, we found four total fractures in a total of 31 fittings. Of these total fractures, three occurred in fitting 5 after 1,728 2,246, and 2,280 TCTP component hours, respectively, as well as a consecutive fracture in fitting 4. The most significant cracks and fractures occurred primarily in the first hole rows on the side of the fuselage. After modifying the fittings (material change from 7079 or 7075, respectively, to AZ 74, thickening of the flange, and widening) within the framework of the retrofit program, we find a considerable improvement in the fatigue properties (see Figure 11).

— lower wing skin WS 63/67 inner pylon fitting connection

After a calculated 5,107 TCTP wing test hours, the right lower wing skin at WS 66.3 collapsed completely in the basic wing (see Figure 12). At the same time, after 4,654 TCTP component test hours, we found a crack about 35 mm long in the left basic lower wing skin in the same region at WS 63.7. The cracks in the retrofit wing

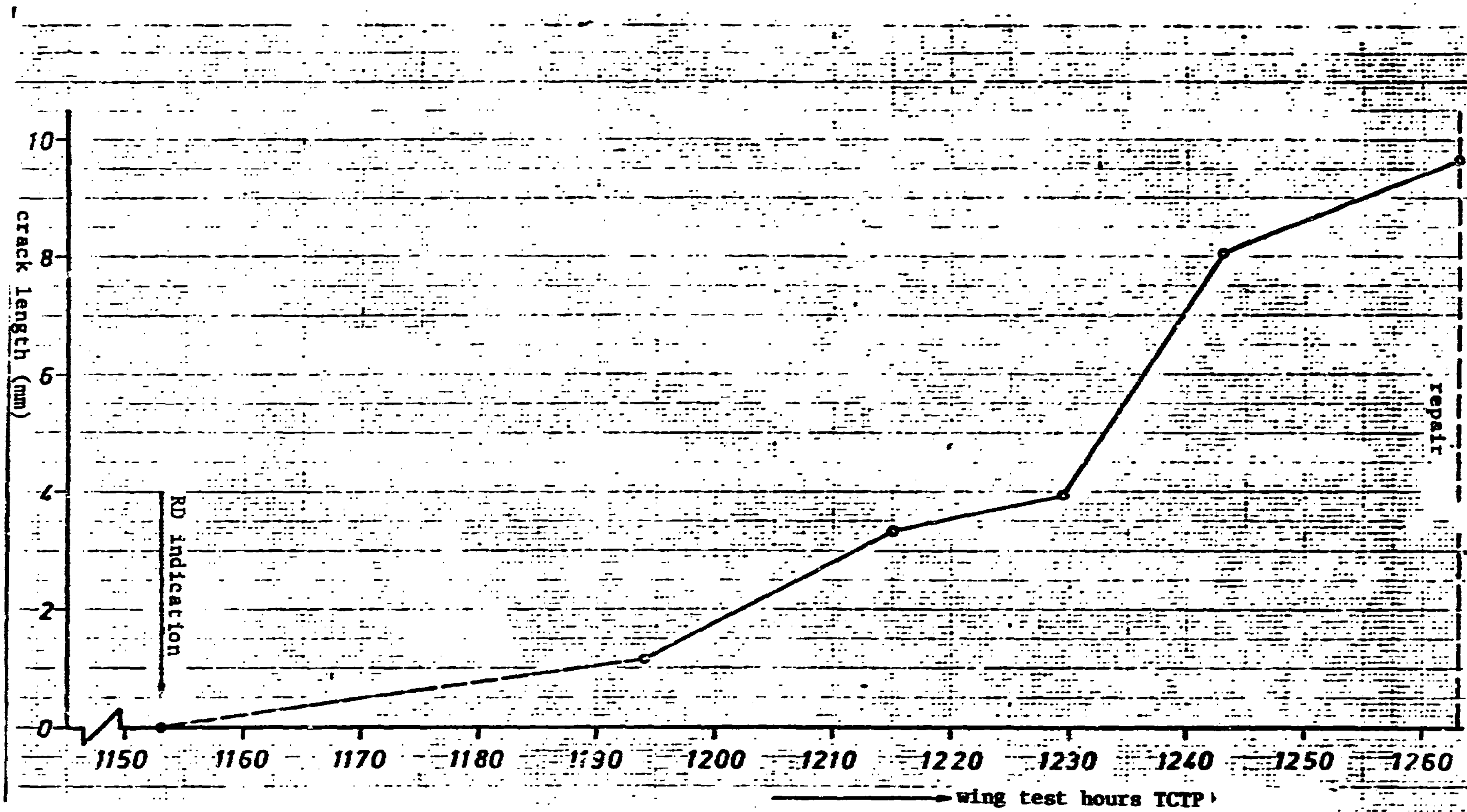
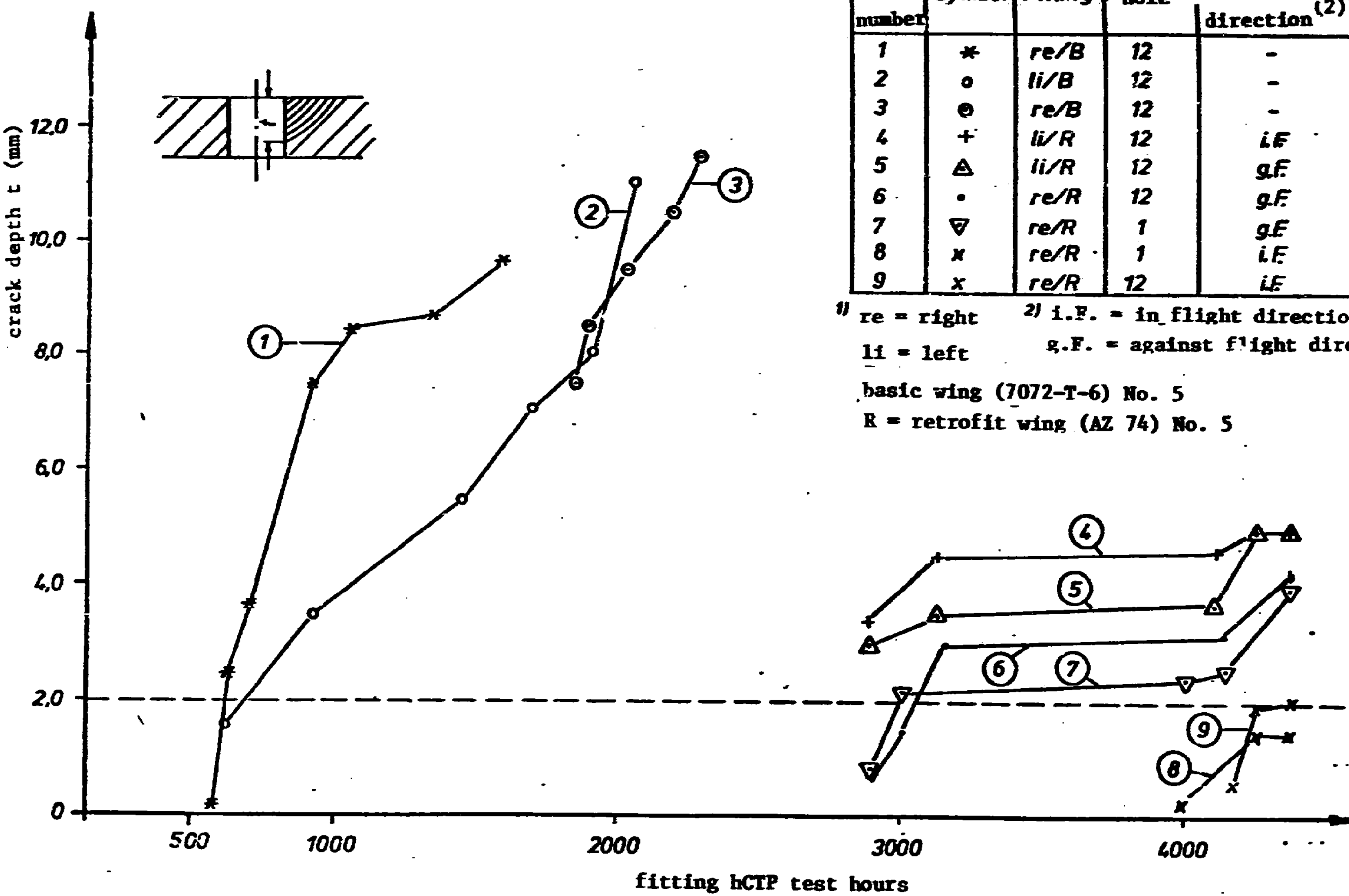


Figure 10. Crack advance variation for opening at the aileron servo. Damage No. F1 (right wing lower side, WS 80.7).



curve number	Symbol	Fitting[1]	hole	crack : direction(2)
1	*	re/B	12	-
2	o	li/B	12	-
3	⊖	re/B	12	-
4	+	li/R	12	i.F
5	△	li/R	12	g.F
6	•	re/R	12	g.F
7	▽	re/R	1	g.F
8	x	re/R	1	i.F
9	x	re/R	12	i.F

1) re = right
li = left
basic wing (7072-T-6) No. 5
R = retrofit wing (AZ 74) No. 5

2) i.F. = in flight direction
g.F. = against flight direction

Figure 11. Crack propagation fitting No. 5 AZ 74.

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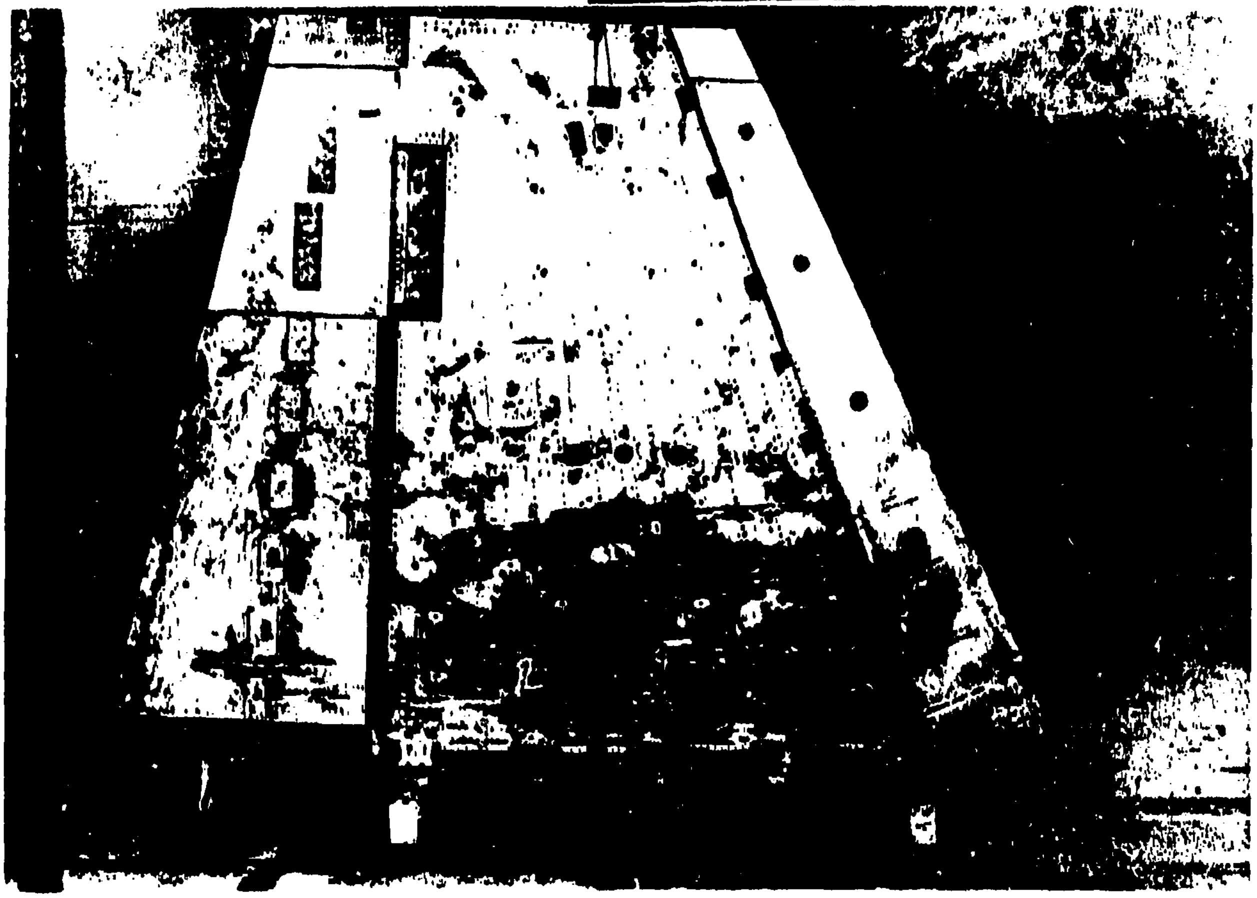

Figure 12. Fracture of the lower wing skin of the right wing at WS 66.3.

propagated over a total length of 25.9 mm in the right lower skin and 2.19 mm in the left lower skin at 6,182 TCTP retrofit test hours.

