

EO 05-1-8

ROYAL CANADIAN AIR FORCE



AIRCRAFT WEIGHT & BALANCE DATA

"REVISION"
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Insert revised pages into basic
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PART 1

DESCRIPTION AND INSTRUCTIONS FOR THE USE OF EO 05-1-8

DESCRIPTION

1 This EO contains information necessary to personnel involved in the weighing of RCAF aircraft.

2 Due to the variety of aircraft employed by the RCAF, it has become necessary to issue a general instruction EO 05-1-8, Weight and Balance Data, and to issue supplementary Weight and Balance Data in the "-8" EO series for the particular type of aircraft being weighed.

3 This EO includes standard definitions and instructions to be carried out prior to weighing the aircraft and instructions for the use of the two weighing Forms L36 and L38. The EO for the particular aircraft shall provide all the necessary information to determine the weight and centre of gravity location under various load conditions which may be encountered by the field.

INSTRUCTIONS FOR USE

4 EO 05--8 shall be considered part of the aircraft equipment for transport, communications aircraft, helicopters and other types not covered below and as such shall be carried at all times. It is not necessary to carry the -8 EO in fighter aircraft, fighter type aircraft employed on training roles and single engine training aircraft.

5 The current duplicate copy of the aircraft Forms L36 and L38 shall be held with the aircraft log books by the unit operating the aircraft. A copy of the current Form L36 shall be forwarded to CHQ and a copy to AMCHQ after each aircraft weighing.

NOTE

The requirement for a CHQ copy may be cancelled by the command concerned.

6 Personnel responsible for the weighing of aircraft shall fill in the name of the unit or detachment carrying out the weighing in the Aircraft Basic Weight Change Record L38 contained in the Aircraft EO 05--8.

7 An aircraft shall be weighed:

(a) At time of manufacture.

(b) After a modification, when the leaflet so directs.

(c) At the discretion of the Chief Technical Services Officer.

(d) Whenever the validity of the weighing record is in doubt.

