FINAL REPORT No. 285 COPY No. 314

ITEM No 25

UNCLASSIFIED

[redacted]

BRITISH

STRUCTURAL WORK AT FOCKE-WULF, BAD EILSON.

[redacted]

"This report is issued with the warning that, if the subject matter should be protected by British Patents or Patent applications, this publication cannot be held to give any protection against action for infringement."

BRITISH INTELLIGENCE OBJECTIVES SUB-COMMITTEE.

LONDON - H.M. STATIONERY OFFICE.

STRUCTURAL WORK AT FOCKE-WULF, BAD EILSEN

RESTRICTED

REPORTED BY

F/LT. D.C. APPLEYARD, R.A.E.

BIOS Target No. 25/15

AIRCRAFT

BRITISH INTELLIGENCE OBJECTIVES SUB-COMMITTEE

32 BRYANSTON SQUARE, W.1.

TABLE OF CONTENTS

Personnel of Team

F/Lt. D.C.Appleyard, R.A.E.

STRUCTURAL WORK AT FOCKE-WULF, BAD EILSEN

Summary

This Report records information obtained during discussions which were held with members of the structural branches of the Focke-Wulf company at Bad Eilsen.

Information was obtained on the testing of structures under repeated loading, on experimental work on stressed skin structures and on photoelastic research. In addition discussions were held on constructional methods and the use of high tensile steel, spot welding, wood and plastics in aircraft.

1 Introduction

A visit was made to Bad-Eilsen, from August 1st to August 16th 1945, to interrogate members of the staff of the Focke-Wulke aircraft company.

The object was to obtain information on items of research and development in the structural field which had been in progress at the firm during the war.

The opportunity was taken to visit the testing laboratory at Detmold and to interrogate members of the staff there and in the neighbourhood.

2 General

Some difficulty was encountered during these interrogations by the fact that all documents and reports had been cleared from both Detmold and Bad Eilsen, so that investigation in detail of some of the interesting items must be delayed until the mass of documents so cleared has been sorted.

This report is confined to records, under subject headings, of the discussions which were held [redacted]

3 Personnel Interrogated

In Bad Eilsen and district:-

Menzel (Deputy for Dr. Heintzelmann in the stress group)	Buckebourg, Hannoversche Str. 6.
Czerny (Deputy for Dr. Cassens in the load analysis group)	Bad Eilsen
Wehrse (Head of group dealing with new constructional methods)	Küttenhausen (near Minden)
Gscheidlinger (Development of plastics for aircraft use)	Kleinenbremen, Everdingsbrink
Heck (employed in stress group)	Bad Eilsen Schrebling 76.

In Detmold and district:-

Dose (Research testing and development of testing methods)	Vereinigte Möbelfabriken, Detmold.
Müller (welding and glueing)	" "
Durnheim (Dynamic testing)	Berlebeck 5. (near Detmold).

4 Design Requirements and Technical Administration

4.1 Information from various personnel confirmed that the latest design requirements issued by the R.L.M. were those in the 1936 edition of the "Bauvorschriften" and that for all recent types the basic design conditions were proposed by the firm in their design tender and eventually agreed between the firm and R.L.M. at a conference at which the Festigkeits Prüfstelle (Dr. Pilgrim's Department in the R.L.M.) was represented. The agreed conditions were recorded in one volume forming the first of a series of Statische Berechnung files and it appears that these are the most likely documents from which an up-to-date knowledge of German design requirements can be obtained.

4.2 The R.L.M. maintained a close interest, although not a great control, in the development stages of a new project. This was done by maintaining an official representative at the firm, whilst other official representatives, responsible each for one operation type (fighters, bombers, etc.) were employed in frequent visits between all firms engaged on the aircraft of the type for which he was responsible.

4.3 A further scheme evidently intended to keep all firms up-to-date on design matters were the "Entwicklungs" and "Arbeits-Gruppe" organisations. These groups were recruited from firm's personnel, and they covered both design and production questions. A table showing the organisation is given as an Appendix. Accounts differed as to the authority which these groups possessed. Some said that the head of each group was responsible to a high authority for seeing that firms worked to the recommendations of the group, whilst others stated that the groups were intended only to promote free discussion between firms of common problems. [redacted]

5 Loading Conditions

5.1 To assist the R.L.M. in deciding the flight factor for a new type, the firm provided curves in their design tenders showing the weight and performance for various values of the flight factor.