Except for the surface treatment (shot hardening), the wing skins of the basic and retrofit wings are identical. In August of 1973, we found a crack about 2.0 mm long on an aircraft stationed at Luke AFB.

— lower wing skin WS 74 pylon manifold

At 4,971 TCTP wing test hours, we detected a crack with a total length of about 27 mm (see Figure 13) at the attachment hole for the fuel connection cover in the lower wing skin of the basic wing. After 4,015 TCTP wing test hours, we found cracks with a length of 0.5 to 2.5 mm in the region of the attachment holes at the left and right retrofit wings. These became enlarged up to the end of the experiment after 14,869 total test hours, corresponding to 6,182 TCTP component test hours, up to 10.3 mm. The skin thickness in this region is the same for the retrofit wing and the basic wing.

In addition to the points with extreme critical fatigue conditions mentioned above, in which the crack propagation rates partly show a strongly progressive character at a relatively early point in time and which were also partly found in troop aircraft, there are a few structural regions which can be considered to be critical for fatigue. In the following, we will discuss a representative selection of such damage:

— wing skin WS 36/48 fitting connection

The first cracks were already established in the basic wing at a relatively early point in time (about 2,200 TCTP component test hours, average crack length 1.55 mm). On the other hand, the cracks found in the retrofit wing were first found after 4,369 TCTP component hours in this region and they had a length of 0.6 mm on the average. During the concluding inspection after 6,182 TCTP component test hours, they had an average length of 1.3 mm. This tendency towards improvement can be primarily attributed to the increased skin thickness in the connection region of the fittings which was introduced.

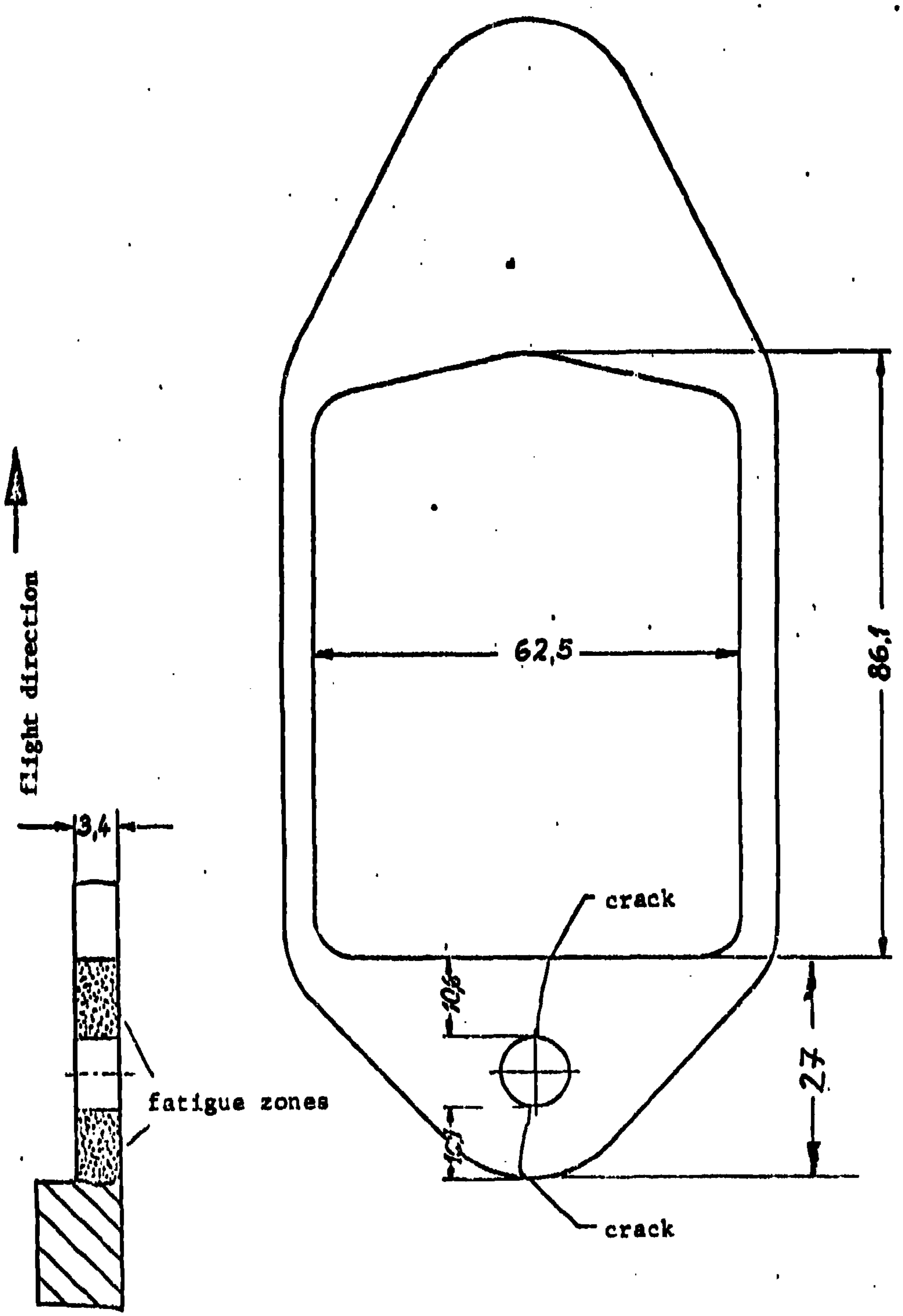

Figure 13. Small crack in the holes on the pylon manifold at WS 74 for the basic wing for 4,971 TCTP wing hours.

— lower wing skin WS 48/74 beam connection in the inner wing region

During the concluding inspections of the basic wings (right basic wing at 5,107 TCTP wing test hours, left basic wing at 6,934 TCTP wing test hours) and of the retrofit wings (right and left retrofit wings at 6,182 TCTP wing test hours), we found a number of cracks with a length of up to 6.5 mm in the countersunk holes of the beam screw connection in the lower skin.

— aileron servo block and lower skin in the region of the connection with the aileron servo block WS 92/93

After 14,869 total test hours, corresponding to 6,182 TCTP wing test hours, the lower skin of the retrofit wing assembly suddenly tore in the region of the connection with the aileron servo and the flange of the aileron servo must have been completely separated before this. Here again a comparison showed that the fatigue fracture surface only amounts to 3 — 4% of the net total fracture surface area of the lower skin.

5. Summarizing Evaluation — Operational Time Intervals, Measures and Inspection Intervals

As can be seen from this short discussion of the damage in this report and from the detailed data in the partial reports, damage occurred early within the framework of the F 104 G total airframe fatigue experiment, which required special measures to be carried out, or means that these still have to be carried out for a high number of flight hours, respectively. The weak points are concentrated essentially in the wing-fuselage connection region, as well as in the region of the lower wing skin between the canted rib and the pylon rib.

In the following, will give a brief discussion of the measures already taken or those for which a decision has already been made as far as the critical structural parts are concerned. We will make recommendations for further procedures.

Basic Wing

— Special measures were taken early for the critical damage in the lower skin of the wing assembly in the region of the aileron servo (WS 80.7), which occurred very early during the fatigue experiment (see point 4.4.3) and which led to the loss of an aircraft at Luke.*

— In addition to the damage mentioned above at WS 80.7, the wing connection fittings and especially fitting No. 5 must be considered as critical components. Therefore, special measures were formulated for these relatively early. The fittings were investigated for initial cracks in the critical hole 12 using a special eddy current method developed by the IABG. In these investigations, we detected initial cracks in a number of fittings before the maximum operational time interval for these components had been reached, which is fixed at 1500 flight hours (exchange within the framework of the retrofit program). Just as before, the fittings should be immediately exchanged in such cases.

— Based on the high stresses in the region of WS 47/48 which we found, as well as the fact that a fracture occurred in the Lockheed fatigue test (however, the fracture occurred after the fatigue program proper, after the load spectrum was increased), this region was first looked upon as the one most critical for fatigue. The initial cracks occurred at a relatively early point in time (about 2000 TCTP hours) during the total airframe fatigue experiment described here as well. However, they did not propagate as much as expected <u>up to the end of the investigations</u> with the basic wing. However,

*[Translator's Note: Luke Air Force Base.]

since damage was found in the aircraft located at Luke and since it is not clear whether cracks are also present in the skins which were replaced at 1500 operational hours for aircraft located in Germany, we believe that the inspection procedure after TA 870 should be retained for the time being.

— After the conclusion of the investigations with the basic wing, we found that the regions WS 63/67 (inner pylon fitting connection) and the region of WS 74 (pylon manifold) were found to be the most critical for the lower skin. The total lifetime reached in the experiment was about 5,000 TCTP wing test hours. Assuming that a softer load spectrum will occur for troop operation which, on the average, will correspond to the MFG program (lifetime increase factor about 1.7 compared with TCTP) as flight measurements showed, we believe that no special measures are necessary within the framework of the retrofit program up to the specified exchange time of the lower skin.

Retrofit Conversion

— As is known, the wing lower skin, the wing connection fittings, the rear spar as well as obviously damaged parts are exchanged within the framework of the retrofit conversion.

— During the crack investigation within the framework of this conversion, it is especially important to investigate the end rib, the aileron servo block, the connection U profile, and the canted rib for cracks in the regions determined to be critical for fatigue during the fatigue experiment (detailed indications on these regions are contained in IABG reports TFS 81/21.6, B-TF 81/21.7, and TF 81/21.10). In addition, the pylon fittings should be included.

— In addition, the front spar should be very critically examined for initial cracks (critical region see IABG reports TF 81/21.6 and TF 81/21.7). After an exchange has taken place, one should make sure that there is an exact fit of the nose flap push bar in the region of the upper skin and of the front spar.

We were able to find wear points in the upper skin in this region on the left converted retrofit wings during the total airframe fatigue experiment. Apparently these contributed to the 80 mm crack in the flange of the front spar. Similar damage occurred in Italy, according to data by the firm Fiat.

— Within the framework of the retrofit conversion for the test airframe, we established a large number of small initial cracks in the sheet spars (beams). As already surmised in Report TFS 81/21.6, this damage, which was partially left in the retrofit surfaces, was not found to be especially critical in the subsequent fatigue experiment. However, it is recommended to visually inspect (with a magnifying glass) these regions for initial cracks and to exchange damaged beams. It is assumed that cracks with a length above 2 mm can be detected with certainty.

Retrofit Wing

— Based on the results with the retrofit version, in conclusion we may say that the fatigue properties of the fittings are considerably better than the fittings of the basic version. The main effect is probably due to the increased material thickness, i.e., the reduction of the stress level in the critical region. In addition, the critical crack length or the fatigue surface at the time of fracture, respectively, is considerably more favorable, i.e., it is greater than for the fittings made of AZ 74 (see also IABG reports TF 81/21.9 and TF 248/1) than for the basic version.

— The critical fitting No. 5 was exchanged during the fatigue experiment at 4,369 TCTP test hours with even more damage. The participating entities (essentially the MBB-UF and IABG) carried out statistical investigations based on the experimental results including the scatter and risk factors. These had the purpose of determining a realistic minimum lifetime for an acceptable failure probability. During a discussion between BWB-ML, LBF, MBB-UF, and the IABG, we established that an expected operational time period of 2300 MFG flight hours (recently called the unit program) would be acceptable. However, it is assumed that fitting No. 5 will be inspected at the critical hole No. 2 using the eddy current crack test according to TA 979 after 1800 flight hours, which have been used previously in the basic wing. Based on the more favorable behavior of the retrofit fittings, as far as crack propagation is concerned, we believe that the inspection interval can be increased from 50 flight hours, as was the case up to the present, to 100 flight hours, for the retrofit wing.

— In the discussion given above, we agreed that the expected operational time period for the wing lower skin was also 2300 unit program flight hours. This was concluded on the basis of available test results. From our present day knowledge, we believe that no additional inspections are necessary for the skin up to this time. The given lifetime of 2300 flight hours could be increased according to our present knowledge, if special inspections, essentially concerned with the lower skin in the region of the pylon fitting and the pylon manifold, could be carried out separately. These inspections are somewhat problematical, however, because the pylon manifold is not freely accessible. Also, as the fatigue experiment shows, there is in part a very strong crack progression, so that short inspection intervals (a maximum of 50 hours) would be necessary.

— The lower wing skin in the region of WS 36/48, which was already found not to be as critical as originally assumed in the basic wing, is even less critical for the retrofit wing, because of the thicker skin in this region. Special measures are not necessary for the retrofit wing in this region.

— In addition to the measures given above, all remaining damage (see point 4.4.2) classified under A and B must be carefully inspected during change maintenance procedures of the retrofit wing.

Fuselage Structure

— No serious damage was found in the fuselage structure during the F 104 G total airframe fatigue test. In other words, no special measures are required up to the end of operations using the second pair of wings (retrofit). However, it is assumed that regions classified in this report under classifications A and B will be carefully inspected within the framework of change maintenance procedures, and that possible damage will be rectified, because much of the fuselage damage considered critical can lead to secondary effects, stress redistributions, etc., and, therefore, overloads of supporting members, if the fuselage damage increases. The upper longitudinal supports must be inspected with special care.

