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.

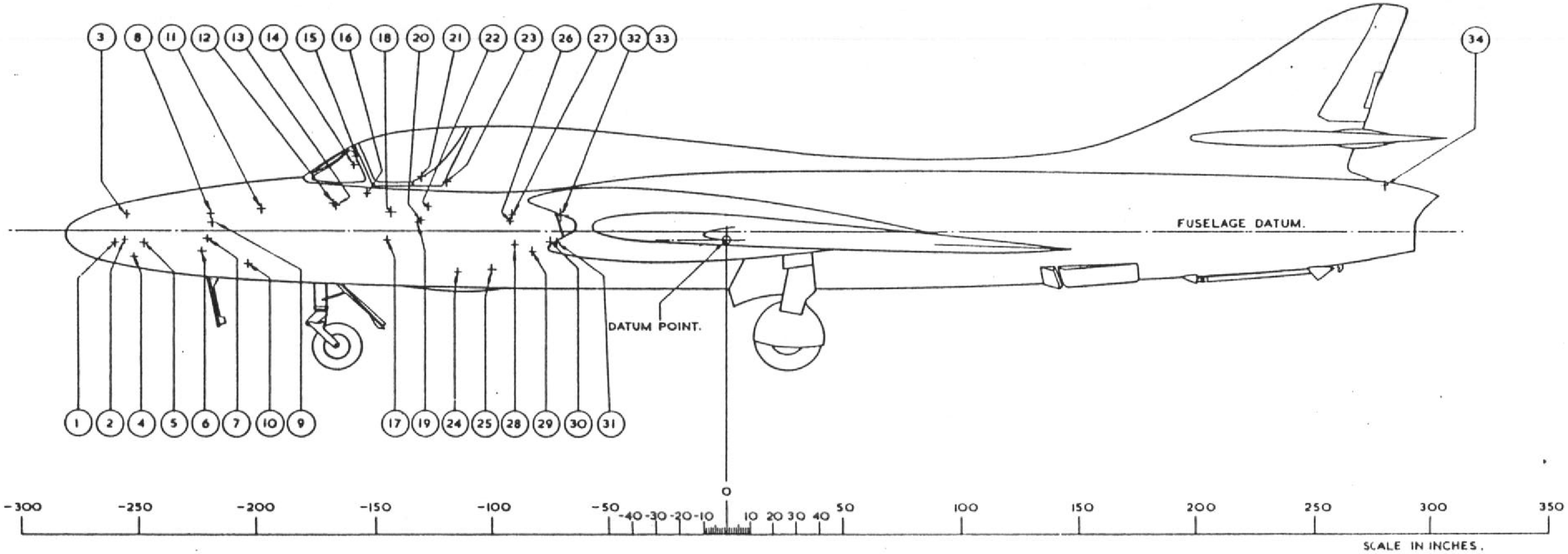

FIG. 1. LOADING AND C.G. DIAGRAM
FOR TABLE 1 ONLY.

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TABLE 1 Removable equipment included in basic weight

Item No.	Ref.No.	Description	Weight (lb.)	Moment (lb.in.) −	+
A.R.I.5840					
1	10D/18554	Radar head *(Pre mod. 982 or 1140)*	50.0	12 675	
5	10D/18553	Junction box *(Pre mod. 982 or 1140)*	1.5	373	
11	10Q/16076	Ranging unit *(Pre mods.982 or 1140)*	26.5	5 262	
Air data system					
2	6A/5404	Air data computor	29.0	7 514	
4	6A/6434	Transducer - Static	5.5	1 403	
8	6A/6435	Transducer - Pitot static	5.5	1 224	
9	6A/8548	Power supply unit	9.0	1 998	
A.R.I. 18107					
6	5826-00-691-4896	Trans/rec unit, Type R.T.220C/ARN-21C	60.0	13 509	
	or				
	5826-00-610-2395	Trans/rec unit, Type R.T.220/ARN-21	60.0	13 509	
7	10D/21511	Coupling unit	7.5	1 675	
A.R.I.18124 (Post mod.807)					
12	10L/9428543	Control unit, Type C1607	3.0	506	
	or				
	5821-99-942-8543				
31	10D/9428542	Trans/rec unit, Type 5	47.0	3 438	
	or				
	5821-99-942-8542				
A.R.I.5490 (Pre mod.807)					
16	10L/246	Control units	1.0	155	
30	10D/17693-4	Trans/rec units	52.5	3 943	
A.R.I. 18085 (Pre mod.807)					
27	10D/19783	Modulator unit	5.0	457	
A.R.I.23057 (Post mod.807)					
26	10D/20773	Trans/rec. unit, Type T.R.10056			
or	10D/23507	Trans/rec unit, Type M.4	10.5	975	
or	5821-99-945-6276	Trans/rec unit, Type M.6			
29	5J/3458	Battery	17.0	1 423	
A.R.I.5307 (Pre mods. 982 or 1140)					
18	10L/204	Control unit, remote, Type 845	1.0	144	
32	10D/2654	Receiver, R-4 ARR-2 modified	6.5	458	
83	110K/457	Dynamotor, DY-2/ARR-2	3.0	212	

