▶ Chapter 3 - LOADING, C.G. AND FATIGUE DATA ◀

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LOADING AND C.G. DATA

General

1. It is essential that the loading of an aircraft be kept within the limitations of the approved C.G. range and the all-up weight. So far as the C.G. range of this aircraft is concerned only the fore-and-aft location of the C.G. need be calculated. To determine the C.G. position the aircraft is considered standing with the fuselage datum line horizontal and the undercarriage down. Reference should be made to A.P.119W-0001-1 for general information on aircraft loading.

Datum point

2. This is the foremost face of a spigot hole situated in the wheel bay on the fuselage skin just forward of the undercarriage door hydraulic jack. This fixed point is located 19 inches aft of the main spar frame and 4 inches below the fuselage datum.

Weight limitations

3. (1) *Clean.* The maximum permissible all-up weight of the clean aircraft for take-off and all forms of flying is 18 400 lb.

(2) *With external stores.* When carrying external stores, the maximum permissible all-up weight of the aircraft for take-off and all forms of flying is 25 000 lb.

(3) *Landing.* The maximum permissible landing weight of the aircraft (except in an emergency) is 18 500 lb.

Note . . .

Pilots are warned to exercise particular care when landing at this weight on rough or semi-prepared airfields, or in other conditions likely to create high undercarriage loads.

C.G. Range

4. The approved limits of C.G. travel, measured parallel to the fuselage datum are 0 inches to 14.5 inches aft of the C.G. datum point, as illustrated on Fig. 2.

Note . . .

The aft limit (14.5 in. aft of the datum) as originally approved by A. & A.E.E. Boscombe Down was obtained by assuming that fuel was completely consumed.

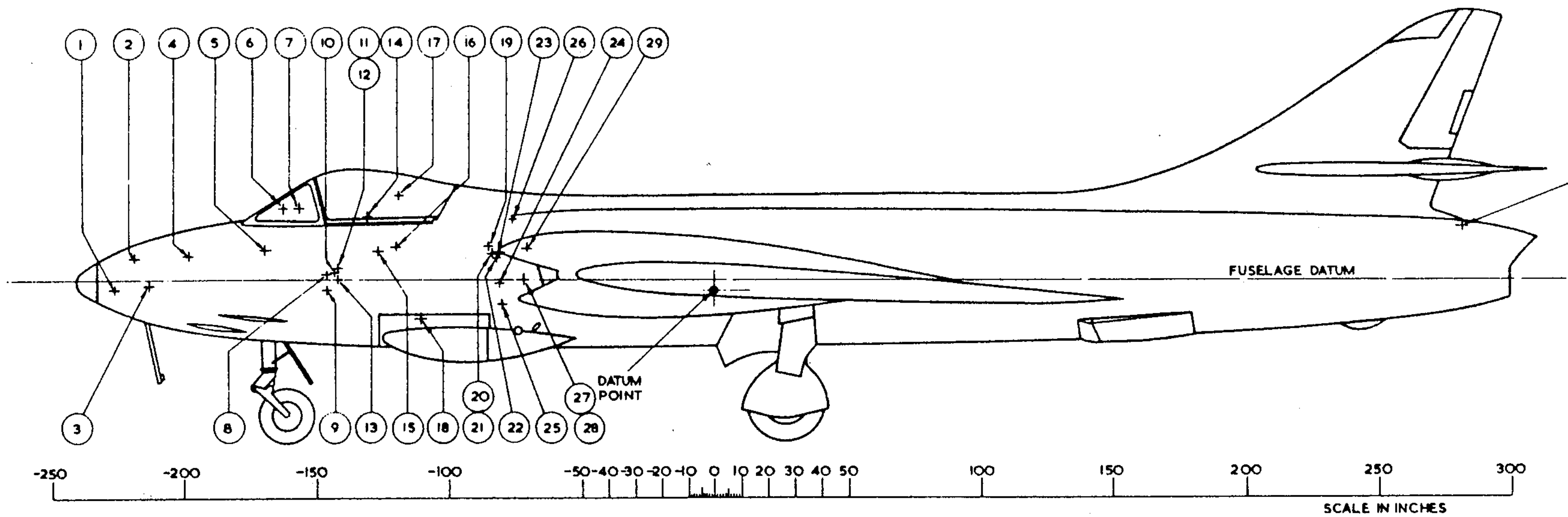

FIG. I LOADING AND C.G. DIAGRAM
FOR TABLE I ONLY.

