Chapter 3 - LOADING, C.G. AND FATIGUE INDEX DATA

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LOADING AND C.G. DATA

General

1. It is essential that the loading of an aircraft is kept within the limitations of the approved C.G. range and all 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) The maximum permissible all-up weight of the aircraft is 25 000 lb.

(2) *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.

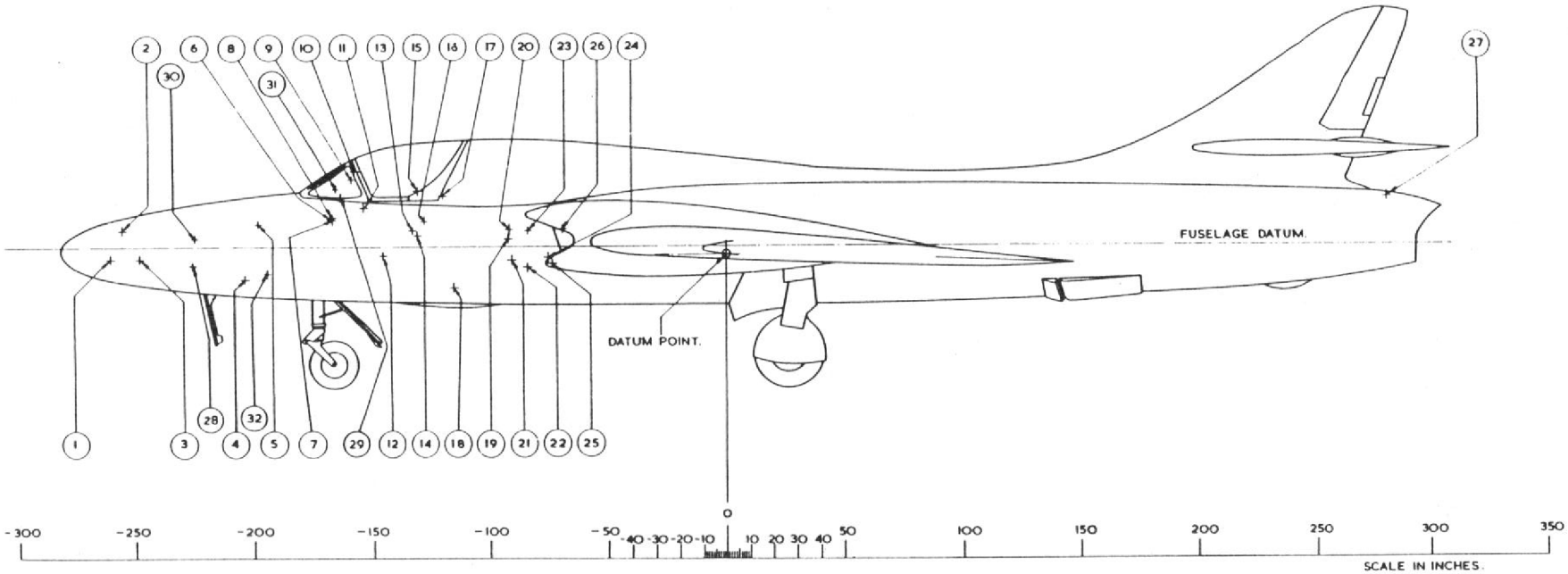

FIG. 1. LOADING AND C.G. DIAGRAM
FOR TABLE 1 ONLY.