TABLE 1 - continued

Item No.		Ref. No.	Description	Weight (lb.)	Moment - lb.in. −	Moment - lb.in. +
Navigational						
19		6B/3243	Amplifier, Type B	11.0	1 465	
25		6G/36	Master reference gyro, Mk.1, Type 'E'	38.0	3 849	
	or	6G/14	Master reference gyro Mk.1, Type 'B'			
Miscellaneous equipment						
3		14A/4929	Camera gun G.90 *(Pre. mod. 874)*	7.0	1 793	
	or	14A/4981				
10		27L/1534	Harness apron	2.0	408	
13		6A/2089	Clock	0.5	84	
	or	6A/2958				
14		8B/3593	Gunsights	18.0	2 873	
15		14A/4196	Camera recorder *(Pre. mod. 874)*	2.5	395	
17		27C/2557	Two survival packs	63.5	9 258	
20		6D/2095	Emergency oxygen equipment	6.0	785	
21		15A/941	Two parachutes	52.5	6 851	
22		12K/1335	Seat cartridges	2.5	305	
	or	12K/1315				
	or	12K/1301				
23		9A/02450	First aid kit	0.5	60	
24			Gun and accessories *(Pre mod. 982 or 1140)*	211.5	24 377	
28		10U/16596	Radio I.C.A.1961 amplifier	6.5	589	
34		15D/732	Brake parachute	12.0		3 384

Aircraft at basic weight	Weight (lb.)	Moment (lb.in.)
Hunter T MK.8	13 500	+ 165 375
Hunter T MK.8B	13 700	+ 160 290
Hunter T MK.8C	13 600	+ 153 000

(These are typical figures and should only be used if the basic weight and moment record is out of date or inaccurate).

Weight limitations

3. (1) *Clean.* The maximum permissible all-up weight of the clean aircraft for take-off and all forms of flying ◀ is 17 500 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 21 650 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 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.

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 when the radar head and ranging unit are not fitted, it is essential that ballast be fitted in lieu.

(2) When all ammunition (150 rds.) is expended the combined weight of links and cases retained is 72 lb. with a corresponding moment of -6 082 lb. in. In all C.G. calculations which allow for the expenditure of ammunition the effect of these retained links and cases must be included.

(3) When H.V.A.R. are carried, only wing stations A, B and D may be loaded.

Loading and C.G. Computor

6. A Loading and C.G. Computor has been prepared for use with this aircraft, it is introduced by Modification Hunter G.E.821. This computor consists of a transparent screen on which is engraved a graphical grid having ordinates of aircraft weight and C.G. position. Beneath the transparent screen is a sheet engraved with a series of lines giving, to the appropriate scale, the weight and C.G. movement due to items of Operational and Expendable load which may be added to the aircraft Basic Weight.