TABLE 1
Removable equipment included in basic weight

Item No.	Ref. No.	Description	Weight (lb.)	Moment (lb. in.) −	Moment (lb. in.) +
A.R.I. 5820					
1	10D/18554 or 10D/21292	Radar head, Type 2 / Radar head, Type 2A	48·5		10 966
4	10D/18553	Junction box, Type 370	1·5		320
5	10Q/16076	Ranging unit	26·5		5 263
A.R.I. 18124/1 (Post Mod. 968)					
10	10L/9990839	Control unit, Type C.1607/2	3·0		435
27	10D/9428542	Trans/rec. unit, Type 5	47·0		3 398
A.R.I. 23057 (Post Mod. 968)					
24	10D/20773 or 10D/23507	Trans/rec. unit, Type T.R.10056 / Trans/rec. unit, Type M.4	10·5		855
	10D/20773 or 10D/23507	Trans/rec. unit, Type T.R.10056 / Trans/rec. unit, Type M.4 (Post Mod. 1096)	10·5		840
25	5J/3458	Battery	17·0		1 377
A.R.I. 18064 (Pre. Mod. 968 or Post Mod. 973)					
8	10L/246	Control unit, Type 382	1·5		219
28	10D/21507–8	Trans/rec. units, Types T.R.1985–6A	52·5		3 770
A.R.I. 5848					
11	10L/16192	Control unit, Type 927	1·5		215
12	16K–1660–036290585	Control unit, Type C.1128/APX-25	1·0		143
22	16K–1660–036290932	Coder unit, Type KY-95A-APX-25	10·5		870
29	10D/20334	Trans/rec. unit, Type T.R.4585	33·0		2 366
A.R.I. 23013					
13	10L/16264	Control unit, Type 8197	2·5		355
20	10D/19594	Trans/rec. unit, Type T.R.8193	31·5		2 621
	10D/19594	Trans/rec. unit, Type T.R.8193 (Post Mod. 1096)	31·5		2 586
21	10D/19595	Junction box, Type 8196	3·0		849
A.R.I. 5877					
17	10U/17211	R.F. amplifier, Type 8281	5·0		590
26	10U/17212	I.F. amplifier, Type 8282	9·0		693

TABLE 1

Removable equipment included in basic weight (Contd.)

Item No.	Ref. No.	Description	Weight (lb.)	Moment (lb. in.) −	Moment (lb. in.) +
A.R.I. 18120/1					
19	10D/20572	A.F. unit, Type 9635	7·0	601	
23	10D/20571	R.F. unit, Type 11037	12·0	984	
Miscellaneous equipment					
2	14A/4929 or 14A/4981	Camera gun, G90	7·0	1 532	
5	6A/2958 or 6A/2089	Clock, Mk. 4B / Clock, Type 5 ACA	0·5	85	
6	8B/3593 or 8B/3772	Gunsight, Mk. 8 (Post Mod. 378) / Gunsight, Mk. 5B (Post Mod. 700)	9·0	1 463	
7	14A/4196	Camera recorder	2·5	391	
9	27C/2319 or 27C/2393 or 27C/2228	Survival pack, Type Q c/w seat cushion 15A/729 (Pre ejection seat Mod. 421) / Survival pack, Type R c/w seat cushion 27C/2428 (Post ejection seat Mod. 421) / Survival pack, Type J (Pre. Mod. 282)	33·0	4 818	
14	15A/671 or 15A/684	Parachute assembly, back type Mk. 9 c/w Back pad 15A/780 (Post Mod 282) / Parachute assembly, back type Mk. 13 (Pre Mod. 282)	34·0	4 437	
15	12K/1300 or 12K/1314	Seat cartridges	1·0	127	
16	27C/2380–1	Survival packs (Mod. 847)	14·0	1 659	
18		Guns and accessories	827·4	91 301	
30	15D/732	Brake parachute, Type LB.52 Mk. 3	12·0		3 384

AIRCRAFT AT BASIC WEIGHT 14 572 lb. Moment 181 130 lb. in.