In checking the strength of the aeroplane for the normal flight cases, the wing load distribution was calculated assuming a structural deformation appropriate to the "safe load" p. (where 1.8p is the ultimate load). This distribution was used in checking against proof and ultimate loads and was the distribution used in the static tests.

5.2 Repeated Loading

It was known that considerable attention had been paid at this firm to the testing of structures under conditions of repeated loading and it had been hoped to obtain details of the basic work leading to the loading conditions adopted. It became clear, however, that the firm themselves took no great part in formulating these conditions and that the fundamental work had been done by the D.V.L. in Berlin, under the direction of Dr. Gassner. Gassner was said to be living in Darmstadt, and to be in contact with Prof. Walter at the Darmstadt Technical High-school.

Repeated loading tests were made by this firm in addition to the more conventional static tests called for in the German requirements. In the absence of any reports, the informants were not able to give precise figures for the loads used and the number of applications. As an example, two points on the frequency curve for a fighter were given, in terms of p, where 1.5p gives the ultimate load; in this example 0.2p was to be applied 1.8×10^6 times and 0.5p about 50 times. Acceptance was based on a "design life" for the aeroplane, of which the following were given as examples:

Fighter, 500 hrs. (later reduced to 50 hrs.)

Bomber, 1000 hrs.

Transport, 10,000 hrs.

The number of applications of a given acceleration was deduced from records made during operational flights. The total time represented [redacted] these [redacted] be in the neighbourhood of 50 - 100 hrs. [redacted] that this [redacted] for a representative frequency curve to be deduced.

For test purposes, the loading curve chosen as representing the required "design life" of the aeroplane was divided up between an arbitrary number of equal time intervals such that by repeating this number of times all the load applications represented by an interval, the structure would have withstood all the load applications appropriate to the design life. The time interval usually chosen was one tenth of the required design life of the aeroplane. The object of so dividing the total number of applications was twofold. Firstly, it had the effect of spreading the application of the higher order loads in a way more nearly representing the conditions of service. Secondly, it made possible the estimation of the life of the aeroplane should it fail before the requisite number of applications of load had been made.

Repeated load tests of undercarriage structures had also been made, using a theoretical loading curve. Gassner was said to be collecting experimental data with the object of producing a more realistic loading curve for testing undercarriage structures.

6 Experimental and Theoretical Work

6.1 Thin Sheet Construction

A considerable amount of test work had been done by the firm on the compression strength of stiffened sheets in light alloy and steel, of both spot welded and riveted construction. The objects were:-

(a) To provide data for further investigation of the problem of the origin of failure of panels under this type of loading.

(b) To compare spot welding and riveting as methods of attaching the stringers.

(c) To provide data for comparison between the merits of dural and steel construction.

(d) To find the most efficient form of section for the stringers.

The bulk of this experimental work had been completed before the outbreak of war and was finished during the first years of the war, but the results, although reported, were never fully analysed. The analysis for (a) was to have been done by Heck and (b), (c) and (d) by Wehrse. The latter work, which dealt fully with the relative merits of steel and light alloy construction, was 75% complete.

[redacted]

6.2 Photoelasticity

Dose, who worked at the laboratory in Detmold, had spent considerable time on photoelastic work in the past three years. His apparatus was destroyed by bombing in 1942 and he had re-equipped his laboratory just before the occupation. There is now little left of the new equipment. He said that he had not been interrogated in connection with his activities on photoelasticity.

He has investigated, in particular, the stress distribution in a cantilever beam, with large circular cut-outs, in bending. The test piece is sketched in Fig.1. The magnitude and distribution of stress were completely determined for this case and the results checked with theory. 10% to 15% discrepancy was found.

He has also investigated the diffusion of load from the point supports of an I section beam into the webs.

He claims to have found a new method for determining $(\sigma_1 + \sigma_2)$, which is simpler than the classical methods and is the only commercially feasible method of which he is aware. He has written a report on this method.

