DE HAVILLAND SUPPORT LIMITED
DUXFORD AIRFIELD, CAMBRIDGESHIRE, CB2 4QR, ENGLAND

CAA APPROVAL
Ref. AD/1819/00
Groups E1 & E2

WEBSITE
www.dhsupport.com

TELEPHONE
+44 (0) 1223 830090
FAX
+44 (0) 1223 830085
E-MAIL
info@dhsupport.com

SCOTTISH AVIATION BULLDOG AIRCRAFT SERVICE LETTER

SERVICE LETTER No. BDG/1/2004, ISSUE 2

STRUCTURAL LIFE AND FATIGUE DATA RECORDING

1. AIRCRAFT AFFECTED

All models of Scottish Aviation Bulldog

2. REASON FOR ISSUE

The Bulldog Full-Scale Fatigue Test has demonstrated that the critical (life-limiting) fatigue feature of the aircraft type is the wing-to-fuselage (stub wing) main spar joint. Depending upon whether an individual aircraft is, or has been, fitted with a fatigue meter, so the cleared safe life of this critical joint may be expressed in terms of either Fatigue Index or flying hours. Whilst there are several references to this subject within Service Bulletins and other Bulldog technical publications, there remains some doubt amongst owners regarding the meaning of Fatigue Index and its relationship to flying hours. The aim of this Service Letter is to draw together the relevant facts from the various references on the subject, to explain the concept of Fatigue Index (FI), and to advise owners of Bulldogs fitted with fatigue meters of the current requirements for fatigue data collection and calculation. The letter also gives planning advice regarding other life-limiting features of the Bulldog and an overview of work in progress regarding a modification for retrospective installation of fatigue meters.

3. FATIGUE DATA

3.1 General

Every metal aircraft suffers fatigue damage caused by the reversals and fluctuations of load applied to the airframe during all phases of operation. Fatigue damage accumulates continuously, although its effects are not detectable until it eventually appears as a crack in a structural component. Since such cracks may have catastrophic results, it is necessary in the interests of safety to declare a safe fatigue life at which non-damage-tolerant aircraft must be either retired from service or modified to permit further flying.

In-service fatigue consumption must be monitored continually to ensure that the proven safe fatigue life is not exceeded.

3.2 **Fatigue Index**

Fatigue life consumption is measured as the consumption of 'Fatigue Index' (FI). This is a non-dimensional number, derived from a fatigue formula specific to the aircraft type. The FI consumed is normally calculated from records of the aircraft's fatigue meter counters taken before and after each flight. The changes in the counter readings, together with the number of landings, are inserted into the fatigue formula to obtain the FI consumed over a specific period, so enabling the total FI of an individual aircraft to be monitored throughout its life. Analysis of the Bulldog Full Scale Fatigue Test results has shown that the maximum safe FI value of the aircraft, as built, is 114. The manufacturer has also determined that if the wing-to-fuselage (stub-wing) main spar joint is strengthened and otherwise improved by embodiment of Bulldog Modification No. BH.193, then the ultimate safe FI value is increased from 114 to 200. These limiting FI values, which were derived using appropriate safety factors, have been accepted by the UK CAA as the maximum safe FI values for both pre- and post-Mod BH.193 aircraft.

3.3 **Unmetered Flying**

When a fatigue meter is not installed, is unserviceable or out of calibration, fatigue consumption could be assessed from the details of the sorties flown. However, different types of manoeuvre impose different loads on the aircraft and, to enable the Type Design Organisation to estimate fatigue consumption rates, it would be necessary to identify the different sortie profiles expected in service. This is not generally possible with privately owned individual aircraft, so estimated consumption rates must be based on average expected loadings and then increased by an agreed safety factor to allow for 'worst case' conditions. Unmetered fatigue consumption assessed in this way is therefore always greater than the more accurate consumption calculated from fatigue meter data. The Civil (non-RAF) aircraft wing safe life has been derived by assuming the same mean fatigue consumption as the RAF Bulldog fleet, with conservative factoring from the fleet mean to cover usage variability. From this analysis the manufacturer determined that, in the absence of a serviceable fatigue meter to enable continuous monitoring of fatigue consumption, the latest embodiment point for the wing spar modification is 5000 flying hours. The post-Mod BH.193 limit of 200FI equates to 8760 flying hours where a fatigue meter is not installed. These flying hour limitations are summarised in the table below:

Summary of Wing Spar Joint Life Limitations

Modification Status	Metered Aircraft	Unmetered Aircraft
Pre-Mod BH.193	114 FI	5000 Flying Hours
Post-Mod BH.193	200 FI **	8760 Flying Hours

** But see paragraph 7 below.

4. EX-RAF T Mk1 AIRCRAFT

4.1 Sale Information

When the RAF phased out its last 97 Bulldog T Mk1 aircraft, they were sold to customers living mainly in the UK, France or the USA. These Bulldogs had flown an average of 8153 hours in RAF service and the average Fatigue Index was 103FI. All aircraft had been fitted with fatigue meters throughout their life, and each was sold with a fatigue meter installed and with an individual statement of FI consumed. Notwithstanding the manufacturer's clear limit of 114FI, the RAF had permitted 19 Bulldogs to continue in service up to a maximum of 116FI, but with severe flight limitations applied beyond 114FI. At the time of RAF disposal the manufacturer (BAE Systems) issued unequivocal instructions to all potential buyers that Bulldogs at or above 114FI must not be flown until or unless Modification BH.193 was embodied.

Note Whilst the RAF decided that some of its Bulldog aircraft may consume up to 116FI prior to the wing joint modification being carried out, this figure has never had approval from either the aircraft manufacturer or the UK CAA.

4.2 Aircraft Converted to Series 120, Model 121

Since sale from the RAF, approximately 50 ex-RAF T Mk1 aircraft have been converted to Bulldog Series 120, Model 121 aircraft making them eligible for UK civil registration and issue of a UK Certificate of Airworthiness. All these aircraft have fatigue meters and the UK CAA has permitted continuing use of the data from these meters to enable ongoing monitoring of fatigue consumption. All operators chose to continue with the fatigue meter as this was perceived as giving the maximum flying hours remaining to the point (114FI) where Mod BH.193 would be necessary.

4.3 Fatigue Meter Benefits

Analysis of fatigue data from UK-registered Model 121 aircraft has shown that the continued use of fatigue meters has been extremely beneficial to aircraft owners, with monitored fatigue consumption typically only 10% to 15% of that which would have to be assumed in the absence of a fatigue meter. A real data example taken from a Model 121 Bulldog may assist a clearer understanding of this benefit:

Initial Data When Purchased From RAF:

Hours flown by RAF = 8371 Fatigue Index when sold from RAF = 107.185FI

FI per 1000 hours in RAF use = 107.185 ÷ 8.371 = **12.8**

Hours remaining to 114FI (without fatigue meter) = $\frac{(114 - 107.185)}{114} \times 5000 =$ **299**

After Two Years Civil Flying (using Fatigue Meter):

Hours flown by present owner = 160

FI consumed in present ownership (from fatigue data) = **0.3391**

Actual FI per 1000 hours in present ownership = 0.3391 ÷ 0.160 = **2.12**

Assumed FI for 160 hours if no fatigue meter fitted = (160 x 114) ÷ 5000 = **3.648**

Assumed FI/1000 hours if no fatigue meter fitted = 114 ÷ 5000 = 22.8

So the actual fatigue consumption using the meter (0.3391), has been only 9% of that which would have been assumed (3.648) if the fatigue meter had not been used. In the example, it also means that if the present owner flew in the same style as his recent flying, and continued to use the fatigue meter, he may expect a further 3054 hours before reaching 114FI. However, had he opted not to use the fatigue meter, he would have had only 299 flying hours permitted from point of sale to the embodiment of Modification BH.193, and he would have already used up more than half that entitlement.

Note The Bulldog in the above example has been used for general flying, including some aerobatics, for the past two years. Whilst its fatigue consumption rate is typical for UK registered Model 121 Bulldogs, the rate for individual aircraft will depend entirely upon the type of flying. Bulldogs used almost exclusively for aerobatic training and/or display work may well have a fatigue consumption rate greater than that in RAF service, and may even approach the assumed non-metered rate of 22.8FI per 1000 hours.