(These are typical figures and should only be used if the basic weight and moment record card, R A F. Form 4908, is out of date or inaccurate).

Operational notes

5. The following notes are inserted to give guidance on particular items of loading peculiar to the type :—

(1) In order to maintain the C.G. position between the given approved limits, it is essential that ballast is fitted if the following items of equipment are not carried :—

(*a*) When the radar head and ranging unit are removed, fit ballast Ref. No. 26FX/100021 (Mod. 21) or 26FX/100637 (Mod. 637).

(*b*) When I.F.F. Mk. 3 is removed, fit ballast Part No. C.206617 (Mod. 247). Ballast in lieu of I.F.F. Mk. 10, on aircraft Post Mod. 794, is not required.

(*c*) When D.M.E. is removed, fit ballast Part No. C.206618 (Mod. 246)

(2) When external link collectors (Mod. 302) are fitted the weight of 540 retained links is 67·5 lb, with a load arm of −98·75 in. (Moment −6 666 lb in.). In all C.G. calculations which allow for the expenditure of ammunition, the effect of these retained links must be included.

(3) When drop tanks are carried on outboard pylons, ammunition or ballast in lieu must be carried. This proviso does not preclude the expenditure of ammunition after the rear fuselage tanks have been emptied.

(4) Landing with full R.P. load, ammunition having been expended, must be regarded as an emergency condition, due consideration being given to the aft C.G. position then obtained.

(5) Modifications 941 and 942 must be incorporated on any aircraft prior to its assuming a load of or including 24 R.Ps. with 25 lb heads.

(6) Changes in fuel tank capacities occur with variations in drop tank configurations (c f. Leading Particulars—Engine). The load arms for fuel given in Table 3 will not alter for these capacity changes

Changes in weight and moment due to modifications

6. When the modification state of an aircraft is changed, the appropriate aircraft basic weight and moment record card (MOD Form 751) should be amended in accordance with the weight and moment figures to be found in paragraph 12 of the relevant modification leaflet.

E.C.U. included in given basic weight

7. The E.C.U. installed in this aircraft is an Avon Mk.20701 having an average weight of 2883 lb with a C.G. position 21.58 in. aft of engine C.G. datum (centreline of front suspension).

Changes of E.C.U.

8. When an E.C.U. is changed, reference should be made to the appropriate Form 753 for its weight and C.G. position. If the Form 753 quotes two weights and two C.G. positions, the highest figures are to be used for any aircraft weight and moment records. The aircraft C.G. datum point is 51.05 in. forward of the engine C.G. datum point, therefore this dimension must be added to the dimension for the C.G. of the E.C.U. to obtain the moment for the E.C.U. weight about the aircraft C.G. datum,e.g.:-

Form 753 quotes:-

2847 lb/2912 lb C.G. 21.33 in/21.83 in. aft of centreline front suspension.
Highest weight 2912 lb highest C.G. position 21.83 in. aft.

Moment of E.C.U. weight about aircraft datum is:-

2912 x (21.83 + 51.05) = 2912 x 72.88 = 212226 lb in.

In this manner it is possible to ascertain the weight difference and change in moment for a change of E.C.U. for inclusion in the information recorded on the Aircraft Basic Weight and Moment Record (MOD Form 751).

