

Standard fatigue loading sequences

Associated software: **VIEWpac FALSTAFF**
 VIEWpac TWIST

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STANDARD FATIGUE LOADING SEQUENCES

1. INTRODUCTION

Standard loading sequences are available for simulating the magnitude and frequency of the applied service loadings of particular components or structures. These sequences are primarily used in the comparison of fatigue performance of different materials or components under various conditions. They are also used for the evaluation of fatigue data for preliminary design, the evaluation of fatigue life prediction models, assessing the degree of scatter in fatigue life data and other related evaluation and comparison exercises.

This Data Item describes three standard loading sequences for use in the fatigue assessment of aircraft structures: TWIST (and Mini-TWIST), FALSTAFF (and ENSTAFF) and Helix/Felix. A description and analysis of each of the standards is given. Additionally the FALSTAFF and TWIST standard loading sequence turning points can be found on the CD in the Fatigue – Endurance Data Software Volume, within ESDUscope (the electronic version of the Series) and on the internet version of the Series.

2. NOTATION AND ABBREVIATIONS

2.1 Notation

Both SI and lbf in units are quoted. Note that for temperature the Kelvin scale must be used. The notation given here is common to all of the loading sequences described and, where necessary, additional notation is given in the appropriate section.

n	number of cycles	cycles	cycles
N	endurance	cycles	cycles
S	stress	N/m ²	lbf/in ²
T_a	ambient air temperature for flight altitude	K	K
T_w	adiabatic wall temperature	K	K
M	Mach number		

2.2 Abbreviations

kn	knot
Vne	velocity never exceeded
Vno	normal operating velocity

3. DEFINITION

The number of possible stress histories is infinite in principle and thus, for design purposes, the development of standard loading sequences is helpful in order to carry out fatigue evaluations on a basis that enables meaningful results to be obtained and compared.

In order to construct a useful standard loading sequence the following criteria should be considered.

- (a) The spectrum of the standard loading sequence should exhibit a shape similar to that of the characteristic loading to which the structure under consideration is subjected in service.
- (b) The standard loading sequence should contain sequences of loads that represent real phenomena, for example gust and manoeuvre loads.
- (c) The standard loading sequence should be such that it can be generated consistently.

Standardised loading sequences find many uses in design against fatigue and in fatigue research, among which are the following.

- (i) Evaluation of the fatigue strength of materials and actual components under conditions close to those encountered in service. In particular to show behaviour not apparent under constant amplitude loading.
- (ii) Derivation of fatigue data for preliminary design studies.
- (iii) Evaluation of scatter in fatigue data.
- (iv) Assessment of fatigue life prediction models.
- (v) Assessment of the influence of design features, for example the effect of fillet radii, or different fastener systems.
- (vi) Comparison of the effect of processes that may affect fatigue life, for example, shot peening, anodising, heat treatment, *et cetera*.
- (vii) Assessment of the consequence of manufacturing processes on fatigue strength.

The standard loading sequences described in this Data Item are listed in Table 3.1 over the page. The table lists the name of the sequence, its purpose and the section of this Data Item in which a full description of the sequence is to be found. Each of the standard fatigue loading sequences described within the Data Item was defined and fixed by the issuing authority. The derivation(s) for each sequence are given at the end of the appropriate section.

TABLE 3.1 Details of Standard Loading Sequences

<i>Loading Sequence Name/Acronym</i>	<i>Purpose</i>	<i>Section</i>
FALSTAFF	Fighter Aircraft Loading STandard For Fatigue. Represents the stresses on the lower wing surface near the wing-to-fuselage joint in tactical aircraft.	4
ENSTAFF	Enviromental FALSTAFF.	5
TWIST, Mini-TWIST	Transport WIng STandard. Represents the stresses on the lower wing skin at the wing root of a transport aircraft. Mini-TWIST is a shortened version of TWIST in which many of the small amplitude loads are omitted.	6
Helix, Felix	Helicopter main rotor blades: Helix for 'hinged' or articulated rotor blades and Felix for 'fixed' or semi-rigid rotor blades.	7