The method of using the computor is to start by marking on the transparent screen a point representing the current Basic Weight and corresponding C.G. position. The screen is then placed relative to the sheet beneath it so that the point representing the Basic aeroplane coincides with the lower end of the line on the sheet which represents the load to be added. A line is now traced on the screen of the same length and direction as 'load line' on the sheet. This process is repeated by placing the top of the traced line coincident with the bottom of the next 'load line' until a continuous series of lines are traced on the transparent grid representing all the Operational and Expendable load items required for the sortie. The position of the top end of the traced line on the graphical grid will indicate the loaded weight and C.G. position of the aeroplane at take-off. By reversing the above process the effect of fuel consumption and of expending stores during flight may also be shown.

Changes in weight and moment due to modifications

7. When the modification state of an aircraft is changed, the appropriate aircraft basic weight and moment record card (Naval Form A.700) should be amended in accordance with the weight and moment figures to be found in paragraph 12 of the relevant modification leaflet.

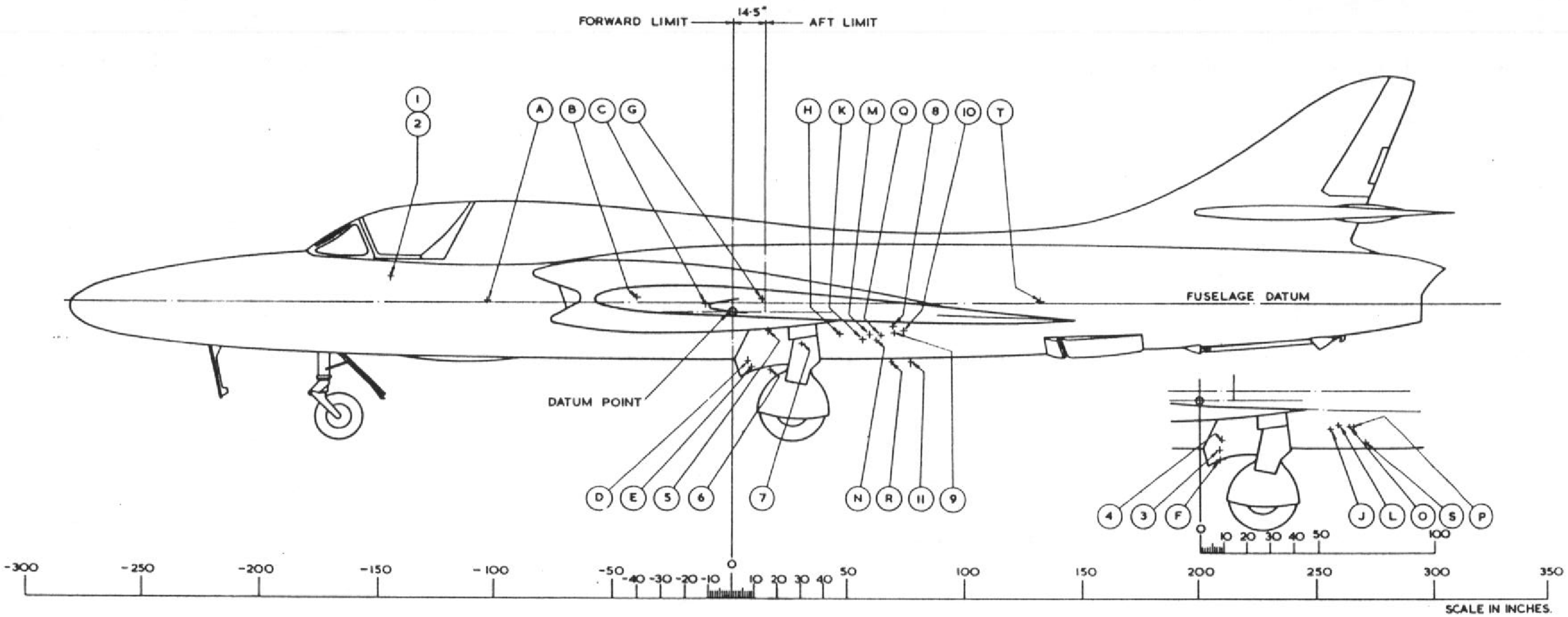

Fig.2 Loading and C.G. diagram for Tables 2 and 3

T.P. 17788

TABLE 2

Operational load items

Item No.	Description	Weight (lb)	Arm (in.)	Moment - lb in. −	Moment - lb in. +
1	Instructor	180	-145.90	26 262	
2	Pupil	180	-145.90	26 262	
3	Two 24 unit rocket batteries, unloaded	222	8.65		1 920
4	Two light series carriers on inboard pylons	48	9.55		458
5	Two inboard pylons	118.0	15.80		1 864
6	Two 100 gal. drop tanks on inboard pylons	300.0	16.40		4 920
7	Spare starter cartridges in stowage	10.5	30.50		320
8	R.P. removable mountings, comprising:-	130.0	70.00		9 100
	Launchers 'A' (Outboard)	32.5	86.05		2 797
	Launchers 'B'	32.5	79.00		2 568
	Launchers 'C'	32.5	63.25		2 056
	Launchers 'D' (Inboard)	32.5	51.55		1 675
9	Two light series carriers on outboard pylons	48.0	70.40		3 379
10	Two outboard pylons	72.0	74.65		5 375
11	Two 100 gal. drop tanks on outboard pylons	300.0	77.25		23 175

TABLE 3 **Expendable load items**

Item Letter	Description	Weight (lb)	Arm (in.)	Moment - lb in. —	Moment - lb in. +
A	Ammunition 150 rds.	162.0	-103.50	16 767	
B	**Fuel, front tanks (202 gal.)**	1 555.0	- 40.50	62 978	
◄ C	Fuel, wing tanks (140 gal.), without drop tanks fitted	1 078.0	–11.50	12 397	