8 Each aircraft shall be weighed every two years with a tolerance of ± 60 days.

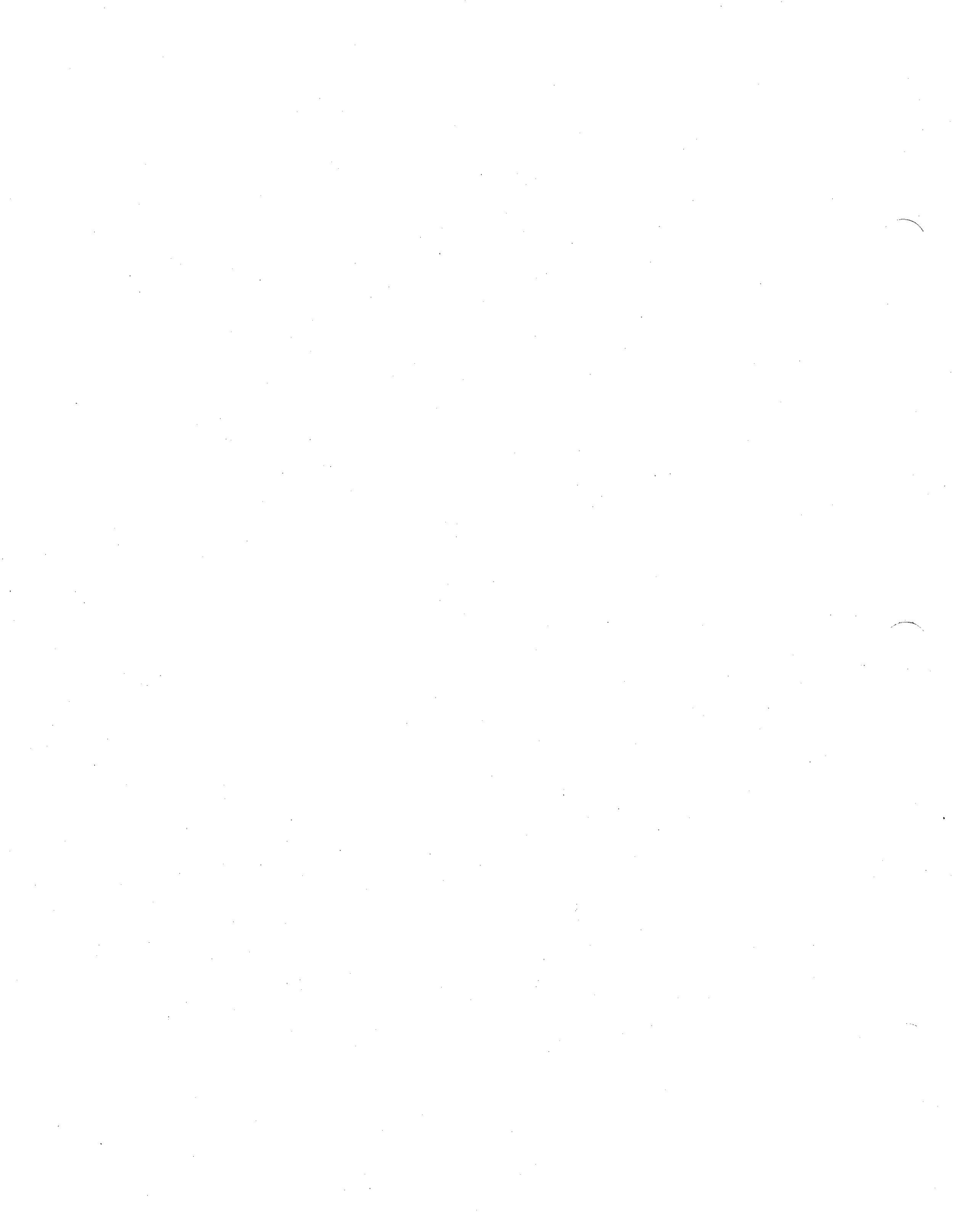
RESPONSIBILITY FOR WEIGHING AIRCRAFT

9 The repair, overhaul, modification and calibration of aircraft weighing scales shall be in accordance with CAP 16, Vol. 1, Chap. 12.11. The distribution shall be in accordance with CAP 603, D116 dated 19 Jul 56.

10 Commands and #1 Air Division shall be responsible to arrange for short courses of instruction for selected personnel on the weighing of aircraft and operation of aircraft weighing scales.

11 Commands and #1 Air Division shall be responsible for ensuring that the provisions of EO 05-1-8 are being carried out by units under their Command.

12 The Unit Chief Technical Services Officer shall be responsible for the compliance of instructions contained in EO 05-1-8.



PART 2

STANDARD DEFINITIONS

WEIGHT

1 All weights shall be stated in pounds and weight totals shall be given to the nearest whole pound.

BASIC WEIGHT

2 The Basic Weight is defined as the weight of an aircraft and its normal operational equipment necessary to enable the aircraft successfully to complete its role, and includes all fluid systems filled to capacity (hydraulic system, coolant system, de-icer system, etc.) but not including fuel, oil, drinking and washing water. Trapped fuel and oil is included in the aircraft Basic Weight.

OPERATIONAL LOAD

3 For weight and balance calculations operational load shall be defined as crew, fuel, oil and cargo. The word crew shall be taken to mean all personnel carried in the aircraft and responsible for the operation and maintenance of the aircraft for any particular flight. Cargo shall be taken to mean any or all of the following:-

- (a) Freight.
- (b) Passengers.
- (c) Baggage, crew and passenger.
- (d) Catering requirements, crew and passenger.
- (e) Additional safety equipment over and above the scale laid down for the Basic Weight.
- (f) Ammunition.

(g) Bombs.

(h) Rockets.

(j) Pyrotechnics over and above the scale laid down for the Basic Weight.

GROSS WEIGHT

4 The Gross Weight or All Up Weight as it is sometimes referred to is obtained by adding the basic weight and the operational load. The Gross Weight may be referred to as:-

DESIGN GROSS WEIGHT

(a) The Design Gross Weight is defined as the weight of an aircraft when loaded for its primary role. This is the weight upon which stress analysis is generally based.

MAXIMUM GROSS WEIGHT FOR TAKE-OFF

(b) This is the maximum overload gross weight at which the aircraft may take off. If this is greater than the Design Gross Weight, the aircraft shall be restricted to level flight and gentle manoeuvres until such time as the weight has been reduced by fuel consumption, dropping of bombs, etc., to the Design Gross Weight.

MAXIMUM GROSS WEIGHT FOR LANDING

(c) This is the Maximum Gross Weight at which the aircraft may be landed. Usually this conforms to the design gross weight, but in certain cases landing at a weight above normal is permitted. When this Maximum Landing Weight is not quoted, it is understood that the Design Gross Weight is to be the Maximum Weight for landing.

REFERENCE DATUM

5 The Reference Datum is an imaginary plane at or forward of the nose of the aircraft chosen so that all moments will be positive. All horizontal distances for balance purposes are measured from this line which is a pre-determined distance from some fixed jig point on the airframe. Diagrams for each aircraft show this reference datum as balance station zero.