4. FALSTAFF

4.1 Introduction to FALSTAFF

The FALSTAFF standard loading sequence has been developed to represent the stresses on the lower wing surface near the wing-to-fuselage joint in tactical aircraft: the acronym is derived from **F**ighter **A**ircraft **L**oading **S**Tandard **F**or **F**atigue. It is based on load factor and strain measurements of five aircraft: Fiat G-91, Northrop NF-5A, Dassault Mirage III and two Lockheed F104G flying with two different air forces (Derivation 4.4.2)

The loading sequence was derived from a variety of sortie types, for example high/low navigation, instrument flying, combat patrol, tactical weapons training, conventional weapons training, close air support, forward area control, interdiction, air combat manoeuvring, interception, air-to-air gunnery, formation flying, reconnaissance, special weapons delivery, and functional checks.

A self-extracting text file containing the FALSTAFF standard loading sequence turning points can be found on the CD in the Fatigue – Endurance Data Software Volume. The same text file is also available within ESDUscope (the electronic version of the Series) and on the internet version of the Series.

4.2 Definition of FALSTAFF

Load factor time histories were recorded for the five aircraft each covering a selection of mission types. From each of the recorded data samples 40 individual load factor flight histories were selected, in accordance with the respective aircraft operation, thus producing a spectrum comprising 200 flights which represents 1 year of typical usage.

4.2.1 Unification of load factor scale

The load factor time histories from the five aircraft were transformed to a common basis. This was done by determining the discrete load factor level exceeded once-per-flight for a specific flight type and taking the mean value and scaling up or down to this.

4.2.2 Stress conversion data and configuration assignment

In order for the load factor time histories to be converted into stress time histories, an hypothetical aircraft with a particular stress response was defined. Only two variables were considered, take-off weight configuration and fuel consumption during flight. For simplicity the aircraft was considered to operate in only the following configurations: (a) clean (no external wing stores) or (b) with a pylon tank (full).

In accordance with fighter aircraft current at the time of development, the adopted relative weight figures were as follows: internal fuel capacity equal to 40 per cent of operating empty weight, and a pylon tank fuel weight equal to 25 per cent of operating empty weight.

Further definition of the stress-response involved the following assumptions/simplifications.

- (a) The fuel consumption rate is constant.
- (b) There is zero stress at zero load factor.
- (c) The bending stress varies linearly with load factor.
- (d) The pylon tank fuel assumed does not alter the stress response at the wing-to-fuselage joint (pylon tank located such that additional lift forces are offset by the additional mass relief).
- (e) All pylon tank fuel is used up first.

- (f) Excluding the pylon tank fuel, the bending stress per unit load factor is proportional to the remaining aircraft weight.
- (g) An allowance of 10 per cent of full internal fuel weight was made for each take-off and touch down.

Each of the 200 selected flights was assigned either the clean or pylon tank configuration by considering the actual configuration, the flight duration and the type of flight. The resulting configuration frequencies are (a) 45 flights assigned a clean configuration and (b) 155 flights assigned a pylon tank configuration.

4.2.3 Data compression and range filtering

The derived stress time histories were processed such that only the series of peak and trough values, in their original chronological order, remained (data compression). All intermediate minor stress changes smaller than the prescribed range-filter threshold were deleted. Therefore, the final compressed stress history is a series of peaks and troughs that are all associated with a stress range of at least the adopted range-filter magnitude and the process produced an average of 172 airborne stress ranges per flight.

4.2.4 Mission type grouping

Three basic mission types were identified and all flights were assigned to one of these according to flight profile.

- Type 1 – This group comprises all flights exhibiting repetitive patterns of severe manoeuvring (for example, conventional air-ground weapon training, close-air-support).
- Type 2 – This group comprises all flights exhibiting severe manoeuvring without repetitive patterns (for example, combat manoeuvring, functional check flights).
- Type 3 – This group comprises all other flights, mainly involving moderate manoeuvring or just incidental severe manoeuvring (for example, tactical weapon training, special weapons delivery).