TABLE 1

Removable equipment included in basic weight

Item No.	Ref. No.	Description	Weight (lb.)	Moment (lb. in.) –	+
A.R.I. 5840 (Pre Mod. 1321)					
1	10D/21292	Radar head, Type 2A	50·0	13 067	
3	10D/18553	Junction box	1·5	373	
5	10Q/16076	Ranging unit	26·0	5 162	
A.R.I. 18124 (Post Mod. 979)					
6	10L/9428543 or 10L/9990839	Control unit, Type C1607 / Control unit, Type C1607/2	3·0	506	
25	10D/9428542	Trans/rec. unit, Type 5	47·0	3 438	
A.R.I. 23057 (Post Mod. 979)					
22	5J/3458	Battery	17·0	1 423	
23	10D/23507 or 10D/9956726	Trans/rec. unit, Type M.4 / Trans/rec. unit. Type M.6	10·5	877	
A.R.I. 23013 (Pre Mod. 1321)					
8	10L/16264	Control unit, Type 8197	3·0	501	
26	10D/19594	Trans/rec. unit, Type T.R.8193	29·5	2 044	
A.R.I. 18064 (Pre Mod. 979 or Post Mod. 980)					
11	10L/246	Control units, Type 382	1·0	155	
24	10D/21507–8	Trans/rec. unit, Type T.R.1985–6A			
	10D/21509	Trans/rec. unit, Type T.R.1987A (Post Mod. 980)	52·5	3 943	
A.R.I. 5877 (Pre Mod. 1321)					
13	10U/17211	R.F. amplifier, Type 8281	5·0	667	
19	10U/17212	I.F. amplifier, Type 8282	9·0	828	
A.R.I. 18085					
20	10D/19783	Modulator unit, Type 7747	5·0	457	
A.R.I. 18107 (Post Mod. 1321)					
28	110D/6914896	Trans/rec. unit	61·0	13 804	
29	10L/16324	Control unit, Type 9273A	1·7	278	
30	10D/22534	Coupling unit, Type 9546	7·5	1 685	

TABLE 1

Removable equipment included in basic weight (Cont.)

Item No.	Ref. No.	Description	Weight (lb.)	Moment (lb. in.) –	+
A.R.I. 23134 (Post Mod. 1356)					
31	–	Control unit, Type X16929	2·0	332	
32	–	Transponder, Type X16928	30·3	584	
Miscellaneous equipment					
2	–	Camera gun, G.90 (Pre Mod. 1321)	7·0	1 792	
4	–	Harness apron, Type MBEU/8516	2·0	408	
7	6A/4339520	Clock	0.5	84	
9	–	Gunsights, Mk. 8	18·0	2 873	
10	14A/4196	Camera recorder	2·5	395	
12	–	Personal survival pack, Type R Mk.2	63·5	9 258	
14	6D/2095	Emergency oxygen sets	6·0	785	
15	–	Parachute assy, back Type B Mk.41	52·5	6 851	
16	12K/1301 or 12K/1315 or 12K/1335	Seat cartridges	2·5	305	
17	9A/02450	First aid kit	0·5	60	
18		Gun and accessories (Pre Mod. 1321)	212·0	24 443	
21	–	Radio I.C. Amplifier, Type A1961	6·5	589	
27	–	Brake parachute, Type LB52 Mk. 3	12·0		3 384
AIRCRAFT AT BASIC WEIGHT			13 497		155 216

(These are typical figures and should only be used if the basic weight and moment record card (MOD Form 751) is out of date or inaccurate.)

C.G. range

4. The approved limits of C.G. travel measured parallel to the fuselage datum are 1 inch forward 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.

TABLE 2

Operational load items

Item No.	Description	Weight (lb.)	Arm (in.)	Moment (lb.in.) –	Moment (lb.in.) +
1	Instructor	180.0	–145.90	26 262	
2	Pupil	180.0	–145.90	26 262	
3	Two inboard pylons	115.0	15.75		1 811
4	Two 100 gal. drop tanks on inboard pylons	300.0	16.40		4 920
5	Spare starter cartridges in stowage	10.5	30.50		320
6	R.P. removable mountings	130.0	70.00		9 100
7	Two outboard pylons	72.0	74.65		5 375
8	Two 100 gal. drop tanks on outboard pylons	300.0	77.25		23 175