ARM

6 For balance purposes the "Arm" shall be taken to mean the horizontal distance from the reference datum line to the C of G of the item given in inches.

7 Moment is defined as the weight of an item multiplied by its arm and is to be given the "inch-pounds" for these calculations.

AVERAGE ARM

8 The average arm of a system can be defined as follows:

$$\text{Average Arm} = \frac{\text{Sum of the Moments of that System}}{\text{Total Weight of the System}}$$

When an aircraft is weighed in its basic condition, the resultant will be known as Basic Arm.

BASIC MOMENT

9 The Basic moment is the sum of the moments of all items included in the basic weight. When using data from an actual weighing of an aircraft, the Basic Moment is the total moment of the Basic aircraft in respect to the reference datum.

CENTRE OF GRAVITY

10 The Centre of Gravity of an aircraft is defined as the point at which the total weight of the aircraft is assumed to act and about which the aircraft would balance if suspended. The distance of the C of G from the reference datum is found by dividing the total moment by the weight of the aircraft.

C OF G LIMITS

11 The C of G Limits encompass the range

of movement which the C of G can have without making the aircraft unstable. The C of G of an operationally loaded aircraft must be within these limits at all times. In some cases the take-off and landing limits may be specified.

TRAPPED FUEL AND OIL

12 The weight of fuel and oil remaining in the aircraft fuel and oil system when they are drained using the draining points provided and with the aircraft in the normal ground position.

RESIDUAL FUEL

13 The weight of fuel which cannot be used by the engines under normal conditions of flight but which may be drained using the draining points provided with the aircraft in the normal ground position.

BALLAST

14 Permanent fixed ballast, that is bolted or otherwise permanently attached to the aircraft and is required to maintain the proper C of G conditions, is to be shown on the applicable basic weight checking list in the -8 EO of the aircraft and will therefore be weighed and reflected in the basic weight. (Permanent Ballast is usually necessary to compensate for permanently removed items of basic equipment or to maintain C of G positions within C of G limits).

15 Semi-permanent fixed ballast that is not shown on the applicable basic weight check list in the -8 EO of the aircraft but is weighed with the aircraft will be shown in column 1 of the L36.

16 Loose or temporary ballast such as shot or sand bags etc. are to be removed from the aircraft prior to weighing. (Semi-permanent or temporary ballast is used to compensate for items that make up operational load that have been removed on a temporary basis e.g. ammunition, bombs, crew member etc.).

NOTE

If the removal of loose ballast is not feasible and is thereby weighed with the aircraft, it must be recorded in column 1 of the L36 and calculated accordingly.

PART 3

INSTRUCTIONS FOR USE OF CHARTS AND FORMS

GENERAL

1 There are two parts to the weight and balance problem. First, we must have the correct information as to basic weight and moment; second, the gross weight and balance must be retained within safe limits with the addition of the operation load. The first part is controlled after the basic weight and balance have been determined by weighing the aircraft. The second part is controlled in the loading of the aircraft and is indicated on the weight and balance clearance form.

PRIMARY WEIGHING INSTRUCTIONS

2 The following instructions are to be followed:-

(a) Assemble the necessary equipment,

including scales, hoisting equipment, jacks, cribbing, levelling bars, level, measuring tape, plumb bob and string.

(b) Clean the aircraft removing grease, dirt and moisture.

(c) Pump the fuel from the aircraft tanks into the refuelling tender. A sufficient quantity of fuel shall be left in the aircraft tanks to enable draining to be completed using tank drains with the aircraft in the normal ground attitude. All draining of fuel tanks shall be carried out in compliance with the safety precautions laid down in EO 00-80-4/6.

(d) Drain the oil tanks, but if this is impractical, fill the tanks to normal capacity.

(e) Fill the reservoirs of the hydraulic anti-icer and coolant system to normal level.