6.3 Strain Gauges

The development of strain gauges in which Dose has been engaged has been almost wholly connected with the Huggenburger type. He has developed a modified form of this type for use in investigating buckling problems, which combines the action of a strain gauge and a spherometer. The change in curvature is read from a second pointer moving over the Huggenburger dial. A second development of the Huggenburger was a "tripod" gauge in which the strains between the three vertices of a small equilateral triangle could be determined. This instrument was intended for use in diffusion investigations. A variable-inductance electrical form of this gauge was being developed by Askania.

Dose had had no interest in wire resistance strain gauges and was not aware of any development of their use in Germany.

6.4 Stress Lacquers

Dose has made several tests with lacquers supplied by different firms. The best, for use on steels, was produced by Maybach Motorenwerke, Friedrichshaven, but his opinion was that this method held little promise for quantitative application and he was sceptical of the glowing reports he has heard from the manufacturers of these lacquers.

6.5 Fatigue Testing of Joints

Reports had been made from time to time on fatigue tests on welded, riveted and bolted joints and on joints in wood. Particular attention had been paid to the effect on fatigue strength of rolling and shot-blasting a welded joint. It was said that Prof. Otto Föppl at Brunswick and Prof. Thum at Darmstadt Technical High-school had been engaged on similar joint fatigue problems.

7 Materials of Construction and Fabrication Methods

7.1 From conventional dural construction in the F/W 190 the firm had changed over to wood and plastics in the T.A. 154, mainly on account of difficulties in the supply of light alloy. At the same time the firm was interested in the development of all-steel construction and in particular the use of high tensile (120 kg/sq.m.m.) plain carbon steel. Tank's opinion was that steel construction would be profitable for large aircraft of high speed, where stiffness problems become overriding. In addition, Germany's output of steel suitable for aircraft work was better than that of light alloy.

7.2 Wooden Construction

The firm had concentrated on the development of laminated wood construction, initially of the form of "buche" or "breche", 0.5 mm. thick with Tegofilm adhesive layers and later of pine or alder laminations impregnated.

Considerable trouble was taken in the manufacture of fittings in laminated wood, in order that the good bearing properties of the highly compressed material could be had in combination with the good glueing properties of the lightly compressed material. An example of this is given in the method of fabricating the rib fitting aft of the main spar in the T.A.154 wing, which also comprises the engine mounting root fitting. A section of the wing showing this fitting is sketched in Fig. 2.

In manufacture, the pressure is applied in the chordwise direction, producing high density material in the position of the bolt hole and low density material in the region of the upper and lower wing surfaces.

The glue in most common use was P.600 manufactured by Dynamit A.G. but other p/f glues were also used. Experiments had been made on the characteristics of glues with various ratios of resin to acid setting compound. A ratio of 6:1 was found best for strength but 5:1 could be used if glueing was done at a high temperature and in this case a reduced glueing time was achieved, but with a tendency to burn the wood. A special p/f varnish was sometimes used and it was then found possible to use 5:1 satisfactorily without high temperature.

7.3 The Use of Plastics

The most outstanding example of the use of plastics for load-bearing fittings was the root-end fitting of the radius rod on the undercarriage of the T.A.154. This was of the form of a flat plate some two feet square. The thickness was gradually increased to a point near the middle of one edge of the plate. At the thickness section, where the depth was about 5 ins., a steel bush "cast" into the plate took the radius rod. The sketch in Fig. 3 illustrates this fitting.

It was made up from laminated plastic sheets pressed together but on the flat upper surface there was a wood lamination to facilitate glueing to the wing. The plastic material was supplied by D.A.G. Troisdorf.

Several tests had been made at Detmold before the final shape and method of fabrication were fixed, but even so the scatter of strength under loads applied through the radius rod was from 35 tons to 50 tons. None of the informants knew the ultimate design load so that it was not possible to assess what factor was chosen to allow for this scatter. No R.L.M. strength requirements exist for plastic components.

The experimental presses in which these components were developed were located at Kirchhorsten, near Buckebourg.

... interested in the use of light weight plastic foam fillers for control surfaces and tabs. The use of these foams is not new and the details are well-known.