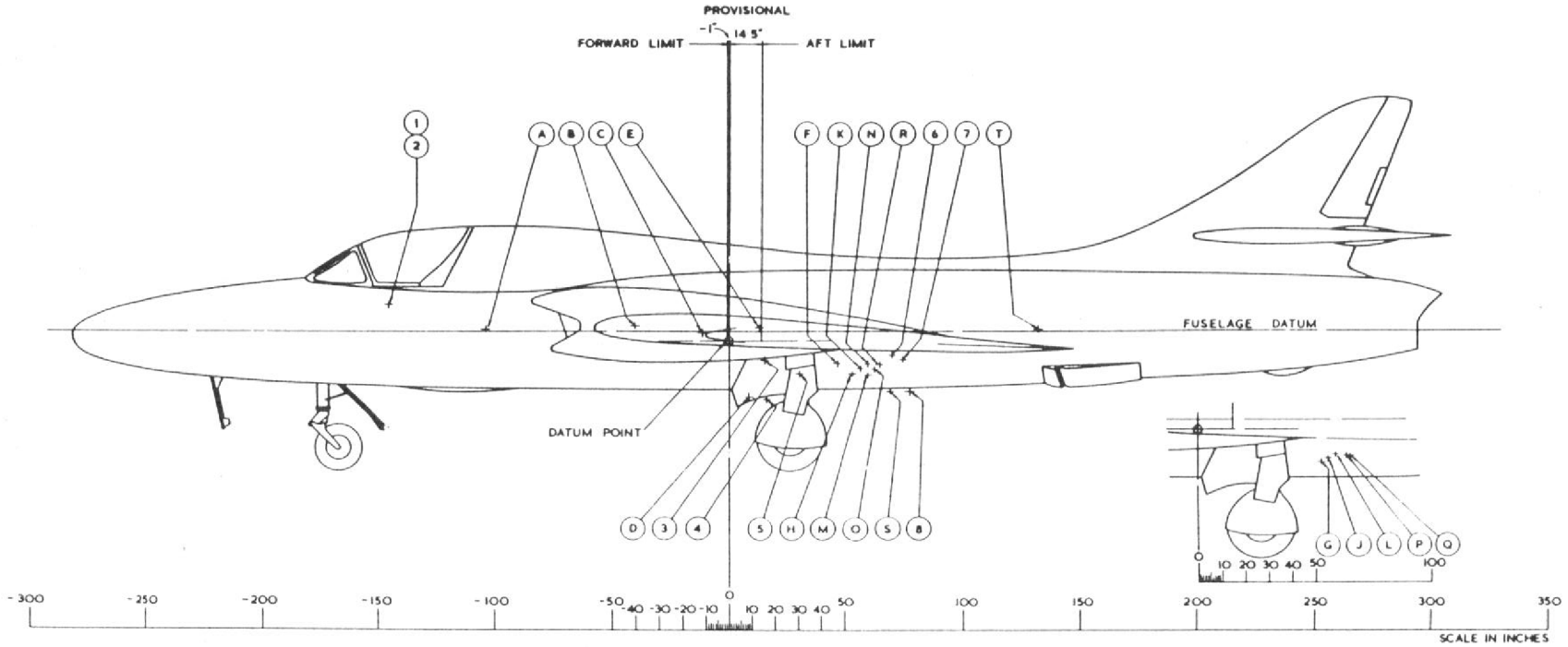

Fig.2 Loading and C.G. Diagram for Table 2 and 3 items

Changes in weight and moment due to modifications

6. Where 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. 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. ▶

TABLE 3

Expendable load items

Item No.	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.)	1 078.0	− 11.50	12 397	
D	Overload fuel in inboard drop tanks	1 540.0	8.80		13 552
E	Fuel, centre tanks (72 gal.)	554.0	13.30		7 368
F	8 R.P. single tier, 60 lb. head	760.0	47.55		36 138
G	24 R.P. triple tier, 25 lb. head	1 440.0	52.15		75 096
H	24 R.P. triple tier, 18 lb. head	1 272.0	53.25		67 734
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	24 R.P. triple tier, 12 lb. head	1 128.0	59.45		67 060
N	8 R.P. single tier, 18 lb. head	424.0	59.55		25 249
O	16 R.P. double tier, 12 lb. head	752.0	62.60		47 075
P	6 H.V.A.R. single tier 52 lb. head	1 120.0	63.05		70 616
Q	6 H.V.A.R. single tier 35 lb. head	984.0	64.65		63 616
R	8 R.P. single tier, 12 lb. head	376.0	65.75		24 722
S	Overload fuel in outboard drop tanks	1 540.0	69.65		107 261
T	De-icing fluid	8.0	131.75		1 080

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 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 information recorded on the Aircraft Basic Weight and Moment Record (MOD Form 751).