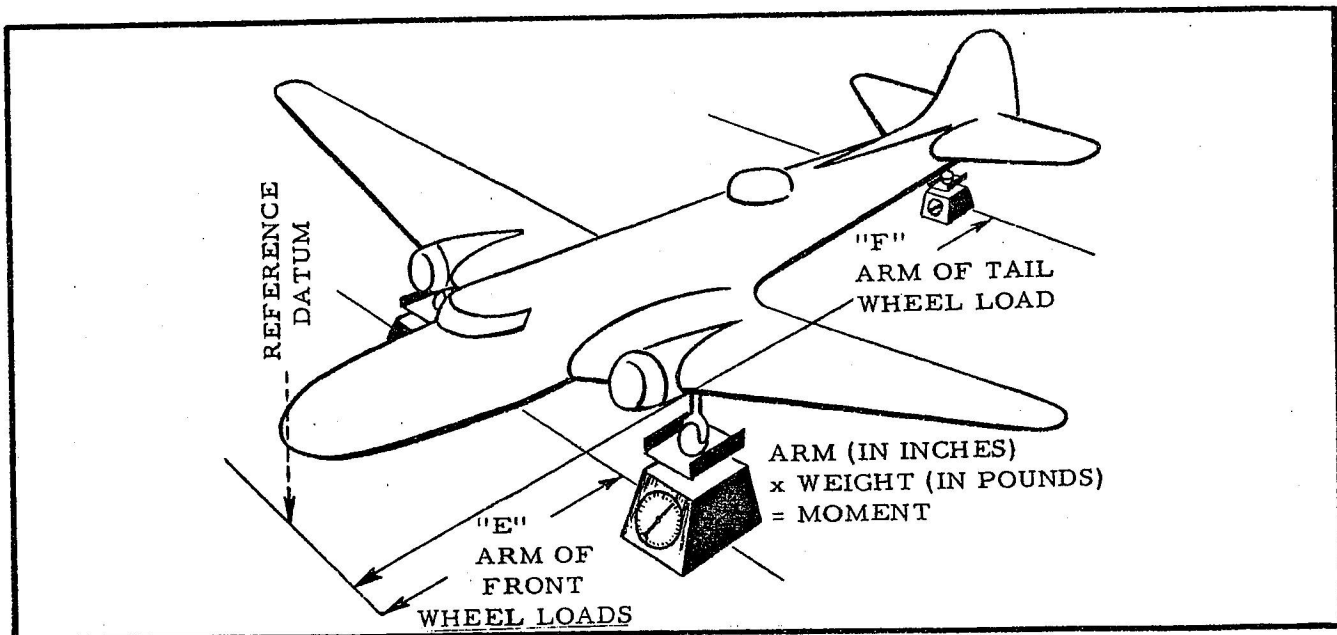


Figure 3-1 Weighing Aircraft

RCAF L36 (REV.)
40M-7-54

AIRCRAFT WEIGHING RECORD

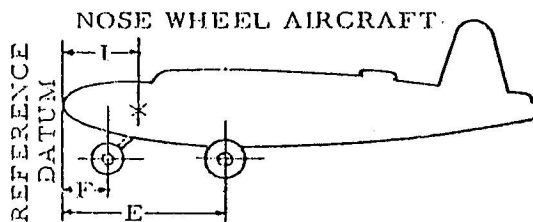
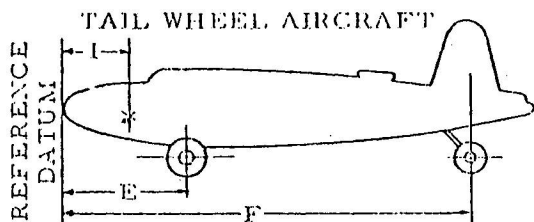
Date Weighed _____ Type and Mark _____ RCAF NO. _____

Place Weighed _____ Weighing Officer _____

Wheel	Scale Reading	Tare	Net Weight	Arm (Inches)	Moment
Left Main				X	X
Right Main				X	X
Sub-Total (Both Main)				E	
Nose or Tail				F	
Total (As Weighed)				H(C of G)	

MEASUREMENTS

- I = inches, the distance from the reference datum to some accessible exterior jig point or frame of the aircraft from which a plumb bob can be dropped to the ground. Obtain from the diagram on the balance computer or relevant EO.
- E = inches, the distance from the reference datum to the center line of the main support points.
- F = inches, the distance from the reference datum to the center line of the nose or tail support point.



DIAGRAMS FOR MEASURING VARIOUS TYPES OF AIRCRAFT TO DETERMINE ARM OF SUPPORT POINTS

NOTE: Existing stock of 40M-7-54 are to be used until depot stocks are depleted.