4.3 Characteristics and Analysis of FALSTAFF

4.3.1 Statistical presentation of derived stress data

With each mission group FALSTAFF allows for three different flight length values, these length values and their number of occurrences being determined in accordance with the actually observed distributions. The final flight length values adopted and their occurrence frequencies are presented in Table 4.1.

TABLE 4.1 Distribution of Flight Types with Respect to Mission Type and Airborne Flight Length

Flight length index Mission Type	Number of flights			
	1	2	3	Total
1	21	20	6	47
2	44	13	7	64
3	47	23	19	89
Totals	112	56	32	200

Peak and trough values presented in the derived compressed stress data histories were classed into 32 equidistant discrete levels. Level 1 was assigned to the lowest occurring trough value, and level 32 assigned to the highest peak value. All the other peak and trough values were rounded to the nearest discrete level. The coarsened series of peak and trough values was analysed in accordance with the range-mean counting method. This yielded three matrices, one for each of the three mission types and each comprising 32×32 element values as presented in Tables 4.2 - 4.4.

4.4 Application of FALSTAFF

As mentioned in Section 4.3.1, the FALSTAFF sequence consists of loads normalised to 32 equidistant discrete levels, 1 to 32. The point of zero loading in terms of this scale is 7.5269. Thus, in order to be able to scale the spectrum by a single factor to give a desired maximum loading corresponding to level 32 (or, indeed, to scale the spectrum by a single factor to give some other loading corresponding to some other load level), 7.5269 must first be subtracted from each load level value in the spectrum. (As can be seen, failure to do this would result in a loading sequence that was entirely tensile.)

Two self-extracting text files can be found on the CD in the Fatigue – Endurance Data Software Volume. The same files are also available within ESDUscope (the electronic version of the Series) and on the internet version of the Series. One file, FALSTAFF.txt, contains the original FALSTAFF standard loading sequence turning points; the other file, FSTAFFmd.txt (md for ‘modified’), contains the FALSTAFF standard loading sequence with 7.5269 subtracted from each turning point.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7	0	0	0	0	0	0	0	0	0	0	0	3	1	0	1	1	1	0	1	0	0	1	1	1	0	0	0	0	0	0	0	
8	0	0	0	0	0	0	0	0	0	0	17	29	43	29	28	11	25	7	2	3	4	0	1	0	0	0	0	0	0	0	0	
9	0	0	0	0	0	0	0	0	0	0	0	256	321	115	55	20	16	15	14	2	7	3	0	0	0	0	0	0	0	0	0	
10	0	0	0	0	0	0	0	0	0	0	0	1974	968	312	101	58	72	28	19	10	6	2	0	0	0	0	0	0	0	0	0	
11	0	0	0	0	0	0	0	17	0	0	0	0	1252	366	169	100	80	60	38	18	10	7	2	2	0	0	0	0	0	0	0	
12	0	0	0	0	0	1	27	260	0	0	0	0	0	0	171	102	75	39	33	16	4	4	1	0	0	0	0	0	0	0	0	
13	0	0	0	0	0	2	26	296	2015	0	0	0	0	0	57	41	5	10	12	6	1	2	1	0	0	0	0	0	0	0	0	
14	0	0	0	0	0	4	52	112	967	1230	0	0	0	0	0	35	27	16	9	10	3	1	0	0	0	0	0	0	0	0	0	
15	0	0	0	0	0	2	25	88	237	395	186	0	0	0	0	0	29	22	13	2	0	1	2	0	0	0	0	0	0	0	0	
16	0	0	0	0	0	2	20	31	89	174	92	53	0	0	0	0	24	13	10	1	0	0	0	2	0	0	0	0	0	0	0	
17	0	0	0	0	0	0	19	14	77	114	43	32	53	0	0	0	0	16	7	0	2	2	0	1	0	0	0	0	0	0	0	
18	0	0	0	0	0	1	0	8	4	71	68	42	21	27	32	0	0	0	0	5	2	0	1	0	0	0	0	0	0	0	0	
19	0	0	0	0	0	0	0	3	42	53	45	16	11	14	26	0	0	0	0	0	2	3	0	0	0	0	0	0	0	0	0	
20	0	0	0	0	0	0	1	0	32	39	19	4	5	16	8	17	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	
21	0	0	0	0	0	0	0	8	11	19	13	4	3	3	11	6	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
22	0	0	0	0	0	0	2	2	3	7	3	3	1	3	4	1	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	
23	0	0	0	0	0	0	2	5	2	0	0	1	1	1	1	3	1	2	2	0	0	0	1	0	0	0	0	0	0	0	0	
24	0	0	0	0	0	0	0	2	1	2	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
25	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	
26	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