— One may consider the use of a third pair of wings after specifying special measures. Special inspections for the upper longitudinal supports and for the main rib are required. From our present knowledge, we believe that at least the wing-fuselage connection ribs No. 3 to No. 5 should be routinely x-rayed in the critical region of the rib-spar rivet connection (see partial report TF 81/21.11). Since no data is available on the crack propagation, and since we expect a strong progression of the crack propagation, the inspection intervals should not exceed 50 operational hours.

— For the data on the operational time interval of the fuselage, one must consider the fact that only the central region was loaded and tested in a representative way during the fatigue experiment. Damage which could occur in the region of the nose and front part of the fuselage and, especially in the inlet tracks, is not covered by this. An especially careful inspection within the framework of the change maintenance procedure must be made for these regions, if the fuselage structure is used for the second or even the third pair of wings.

APPENDIX A

TABLE A1

TOTAL FUSELAGE FATIGUE TESTS F 104 G

List of Reports

Titel / Title	Datum / Date	Bericht Nr. / Report No.
Einfluß von Klappenausschlägen auf die Spannungsverteilung am Flügel der F 104 G Influence of Flap Deflections on Stress Distribution on F 104 G Wing Root	16.06.67	81/01
Einfluß von Klappenausschlägen auf die Spannungsverteilung am Flügel der F 104 G Influence of Flap Deflections on Stress Distribution of F 104 G Wing Root	1.07.70	81/02
Lebensdauerverbesserung durch Coinen Fatigue Improvement by Coining Method	15.01.74	81/03
Flügel-Lasteinleitung Load Introduction to Wing Structure	22.09.72	81/04

TABLE A1

Titel Title	Datum Date	Bericht Nr. Report No.
Einstufenversuch an einem gebohrten Probestab zur Erprobung eines Rißerkennungsverfahrens mit Dehnmeßstreifen Constant Amplitude Fatigue Test on a Notched Specimen for Examining a Crack Detection Method	23.10.69	81/05
Spannungsanalyse - Klappenausschläge Stress Analysis for Flap Deflections on F 104 G Wing	20.11.73	81/06
Einfluß von Querruderausschlägen auf die Spannungsverteilung am Flügel der F 104 G Influence of Aileron Deflections on Stress Distribution of F 104 G Wing	9.05.69	81/07
Anordnung der Dehnmeßstreifen, Teil A und B Position of the Straingauges, Part A and B	12.03.74	81/08
Versuchslasten, Teil A, B und C Test-Loads, Part A, B and C	8.02.74	81/09
Belastungsprogramm Loading Programm	28.02.74	81/10
Spannungsanalyse F 104 G, Flügel rechts, Teil A Stress Analysis F 104 G Wing right, Part A	1.04.70	81/11

TABLE A1
(Continued)

Titel Title	Datum Date	Bericht Nr. Report No.
Spannungsanalyse F 104 G, Flügel links und Rumpf, Teil B Stress Analysis F 104 G Wing Left and Fuselage, Part B	1.04.70	81/11
Spannungsanalyse - Retrofitflügel Stress Analysis - Retrofitwing	12.01.74	81/12
Minerrechnung Fatigue Damage Calculation	29.10.71	81/14
Fitting - Probestabversuche Fitting - Specimen Test	1.12.72	81/16
Gesamtzellen- Ermüdungsversuch - Versuchsaufbau Full Scale Fatigue Test Set-Up	24.08.73	81/18
Abschlußbericht Final Report	15.03.74	81/20
Risse im hinteren Tankdeckel Fatigue Cracks in the Rear Fuel Tank Cover	10.12.73	81/21.1

TABLE A1
(Continued)

Titel Title	Datum Date	Bericht Nr. Report No.
Risse am Ausschnitt der Hydraulikklappenöffnung Fatigue Cracks in the Corners of the Hydraulic Access Door	7.10.71	81/21.2
Schäden an der Rumpfstruktur Fatigue Cracks in the Fuselage	13.07.72	81/21.3
Schäden an der Flügelbeplankung Fatigue Damages in the Wing Skin	5.04.73	81/21.4
Beplankungsschäden - Retrofit Fatigue Damages in the Skin of the Retrofit-Wing	22.02.74	81/21.5
Schäden an den Flügelinnenteilen Fatigue Cracks in the Inner Parts of the Wing (Beams, Ribs)	5.05.72	81/21.6
Schäden an den Flügelinnenteilen - Retrofit Fatigue Cracks in the Inner Parts of the Retrofit-Wing (Beams, Ribs)	28.03.74	81/21.7
Schäden an den Flügel-Rumpfanschlußfittingen Fatigue Failures and Cracks in the Wing Attachment Fittings	1.07.72	81/21.8

TABLE A1
(Continued)

Titel Title	Datum Date	Bericht Nr. Report No.
Fittingschäden am Retrofitflügel Fatigue Failures and Cracks in the Retrofit-Wing Attachment Fittings	20.01.74	81/21.9
Risse im Hinterholm und Endrippe Fatigue Cracks in the Rear Beam and the Tip Rib	9.05.73	81/21.10
Rumpfschäden zwischen 8667 und 14869 Gesamtteststunden Fatigue Cracks in the Fuselage between 8687 and 14869 Total Test Hours	14.03.74	81/21.11
Wirbelstrom - Rißprüfverfahren I für Tragflügel F 104, Fitting 5, Boltbole 12 Eddy-Current Crack Inspection for the Wing of the F 104 G, Fitting 5, Bolthole 12	19.11.70	81/22

APPENDIX B

TABLE B1. DAMAGE TO BASIC WINGS

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage			Determined after number of test hours	TCTP component hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
				Type 1)	Direction 2)	Size (mm)					
F1	right wing 7210 lower wing skin 783194-2	opening for the aileron servo, rear radius	80.7	R RV RV RV RV RV	g.F.	< 1.0 < 1.0 4.0 4.0 9.0 9.3	1566 1604 1625 1639 1653 1673	1156 1194 1215 1229 1243 1263	81/21.4 Kap.3.1.5.1 -	similar to damage F 31 repair according to IABG drwg. No. 2135-249.00C	X
F2	right wing 710 upper wing skin 783193-2 left wing upper wing skin 783193-1	radius at the trailing edge of the opening for the aileron servo beam 14	89.0	R	g.F.	1,5 10,0	1673 1673	1263 1363	81/21.4 Kap.3.2.1.1 Kap.3.2.1.2	repair by reinforcing with T profile according to drwg. No. 2135-250.00C analog damage F33, F48	A
F3	right wing 7210 bent U profile 783217-8 left wing 7210 bent U profile 783217-7	connection U profile, beam 14 /aileron block, radius at upper web flange	88.7	MR R		max.22.4 22.4	1673 1673	1263 1263	81/21.7 Kap.4.1.1	similar to damage F7, F23, F29, F51 exchange for a new part	A

1) R = crack
B = fracture
RV = crack extension

2) o = upwards
u = downwards
MR = several cracks
i.F. = in flight direction
g.F. = against flight direction

i = inwards
a = outwards
i.S. = in span direction
R.M. = to fuselage center

Kap = chapter
ABB = figure

TABLE B1. DAMAGE TO BASIC WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage			Determined after number of test hours	TCTP component hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
				Type 1)	Direction 2)	Size (mm)					
F4	right wing 7210, beam 14, 783217-6	attachment holes for rubbing block	76.7 - 88.5	MR		max. 4.0	1673	1263		beam was reinforced according to IABG Drwg. No. 2135-250.00R	C
F5	left wing 7210 lower wing skin 783 194-1	opening for tip tank jettison arming switch. crack at rear radius.	117,1	R RV RV	g.F. g.F. g.F.	7.5 15.0 15.0	1754 2130 8687	1344 1720 6934	81/21.4 Kap.3.1.6.2	comparable damage F9	C
F6	right wing 7210 lower wing skin 783 194-2	Jo-Bolt hole 12, beam 11	66.0	R RV R RV RV	i.S. i.S.	5,0 5,0 10.0 13.0 13.0	1816 6407 1816 2008 6407	1406 5107 1406 1598 5107	81/21.4 Kap.3.1.3.1	apparently caused by introduction of force, therefore, not representative	C
F7	right wing 7210, bent J profile 783 217 2	crack in the radius at upper web flange	88.7	R		9.5	2133	1723	81/21.1 Kap.4.4.1	exchange for a modified new part (without penetration according to IABG Drwg. No. 2135-253.00D	A

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TABLE B1. DAMAGE TO BASIC WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage			Determined after number of test hours	TCTP component hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
				Type 1)	Direction 2)	Size (mm)					
F7										similar to damage F3, F23, F29, F51.	
F8	right wing 7210 lower wing skin 783194-2	crack in the depressed hole of the line of screws. Rib WS 94	93,5	R	i.F.	0,5	2074	1664	—	no continuation determined	C
F9	left wing 7210 lower wing skin 783194-1	opening for tip tank jettison arming switch	117,5	R	i.S.	12,8 12,8	2138 8687	1728 6934	81/21.4 Kap.3.1.6.2	similar to damage F5	A
F10	left wing 7210, fitting 5, 783199-1	fracture on the fuselage side first and second row of holes, lower flange	35 - 36	B			2138	1728	81/21.8 Kap.3.5.1.1	exchange against new part similar to damages F10, F13, F14, F15, F22, F28, F42, F46, F67, F68	X
F11	right wing 7210 landing flap actuator D 1228-[illegible]	lower flange	-	B			2138	1738	-	no evaluation value because it is an old repaired part	C

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TABLE B1. DAMAGE TO BASIC WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage			Determined after number of test hours	TCTP component hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
				Type 1)	Direction 2)	Size (mm)					
F12	right wing 7210, fitting 5, 783 199-2	fracture in the fuselage side first row of holes, lower flange	35	B			2656	2246	81/21.8 Kap.3.5.2.1	exchanged for new part. Similar to damage F12, F10, F13, F14, F15, F22, F28, F42, F46, F67, F68	X
F13	right wing 7210, fitting 4, 783 198-2	fracture in the hole row on the fuselage side, lower flange	35	B			2656	2246	81/21.8 Kap.3.4.2.1	Secondary fracture because of F12, exchanged. Similar to damage F10, F12, F15, F14, F22, F28, F42, F46, F67, F68	X
F14	right wing 7210, fitting 3, 783 198-2	cracks in upper and lower chord	36 - 48	R		< 1.0	2656	2246	81/21.8 Kap.3.3.2.1	exchanged for new part. Similar to damage F10, F12, F13, F15, F22, F28, F42, F46, F67, F68	X

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TABLE B1. DAMAGE TO BASIC WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage: Type 1)	Damage: Direction 2)	Damage: Size (mm)	Determined after number of test hours	TCTP component hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
F15	right wing 7210 fitting 2, 783 196-2	cracks in upper and lower chord	36 - 48	B		<1.0	2656	2246	81/21.3 Kap.3.2.2.1	exchange for new part, similar to damage F10, F12, F13, F14, F22, F28, F42, F46, F67, F68	X
F16	right wing 7210 lower wing skin 782 194-2	cracks in the countersunk holes skin-fitting-connection-holes 7, 14, 15, 23, and 30	44 - 47						81/21.4 Kap.3.1.1.1	similar to damage F17, F44, F24, F65	A
		Hole 7		R	i.F.	0,5	2656	2246			
					and	max.:					
				RV	g.F.	1,5	6407	5107			
				R	g.F.	0,5	2656	2246			
				R	i.F.	0,5	6407	5107			
		Hole 14		R	i.F.	0.5	2656	2246			
				RV	and	1.5	2740	2330			
		Hole 15		RV	g.F.	2.0	3981	3571			
				RV		5.0	4246	3836			
				RV		5.0	6407	5107			
				R	i.F.	<0.5	2656	2246			A
		Hole 23		RV	and	1,5	2740	2330			
				RV	g.F.	2.0	3981	3571			
				RV	i.F.	4.0	4246	3836			
				RV	g.F.	5.0	4246	3836			
				RV	i.F.	4.0	6407	5107			
				RV	g.F.	5.0	6407	5107			

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TABLE B1. DAMAGE TO BASIC WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage			Determined after number of test hours	TCTP component hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
				Type 1)	Direction 2)	Size (mm)					
F17	right wing 7210 lower wing skin 783 194-2	fitting-skin-connection and region of canted rib	47/48	R	i.F/g.F.		2656	2246	81/21.4 Kap.3.1.1.1	crack propagation of F16	A
F18	right wing 7210 intercostal 760 484	intercostal No. 4 first Huck bolt hole on fitting No. 5 of the lower wing skin connection	36	R	38,5	max.50	2656	2246	—	exchange crack in shape of a spider	C
F19	right wing 7210 rear spar 783 194-2	rounding radius. web — lower flange	86.9	R	RM	38,5	2656	2246	81/21.10 Kap.2.3	repair. Similar to damage F35, F39, F43, F62.	A
F20	right wing 7210 lower wing skin 783 194-2	radius of milling for the landing flap hinge	91	R RV	RM	22,5 36,0	2656 6407	2246 5107	81/21.10 Kap.2.1	similar to damage F30, F43	A
F21	left wing 7210 end rib	rivet mother disc for position lamp attachment	131	R	·	2,0	2656	2246	81/21.10 Kap.3.1	similar to damage F36. Exchange	C