7.4 Steel Construction

Wehrse was confident that for an aircraft designed from the outset for all steel construction, structural efficiency as good as that for dural could be attained, whilst for large aircraft it might be improved upon. This opinion had been confirmed to some extent by experience in the design of an experimental steel wing for the T.A.152 and the records of this design should be worth examining.

7.5 Spot Welding

The firm had not a great deal of experience in spot welding and the only major experiment in which they were involved was the manufacture of ten F.W.190 fuselages employing spot welding. These aircraft had gone into service during 1943 but the firm had never received any reports on their behaviour.

Heck had done some work on the analysis of single spot welded joints and this has been reported. The work had not, however, been extended to the more difficult problem of design allowables for multi-spot joints.

From the production point of view, the advantages of spot welding were not considered outstanding in comparison with automatic punch riveting. The reasons given were that the setting of the machine must be changed for each different thickness of sheet along, say, the span of a wing and, particularly for steels, surface imperfections cause considerable trouble. The firm was engaged in developing the punch rivet apparatus for use with steel and on the whole were inclined to favour this method over spot welding.

8 Accident and Defect Work

8.1 Informants confirmed that v.Pilgrim, of the R.L.M. was in charge of the official investigation of accidents and defects. They said that monthly reports of defects were sent out to all firms and they believed that Gassner of the D.V.L. was engaged on the statistical analysis of accidents.

Some trouble had been met with the F.W.190 tail control surfaces. Accidents had occurred due to rudders breaking away at the hinge during flight. Considerable investigation was made into the loads occurring and rudders were tested to destruction by Ebner, in the water channel at the D.V.L. Hydrodynamic Institute at Hambourg. The trouble was eventually traced to possible high rudder loads caused by shimmy of the tailwheel. Elevator failures which occurred were also traced to ground loads and it was not until these had occurred that the firm began to use the results of drop tests in deciding strength for landing loads.

9 Incidental [illegible]

Informants gave a number of names of personalities in Germany known to be working on [illegible], structural problems. These are given in the list below.

Organisation	Type of Work	Name	Present Location (where differing from Column 1)
D.V.L. Structures Dept. Saulgau Apotheke (Scharzwald)	(Shells, stability.	(Flügge (Marguerre (Kappus	
	(Fatigue.	(Gassner (Teichmann	Darmstadt
	(Cable Impact.	Köller	Wüsten, Post Herford (near Bad Salzuflen)
	(Vibrations.	(Borkmann (Leisse	
	(Tyres.	Martin	
D.V.L. Hydrodynamic Institute, Hambourg	All water loads and strength tests in water channel.	Ebner	
R.L.M. Berlin	Accidents, defects and general problems.	(Pilgrim (Jehle	Possibly at Volkenrode.
Hermann Goering Institute Brunswick	(Materials.	Dirksen	
	(Fatigue.	O Föppl	
Darmstadt Technical High-school	Fatigue.	Thum.	

10 Conclusions [redacted]

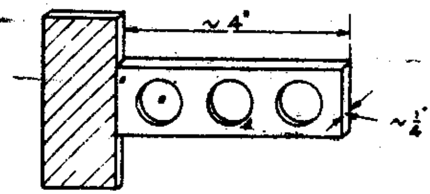
10.1 Design Requirements

The evidence is that the most up-to-date complete knowledge of German strength requirements would be obtained by examination of the Statische Berechnung files for each type. [redacted]

10.2 Repeated Loading of Aircraft Structures

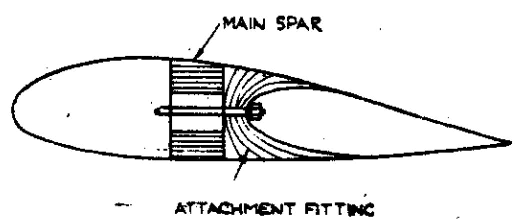
The information obtained in Bad Eilsen is sufficient to give a good idea of the principles of the method used and it is significant that such testing has been in progress for some time. There are some points, however, which still require elucidation, such as the maximum load factors which were applied in the tests and the correlation, if any, of the repeated load test with the static test. [redacted]

FIG. 1.