NOTE:

Load changes from a peak to a trough are drawn from the upper right area of the table

Load changes from a trough to a peak are drawn from the lower right area of the table

TABLE 4.2 In-Flight Load Change Occurrence Frequency Matrix with Mission Type 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	11	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	10	0	2	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	2	5	2	2	1	1	2	1	0	2	2	0	0	0	0	0	1	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	13	11	36	26	37	17	11	19	28	14	17	13	14	3	2	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	121	198	116	53	63	48	39	56	22	16	11	3	5	4	2	11	0	1	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	913	504	200	131	92	78	51	56	35	10	11	15	7	4	4	3	0	2	0	1
11	0	0	0	0	0	0	1	23	0	0	0	0	0	598	267	134	118	80	69	41	35	35	12	18	5	12	5	2	1	2	0	1
12	0	1	0	0	1	0	1	12	119	0	0	0	0	0	143	86	76	54	60	28	25	37	7	19	2	3	0	0	0	0	0	0
13	0	0	0	0	1	2	2	32	209	908	0	0	0	0	0	98	72	54	37	20	29	26	13	8	1	3	1	10	3	0	0	0
14	0	0	0	0	11	0	2	36	102	503	596	0	0	0	0	0	51	43	43	14	17	25	23	5	12	3	0	0	0	0	0	0
15	0	0	0	2	0	1	4	25	59	173	283	158	0	0	0	0	0	51	26	15	19	15	6	0	7	12	1	0	0	0	0	0
16	1	0	0	3	2	10	2	29	47	105	110	91	131	0	0	0	0	0	24	39	14	13	9	19	2	1	1	1	0	0	0	0
17	0	0	1	0	0	0	2	18	49	81	99	68	72	90	0	0	0	0	0	28	19	7	1	3	3	5	0	2	0	0	0	0
18	0	1	0	0	0	1	0	16	41	61	76	54	65	51	55	0	0	0	0	0	19	8	4	3	0	3	2	2	3	0	0	0
19	0	0	0	0	0	0	0	20	46	58	64	53	34	30	33	58	0	0	0	0	0	9	5	3	1	0	1	0	2	0	0	0
20	0	0	0	0	0	0	1	3	21	50	47	27	19	25	17	33	35	0	0	0	0	0	11	2	2	0	3	0	0	0	0	0
21	0	0	0	0	0	1	2	3	20	47	34	16	34	23	21	9	21	18	0	0	0	0	0	2	5	0	0	0	0	0	0	0
22	0	0	0	0	0	0	2	11	11	46	50	31	7	1	20	3	8	14	10	0	0	0	0	0	2	0	0	0	0	1	0	0
23	0	0	0	0	1	0	0	7	11	30	14	15	5	10	3	2	3	5	4	11	0	0	0	0	0	1	2	0	0	0	0	0
24	0	0	0	0	0	0	1	12	20	24	11	2	3	3	2	11	1	7	2	4	3	0	0	0	0	0	0	1	1	0	0	0
25	1	0	0	0	0	0	0	10	10	11	5	4	0	1	0	4	0	0	3	1	3	2	0	0	0	0	0	1	0	0	0	0
26	0	0	0	0	0	0	1	1	2	7	6	20	4	0	0	1	0	0	1	2	1	1	2	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	2	2	5	18	0	1	1	0	2	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	1	0	6	13	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	3	4	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