	Fuel, wing tanks (146 gal.), with inboard drop tanks fitted	1 124.0	–11.50	12 926	
	Fuel, wing tanks (150 gal.), with inboard and outboard drop tanks fitted	1 155.0	–11.50	13 283	►
D	48-2 in. rockets	484.0	6.95		3 364
E	Overload fuel in inboard drop tanks (200 gal.)	1 540.0	8.80		13 552
F	Four 25 lb practice bombs, on inboard pylons	100.0	8.80		880
G	**Fuel, centre tanks (72 gal.)**	554.0	13.30		7 368
H	**8 R.P. single tier, 60 lb head**	760.0	47.55		36 138
J	**16 R.P. double tier, 25 lb head**	960.0	55.30		53 088
K	**16 R.P. double tier, 18 lb head**	848.0	56.40		47 827
L	**8 R.P. single tier, 25 lb head**	480.0	58.45		28 056
M	8 R.P. double Tier, 18 lb head	424.0	59.55		25 249
N	**16 R.P. double tier, 12 lb head**	752.0	62.60		47 075
O	**6 H.V.A.R. single tier 52 lb head**	1 120.0	63.05		70 616
P	**6 H.V.A.R. single tier 35 lb head**	984.0	64.65		63 616
Q	**8 R.P. single tier, 12 lb head**	376.0	65.75		24 722
◄ R	Overload fuel in outboard drop tanks (198 gal.)	1 525.0	69.65		106 216
S	Four 25 lb practice bombs on outboard pylons	100.0	69.65		6 965 ►
T	De-icing fluid	8.0	131 75		1 080

E.C.U. included in given basic weight

8. The E.C.U. is an Avon Mk.12201 having an average weight of 2597 lb with a C.G. position 26.2 in. forward of engine C.G. datum.

Changes of E.C.U.

9. 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 97.2 in. forward of the engine C.G. datum point, therefore the dimension for the C.G. of the E.C.U. must be subtracted from this dimension to obtain the moment for the aircraft C.G. datum,eg:-

Form 753 quotes:-

> 2629 lb/2565 lb. C.G. 26.45 in/25.95 in. forward of the centreline of the engine mounting trunnion.
> Highest weight 2629 lb. Highest C.G. position 26.45 in. forward.

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

> 2629 x (97.2 – 26.45) = 2629 x 70.75 = 186002 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 informat-ion recorded on the Aircraft Basic Weight and Moment Record (MOD Form 751).

FATIGUE DATA

Introduction

10. 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.

11. 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.

12. 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 AP100B-01 Order 0768 (for the RAF) and in AP(N) 100N-0140 (for the RN).

Structural integrity

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

14. 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.

15. 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.

16. 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.