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TABLE B1. DAMAGE TO BASIC WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage: Type 1)	Damage: Direction 2)	Damage: Size (mm)	Determined after number of test hours	TCTP component hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
F22	left wing 7210 fittings	cracks in wind connection holes	36 ÷ 47	R	i.F./g.F.				81/21.8	Exchange of fittings 2 — 5. Similar to damage F10, F12, F13, F14, F15, F28, F42, F46, F67, F68	X
	783 196-1	Fitting No. 2									
	783 197-1	Fitting No. 3				0,3÷0,8	3000	2590	ABB 6		
	783 198-1	Fitting No. 4				0,2÷1,6	3000	2590	ABB 12		
	783 199-1	Fitting No. 5				0,3÷1,8	3000	2590	ABB 19		
						<1,0	3000	862	ABB 30		
F23	left wing 7210 bent U profile 783 217-7	radius at the upper web flange	85,7	R		15	3000	1327	81/21.7 Kap.4.1	similar to damage F3, F7, F29, F51	A
F24	left wing 7210 lower wing skin 783 194-1	countersunk holes of skin, fitting connection bolts, fitting No. 3, region, holes 6, 7, 15, 23, 24, 30	44 ÷ 47	R	i.F./g.F. i.F./g.F.	0.1÷ 1,5 3,8÷ 4,8	3000 8687	2590 6934	81/21.4 Kap.3.1.1.2	similar to damage F16, F17, F44, F65	A
F25	left wing 2003 fittings		37 ÷ 47	R	i.F./g.F.	0,1÷ 1,1	4000	1000 unknown operational hours	-	exchange evaluation of damage not possible	
	783 196-1	Fitting No. 2									
	783 197-1	Fitting No. 3									
	783 198-1	Fitting No. 4									
	783 199-1	Fitting No. 5									

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TABLE B1. DAMAGE TO BASIC WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage: Type 1)	Damage: Direction 2)	Damage: Size (mm)	Determined after number of test hours	TCTP component hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
F26	left wing 2003 bent U profile 783 217-1	radius at the upper web flange	88,7	R		32	4000	1000 + unknown operational hours	81/21.7 Kap.4.1	Exchange similar to damage F32, F63	A
F27	right wing 7210 lower wing skin 783 194-2	beginning cracks in the counter-sunk holes of the skin fitting connection. Holes 7, 14, 15, 23	44 ÷ 47	RV	iF/gF	max. 4,5	4246	3836	-	crack extension of damage R16	A
F28	right wing 7210 fittings		36 ÷ 47	R	iF/gF				81/21.8	similar to damage F10, F12, F13, F14, F15, F22, F42, F46, F67, F68 Fittings 2 — 5 exchanged for new version.	X
	783 195-2	Fitting No. 1				0,3÷0,6	4246	3836	ABB 4		
	783 196-2	Fitting No. 2				<0,5	4246	1590	ABB 10		
	783 197-2	Fitting No. 3				0,2÷2,0	4246	1590	ABB 17		
	783 198-2	Fitting No. 4				0,2÷4,0	4246	1590	ABB 25		
	783 199-2	Fitting No. 5				0,2÷2,5	4246	1590	ABB 37		
F29	right wing 7210 bent U profile 783 217-2	radius at the upper web flange	88,7	R		9,0	[illegible]	2108	81/21.7 Kap.4.1	Similar to damage F3, F7, F23, F51 exchange	A

1) R = crack
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RV = crack extension

2) o = upwards
u = downwards
MR = several cracks
i.F. = in flight direction
g.F. = against flight direction
i = inwards
a = outwards
i.S. = in span direction
R.M. = to fuselage center

Kap = chapter
ABB = figure

TABLE B1. DAMAGE TO BASIC WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage			Determined after number of test hours	TCTP component hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
				Type 1)	Direction 2)	Size (mm)					
F30	left wing 7210 lower wing skin 783 194-2	radius of milling for the landing flap hinge	91	R RV	RM	32,0 35,0	5021 8687	3611 6934	81/21.10 Kap. 2	similar to damage F20, F43	A
F31	right wing 7020 lower wing skin 783 194-2	opening for the aileron servo rear radius	80,7	R RV RV RV		0,4 3,6 6,0 7,4	4883 5100 5133 5136	637 854 887 890 additionally 1342 troop operational hours	81/21.4 Appendix A	similar to damage F1	X
F32	right wing 7020 bent U profile 783217-2	radius at upper web flange	88,7	R			5136	890 additional troop operational hours	81/21.7 Kap. 4.1	similar to damage F26, F63. exchange	A
F33	right wing 7210 upper wing skin 783193-2	cover for aileron servo	94	R		135,0	5326	4026	81/21.4 Kap. 3.2	exchange	A

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i.S. = in span direction
R.M. = to fuselage center

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TABLE B1. DAMAGE TO BASIC WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage			Determined after number of test hours	TCTP component hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
				Type 1)	Direction 2)	Size (mm)					
F33	left wing 7210 upper wing skin 783193-1			R		66,0	5326	3916		exchange similar to damage F2, F48	
F34	right wing 7210 lower wing skin 783 194-2	holes for the extension of beam 11A	93,5	R		0,2 0,2	5626 6407	4326 5107	81/21.4 Kap.3.1.5.1		C
F35	right wing 7210 rear bar 760 315R	at the repair point in the rounding radius between flange and web	88,9	R		22,0	6000	2454	81/21.10 Kap. 2.2	similar to damage F19, F39, F62	A
F36	right wing 7210 end rib 783 460-2	rivet mother plate hole for position lamp attachment	131	R		1,2 ÷ 3,4	6000	2454 additional troop operational hours	81/21.10 Kap. 3.1	similar to damage F2. exchange	C
F37	right wing 7210 end rib 783 460-2	radius of the flange-web intersection edge	131	R		45,0	6000	2454 additional troop operational hours	81/21.10 Kap. 3.2	similar to damage F52, F53, F54. exchange.	B

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g.F. = against flight direction
i = inwards
a = outwards
i.S. = in span direction
R.M. = to fuselage center

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TABLE B1. DAMAGE TO BASIC WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage Type 1)	Direction 2)	Size (mm)	Determined after number of test hours	TCTP component hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
F38	left wing 7210 lower wing skin 783 194-1	beginning cracks in the countersunk holes of the skin fitting connection	34 - 40	RV	iF/gF	0,2-6,0	6064	4654	–	crack propagation	–
F39	left wing 7210 rear spar 760 315-L	rounding radius web-flange	83,9	R	RM	45,0	6064	4654	81/21.10 Kap.2.2	similar to damage F19, F35, F62. Repair	A
F40	left wing 7210 lower wing skin 783 194-1	inner pylon fitting connection region	63,7	R	iF/gF	35,0	6064	4654	81/21.4 Kap.3.1.2.2	similar to damage F44	X
F41	left wing 7210 lower wing skin 783 194-1	connection of beam 10, hole 13	59,7	R RV RV R	g.F. g.F. i.F. i.F.	2,4 4,1 7,4 2,0	6064 7257 8687 8687	4654 5504 6934 6934	81/21.4 Kap. 3.1.3.2	similar to damage F6, F44, F60, F61 F65	A
F42	left wing 2710 fittings 783 196-1 783 197-1 783 198-1 783 199-1	 Fitting No. 2 Fitting No. 3 Fitting No. 4 Fitting No. 5	36 ÷ 48	R	iF/gF	 <0,5 0,2÷1,4 0,3÷1,2 0,3÷2,4	 6064 6064 6064 6064	 2064 2064 2064 2064	81/21.8 ABB 7 ABB 13 ABB 20 ABB 31	similar to damage F10, F12, F13, F14, F15, F22, F28, F46, F67, F68	X
F43	left wing 2003 lower wing skin 783 194-1	radius of milling for landing flap hing	91	R	RM	2,0	6344	1280 + troop operational hours	81/21.10 Kap. 2.1	similar to damage F20, F30	A

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i.S. = in span direction
R.M. = to fuselage center

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TABLE B1. DAMAGE TO BASIC WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage			Determined after number of test hours	TCTP component hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
				Type 1)	Direction 2)	Size (mm)					
F43	rear spar 760 315-1	cross section transition I-E	89	R	i.F.	7,0	6344	1280 + troop operational hours	81/21.10 Kap.2.3	similar to damage F19, F35, F62, F39	A
F44	right wing 7210 lower wing skin 783 194-2	fraction of the lower wing skin and beams cracks in the beam connection holes	63 ÷ 67 48 ÷ 72	B R	 iF/gF	 5,0	6407 6407	5107 5107	81/21.4 Kap.3.1.2.1 Kap.3.1.3.1	similar to damage F40, F16, F24, F17, F65	X
F45	right wing 7210 landing flap 784 670-4	lower flap skin	36 ÷ 43,1	B		330,0	6407	5107	-	flap was taken apart	C
F46	right wing 7210 fittings		36 ÷ 47	R	iF/gF				81/21.8	similar to damage F10, F12, F13, F14, F15, F22, F28, F42, F67, F68	X
	783 195-2	Fitting No. 1				0,3÷1,0	6407	5107	ABB 5		
	783 196-2	Fitting No. 2				0,8÷2,0	6407	1271	ABB 11		
	783 197-2	Fitting No. 3				0,5÷2,0	6407	1271	ABB 18		
	783 198-2	Fitting No. 4				0,3÷0,8	6407	1271	ABB 26		
	783 199-2	Fitting No. 5				0,3÷1,0	6407	1271	ABB 38		
F47	left wing 7210 upper wing skin 783 193-1	inner pylon fitting connection first countersunk hole	63,7	R		0,7	6466	4713	81/21.4 Kap.3.2.1.2		C

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g.F. = against flight direction
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i.S. = in span direction
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TABLE B1. DAMAGE TO BASIC WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage			Determined after number of test hours	TCTP component hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
				Type 1)	Direction 2)	Size (mm)					
F48	right wing 7020 upper wing skin 783193-1	cover for aileron block, crack in radius of depression	74,5	R		27	6724	2288	81/21.4 Appendix A	made up from wing 7210 at 6047 hours, similar to damage F2, F33, F48	A
F49	left wing 7210 lower wing skin 783 194-1	hole for attaching the pylon fuel tank connection	73,5	R		* 27,0	6724	4971	81/21.4 Kap.3.1.4.2	*including ø 6.3 mm hole	X
F50	left wing 7210 lower wing skin 783 194-1	hole for attaching electrical connection	75,5	R	RM	7,0	7007	5254	81/21.4 Kap. 3.1.4.2		C
F51	left wing 7210 bent U profile 783 217-7	radius at the upper web flange	88,7	R		12,0	7108	2765	-	similar to damage F3, F7, F23, F29	A
F52	left wing 7210 end rib 783460-1	radius of the flange-web intersection edge	131	R R RV RV RV RV		o 1,9 u 1,6 o 2,5 u 2,8 o 3,2 u 3,5	7108 7108 7216 7216 7469 7469	5355 5355 5463 5463 5716 5716	81/21.10 Kap.3.2	similar to damage F37, F53, F54 as an extension to R52	B

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TABLE B1. DAMAGE TO BASIC WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage Type 1)	Direction 2)	Size (mm)	Determined after number of test hours	TCTP component hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
F53	right wing 7020 end rib 783 460-2	radius of the flange-web intersection edge	131	R R RV RV RV R RV		o 1,5 u 1,3 o 3,5 u 2,3 o 4,0 o 5,0 u 4,0	7108 7108 7469 7469 7805 7805 7805	1591 + 1591 + 1852 + 1952 + 2288 + 2288 + 2288 + troop operational hours	81/21.10 Kap. 3.2	F37, F52, F54	B
F54	left wing 7210 end rib 783 460-1	radius of the flange-web intersection edge	131	RV RV		o 2,5 u 2,8	7216 7216	5463 5463	81/21.10 Kap.3.2	see damage F37, F52, F53	B
F55	left wing 7210 lower wing skin 783 194-1	countersunk hole at beam 10, hole No. 13	59,7	R	g.F. i.F.	4,1 0,8	7257	5914		crack propagation	A
F56	left wing 7210 lower wing skin 783 194-1	countersunk hole 24 in fitting 3 range	36	R	i.F. g.F.	0,3 0,8	7469	6136		crack propagation	-
F57	right wing 7020 lower wing skin 783 194-2	tip tank bolt region	131	R		< 0,5	7469	1952 + troop operational hours	81/21.4 Kap. A		C