NOTE:
 Load changes from a peak to a trough are drawn from the upper right area of the table

Load changes from a trough to a peak are drawn from the lower right area of the table

TABLE 4.3 In-Flight Load Change Occurrence Frequency Matrix with Mission Type 2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
8	0	0	0	0	0	0	0	0	0	0	0	4	13	9	20	13	7	4	2	1	2	2	2	2	1	0	0	0	0	0	0	
9	0	0	0	0	0	0	0	0	0	0	0	59	91	39	33	32	29	22	14	5	9	7	2	2	0	1	1	0	0	0	0	
10	0	0	0	0	0	0	0	0	0	0	0	409	218	74	61	58	54	31	42	37	22	14	10	8	4	2	0	0	0	0	0	
11	0	0	0	0	0	0	0	1	0	0	0	0	213	113	83	58	79	93	59	60	40	15	17	12	5	2	0	0	0	0	0	
12	0	0	0	0	0	0	1	2	61	0	0	0	0	0	102	61	78	34	70	28	26	22	11	18	3	5	1	0	0	1	0	0
13	0	0	0	0	1	0	0	12	90	411	0	0	0	0	0	29	35	32	31	19	18	18	10	7	4	0	1	0	0	0	0	
14	0	0	1	1	0	0	1	17	32	201	227	0	0	0	0	41	31	43	14	16	12	9	1	4	0	2	1	0	0	0	0	
15	0	0	0	0	0	0	1	8	28	74	124	108	0	0	0	0	22	34	13	6	7	9	5	6	2	2	0	0	0	0	0	
16	0	0	0	0	0	1	0	16	23	43	72	72	53	0	0	0	0	20	16	7	7	4	4	1	2	1	0	0	0	0	0	
17	0	0	0	0	0	0	0	11	23	47	68	50	39	69	0	0	0	0	0	17	11	4	3	2	0	0	0	1	0	1	0	
18	0	0	0	0	0	0	0	3	14	47	59	35	41	37	42	0	0	0	0	0	2	6	4	3	0	2	0	0	0	0	0	
19	0	0	0	0	0	0	0	2	21	51	52	93	28	27	34	30	0	0	0	0	4	3	1	3	0	0	0	0	0	0	0	
20	0	0	0	0	0	0	0	1	10	37	59	29	12	16	14	16	21	0	0	0	0	0	3	0	0	0	0	0	0	0	0	
21	0	0	0	0	0	0	1	1	11	49	55	23	9	8	6	12	9	10	0	0	0	0	0	0	1	0	0	0	0	0	0	
22	0	0	0	0	0	0	0	3	13	30	58	14	5	5	3	4	4	6	6	0	0	0	0	0	0	0	0	0	0	0	0	
23	0	0	0	0	0	0	0	1	6	24	25	11	4	7	4	0	4	0	0	3	0	0	0	0	0	0	0	0	0	0	0	
24	0	0	0	0	0	0	0	3	4	13	21	7	12	1	3	0	0	1	4	0	5	0	0	0	0	0	0	0	0	0	0	
25	0	0	0	0	0	0	0	1	7	9	17	6	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
26	0	0	0	0	0	0	0	0	2	6	5	7	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
27	0	0	0	0	0	0	0	0	1	1	5	4	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
28	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
30	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

NOTE:

Load changes from a peak to a trough are drawn from the upper right area of the table

Load changes from a trough to a peak are drawn from the lower right area of the table

TABLE 4.4 In-Flight Load Change Occurrence Frequency Matrix with Mission Type 3