4.4 **Use of Fatigue Meters and Fatigue Data Recording – Detailed Requirements**

Accurate monitoring of fatigue life consumed is only possible with the co-operation of pilots, operators, maintenance organisations and the Type Design Organisation. Whilst most owners appreciate the need to send fatigue meter readings to the Type Design Organisation for calculation of the FI consumed, many are not aware of all the requirements stated in various unpublished references. For the convenience of owners, the essential points are detailed below:

a. The Fatigue Meter (Negretti & Zambra M 1967D) must be installed, serviceable and within its three-year calibration/overhaul period whenever the aircraft is flown. (See Item 4.6 regarding overhaul facilities and shelf life.)

b. The 28V power supply must be available via CB16 whenever the aircraft is flown.

c. The eight counters on the forward face of the fatigue meter must be read after each flight, with the values displayed being recorded on a copy of the Fatigue Monitoring Sheet at page 11-5-9 of the Operating Manual. (See Attachment 1 for an example of the blank proforma and Attachment 2 for the way this sheet should be completed. Note that the example proforma at Attachment 1 has been revised and the Operating Manual will be amended in due course).

d. The date, duration of flight and number of landings occurring in the flight must also be recorded on the Fatigue Monitoring Sheet. Following introduction of Service Bulletin BDG/100/172 Main Landing Gear Radius Arms – NDT Inspection, provision was made for recording the type of landing - whether on paved or unpaved surfaces and whether full-stop or ‘roller’ landings - in addition to the total number of landings since manufacture. This information is required for de Havilland Support Ltd to justify any future relaxation of the undercarriage inspection periodicity, if it is deemed appropriate. Serial numbers of the Main Landing Gear Radius Arms should be recorded in the spaces provided.

e. The Pilot of the aeroplane should sign or initial the form following each flight, in the column provided, to confirm that the data entered for the flight is correct and that all required data is present.

f. Whenever a fatigue meter is removed and a replacement installed, the final meter readings of the outgoing unit and the initial meter readings of the replacement unit must be recorded on the Fatigue Monitoring Sheet. (Attachment 2 shows how this may be recorded.)

g. Before submitting fatigue data to the Type Design Organisation for assessment (see Item 4.5) the Certifying Engineer should sign the form to confirm that the Fatigue Meter has been within calibration for the entire period of the recorded data, the total hours recorded on the sheet are the same as indicated in the Airframe Logbook and that the final meter readings recorded are identical to the eight meter windows in the aeroplane.

h. Any Fatigue Monitoring Sheet found by the Type Design Organisation to be incorrectly completed may not be processed until all the data is present. Additional work required to correctly populate the sheet and correct major anomalies may be subject to an additional fee.

Note Owners of UK-registered Bulldogs are reminded that the Fatigue Monitoring Sheet is a document affecting airworthiness and, in terms of completeness and accuracy, is subject to the requirements of the Air Navigation Order 2000.

4.5 **Analysis of Fatigue Data**

Once each year, completed Fatigue Monitoring Sheets must be submitted to the Type Design Organisation (de Havilland Support Ltd) for review of the data and calculation of the fatigue index consumed in the period under review. The Type Design Organisation will calculate the total FI consumed for the aircraft and provide a certificate which should be attached to the aircraft log book. A convenient opportunity for this work to be carried out is at the aircraft's Annual Maintenance Check. Details of the fee payable for this service can be obtained from de Havilland Support Ltd.

Where the total FI for an individual aircraft is seen to be greater than 112.86, the Type Design Organisation will notify the operator of the need for FI re-assessment every 50 flying hours or Annually, which ever comes first.

4.6 **Fatigue Meter Overhaul & Shelf Life**

The Fatigue Meter Type M1967D is an item proprietary to Meggitt (UK) Ltd. The in-service life of this unit is 30,000 cycles or three years – whichever is sooner. After this period has expired the unit must be overhauled. This maintenance policy was in force throughout the RAF service life of the Bulldog T Mk1, and the policy was reviewed and confirmed as remaining valid only shortly before the aircraft were sold into civilian hands.