FATIGUE INDEX DATA

Fatigue index data — introduction

General

9. The Fatigue Index is defined as a figure indicating the fatigue consumption of an aircraft as obtained from the application to the fatigue formula of fatigue meter readings or other assessments. It follows that the Fatigue Index figure will be inaccurate if recording is slovenly or should the fatigue meter be unserviceable. It is imperative that all personnel are aware of these two vital aspects to the conservation and safety of aircraft.

Assessing consumption of fatigue index

10. The most accurate current method of determining the Fatigue Index consumed is by means of a fatigue meter. This instrument includes a number of counters which indicate when "g" thresholds are exceeded. The substitution of these "g" counts in a formula gives the Fatigue Index consumed for the period concerned. There may be several formulae for one type of aircraft to correspond with different all-up weights, different weight distributions or different types of fatigue meters which may be fitted.

Unmetered flying

11. Unless a fatigue meter is fitted to the aircraft (*or when an installed fatigue meter is unserviceable*) fatigue consumption is assessed from details of the flying carried out. Different types of manoeuvre impose varying loads on aircraft and it is necessary to break down the flying carried out into the various sortie patterns expected in service. The particular theatre of operations may also affect the fatigue consumption of an aircraft and in such cases a separate factor or formula will be quoted for each theatre. It is then possible for the design authority to estimate a fatigue index consumption rate for each sortie pattern. Because fatigue damage estimates based on sortie patterns are derived from the average expected loadings, the rates are factored to allow for "worse case" situations. Thus, fatigue consumption assessed on a sortie pattern basis is extravagant when compared with the more accurate fatigue meter based index. Hence, it is essential that priority is always given to the replacement of defective fatigue meters.

Recording fatigue consumption data

12. The consumption of Fatigue Index is to be recorded on Form 700 and Form 4832A or B as appropriate. Instructions for compilation in the Form 700 are contained in the General Instructions for that form; the Forms 4832 Series are to be kept in the Form 4832, a manilla folder expressly designed for the purpose. All personnel responsible for the collection and compilation of fatigue data should appreciate the need for accuracy, neatness and legibility of the entries. Careless or incomplete recording is dangerous if it causes a less damaging sortie to be assumed; it is wasteful if in the interests of safety the worse case has to be assumed. In extreme cases, continued careless or incomplete recording can result in the expensive premature removal of an aircraft from service because of doubt regarding the true situation. Examples of correct and bad recording are shown in the associated A.D.101A-1200-D1, Aircraft Fatigue Recording.

Aircraft fitted with fatigue meters

13. The fatigue data for aircraft fitted with fatigue meters is to be recorded on Form 4832A or Form 700. In respect of Forms 4832A, the aircraft captain is responsible for action in the columns (a) to (l). The responsibility for reading the meter and completing columns (m) to (ad) may rest with either a crew member or servicing personnel depending on the type of aircraft. The Unit Engineering Records Section is responsible for calculating the Fatigue Index consumed. The attention of all personnel responsible for reading fatigue meters is to be drawn to the serviceability checks described in the publication "Fatigue Meters", A.P.112G-0203-1, Chapter 2.

Arcraft without fatigue meters

14. The captain of the aircraft is responsible for the accuracy of columns (a) to (l) in Form 4832B and the Unit Engineering Records Section is responsible for completing the cumulative totals, factorizing the flying hours, and expressing the life used as the Fatigue Index.

Refining of fatigue index

15. When the fatigue records for an aircraft show that its Fatigue Index is 80, action is to be taken in accordance with Leaflet C6 of A.P.3158, Vol. 2.

Changes in recording to be made on fitment of a fatigue meter

16. On fitment of the meter it will be necessary to obtain the Fatigue Index already consumed from the last Form 4832B and carry it forward to the first Form 4832A which will be brought into use on fitment of the meter.