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i.F. = in flight direction
g.F. = against flight direction

i = inwards
a = outwards
i.S. = in span direction
R.M. = to fuselage center

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TABLE B1. DAMAGE TO BASIC WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage			Determined after number of test hours	TCTP component hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
				Type 1)	Direction 2)	Size (mm)					
F58	left wing 7210 lower wing skin 783 194-1	countersunk holes in fitting No. 3 region	46	RV	iF/gF	0,5 ÷ 4	7596	5843	-	extension of damage F24	A
F59	left wing 7210 lower wing skin 783 194-1	attachment holes of the aileron servo at the skin	73 ÷ 84,2								A
		Hole 2		R	g.F.	1,6	7596	5843	81/21.4 Kap.3.1.5.2		
				RV	g.F.	2,5	8687	6934			
		Hole 3		R	g.F.	0,8	7596	5843			
				RV	g.F.	5,8	8687	6934			
		Hole 4		R	g.F.	1,3	8687	6934			
				R	g.F.	3,5	7596	5843			
				RV	g.F.	3,6	8687	6934			
				R	i.F.	1,8	8687	6934			
		Hole 6		R	g.F.	4,6	8687	6934			
					i.F.	1,4	8687	6934			
F60	left wing 7210 lower wing skin 783 194-1	Jo-Bolt hole ahead of fitting 3 above the canted rib	48	R	g.F.	0,5	7596	5843	81/21.4 Kap.3.1.3.2	similar to damage F6, F41, F44, F61, F65	A
				RV	g.F.	3,5	8642	6889			
				RV	g.F.	4,2	8650	6897			
				RV	g.F.	7,3	8687	6934			
F61	left wing 7210 lower wing skin 783 194-1	beam 8, Jo-Bolt hole 10 — 14	62 ÷ 66	R	iF/gF	0,5÷4,5	7804	6051	81/21.4 Kap.3.1.3.2	similar to damage F6, F41, F44, F60, F65	A

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g.F. = against flight direction
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a = outwards
i.S. = in span direction
R.M. = to fuselage center

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TABLE B1. DAMAGE TO BASIC WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage Type 1)	Damage Direction 2)	Damage Size (mm)	Determined after number of test hours	TCTP component hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
F62	right wing 7020 rear spar 760 315R	rounding radius flange-web	88,9	R	RM	46,5	7805	2288 + troop operational hours	81/21.10 Kap.2.2	similar to damage F19, F35, F39	A
F63	right wing 7020 bent U profile 783 217-8	radius in the upper web flange	89,7	R		2,0	7805	1398	81/21.7 Kap. 4.1	similar to damage F26, F32	A
F64	right wing 7020 fittings		36 ÷ 48	R	iF/gF				81/21.8 Kap. A		X
	783 196-2	Fitting No. 2				0,2÷1,3	7805	2288 +	ABB A1		
	783 197-2	Fitting No. 3				0,4÷1,5	7805	2288 +	ABB A2		
	783 198-2	Fitting No. 4				0,2÷1,3	7805	2288 +	ABB A3		
	783 199-2	Fitting No. 5				0,4÷1,3	7805	2288 + troop operational hours	ABB A4		
F65	left wing 7210 lower wing skin 783 194-1	countersunk holes in fitting connection region and canted rib II region	36 ÷ 47 48	R	iF/gF	0,5÷1,7	8687	6934	81/21.4	similar to damage F6, F41, F44, F60, F65	A
F66	left wing 7210 lower wing skin 783 194-1	beam 8, Jo-Bolt hole 13	60	R	g.F.	5,3	8515	6762		extension to damage F41	A

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g.F. = against flight direction
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i.S. = in span direction
R.M. = to fuselage center

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TABLE B1. DAMAGE TO BASIC WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage			Determined after number of test hours	TCTP component hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
				Type 1)	Direction 2)	Size (mm)					
F67	left wing 2710 fitting 5, 783 199-1	fracture of fitting 5	36 ÷ 47	B			8687	2280	81/21.8	similar to damage F10, F12, F13, F14, F15, F22, F28, F42, F46, F68 termination of test with basic wing	X
F68	left wing 7210 fittings		36 ÷ 47	R	iF/gF				81/21.8	similar to damage F10, F12, F13, F14, F15, F22, F28, F42, F46, F67	X
	783 195-1	Fitting No. 1				0,2÷1,0	8687	6934	ABB 3		
	783 196-1	Fitting No. 2				<0,5	8687	2280	ABB 8		
	783 197-1	Fitting No. 3				<0,5	8687	2280	ABB 14		
	783 198-1	Fitting No. 4				0,5÷2,0	8687	2280	ABB 21		

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g.F. = against flight direction
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a = outwards
i.S. = in span direction
R.H. = to fuselage center

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TABLE B2. DAMAGE TO RETRO FIT WINGS

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage			Determined after number of test hours	TCTP component and other hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
				Type 1)	Direction 2)	Size (mm)					
RF1	left wing 7210 tip tank	sleeve for tip tank alignment bolt	131.0	R	a	27,0	8978	7952	81/21.7 Kap. 4.2	exchanged at 9705 total test hours. damage similar to RF25, RF26, RF28, RF30	C
RF2	left wing 7210 upper wing skin 783193-1	milling radius at the aileron servo cover opening	95,2	R		59,0	9705	7952	81/21.5 Kap. 3.2.1	repair with reinforcement plate similar to damage RF18	A
RF3	left wing 7210 bent U profile 783217-101	between beam 14 and aileron servo block radius at the upper web flange	88.7	R	g.F.	1,5	9705	1018	81/21.7 Kap. 4.1	reinforced version, part exchanged, similar to damage RF17	A
RF4	right wing 8166, fitting 783199-2	Fitting No. 5	37,0	R	g.F.	0,9	11559	2872	81/21.9 Kap. 3.1.10	similar to damage RF5, RF6, RF7, RF8, RF9, RF10, RF11, RF12, RF16	X
		Hole No. 1		RV	g.F.	2,2	11705	3018			
		Hole No. 1									
		Hole No. 1		RV	g.F.	2,3	12702	4015			
		Hole No. 1		R	i.F.	0,3	12703	4015			
		Hole No. 1		RV	g.F.	2,4	12625	4138			
		Hole No. 1		RV	i.F.	0,8	13056	4.369			
		Hole No. 1		RV	g.F.	4,0	13056	4.369			

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i.S. = in span direction
R.M. = to fuselage center

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TABLE B2. DAMAGE TO RETRO FIT WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage: Type 1)	Damage: Direction 2)	Damage: Size (mm)	Determined after number of test hours	TCTP component and other hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
RF5	right wing 8166 fitting 783199-2	Fitting No. 5	37	R	g.F.	0,7	11559	2872	81/21.9 Kap.3.1.10	similar to damages RF4, RF6, RF7, RF8, RF9, RF10, RF11, RF12, RF16	X
		Hole No. 12		RV	g.F.	1,5	11705	3018			
		Hole No. 12		R	i.F.	0,3	12702	4015			
		Hole No. 12		RV	i.F.	0,4	12825	4138			
		Hole No. 12		RV	g.F.	3,2	12825	4138			
		Hole No. 12		RV	i.F.	1,4	13056	4.369			
		Hole No. 12		RV	g.F.	3,8	13056	4.369			
		Hole No. 12									
RF6	left wing 7210 fitting 783199-1	Fitting No. 5	37	R	i.F.	3,4	11559	2872	81/21.9 Kap.3.1.9	similar to damages RF4, RF5, RF7, RF8, RF9, RF10, RF11, RF12, RF16	X
		Hole No. 12		R	g.F.	3,0	11559	2872			
		Hole No. 12		RV	i.F.	4,6	12825	4138			
		Hole No. 12		RV	g.F.	3,7	12825	4138			
		Hole No. 12		RV	i.F.	4,8	13056	4.369			
		Hole No. 12		RV	g.F.	4,7	13056	4.369			
		Hole No. 12									
RF7	right wing 8166 fitting 783198-2	Fitting No. 4	37	R	i.F.	0,4	12702	4015	81/21.9 Kap.3.1.8	similar to damages RF4, RF5, RF6, RF8, RF9, RF10, RF11, RF12, RF16	X
		Hole No. 1		RV	i.F.	0,6	13056	4369			
				R	i.F.	0,6	14869	6182			
RF8	right wing 8166 fitting 783198-2	Fitting No. 4	37	R	i.F.	1,0	12702	4015	81/21.9 Kap. 3.1.8	similar to damages RF4, RF5, RF6, RF7, RF9, RF10, RF11, RF12, RF16	X
		Hole No. 10		RV	i.F.	3,0	14964	6182			

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g.F. = against flight direction

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i.S. = in span direction
R.M. = to fuselage center

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TABLE B2. DAMAGE TO RETRO FIT WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage			Determined after number of test hours	TCTP component and other hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
				Type 1)	Direction 2)	Size (mm)					
RF9	right wing 8166 fitting 783198-2	Fitting No. 4 Hole No. 10	37	R RV	i.F. i.F.	0,5 1,5	12702 14869	4015 6182	81/21.9 Kap.3.1.8	similar to damages RF4, RF5, RF6, RF7, RF8, RF10, RF11, RF12, RF16	X
RF10	left wing 7210 fitting 783198-1	Fitting No. 4 Hole No. 1	37	R RV R	i.F. i.F. g.F.	0,5 1,5 0,5	12702 14869 14869	4015 6182 6182	81/21.9 Kap.3.1.7	similar to damages RF4, RF5, RF6, RF7, RF8, RF9, RF11, RF12, RF16	X
RF11	left wing 7210 fitting 783198-1	Fitting No. 2 Hole No. 16 Hole No. 16	37	R R RV RV	i.F. g.F. i.F. g.F.	0,4 0,6 2,4 3,5	12702 12702 14869 14869	4015 4015 6182 6182	81/21.9 Kap. 3.1.3	similar to damages RF4, RF5, RF6, RF7, RF8, RF9, RF10, RF12, RF16	X
RF12	left wing 7210 fitting 783198-1	Fitting No. 4 Hole No. 18 Hole No. 18	37	R R RV RV	i.F. g.F. i.F. g.F.	0,4 0,4 1,6 1,4	12702 12702 14869 14869	4015 4015 6182 6182	81/21.9 Kap.3.1.7	damage similar to RF4, RF5, RF6, RF7, RF8, RF9, RF10, RF11, RF16	X

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RV = crack extension

2) o = upwards
u = downwards
MR = several cracks
i.F. = in flight direction
g.F. = against flight direction
i = inwards
a = outwards
i.S. = in span direction
R.M. = to fuselage center

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TABLE B2. DAMAGE TO RETRO FIT WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage: Type 1)	Damage: Direction 2)	Damage: Size (mm)	Determined after number of test hours	TCTP component and other hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
RF13	right wing 7210 hinge 784670-4	hinge bands on wing side for landing flap connection	47.3 ÷ 59.6	B			12702	7185 TCTP + approx. 1000 troops	81/21.7 Kap.2.4.2	on 15 hinge members. similar to damages RF14, RF20, RF35, RF37, RF43. Component was exchanged	A
			62.0	R	i.F.	7,0					
			62.7	R	i.F.	6,0					
			63,2	R	i.F.	2,0					
			65,0	R	i.F.	7,0					
			55,6	R	i.F.	4,0					
			66,7	R	i.F.	2,0					
			67,0	R	i.F.	6,5					
			67,7	R	i.F.	2,0					
			68,1	R	i.F.	3,0					
			68,4	R	i.F.	2,0					
			69,4	R	i.F.	5,0					
			71,2	R	i.F.	3.0					
			75,1	R	i.F.	5,0					
			78,7	R	i.F.	2,5					
			80.7	R	i.F.	2.0					
			82,0	R	i.F.	2,0					
			83,5	R	i.F.	1,0					
RF14	left wing 7210 hinge 784670-3	hinge bands on wing side for land flap connection	44.6 ÷ 47	B			12702	6934 basis + 4015 retrofit	81/21.7 Kap.2.4	4 hinge members broken. similar to damages RF13, RF20, RF35.	A
			66.3	R	i.F.	5,0					
			78.7	R	i.F.	12.0					

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B = fracture
RV = crack extension

2) o = upwards
u = downwards
MR = several cracks
i.F. = in flight direction
g.F. = against flight direction
i = inwards
a = outwards
i.S. = in span direction
R.M. = to fuselage center

Kap = chapter
ABB = figure

TABLE B2. DAMAGE TO RETRO FIT WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage: Type 1)	Damage: Direction 2)	Damage: Size (mm)	Determined after number of test hours	TCTP component and other hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
RF14										RF37, RF43 Component was exchanged	
RF15	left wing 7210 lower wing skin 789194-1	rear hole for attaching fuel connection for pylon tank (pylon manifold)	73,5	R	i.F.	2,5	12702	4015	81/21.5 Kap.3.1.4	similar to damage RF41	X
					g.F.	1,5					
				RV	g.F.	1,8	13449	4762			
				RV	i.F.	5,5	13585	4898			
					g.F.	4,0					
				RV	i.F.	10,3	14869	6182			
					g.F.	8,0					
	right wing 8166 789194-2		73,5	R	i.F.	1,5	12702	4015	81/21.5 Kap.3.1.4	crack was milled away and reinforced with repair plate	
					g.F.	0,5					
RF16	left wing 7210 fitting 783199-1	Fitting No. 5 Hole No. 1	37	R	g.F.	0,8	14869	6182	81/21.9 Kap.3.1.9	similar to damage RF4, RF5, RF6, RF7, RF8, RF9, RF10, RF11, RF12	X
RF17	right wing 8166 bent U profile 783217-102	between beam 14 and aileron block	88.7	R		27,0	13056	4369	81/21.7 Kap.4.1.2	upper flange,	A
						17,0				lower flange similar to damage RF3	