The fatigue meter has a shelf life of two years in temperate conditions or one year in tropical conditions. If, following overhaul, a unit is not fitted to an aircraft within this shelf life period, the in-service life is then progressively consumed. (e.g. three years in temperate storage will lead to a reduced in-service life of two years.) Where the

accuracy of the unit is suspect for any reason, the unit should be removed and returned to the overhaul agency for testing and re-certification.

The capability to overhaul and certify the fatigue meters is restricted to only two UK companies, these being Meggitt (UK) Ltd and Pandect Group[1]. Meggitt (UK) Ltd are not currently undertaking overhaul work but are supporting Pandect Group with essential design data and replacement components. A fatigue meter overhaul/exchange service is available through Bulldog Support Ltd[2].

Contact details:

1. Pandect Group, Wellington Road, High Wycombe, Bucks. HP12 3PX England. Tel: +44 (0) 1494-526301

2. Bulldog Support Ltd, 77 Tiddington Road, Stratford-upon-Avon, Warwickshire, CV37 7AF England. Tel: +44 (0) 1789-205258

5. OTHER SERIES & MODELS OF BULLDOG

5.1 Build Status and Life Limitations

At the time of manufacture, almost all other models of Bulldog (Series 100 and Series 120) did not have fatigue meters installed (for fleet sampling purposes, isolated examples were fitted with a fatigue meter to special order). For these aircraft without fatigue meters the wing spar joint is lifed at 5000 flying hours (pre-mod BH.193) and 8760 flying hours (post-mod BH.193).

5.2 Installation of Fatigue Meter

de Havilland Support Ltd is researching the possibility of a modification whereby a fatigue meter could be installed in those Bulldog aircraft which did not have a meter fitted at the time of manufacture. This modification may be a cost-effective approach to delaying the need for Modification BH.193 for an aircraft with relatively high airframe hours (4000+) and where the owner does not intend to perform more than occasional aerobatics. However, the availability of approved spares is uncertain and aircraft owners contemplating this approach should contact de Havilland Support Ltd for advice. Moreover, initial research suggests that it would not be viable to consider installation of a fatigue meter into any model of the Series 100 variant. The installation of a fatigue meter would be classified as a major modification by the UK CAA and an Airworthiness Approval Note would be issued against the individual aircraft to document the fatigue life remaining on transfer from a flying hours to a Fatigue Index basis.

6. BULLDOG MODIFICATION BH.193

6.1 Background

Modification BH.193 was developed by the manufacturer to strengthen and otherwise improve the wing-to-fuselage (stub-wing) main spar joint following the discovery of cracking during the Bulldog Full Scale Fatigue Test. The modification introduces lengthened and strengthened replacement joint straps, replacement doublers attached to the spar and stepped attachment bolts to allow for installation/removal without damage to the spar strap doubler holes from the bolt threads. The modification was incorporated on the fatigue test specimen aircraft and testing continued to verify the post-modification

fatigue life of 200FI/8760 flying hours. Modification BH.193 must therefore be embodied in full, as it was designed, if the results of the Full Scale Fatigue Test are to remain valid. If any changes were to be made to the modification, further testing would be required to re-validate the results and this is not a practical or economic proposition.

Warning. All RAF T Mk 1 Bulldogs had an RAF Modification No. Bulldog/193 embodied during RAF service, this fact being recorded in the RAF records that accompanied each aircraft when sold. This RAF modification introduced an amended shimming arrangement to the wing spar joint but is NOT associated with the main spar joint strengthening Modification No. BH.193 and it confers no increase in fatigue life to the aircraft. Many owners have misunderstood this point, coming to the incorrect conclusion that their aircraft had the wing spar Mod. BH.193 embodied.

6.2 Embodiment of Modification BH.193

To date, modification BH.193 has been embodied on one Series 120 Bulldog whilst still in RAF service and on one Series 100 aircraft located in Malaysia. The process is complex and demanding, relies upon the manufacture of new joint plates and many other detail parts and requires accurate drilling and reaming of numerous bolt holes. The modification cannot be undertaken lightly and it is likely that it will be beyond the capability of most small to medium-sized maintenance organisations. A certain amount of specialist tooling, mostly bespoke drilling and reaming jigs, is required to embody the modification. It is strongly recommended that de Havilland Support Ltd be consulted before embodiment of modification BH.193 is contemplated.