◀ **Fatigue index data — application**

Fatigue index

17. The fatigue index of the aircraft is calculated under two headings, viz the centre fuselage and the wings. The fatigue index of the former is roughly half that of the latter and is based on fatigue damage to the main frame, for which there is currently no planned repair or replacement. The fatigue index consumption prior to conversion from Mk. 4, where applicable, must be calculated separately and added to the consumption since conversion [*para. 20(1)*].

Critical components

18. The critical components are as follows:

(1) *Fuselage front transport joint.* The spigots and nuts of the fuselage front transport joint must be strengthened by embodiment of Mod. 1032 by the time that Fatigue Index 43 is reached on the centre fuselage. Special calculations are necessary for this purpose on aircraft which have been converted from Mark 4 (*para. 21*).

(2) *Fuselage — main plane front locating spigots.* These spigots, which form part of the centre section, are lifed at 35 Fatigue Index on the CENTRE FUSELAGE. When this point is reached, the spigots become subject to the requirements of SI Hunter 96. Replacement of spigots under Mod. 1327 and 1334 (*controlled by MOD*) removes the lifing.

Fatigue meters

19. Either the Mk.2D (*Mod. 494*) or Mk.14 (*Mod. 912*) fatigue meter may be fitted. The key to the letters in the metered formulae given in Table 4 is as follows:—

Mk.2D meter		Mk.14 meter	
'g' level	Counts	'g' level	Counts
−1·5	A	−1·5	A
−0·5	B	−0·5	B
2·5	C	0·25	C
3·5	D	1·75	D
4·5	E	2·5	E
6·0	F	3·5	F
		5·0	G
		7·0	H

Fatigue consumption calculations

20. Fatigue Index consumption is to be calculated for fuselage and wings as indicated in sub-para. (1) and (2) below, the results being added together to give the total consumption for each component. Additional calculations for those aircraft converted from Mark 4 and *not* having Mod. 1032 embodied must be made until the modification is incorporated (*see para. 21*).

(1) *Unmetered flying.* The Fatigue Index consumed per hour of unmetered flying is as follows:—

	Centre fuselage	Wings
As Mk. 4 aircraft	0·006	0·013
As T. Mk.7 aircraft in following roles:		
Instrument flying, ferry, cross-country	0·0028	0·0061
Aerobatics	0·034	0·067
Ground attack	0·025	0·0485
All other flying	0·0075	0·0164

Note . . .

Fatigue consumption prior to the installation of a fatigue meter or during periods of meter unserviceability must be calculated using the preceding factors. Where sortie details are not available, the following rates of fatigue index consumption per hour may be used.

Centre fuselage	Wings
0.0064	0.0139

Note . . .

The serial numbers of aircraft known to be conversions from Mark 4 are as follows:—

XF310*, XF321, WV253, WV318*, WV372, WV383*

* *Aircraft known to have Modification 1032 outstanding as at Aug. 1968.*

(2) *Metered flying.* The Fatigue Index consumed during *metered* flying is to be calculated as shown in Table 4.

Embodiment of Mod. 1032 on ex-Mk. 4 aircraft

21. Owing to the relatively more severe damage to the spigots and nuts at the front transport joint before conversion from Mk. 4, Mod. 1032 must be embodied on all ex-Mk. 4 aircraft before the centre fuselage reaches a Fatigue Index determined as follows:—

43 minus (*Mk. 4 flying hours* × *0·02754*)

TABLE 4 — Metered flying formulae

Type of meter	Centre fuselage	Wings
Mk.2D	$\frac{1}{1000}$ (0·67A + 0·32B + 0·07C + 0·29D + 0·62E + 1·28F)	$\frac{1}{1000}$ (1·13A + 0·6B + 0·22C + 0·55D + 1·1E + 2·1F)
Mk.14	$\frac{1}{1000}$ (0.29A + 0·13B + 0·025C + 0·0004D + 0·07E + 0·38F + 0·94G + 1·76H)	$\frac{1}{1000}$ (0·49A + 0·22B + 0·085C + 0·012D + 0·19E + 0·7F + 1·69G + 2·76H)

▶