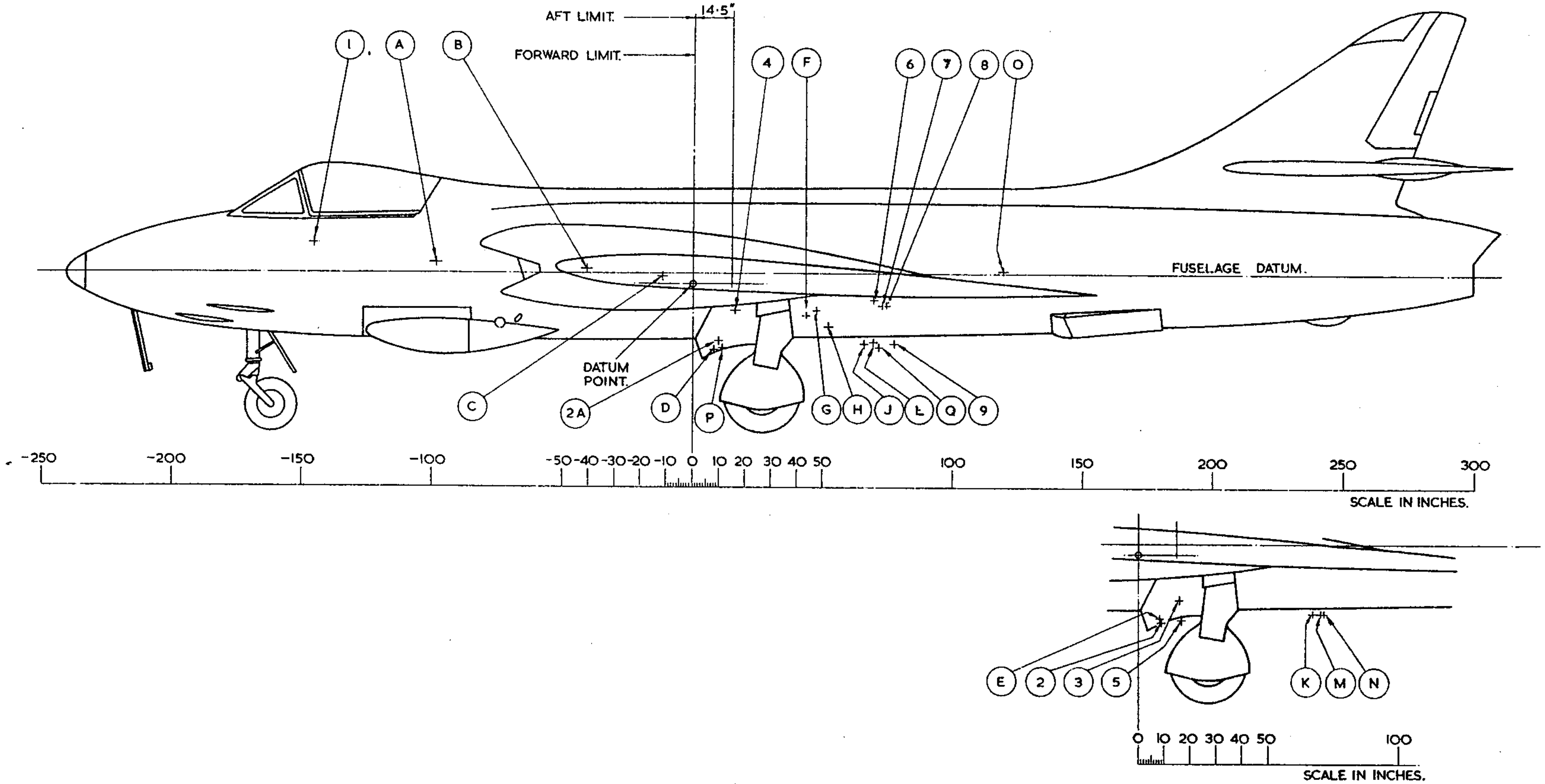

FIG. 2 LOADING AND C.G. DIAGRAM FOR TABLES 2 & 3.