7. OTHER STRUCTURAL LIFE LIMITATIONS

7.1 Empennage Fatigue Life – All Models

Assessment of the original flight test data and tailplane fatigue analysis indicated that the tailplane fatigue life exceeded 20,000 flying hours. That assessment was based upon the RAF training syllabus of 1978 and an updated (1993) fatigue analysis. A subsequent reassessment has shown that in a harsh aerobatic regime the tailplane safe fatigue life may be little more than 15,000 flying hours. Pending further investigation, the results of which will be issued in a future Service Bulletin, an interim cleared safe life for the tailplane and other empennage components is set at 15,000 flying hours. This limitation applies irrespective of the modification state of the wing spar joint. Owners of ex-RAF T Mk1 (now Model 121) aircraft should be aware of this limitation when reviewing the cost-effectiveness of embodying Modification BH.193.

List of Attachments

1. Example of Fatigue Monitoring Sheet (blank)

2. Example of completed Fatigue Monitoring Sheet (includes record of a fatigue meter exchange)

BULLDOG

FATIGUE MONITORING SHEET

SHEET NO

....

Date	Flight Hours	Flight Landings				Total Hours since Manf	Total Landings since Manf	No. of crew	Meter Counts								Pilot signature
		Paved		Unpaved													
		Full Stop	Roller	Full Stop	Roller				-1.5	-0.5	0.25	1.75	2.5	3.5	5.0	6.0	

FATIGUE METER SERIAL NUMBER:	
DATE OF LAST CALIBRATION:	
MAIN LANDING GEAR RADIUS ARM SERIAL NUMBER (PORT):	LKO
MAIN LANDING GEAR RADIUS ARM SERIAL NUMBER (STBD):	LKO

Certifying Engineer:

I confirm the data on this sheet

Signature: .... Authority/Approval ....

Date:

BULLDOG FATIGUE MONITORING SHEET

BULLDOG FATIGUE MONITORING SHEET

SHEET NO 2

Date	Flight Hours	Flight Landings: Paved Full Stop	Paved Roller	Unpaved Full Stop	Unpaved Roller	Total Hours since Manf	Total Landings since Manf	No. of crew	Meter Counts: -1.5	-0.5	0.25	1.75	2.5	3.5	5.0	6.0	Pilot signature
B/F	–	–	–	–	–	8134-00	8765	–	7	403	737	5226	3386	774	1	0	ASmith
1-8-07	1-30	1	2	–	–	8135-30	8768	2	7	407	751	5254	3408	792	2	0	ASmith
15-8-07	2-00	1	–	–	–	8137-30	8769	2	7	407	751	5256	3408	792	2	0	ASmith
15-8-07	1-50	–	–	1	1	8139-20	8771	2	7	408	754	5268	3415	794	2	0	ASmith
19-8-07	–	–	–	–	–	METER SERIAL No. 796/M/61 REMOVED											
						FINAL READINGS			7	408	754	5268	3415	794	2	0	
19-8-07	–	–	–	–	–	OVERHAULED METER SERIAL No. 743/M/63 FITTED											
		READINGS AT INSTALLATION							0	0	0	0	0	0	0	0	
7-9-07	0-25	–	–	1	–	8139-45	8772	1	0	0	2	15	8	1	0	0	BHughes
9-9-07	1-05	1	1	–	1	8140-50	8775	2	0	3	16	42	30	19	1	0	ASmith
14-9-07	2-00	1	–	–	–	8142-50	8776	2	0	3	16	43	30	19	1	0	ASmith

FATIGUE METER SERIAL NUMBER:	743/M/63
DATE OF LAST CALIBRATION:	14-8-07
MAIN LANDING GEAR RADIUS ARM SERIAL NUMBER (PORT):	LKO 998
MAIN LANDING GEAR RADIUS ARM SERIAL NUMBER (STBD):	LKO 999

Certifying Engineer:

I confirm the data on this sheet

Signature: A N Other Authority/Approval AMR 999

Date: 16-8-07

BULLDOG FATIGUE MONITORING SHEET