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g.F. = against flight direction

i = inwards
a = outwards
i.S. = in span direction
R.M. = to fuselage center

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TABLE B2. DAMAGE TO RETRO FIT WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage Type 1)	Damage Direction 2)	Damage Size (mm)	Determined after number of test hours	TCTP component and other hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
RF18	right wing 8166 upper wing skin 783193-2	opening for aileron servo for accepting cover	95,5	R RV		77,0 90,0	13056 14869	4369 TCTP 6182	81/21.5 Kap.3.2.1	repaired. similar to damage RF2 + 1342 troop	A
	aileron servo cover 786426-2	in the center part of the rounding radius	91,5	R		41,5	13056				A
RF19	left wing 7210 front spar 783192-1	upper rounding radius on the side of the flap	39 + 42,2	R	i.S.	80,0	13056	4369	81' 1,7 1	repaired according to GAF.T.0 1F-1046/3. similar to damage RF36, F44	B
RF20	left wing 7210 nose flap 784588-3	nose box spar in web-flange region and at the hinge members	38 + 46,7	B			13056	109		o was nged. ilar to damages RF13, RF14, RF35, RF37, RF43	B
RF21	left wing 7210 lower wing skin 783194-1	countersunk holes of the inner pylon fitting connection						4369	81/21.5	similar to damage RF22	X

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g.F. = against flight direction
i = inwards
a = outwards
i.S. = in span direction
R.M. = to fuselage center

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TABLE B2. DAMAGE TO RETRO FIT WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage Type 1)	Damage Direction 2)	Damage Size (mm)	Determined after number of test hours	TCTP component and other hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
RF21		Hole 1	63.7	R	i.F.	2,5	13056		Kap.3.1.2		
					g.F.	2,9					
		Hole 1	63,7	RV	i.F.	7,5	14869	6182			
				RV	g.F.	8,0					
		Hole 3	65,4	R	i.F.	0,8	13056	4369			
				R	g.F.	0,5					
		Hole 3	65,4	R	i.F.	0,8	14869	6182			
				R	g.F.	0,5					
		Hole 5	66.3	R	i.F.	1,8	13056	4369			
				R	g.F.	0,4					
		Hole 5	66,3	RV	i.F.	2,0	14869	6182			
				RV	g.F.	3,0					
RF22	right wing 8166 lower wing skin 783194-2	countersunk holes in the inner pylon fitting connection							81/21.5 Kap.3.1.2	similar to damage RF21	x
		Hole 1	63,7	R	i.F.	0,6	13056	4369			
				R	g.F.	1,2					
		Hole 1		RV	i.F.	1,6	14869	6182			
				RV	g.F.	2,6					
		Hole 2	64,5	R	i.F.	0,4	13056	4369			
		Hole 2		RV	i.F.	0,4	14869	6182			
		Hole 3		R	i.F.	0,2	13056	4369			
				RV	i.F.	0,2	14869	6182			
				R	g.F.	0,8					
		Hole 4	66,3	R	i.F.	0,4	13056	4369			
		Hole 4	66,3	RV	i.F.	0,8	14869	6182			

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i.F. = in flight direction
g.F. = against flight direction
i = inwards
a = outwards
i.S. = in span direction
R.M. = to fuselage center

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TABLE B2. DAMAGE TO RETRO FIT WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage Type 1)	Damage Direction 2)	Damage Size (mm)	Determined after number of test hours	TCTP component and other hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
RF22		Hole 5	66,3	R	i.F.	3,5	13056	4369			
				R	g.F.	1,8					
		Hole 5	66,3	RV	i.F.	11,0	14869	6182			
				RV	g.F.	8,5					
RF23	right wing 8166 lower wing skin 783194-2	countersunk holes of the fitting skin connection region	36 ÷ 48						81/21.5 Kap. 3.1.1	similar to damages RF24, RF38	A
				R	iF/g.F	0,4÷0,6	13056	4369			
						0,4÷2,4	14869	6182			
		Fitting No. 2		R	i.F./g.F.	0,4÷2,3	13056	4369			
						0,4÷4,0	14869	6182			
		Fitting No. 3		R	i.F./g.F.	0,4÷0,7	13056	4369			
						0,4÷1,0	14869	6182			
		Fitting No. 4		R	i.F./g.F.	0,4÷0,8	13056	4369			
						0,4÷1,0	14869	6182			
		Fitting No. 5									
RF24	left wing 7210 lower wing skin 783194-1	countersunk holes of the fitting skin connections region	36 ÷ 48						81/21.5 Kap.3.1.1	similar to damage RF23, RF38	A
				R	i.F./g.F.	0,4÷1,2	13056	4369			
		Fitting No. 2				0,4÷1,2	14869	6182			
				R	i.F./g.F.	0,4÷0,6	13056	4369			
		Fitting No. 3				0,5÷2,5	14869	6182			
				R	i.F./g.F.	0,4÷1,3	13056	4369			
		Fitting No. 4				0,4÷2,0	14869	6182			

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i.F. = in flight direction
g.F. = against flight direction

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a = outwards
i.S. = in span direction
z.M. = to fuselage center

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TABLE B2. DAMAGE TO RETRO FIT WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage: Type 1)	Damage: Direction 2)	Damage: Size (mm)	Determined after number of test hours	TCTP component and other hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
RF24		Fitting No. 5		R	i.F./g.F.	0,4 0,4+1,5	13056 14869	4369 6182			
RF25	left wing 7210 end rib 783460-1	upper and lower transition radius from the shackle to the U profile at the rear spar connection	131	R	o u	3,0 4,0	13449	4762	81/21.7 Kap.4.2	end rib was exchanged. similar to damages RF1, RF26, RF28, RF30	B
RF26	left wing 7210 end rib 783460-1	hole for connecting the position light	131	R	i.F. i.F.	2,0 4,0	13449	4762	81/21.7 Kap.4.2	end rib was exchanged. similar to damages RF1, RF25, RF28, RF30	C
RF27	left wing 7210 lower wing skin 783194-1	transition radius of the depression for the landing flap hinge	91,0	R RV RV	R.M. R.M. R.M.	1,0 12,0 20,0 40,0	13449 13585 14093 14869	4762 4898 5406 6182	81/21.5 Kap.3.1.5	similar to damage RF34	A
RF28	left wing 7210 tip tank 729477-1	sleeve for tip tank alignment bolts	131	R		26,0	13823	4118	81/21.7 Kap.4.2	similar to damages RF1, RF25, RF26, RF30. crack in radius, exchange	C

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i.S. = in span direction
R.M. = to fuselage center

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TABLE B2. DAMAGE TO RETRO FIT WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage: Type 1)	Damage: Direction 2)	Damage: Size (mm)	Determined after number of test hours	TCTP component and other hours	Explanation, see LABG report no.	Remarks and measures taken	Classification
RF29	left wing 7210 lower wing skin 783194-1	crack starting at the radius of the aileron servo cylinder unit at WS91 ends at the locking opening of the nose flap	91 + 92	B	i.F.		14869	6182	81/21.5 Kap.3.1.6		B
RF30	right wing 8166 end rib 783460-2	upper transition radius from the shackle to the U profile at the front spar connection	131	R	o	54,0	14869	6182 TCTP +1342 troop	81/21.7 Kap.4.2.2	similar to damages RF1, RF25, RF26, RF28	[illegible]
RF31	right wing 8166 rear spar 783460-2	rounding radius web-lower flange	88,9	R	R.M.	18,0	14869	6182	81/21.7 Kap.3.2.2		A
RF32	right wing 8166 cylindrical unit 775256-2	cylinder unit of the aileron servo at the radius of the flange depression	91	R		44,0	14869	6182 TCTP + 1342 troop	81/21.7 Kap.4.3.2	similar to damage RF39	B
RF33	right wing 8166 lower wing skin 783194-2	beam No. 7, Jo-Bolt hole No. 18	65,3	R R	i.F. g.F.	1,0 0,5	14869	6182	81/21.5 Kap.3.1.3		A

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i.S. = in span direction
R.M. = to fuselage center

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TABLE B2. DAMAGE TO RETRO FIT WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage			Determined after number of test hours	TCTP component and other hours	Explanation, see LABG report no.	Remarks and measures taken	Classification
				Type 1)	Direction 2)	Size (mm)					
RF34	right wing 8166 lower wing skin 783194-2	transition radius of the depression for the landing flap hinge	91,0	R	R.M.	20,0	14869	6182	81/21.5 Kap.3.1.5	damage similar to RF27	A
RF35	right wing 8166 hinge 784670-4	hinge band on the wing side for the landing flap connection	54,5 + 57,3	B			14869	2167 TCTP +1063 Trupp	81/21.7 Kap.2.4.2	similar to damages RF13, RF14, RF20, RF37, RF43 5 hinge members broken	B
RF36	right wing 8166 front spar 783192-2	4 cavities for hinge units	72,5 74,0 76,0 88.0	R R R R		10,0 5,0 7,0 11.0	14869	6182 TCTP + 1342 troop	81/21.7 Kap3.1.2	similar to damages RF19, RF44	B
RF37	right wing 8166 nose flap 784588-4	4 hinge units broken	80,0 88,5 129,0 130,0	B B B B			14869	1342 TCTP +1342 troop	81/21.7 Kap.2.4.2	similar to damages RF13, RF14, RF20, RF35, RF43	B
RF38	right wing 8166 lower wing skin 783194-2	Jo-Bolt holes at canted rib II	48	R	i.F./g.F.	0,5+3,2	14869	6182	81/21.5 Kap.3.1.1	similar to damages RF23, RF24	A
RF39	left wing 7210 cylindrical unit 775256-1	cylinder unit of aileron servo, in milled radius of flange	91	B			14869	13116	81/21.7 Kap.4.3.1	similar to damage RF32	B

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i.S. = in span direction
R.M. = to fuselage center

Kap = chapter
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TABLE B2. DAMAGE TO RETRO FIT WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage Type 1)	Damage Direction 2)	Damage Size (mm)	Determined after number of test hours	TCTP component and other hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
RF40	left wing 7210 beam	lower flange and web flange					14869	13116	81/21.7 Kap.2.1.1		B
		Beam 4	95,65	B							
		Beam 5	95,18	B							
		Beam 6	94,40	B							
		Beam 7	96,52	B							
		Beam 8	93,05	B							
		Beam 9	91,20	B							
		Beam 10	91,91	B							
RF41	left wing 7210 lower wing skin 783194-1	front hole for attaching the fuel connection for pylon tank (pylon manifold)	74	R R	i.F. g.F.	1,0 4,5	14869	6182	81/21.5 Kap.3.1.4	similar to damage RF15	X
RF42	left wing 7210 lower wing skin 783194-1	hole for passing the rear shear pin	74	R	g.F.	1,6	14869	6182	81/21.5 Kap.3.1.4		C
RF43	left wing 7210 nose flap 784588-3	first hinge unit	39,7	R	R.M.	6.0	14869	2167TCT +1102 troop	81/21.7 Kap.2.4.1	similar to damges RF13, RF14, RF20, RF35, RF37	B

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i.F. = in flight direction
g.F. = against flight direction
i = inwards
a = outwards
i.S. = in span direction
R.M. = to fuselage center

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TABLE B2. DAMAGE TO RETRO FIT WINGS (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage			Determined after number of test hours	TCTP component and other hours	Explanation, see IABG report no.	Remarks and measures taken	Classification
				Type 1)	Direction 2)	Size (mm)					
RF44	left wing 7210 front spar 783192-1	15 hinge units					14869	6182	81/21.7 Kap.3.1.1	similar to damages RF19, RF36	B
			39,0	R		5,0					
			53,8	R		6,0					
			54,[illegible]	R		4,0					
			57,0	R		2,0					
			59.5	R		7,0					
			60,5	R		8,0					
			61.8	R		5,0					
			63,0	R		8,0					
			64,2	R		5,0					
			65,3	R		7,0					
			66,5	R		2,5					
			81,3	R		1,0					
			87,0	R		6,0					
			88,2	R		8,0					
			124,9	R		2,5					

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g.F. = against flight direction

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a = outwards
i.S. = in span direction
R.M. = to fuselage center

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TABLE B3. DAMAGE TO FUSELAGE