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TABLE 2—Operational load items

Item No.	Description	Weight (lb)	Arm (in.)	Moment (lb in.) −	Moment (lb in.) +
1	Pilot	180·00	−145·90	26 262	
2	Two 230 gal. drop tanks (*pre Mod. 1242*) on inboard pylons	500·00	8·40		4 200
2A	Two 230 gal. drop tanks (*post Mod. 1242*) on inboard pylons	534·00	9·75		5 207
3	Two inboard pylons	125·00	15·80		1 975
4	Side struts for 230 gallon drop tanks	16·00	16·00		256
5	Two 100 gal. drop tanks on inboard pylons	300·00	16·40		4 920
6	R.P. removable mountings	130·00	70·00		9 100
7	Two outboard pylons (Post Mod. 1160)	94·00	74·20		6 975
8	Two outboard pylons	72·00	74·65		5 375
9	Two 100 gal. drop tanks on outboard pylons	300·00	77·25		23 175

TABLE 3—Expendable load items

Item Letter	Description	Weight (lb)	Arm (in.)	Moment (lb in.) −	Moment (lb in.) +
A	Ammunition	582·00	−98·75	57 473	
B	Fuel front tanks (202 gal.)	1 555·00	−40·50	62 978	
C	Fuel wing tanks (150 gal.)	1 155·00	−11·50	13 283	
D	Overload fuel in inboard 100 gal. drop tanks (200 gal.)	1 540·00	8·80		13 552
E	Overload fuel in inboard 230 gal. drop tanks (*pre Mod. 1242*) (478 gal.) Overload fuel in inboard 230 gal. drop tanks (*post Mod. 1242*)	3 681·00	8·80		32 393
P	Front compartment (*365 gal.*)	2 811·00	−10·73	30 162	
Q	Rear compartment (*113 gal.*)	870·00	72·00		62 640
F	16 R.P. double tier 60 lb. head	1 520·00	44·20		67 206
G	8 R.P. single tier 60 lb. head	760·00	47·55		36 138
H	24 R.P. triple tier 25 lb. head	1 440·00	52·15		75 096
J	2 × 19 S.N.E.B./MATRA R.P. launchers, Type 116M (Operational) on outboard pylons	580·00	66·65		38 657
K	2 × S.N.E.B./MATRA R.P. launchers, Type 155 (rockets expended) on outboard pylons	394·00	66·75		26 300
M	2 × S.N.E.B./MATRA R.P. launchers, Type 116M (rockets expended) on outboard pylons	116·00	69·65		8 079
N	2 × 18 S.N.E.B./MATRA R.P. launchers, Type 155 (Practice) on outboard pylons	796·00	71·80		57 153
L	Overload fuel in outboard 100 gal. drop tanks (198 gal.)	1 525·00	69·65		106 216
O	Fuel, rear tanks (52 gal.)	400·00	119·50		47 800

FATIGUE DATA

Introduction

9. Every aircraft suffers fatigue damage caused by the fluctuating loads applied to the airframe. To prevent catastrophic failure of the structure, each type of aircraft, and some of its major components, are given a safe fatigue life at which they must either be retired from service or modified to permit further flying.

10. Fatigue life is usually measured in units of Fatigue Index (FI) which is a non-dimensional number calculated from the fatigue formulae (see paragraph 29). In order to be able to derive the fatigue formulae, the Design Authority needs to know how the aircraft is operated in Service. This information is provided in the Statement of Operating Intent (SOI). On entry into service , the fatigue life is normally defined as 100FI; further testing or modification may, however, result in the fatigue life being changed from 100FI. Lives may also be specified in Flying Hours or Landings.

11. Fatigue life consumption is continuously monitored to ensure that the authorised life is not exceeded. The procedures which are used for the recording and analysis of fatigue data are specified in AP(N) 100N-0140.