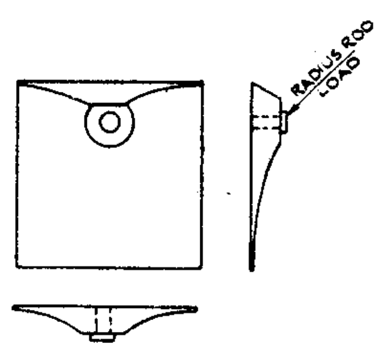
TEST PIECE FOR PHOTOELASTIC INVESTIGATION

FIG. 2.



ENGINE MOUNTING ATTACHMENT T.A. 154

FIG. 3.



PLASTIC ROOT ATTACHMENT FITTING
T.A.154 UNDERCARRIAGE

APPENDIX

THE FOLLOWING TABLE GIVES THE PERSONNEL IN CHARGE OF THE VARIOUS ENTWICKLUNGS & ARBEITS-GRUPPEN DEALING WITH AERONAUTICAL PROBLEMS.

ENTWICKLUNGS-GRUPPE
BAUWEISEN DER FLUGZEUGZELLE
PROF. DR. ING. BOCK, D.V.L.

ENTWICKLUNGS-UNTERGRUPPEN

METALL BAUWEISEN
PROF. BOCK, DR [illegible], R.L.M.

STAHLPROFILE
DR. WIMMER, HOESCH HOHENLIMBURG

STAHL- FEINBLECHE
DIREKTOR CRAMER, DINSLAKEN

KEILBLECHE
DR. ING. KLEIN, HÜSTEN

BLECHVERFORMUNG
DR. BRANDT, AMBI-BUDD, BERLIN

VERBINDUNGSVERFAHREN
PROF. DR. BOLLENRADT, D.V.L.

HOLME
OBERING. NISSEN, JUNKERS

DICKBLECHTEILE
OBERING. RETHEL, MESSERSCHMIDT

DUNNBLECHTEILE
DIR. OKEL, HENSCHEL

STAHLROHRKONSTRUKT
DIPL. ING. DRAEGER, JUNKERS

HOLZ- BAUWEISEN
DIR. DIPL. ING. BLUME ARADO
OBERING. KREKEL, ARADO

ARBEITS - GRUPPEN

LEIMUNG
DR. ING. KÜCH. D.V.L.

KUNSTSTOFF- BAUWEISEN
PROF. DR. ING. TANK
OBERING WEHRSE, FOCKE- WULF

LEIMUNG
DR. ING. KÜCH. D.V.L.
ING. PELIZAEUS R.L.M.

VERGLASUNG
OBERING. WEHRSE, FOCKE- WULF

CHEMISCHE ENTWICKLUNG
DIR. DR. KRANZLEIN, I.G. FARBEN

PHYSIK- ENTWICKLUNG
PROF. DR. VIEWEG, T.H. DARMSTADT

FÜR ALLE DREI UNTERGRUPPEN GEMEINSAM:

TRAGWERK
DIPL. ING. MÜHLBERG, MESSERCHMIDT

RUMPF
DR. ING. RÜHLE, HENSCHEL

LEITWERK UND RUDDER
OBERING. WEHRSE, FOCKE WULF

ENTWICKLUNGS- GRUPPE
DRUCKKABINEN
DIR. NIKOLAUS, HENSCHEL
VERTR. ING. HOLLAND, HENSCHEL

ENTWICKLUNGS- UNTERGRUPPEN

KONSTRUKTIVE GESTALTUNG VON HÖHENKAMMERN
DIPL. ING. MUTTRAY, JUNKERS
ING. HOLLAND, HENSCHEL
OBERING. LIEDTKE, [illegible] ARADO

KLIMA ANLAGEN
DR. ING. IDE
SCHÄFFER u. BUDDENBERG.

ENTWICKLUNGS- GRUPPE
TRIEBWERK
DIR. DR. SCHILO B.M.W.

ENTWICKLUNGS- GRUPPE
FAHRWERK
DIR. MICHAEL, E.C- STUTTGART

ENTWICKLUNGS- GRUPPE
FLUGZEUGSCHUTZ
OBERING. [illegible], JUNKERS

9"