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage: Type 1)	Damage: Direction 2)	Damage: Size (mm)	Determined after number of test hours	Component hours (TCTP)	Explanation, see IABG report no.	Remarks and measures taken	Classification
R1	cover for rear fuel tank 776893-21	right rounding hole at the end of the relief hole	453,6	R RV RV		22,7 27,0 27,0	911 1043 1089	536 633 679	81/21.1	repair	A
		accordingly for the left side		R RV RV		4,3 13,0 13,3	911 1043 1089	536 633 679		repair	
R2	skin fuselage	right front radius of the hydraulic flap opening	520	R RV		6,2 8,2	1070 1089	660 679	81/21.2 Kap. 2.1	similar to damages R6, R24, R44, R13, R36 repair by reinforcement	A
		accordingly for left side		R RV		6,2 11,0	1070 1089	660 .679			
R3	skin fuselage	radius of the fuselage skin of the rear left longitudinal support	505	R		4,8	1111	701	81/21.3 Kap. 2	no crack propagation up to 14869 hours	C
R4	skin fuselage 761451-4	riveting at the upper side of the air inlet channel right	444	R RV		3,8 total 69,6	1153 3000	743 2590	81/21.3 Kap. 3	similar to damages R5, R8, R9, R10, R11, R19, R20 repair	B

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i.F. = in flight direction
g.F. = against flight direction
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a = outwards
i.S. = in span direction
R.M. = to fuselage center

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TABLE B3. DAMAGE TO FUSELAGE (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage: Type 1)	Damage: Direction 2)	Damage: Size (mm)	Determined after number of test hours	Component hours (TCTP)	Explanation, see IABG report no.	Remarks and measures taken	Classification
R5	skin fuselage 761451-4	riveting at the upper side of air inlet panel, right	448	R RV		1,5 ÷ 7 2,1 ÷ 7,6	2008 2074	1598 1664	81/21.3 Kap. 3	similar to damages R4, R8, R9, R10, R11, R19, R20, R47	B
R6	skin fuselage	radius at the right first reinforcement sheet of hydraulic flap opening accordingly on the left side	520	R RV R RV		7,0 7,5 6,0 6,2	2050 2138 2050 2138	961 1049 961 1049	81/21.2	similar to damages R2, R24, R44, R13, R36	A
R7	firewall 761847-103 761847-104	left and right web plate	505	R		6 ÷ 31	2050	1640	81/21.3 Kap. 4	similar to damages R12 damage drilled away	A
R8	skin fuselage 783194-2	riveting at the upper side of air inlet channel, right	448	R RV		3 ÷ 8 total 62	2656 3000	2246 2590	81/21.3 Kap. 3	similar to damages R4, R5, R9, R10, R11, R19, R20 repair	B

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g.F. = against flight direction
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a = outwards
i.S. = in span direction
R.M. = to fuselage center

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TABLE B3. DAMAGE TO FUSELAGE (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage Type 1)	Direction 2)	Size (mm)	Determined after number of test hours	Component hours (TCTP)	Explanation, see IABG report no.	Remarks and measures taken	Classification
R9	skin fuselage 761451-4	riveting at the upper side of the air inlet channel, right. Crack passed from below	456	R		4	2656	2246	81/21.3 Kap. 3	similar to damages R4, R5, R8, R10, R11, R19, R20	B
		radius of opening for the nose flap operation		RV		25,0	3000	2590		repair	–
R10	frame part 761089-9	cover attachment of opening for nose flap operation							81/21.3 Kap. 3	similar to damages R4, R5, R8, R9, R11, R19, R20	B
		upper crack	451	R		32	3000	2590		exchange	
		lower crack	456	R		30	3000	2590		exchange	
R11	cover 761089-9	cover above opening for nose flap operation, right side	451	B			3000	2590	81/21.3 Kap. 3	similar to damages R4, R5, R8, R9, R10, R19, R20, R65 fracture of corner, exchanged	B
R12	firewall 761847-103 761847-104	cracks in hole from damage R7	505	R		6 + 50	3000	2590	81/21.3 Kap. 4	similar to damage R7	A
							14869	14459		no crack extension	

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g.F. = against flight direction
i = inwards
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i.S. = in span direction
R.M. = to fuselage center

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TABLE B3. DAMAGE TO FUSELAGE (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage Type 1)	Damage Direction 2)	Damage Size (mm)	Determined after number of test hours	Component hours (TCTP)	Explanation, see IABG report no.	Remarks and measures taken	Classification
R13	skin fuselage	radius of first reinforcement plate for hydraulic flap opening	520	RV		10,8	4000	2911	81/21.2	similar to damages R2, R6, R24, R36, R44	A
		accordingly for left side		RV		6,2	4000	2911		exchange of first plate against second plate	
R14	angle profile	at bending radius	422						81/21.3 Kap. 5	similar to damages R16, R49	A
	769787-86			R		43,5	4486	4076			
		right profile		RV		240,0	5326	4916			
				RV		240,0	6407	5997			
				R		41,5	4486	4076		exchange	
		left profile		RV		240,0	5326	4916			
				RV		240,0	6407	5997			
R15	skin fuselage	radius of ammunition area opening	335						81/21.3 Kap. 6	exchange	C
				R		3,4	5136	4726			
		left side		RV		3,4	6407	5997		repair	
		right side		R		0,2	5136	4726			

1) R = crack
B = fracture
RV = crack extension

2) o = upwards
u = downwards
MR = several cracks
i.F. = in flight direction
g.F. = against flight direction
i = inwards
a = outwards
i.S. = in span direction
R.M. = to fuselage center

Kap = chapter
ABB = figure

TABLE B3. DAMAGE TO FUSELAGE (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage			Determined after number of test hours	Component hours (TCTP)	Explanation, see IABG report no.	Remarks and measures taken	Classification
				Type 1)	Direction 2)	Size (mm)					
R16	angle profile	right passage hole	422	R		25	5296	4886	81/21.3 Kap. 5	similar to damages R14, R49	A
	769787-86			RV		25	6407	5997		exchange	
		left passage hole		R		25	5296	4886			
				RV		25	6407	5997		exchange	
R17	skin fuselage	plate field M48 near hinge for hydraulic flap	577,4	R		11,0	5562	5152	81/21.3 Kap. 7		C
				RV		11,0	14869	14459			
R18	fuselage tail	lower connection fitting	614						81/21.3 Kap. 17	similar to damage R33	C
		right		R		2,0	5562	5152		exchange	
		left		R		2,0	5562	5152		exchange	
R19	fuselage skin	plate field M13 at upper side of left inlet air channel	450	R		4,5	5799	5389	81/21.3 Kap. 3	similar to damages R4, R5, R8, R9, R10, R11, R20	B
				RV		5,0	6407	5997			
R20	skin fuselage	plate field M13, holes 15, 16, 17	450	R		4 ÷ 5	6344	5934	81/21.3 Kap. 3	similar to damages R4, R5, R8, R9, R10, R11, R19	B
R21	bulge for landing flap actuator 761467-26	both upper corner roundings	526,9	R		40	6407	5997	81/21.3	similar to damages R25, R26, R27	B
		right fuselage side	538,3	R		15	6407	5997	Kap. 8	exchange	

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i.S. = in span direction
R.M. = to fuselage center

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TABLE B3. DAMAGE TO FUSELAGE (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage			Determined after number of test hours	Component hours (TCTP)	Explanation, see IABG report no.	Remarks and measures taken	Classification
				Type 1)	Direction 2)	Size (mm)					
R22	skin fuselage	sheet field M30, riveting with main spar 5, hole No. 2	520.5	R RV	g.F. g.F.	3,5 12,5	6407 14869	5997 14459	81/21.11 Kap. 2.1	similar to damages R40 and R41	B
R23	skin fuselage 775044-3	upper left radius of ground cooling door	558,0	R RV		10,0 40,0	6407 11957	5997 11547	81/21.11 Kap. 2.2	similar to damage R29 repaired	B
R24	skin fuselage	radius of second reinforcement sheet of hydraulic flap opening accordingly for left side	520	R R		11,0 9,5	6407 6407	2407 2407	81/21.2	similar to damages R2, R6, R13, R44, R36 second repair plate replaced by third repair plate	A
R25	bulge for landing flap actuator, 761467-25	right lower corner rounding left fuselage side	538,3	R RV RV RV RV RV		22,3 22,5 23,0 32,0 33,0 33,0	6466 6540 6662 6845 7469 7805	6056 6130 6252 6435 7059 7395	81/21.3 Kap. 8	similar to damages R21, R26, R27 exchange	B

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TABLE B3. DAMAGE TO FUSELAGE (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage Type 1)	Damage Direction 2)	Damage Size (mm)	Determined after number of test hours	Component hours (TCTP)	Explanation, see IABG report no.	Remarks and measures taken	Classification
R26	bulge for landing flap actuator	upper corner rounding left right	538,3 527,3	R RV R RV		17 17 1 + 2 1 + 2	6845 7805 6845 7805	6435 7395 6435 7395	81/21.3 Kap. 8	similar to damages R21, R26, R27 exchange exchange	B
R27	761467-25 bulge for landing flap actuator	lower left corner rounding left fuselage side left fuselage side	527,3	R RV RV		22,0 28,0 28,0	6845 7469 7805	6435 7059 7395	81/21.3 Kap. 8	similar to damages R21, R25, R26 exchange	B
R28	skin fuselage	sheet field M31 over the hydraulic flap left side	530,7	R RV		66,6 66,6	6968 7108	6558 6698	81/21.3 Kap. 11	similar to damages R30, R35, R52 repaired	B
R29	skin fuselage 775044-3	lower right radius of ground cooling door	546,5	R RV		3,2 33,0	6968 11957	6558 11547	81/21.11 Kap. 2.2	similar to damage R23 repaired	B
R30	skin fuselage	sheet field M31 above the hydraulic flap, reinforcement sheet lower radius	530,9	R RV		2,8 4,8	7216 7534	6806 7124	81/21.3 Kap. 11	similar to damages R28, R35, R52	B
R32	skin fuselage	riveting of the sheet field M6 right side	405,8	R RV		2,9+ 6,5	7216 12316	6806 11906	81/21.11 Kap. 2.3	similar to damage R37 repaired.	B

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TABLE B3. DAMAGE TO FUSELAGE (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage			Determined after number of test hours	Component hours (TCTP)	Explanation, see IABG report no.	Remarks and measures taken	Classification
				Type 1)	Direction 2)	Size (mm)					
B33	fuselage tail	lower connection fitting, left, crack in welding seam	614	R		1,5	7361	1799	81/21.1 Kap. 17	similar to damage R18	C
B34	air suction scoop 760218-101	below the covering sheet 2 holes from bottom, left side	423	R		5,7	7351	1799	81/21.3 Kap. 13	similar to damages R38, R39	C
R35	skin fuselage	sheet field M31 above hydraulic flap, reinforcement plate, upper radius	529,3	R RV RV RV		1,6 3,5 4,0 4,0	7361 7534 10550 14869	6951 7124 10440 14459	81/21.11 Kap. 2.4	similar to damages R28, R30, R52	B
R36	skin fuselage	radius of third right reinforcement sheet of hydraulic flap opening	520	R			7469	1062	81/21.11 Kap. 2.6	similar to damages R2, R6, R13, R24, R44	A
R37	skin fuselage	riveting of sheet field M5, riveting hole 6	405,8	R RV		3,3 5,5	7469 14869	7059 14459	81/21.11 Kap. 2.3	similar to damage R32	B

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a = outwards
i.S. = in span direction
R.M. = to fuselage center

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TABLE B3. DAMAGE TO FUSELAGE (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage: Type 1)	Damage: Direction 2)	Damage: Size (mm)	Determined after number of test hours	Component hours (TCTP)	Explanation, see IABG report no.	Remarks and measures taken	Classification
R38	air inlet scoop	below covering sheet, second hole from the bottom, right side	422	R	g.F.	5,0	7469	7059	81/21.11 Kap. 2.5	similar to damages R34 and R39	C
				R	i.F.	2,5	9844	9434			
				RV	i.F.	3,0	11559	11149			
				RV	i.F.	3,5	13823	13413			
				R	g.F.	5,5	13449	13039			
				RV	g.F.	5,6	13823	13413			
				RV	g.F.	6,0	14178	13768			
				RV	g.F.	6,0	14869	14459			
R39	air inlet scoop	riveting hole in upper radius of riveting with bulkhead rib	422	R		3,2	7469	7059	81/21.3 Kap. 13	similar to damages R34 and R38	C
				RV		3,2	14869	14459			
R40	skin fuselage	sheet field M30, riveting with main rib 5	520,5						81/21.11 Kap. 2.1	similar to damages R22 and R41	B
		second hole		R	i.F.	1,5	7506	7096			
				RV	i.F.	10,5	14869	14459			
		first hole		R	g.F.	2,3	13685	13275			
				RV	g.F.	3,8	14869	14459			
R41	skin fuselage	sheet field M30, riveting with main spar 5	520,5	R	g.F.	2,9	7534	7124	81/21.11 Kap. 2.1	similar to damages R22 and R40	B
				RV	g.F.	7,7	14869	14459			
		third hole		R	i.F.	6,4	14869	14459			