Structural integrity

12. The Hunter is designed in accordance with the 'safe life' philosophy.

13. A total of 21 Hunter wings and one dual seat Hunter airframe has been subjected to fatigue testing. The results of these tests, together with the later refinements have established separate fatigue lives for the mainplane and fuselage as follows:

a. Mainplane. The life of the mainplane is limited to 111FI by the front spar lower boom. The remainder of the mainplane is lifed at 180FI should the front spar boom be replaced.

b. Centre Fuselage. The centre fuselage is limited to 100FI by tensile failure of the Frame 25 tiebars. No recovery scheme exists for the centre fuselage and hence it governs the total life of the aircraft.

c. Front Fuselage. The front fuselage is limited to 100FI by the upper longerons forward of the front transport joint.

14. At intervals of 6FI, calculated using the wing fatigue index formula, the shoulder fillet of the wing main spar lower lug must be subjected to the crack detection inspection ▶ procedure as originally defined in STI/Hunter/ ◀ 431.

15. The primary method of monitoring fatigue life consumption is by use of the fatigue meter. Fatigue meter readings and other flight data are recorded on MOD Forms 725 (Hunter), which are sent to HQSTC (for the RAF) and MACE (for the RN) on a monthly basis where consumed FI is calculated.

16. Fatigue lives are specified in the Component Replacement List published in AP101B-1300-5A1 for RAF aircraft.

Unlifed components liable to fatigue damage

17. Some components that have a critical function and are liable to fatigue damage are not normally lifed because:

(1) Their fatigue lives equal or exceed those of the parent assemblies, and

(2) They are not expected, in the course of normal maintenance, to be transferred between parent assemblies.

18. If such a component is transferred between assemblies with a differing FI, there is a risk that the fatigue life of the transferred component might be exceeded.

Fatigue monitoring

19. The fatigue meters fitted to the Hunter FGA Mk.9 are the Mk.2D under Mod. 870, Mk 14 under Mod.951, and Mk.15 under Mod 1273. The Mk 14 and 15 meters are standard 8 level counters recording from -1.5g to +7.0g (Mk 14) and -1.5 to +8.0g (Mk15) respectively. The meter is mounted on the rear face of Frame 25, on the port side of the engine starter bay. It is operated electrically by an undercarriage switch, which cuts out the system with the undercarriage extended, to prevent the recording of unwanted 'g' excursions during taxying and landing.

20. An example of the fatigue meter tabulation is as follows:

Window	C1	C2	C3	C4	C5	C6	C7	C8
Acceleration Threshold	-1.5	-0.5	0.25	2.5	3.5	5.0	7.0	8.0
Typical Difference Pattern	1	7	28	55	44	36	7	1

Fatigue meter maintenance

21. All personnel responsible for reading fatigue meters and computing fatigue damage are to check the validity of the fatigue meter readings by ensuring that the differences obtained by subtracting successive fatigue meter readings form a similar pattern to that shown in the table above. Thus, the differences should decrease as acceleration threshold either increases or decreases away from the 1.0g level. Occasionally, the pattern obtained from an individual sortie may differ from this standard, but the differences obtained from several sorties should conform. If there is any deviation from this pattern, the fatigue meter is unserviceable. The replacement of unserviceable fatigue meters is a high priority task, because unmonitored flying carries a high penalty in terms of the aircraft's fatigue life.

22. When a new fatigue meter is fitted, a new Form 725 is to be started and readings from the new meter are to be recorded in the Brought Forward column of the Form 725. The following Standard Serviceability Checks specified in AP112G-0203-1 Chap2-0 are to be carried out.

(1) Check the electrical connections.

(2) Ensure the undercarriage switch operates correctly.

(3) Check that the transit lock is in the UNLOCKED position.

23. The meter should then be monitored for 3 further sorties to ensure its correct operation. At least 2 of the sorties must be of a type characteristic of the aircraft (transit flights could give zero results on a serviceable meter). Continue monitoring until 2 characteristic flights have been made.

Fatigue formulae

24. Aircraft FI is calculated sortie by sortie at HQSTC and MACE using revised formulae based on BAe Report No.HUN-HSO-138 Issue 2.

25. Revised fatigue formulae have been derived for the calculations of the FI consumption, incorporating compensation factors for variations in all up weight (AUW) and stores configuration. Total FI consumption is calculated for the fuselage and wings, by adding together monitored and unmonitored FI consumed. Additional calculations for aircraft converted from Mk6 and not having Mod 943 embodied must be made until the modification is incorporated.