17. Fatigue lives are specified in the Component Replacement List Published in AP101B-1300-5A1 for RAF aircraft and in AP101B-1300-5C(N) Section 10 for RN aircraft.

Unlifed components liable to fatigue damage

18. 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.

19. 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. In these cases, action to be taken by user units is detailed in AP 100A-01 Leaflet 330 (RAF only)

Fatigue monitoring

20. The fatigue meter fitted to the Hunter T Mk 8, 8B & 8C is the Mk14, a standard 8 level counter recording from -1.5g to +7.0g. 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.

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

Window	A	B	C	D	E	F	G	H
Acceleration Threshold	-1.5	-0.5	0.25	1.75	2.5	3.5	5.0	7.0
Typical Difference Pattern	1	7	2	5	4	3	7	1

Fatigue meter maintenance

22. 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.

23. 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.

24. 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

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

26. 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 Mk4 and not having Mod 1032 embodied must be made until the modification is incorporated.

Embodiment of Mod 1032 on ex-Mk4 aircraft

27. Due to the added severity of damage to the spigots and nuts at the front transport joint before conversion from Mk4, Mod 1032 must be embodied on all ex- Mk4 aircraft before the centre fuselage reaches a FI determined as follows.

43 - (Mk4 flying hours x 0.02754)

Weight/configuration compensation factors

28. In general the wing stores configuration and the mean all up weight will vary from the selected datum condition. The effect of this is allowed for by the introduction of factors K_W and K_F in the wing and centre fuselage formulae respectively. Values of these factors are given below:

RN Aircraft

Wing Stores Configuration	**Wing Factor K_W**
Clean wing	$2.56 \times 10^{-4}W - 3.20$
Stores mounted on inboard pylons only	$2.67 \times 10^{-4}W - 3.71$
Stores mounted on all four pylons	$2.12 \times 10^{-4}W - 3.34$
Wing Stores Configuration	**Fuselage Factor K_F**
Clean wing	$2.78 \times 10^{-4}W - 3.57$
Stores mounted on inboard pylons only	$2.92 \times 10^{-4}W - 4.15$
Stores mounted on all four pylons	$2.26 \times 10^{-4}W - 3.62$

RAF Aircraft

Wing Stores Configuration	**Wing Factor K_W**
Clean wing	$2.50 \times 10^{-4}W - 3.10$
Stores mounted on inboard pylons only	$2.50 \times 10^{-4}W - 3.35$
Stores mounted on all four pylons	$2.07 \times 10^{-4}W - 3.11$
Wing Stores Configuration	**Fuselage Factor K_F**
Clean wing	$2.72 \times 10^{-4}W - 3.47$
Stores mounted on inboard pylons only	$2.70 \times 10^{-4}W - 3.71$
Stores mounted on all four pylons	$2.20 \times 10^{-4}W - 3.38$

Calculations of FI

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

RN Aircraft

Wing FI

$$= \frac{K_W \times (0.86A + 0.86B + 0.10C + 0.0037D + 0.18E + 0.82F + 2.05G + 3.40H)}{1000}$$

Fuselage FI

$$= \frac{K_F \times (0.61A + 0.53B + 0.038C + 0.0002D + 0.072E + 0.48F + 1.32G + 2.27H)}{1000}$$

RAF Aircraft

Wing FI

$$= \frac{K_W \times (0.66A + 0.87B + 0.11C + 0.004D + 0.19E + 0.84F + 2.1G + 3.65H)}{1000}$$

Fuselage FI

$$= \frac{K_F \times (0.48A + 0.55B + 0.044C + 0.0003D + 0.081E + 0.50F + 1.35G + 2.42H)}{1000}$$

Where A to H are valid counts from the Mk 14 fatigue meter

Unmonitored Flying

30. 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.

31. 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:

RN Aircraft

Wing FI increase factor	= 1.03
Fuselage FI increase factor	= 1.18

RAF Aircraft

Wing FI increase factor	= 1.08
Fuselage FI increase factor	= 1.24

Effect of modifications

32. The spigots and nuts of the fuselage front transport joint must be strengthened by embodiment of Mod 1032 by the time that the centre 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.


TIME
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STATE OF SQUADRONS