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i.S. = in span direction
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TABLE B3. DAMAGE TO FUSELAGE (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage			Determined after number of test hours	Component hours (TCTP)	Explanation, see IABG report no.	Remarks and measures taken	Classification
				Type 1)	Direction 2)	Size (mm)					
R42	skin fuselage	doubler below sheet field M53							81/21.3 Kap. 14	Similar to damages R45, R59, R60, R73, R74, R75, R76 exchange	B
		first crack	493,3	R		24,0	7805	7395			
		second crack	499,5	R		16,0	7805	7395			
		third crack	503,5	R		41,0	7805	7395			
R43	rear fuel container space	upper longitudinal support	438,3	R		17	8304	7894	81/21.3 Kap. 15		B
R44	skin fuselage	radius of third right reinforcement sheet of hydraulic flap opening	520	R			8780	8370	81/21.11 Kap. 2.6	similar to damages R2, R6, R13, R24, R36	C
R45	skin fuselage	doubler below sheet field M53	501						81/21.11 Kap. 3.1	similar to damages R42, R59, R60, R73, R74, R75, R76	B
		Rivet 1		R	o	3,0	8978	8568			
				RV	o	6,5	10504	10094			
		Rivet 2		R	u	7,0	8854	8444			
				RV	u	3)	10504	10094			
				R	o	7,5	10504	10094			
		Rivet 3		R	o	3,0	8854	8444		damage repaired at 10504 total test hours	
				RV	o	3)	10504	10094			
				R	u	2,0	9587	9177			
				RV	u	9,8	10504	10094			
		Rivet 4		R	o	3,0	8978	8568			
				RV	o	10,0	10504	10094			

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i.S. = in span direction
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TABLE B3. DAMAGE TO FUSELAGE (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage: Type 1)	Damage: Direction 2)	Damage: Size (mm)	Determined after number of test hours	Component hours (TCTP)	Explanation, see IABG report no.	Remarks and measures taken	Classification
R46	frame part 761089-3	cover attachment of opening for nose flap attachment	452	R R RV	g.F. i.F. i.F.	2,5 2,5 3,0	8987 10093 11957	5987 7093 8957	81/21.11 Kap. 3.2	similar to damages R10, R65	C
R47	skin fuselage	riveting of sheet field M13 hole No. 9 to 16, left	444	R RV		3,5 + 5,0 3,8 + 11,0	9353 14178	8943 13768	81/21.11 Kap. 3.3	similar to damages R5, R54	B
R48	skin fuselage	riveting of sheet field M12 with upper longitudinal support, right	456 458	R RV R RV	u u u u	3,0 3,0 3,0 3,0	9479 14869 13449 14869	9069 14459 13039 14459	81/21.11 Kap. 3.4	similar to damage R56	C
R49	angle profile 769787-86 769787-85	at bending radius left profile right profile	422	R RV R RV		20,0 20,0 15,0 60	9705 14469 9705 14469	3298 8062 3298 8062	81/21.11 Kap. 3.5	similar to damages R14, F16	A
R50	skin fuselage	riveting of sheet field M6 right side hole 5	399,6	R RV R RV	o u o o	3,5 7,5 3,7 4,0	9705 12316 11957 12316	9295 11906 11547 11906	81/21.11 Kap. 3.7	similar to damages R32, R37, R53 repaired	B
R51	skin fuselage	sheet field M36, rivet hole for attaching hydraulic flap hinge	577,5	R RV		4,0 4,0	9705 14869	9295 14459	81/21.11 Kap.3.8		C

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i.S. = in span direction
R.M. = to fuselage center

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TABLE B3. DAMAGE TO FUSELAGE (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage: Type 1)	Damage: Direction 2)	Damage: Size (mm)	Determined after number of test hours	Component hours (TCTP)	Explanation, see IABG report no.	Remarks and measures taken	Classification
R52	skin fuselage	sheet field M30, right side	530,7	R RV		60 77	10650 11937	10440 11527	81/21.11 Kap. 3.9	similar to damage R28, R30, R35 Repaired	B
R53	skin fuselage	riveting of sheet field M6 Hole 4	399,6	R RV R RV	u u o o	4,5 9,0 4,0 5,0	10850 12316 11559 12316	10410 11906 11149 11906	81/21.11 Kap. 3.7	similar to damages R32, R37, R50 Repaired Repaired	B
R54	skin fuselage	riveting of sheet field M13 Hole 11 Hole 12 Hole 13 Hole 14	440,6	R RV R RV R RV R RV	u u u u u u u u	4,0 4,5 4,0 4,0 4,5 4,8 3,5 3,5	11957 14869 14093 14869 14093 14869 11957 14869	11547 14459 13683 14459 13683 14869 11547 14459	81/21.11 Kap. 3.3	similar to damages R4 and R47	B
R55	upper longitudinal support	lower flange for ground longitudinal support	422	R		56	12516	11906	81/21.11 Kap. 3.6	repaired	A

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g.F. = against flight direction
i = inwards
a = outwards
i.S. = in span direction
R.M. = to fuselage center

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TABLE B3. DAMAGE TO FUSELAGE (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage			Determined after number of test hours	Component hours (TCTP)	Explanation, see IABG report no.	Remarks and measures taken	Classification
				Type 1)	Direction 2)	Size (mm)					
R56	skin fuselage	riveting of sheet field M12 with upper longitudinal support	458	R RV		2,5 2,5	12702 14869	12292 14459	81/21.11 Kap. 3.6	similar to damage R48	C
R57	frame part	attachment of cover at opening to oil tank	536,5						81/21.11 Kap. 3.8		C
		first crack		R RV R RV	o o u u	4,5 4,5 4,5 4,5	13325 14869 13325 14869	12915 14459 12915 14459			
		second crack		R RV R RV	o o u u	3,5 7,0 5,5 3)	13325 14869 13325 14869	12915 14459 12915 14459			
R58	main longitudinal support	outer reinforcement at opening for air removal line	479,5	R RV		5,0 22,0 3)	13056 13449	12646 13039	81/21.11 Kap. 3.10	similar to damages R68, R69, R71	B
R59	skin fuselage	riveting of sheet field M53 at inspection opening for pressurized air controller	536,5						81/21.11 Kap. 3.1	similar to damages R42, R45, R60, R73, R74, R75, R76	B

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i = inwards
a = outwards
i.S. = in span direction
R.M. = to fuselage center

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TABLE B3. DAMAGE TO FUSELAGE (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage Type 1)	Direction 2)	Size (mm)	Determined after number of test hours	Component hours (TCTP)	Explanation, see IABG report no.	Remarks and measures taken	Classification
R59		hole 1		R	o	6,5	13325	12915			
				RV	o	3)	13823	13413			
				R	u	7,0	13325	12915			
				RV	u	3)	13823	13413			
		hole 2		R	o	3,0	13325	12915			
				RV	o	5,0	14093	13683			
				R	u	2,5	13325	12915			
				RV	u	3)	13823	13413			
R60	skin fuselage	riveting of sheet field M53 next to radius for fuel valve opening	503,4	R	u	5,5	13449	13039	81/21.11 Kap. 3.1	similar to damages R42, R45, R59, R73, R74, R75, R76	B
				RV	u	6,2	14178	13768			
R61	skin fuselage	rear radius of ammunition space opening, right side	335	R		1,8	13449	13039	81/21.11 Kap.3.11		C
				RV		4,2	14869	14459			
R62	longitudinal support	landing gear track right side	444,4	R	58,0	13449	13039		81/21.11 Kap.3.12		B
				RV	56,0	14869	14459				
		left side		R	48,0	13449	13039				
				RV	58,0	14869	14459				

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g.F. = against flight direction
i = inwards
a = outwards
i.S. = in span direction
R.M. = to fuselage center

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TABLE B3. DAMAGE TO FUSELAGE (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage Type 1)	Damage Direction 2)	Damage Size (mm)	Determined after number of test hours	Component hours (TCTP)	Explanation, see IABG report no.	Remarks and measures taken	Classification
R63	profile sheet 760491 L	left side hole 2	444,4	R	o	5,4	13585	13175	81/21.11 Kap. 3.12	similar to damage R64	B
				RV	o	6,7	14869	14459			
				R	u	7,8	13585	13175			
				RV	u	8,5	14869	14459			
		hole 3		R	o	4,8	13585	13175			
				RV	o	5,0	14869	14459			
R64	profile sheet 760491 R	right side hole 2	444,4	R	o	10,0	13585	13175	81/21.11 Kap. 3.12	similar to damage R63	B
				RV	o	13,0	14869	14459			
				R	u	14,4	13585	13175			
				RV	u	3)	14869	14459			
		hole 3		R	o	8,6	13585	13175			
				RV	o	3)	14869	14459			
				R	u	5,9	13585	13175			
				RV	u	7,4	14869	14869			
R65	cover 761089-9	cover above opening of nose flap operation right side	452	R	i.F.	3)	13823	10823	81/21.11 Kap. 3.2	similar to damage R11	C
				R	g.F.	3,0	13823	10823			
				RV	g.F.	3,2	14869	11869			
R66	upper covering plate	hole 15	416,3	R	o	4,0	14093	13683	81/21.11 Kap.3.13		C
				RV	o	4,0	14869	14459			
				R	u	5,3	14093	13683			
				RV	u	5,3	14869	14459			

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TABLE B3. DAMAGE TO FUSELAGE (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage Type 1)	Damage Direction 2)	Damage Size (mm)	Determined after number of test hours	Component hours (TCTP)	Explanation, see IABG report no.	Remarks and measures taken	Classification
R67	skin	right side hole 1	520,5	R R	i.F. g.F.	2,2 1,8	14869 14869	14459 14459	81/21.11 Kap. 3.14		A
R68	basic longitudinal support	outer reinforcement on the ventilation line hole, right side	479,5	R	u	14,0	14869	14459	81/21.11 Kap. 3.10	similar to damages R58, R69, R70, R71, R72	B
R69	basic longitudinal support	outer riveted reinforcement, right side	489,5	R	u	2,0	14869	14459	81/21.11 Kap.3.15	similar to damges R58, R68, R70, R71, R72	B
R70	basic longitudinal support	outer riveted reinforcement, right side	505,0	R	u	2,3	14869	14459	81/21.11 Kap.3.10	similar to damages R58, R68, R69, R71, R72	B
R71	basic longitudinal support	external riveted reinforcement at opening for air removal line, left side	479,5	R	o	13,5	14869	14459	81/21.11 Kap. 3.10	similar to damages R58, R68, R69, R72	B
R72	basic longitudinal support	external riveted reinforcement	489,5	R R	u	2,5 1,5	14869 14869	14459 14459	81/21.11 Kap. 3.10	similar to damages R58, R68, R69, R70, R71	B

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TABLE B3. DAMAGE TO FUSELAGE (continued)

Damage no.	Section or component part no.	Description of damage location	Wing station WS	Damage Type 1)	Damage Direction 2)	Damage Size (mm)	Determined after number of test hours	Component hours (TCTP)	Explanation, see IABG report no.	Remarks and measures taken	Classification
R73	skin fuselage	Riveting of sheet field M53 with M33, left side	513,9 ÷ 514,2	R		20,0	14869	14459	81/21.11 Kap. 3.1	similar to damages R42, R45, R68, R60, R74, R75, R76	B
R74	skin fuselage	sheet field M53, cavity for pressurized air controller cover, left side	513,0 ÷ 513,5	R	g.F.	25	14869	14459	81/21.11 Kap. 3.1	similar to damages R42, R45, R59, R60, R73, R75, R76	B
R75	skin fuselage	sheet field M53, cavity for compressed air controller cover, left side, top	512,7	R		11,0	14869	14459	81/21.11 Kap. 3.1	similar to damages R42, R45, R59, R60, R73, R74, R75	B
R76	skin fuselage	sheet field M53, cavity for compressed air controller cover, left side	511,4	R		25,0	14869	14459	81/21.11 Kap. 3.1	similar to damages R42, R45, R59, R60, R73, R74, R75	B
R77	main rib No. 5	right side hole 6	520,5	R	i.F.	1,6	14869	14459	81/21.11 Kap. 3.14		A
		left side hole 7		R	g.F.	1,0	14869	14459			

1) R = crack
B = fracture
RV = crack extension

2) o = upwards
u = downwards
MR = several cracks
i.F. = in flight direction
g.F. = against flight direction
i = inwards
a = outwards
i.S. = in span direction
R.M. = to fuselage center

Kap = chapter
ABB = figure

DOCUMENTATION DATA FOR THE REPORT TF 81/20

TITLE: TOTAL AIRFRAME FATIGUE TEST F 104 G FINAL REPORT

REFERENCE WORDS
OR KEY WORDS: (Characteristic words/concepts from the title, text, and topic to be used for document selection)

(If possible, less than 8 -- 10 lines, about 100 words)

ABSTRACT:
a) Type of Content and b) Summary of the Technical Results

This final report contains the most important information and data concerning the test configuration, test sequence, and results of the F 104 G total airframe fatigue experiment. Details are documented in 31 additional partial reports. In addition, the tables of Appendix B summarize all the damage which the structure experienced during the fatigue experiment. Because of cross references in the text and in the tables, this report can be used for the information contained in the partial reports. This final report includes an evaluation of the most important results (damage) and contains recommendations for measures to be taken or references to actions already taken.

REFERENCE: (fill in when the reference is important for documentation)

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