Embodiment of Mod 943 on ex-Mk6 Aircraft

26. Due to the added severity of damage to the spigots and nuts at the front transport joint before conversion from Mk6, Mod 943 must be embodied on all ex- Mk6 aircraft before the front fuselage reaches a FI determined as follows.

43 - (Mk6 flying hours x 0.02754)

Calculations of FI (Pre Mod 943)

27. The FI consumed is to be calculated using the following formulae:

Wing FI

$$= \frac{1}{1000} \times (1.18C_1 + 0.55C_2 + 0.3C_3 + 0.66C_4 + 1.46C_5 + 2.35C_6)$$

Front Fuselage FI

$$= \frac{1}{1000} \times (1.7C_1 + 0.76C_2 + 0.58C_3 + 0.92C_4 + 2.06C_5 + 3.27C_6)$$

Where C_1 to C_6 are valid counts from the Mk 2D fatigue meter

Wing FI

$$= \frac{1}{1000} \times (0.95C_1 + 0.37C_2 + 0.23C_3 + 0.015C_4 + 0.24C_5 + 0.9C_6 + 2.19C_7 + 3.09C_8)$$

Front Fuselage FI

$$= \frac{1}{1000} \times (1.3C_1 + 0.85C_2 + 0.036C_3 + 0.042C_4 + 0.41C_5 + 1.31C_6 + 3.09C_7 + 4.27C_8)$$

Where C_1 to C_8 are valid counts from the Mk 14 fatigue meter

Calculations of FI (Post Mod 943)

28. The FI consumed is to be calculated using the following formulae:

Wing FI

$$= \frac{1}{1000} \times (1.79C_1 + 0.99C_2 + 0.074C_3 + 0.19C_4 + 0.79C_5 + 1.52C_6 + 4.04C_7 + 5.10C_8)$$

Centre Fuselage FI

$$= \frac{1}{1000} \times (1.17C_1 + 0.57C_2 + 0.023C_3 + 0.076C_4 + 0.47C_5 + 0.97C_6 + 2.68C_7 + 4.00C_8)$$

Front Fuselage FI

$$= \frac{1}{1000} \times (0.68C1 + 0.27C2 + 0.0046C3 + 0.017C4 + 0.23C5 + 0.56C6 + 1.65C + 2.51C8)$$

Where C1 to C8 are valid counts from the Mk 15 fatigue meter

Unmonitored flying

29. Flying with an unserviceable fatigue meter, or taking an incorrect reading carries a penalty in terms of fatigue to allow for the possibility of the unmonitored sortie being unusually severe. It is vital that Form 725s are completed accurately and legibly. In extreme cases, careless or incomplete recording could result in the premature retirement of an aircraft from service because of doubt about its true fatigue life.

30. When no fatigue meter readings are available, the fatigue life consumed for the unmonitored flying is to be calculated as follows:

FI = 1.5 x Average FI/FH for stated SPC x sortie duration

Where:

FI/FH = FI per flying hour

SPC = Sortie Profile Code defined in the Hunter Statement of Operating Intent

Note: Where an hourly FI rate has been calculated using an 'old' formula, it will be necessary to multiply such an FI rate by the appropriate revision factor as listed below:

Wing FI increase factor	= 0.98
Centre Fuselage FI increase factor	= 1.10
Front Fuselage FI increase factor	= 0.61

Effect of modifications

31. The spigots and nuts of the fuselage front transport joint must be strengthened by embodiment of Mod 943 by the time that the front fuselage reaches 43FI.

33. The fuselage/mainplane front locating spigots, which form part of the centre section, are lifed at 35FI on the centre fuselage. When this point is reached, the spigots become subject to the NDT examination procedure originally defined in SI/Hunter/96. Replacement of spigots under Mod 1327 removes the lifing.

34. Mod.943 strengthens the front fuselage transport joint.