Figure 3-2 (Issue 2) Form L36

AIRCRAFT WEIGHING RECORD (Cont'd)				
Description	Net Weight	Arm	Moment	Moment/1000
Total (As Weighed)				
Oil in Aircraft	-		-	
Total of Items Weighed but not Part of Basic Weight (From Col. 1 below)	-		-	
Total of Basic Items not in Aircraft When Weighed (From Col. 2 below)	+		+	
Basic Aircraft		H (C of G) Index		

Column 1				Column 2			
Items Weighed But Not Part of Basic Weight	Weight	Arm	Moment	Basic Items Not in Aircraft When Weighed	Weight	Arm	Moment
TOTAL:		 		TOTAL:		 	

REMARKS:
 Type of Scales used _____
 Method of Support _____
 Attitude (Level-Normal) _____

Whenever possible aircraft are to be weighed with all and only basic equipment installed. If any item of basic equipment is missing, it must be recorded in Column 2. Items weighed, but not part of the basic equipment, must be noted in Column 1. Items listed in Column 1 and/or Column 2 must be considered when finding the CG of the Basic Aircraft.

Figure 3-3 (Issue 1) Form L36 (Cont'd)

(f) Inflate or deflate the main landing gear oleo struts to normal extension or to any desired height. It may be helpful for levelling and in jacking aircraft to lash a rope around the torque arm of the oleo or to apply a stiffener so that the strut will not extend when the aircraft is lifted. The nose wheel may be blocked to prevent turning.

(g) Check the aircraft against the applicable Basic Weight Check List in EO 05--8 and any differences shall be listed in column 1 or 2 of the L36.

(h) If aircraft tail is to be jacked or hoisted to place the aircraft in the level position, the following sequence will be observed:-

- (1) Release brakes.
- (2) Jack or hoist tail to level position, if using a sling check the chain with a level to ensure it is a perpendicular lift.
- (3) Place jacks in wing jacking positions and operate all jacks and hoist simultaneously to maintain a level lift.

NOTE

The above precautions are necessary to reduce the possibility of side loadings or thrust on the scales which may result in a false weight being recorded. Jacking precautions as laid down in the "-2" EO of the Aircraft EO series shall be complied with at all times.

NOTE

The aircraft must be weighed in a closed hangar. Heating fans directed on the aircraft shall be turned "OFF".

USE OF AIRCRAFT WEIGHING RECORD L36

3 Instructions for the use of the form are as follows:-

(a) Fill in the identifying data and enter the actual scale readings in the first column.

(b) Subtract the tare weight, if any, from the scale readings to obtain the net weight. (The tare weight is the weight of equipment required for weighing the aircraft, such as chocks and lifting bars which are included in the scale readings).

(c) Determine the arms E and F by measurement from the datum line to the center line of the aircraft support points when the aircraft is in the horizontal position. Be sure to read the measuring tape graduations correctly.

(d) Multiply the sub-total net weight of the main support points and the net weight of the nose or tail support point by their respective arms (dimensions E and F) to obtain their moment.

(e) Add the net weights and the moments of the main support points and the nose or tail support points.

(f) Divide the total moment by the total net weight to obtain the C of G position in inches from the reference datum.

(g) Transfer "Total (as weighed)" weight, arm and moment to the reference side of the L36.

(h) Subtract the total weight and moment of items entered in column 1.

(j) Add the total weight and moment of items entered in column 2.

NOTE

Aircraft should normally be equipped completely as laid down in the Basic Weight Check List in EO 05--8. If this is done columns 1 and 2 should not normally be required.

When columns 1 and 2 of the Weighing Record are used, they are to be considered as an inventory of any deviation in equipment from the Basic Weight Scale.

(k) Complete final line of the Weighing Record showing the C of G and Moment/1000. For a light aircraft the moment may be given directly, while for heavy aircraft Moment/10,000 may be used. It shall be left to the discretion of the weighing officer to decide the method of recording the aircraft moment.

(m) Information regarding the type of scales used, the attitude of the aircraft, during weighing, the method of support, and the weight and location of ballast, if installed, is to be entered in the "REMARKS" paragraph.

NOTE

Sample copies of Forms L36 and L38 form part of EO 05-1-8. Each relevant aircraft weight and balance EO 05--8 shall contain complete current weight and balance data on these forms and they shall form part of the aircraft "-8" EO. Transport, communication and helicopter aircraft shall carry the completed EO 05--8 at all times. The duplicate copies of Forms L36 and L38 shall be kept with the aircraft log book, plus the L36 from the previous weighing. Stocks of forms are to be demanded as required.

AIRCRAFT BASIC WEIGHT CHANGE RECORD L38

4 This form shall be used to record the result of each aircraft weighing and all changes which may occur as a result of addition or removal of installed equipment. Personnel responsible for the serviceability and loading of the aircraft will observe the following action:-

(a) It is the responsibility of the Chief Technical Services Officer to ensure that the

addition or deletion of basic equipment (see definition of Basic Weight, Part 2, para. 2) after weighing, must be correctly recorded in the L38, Basic Weight Change Record, and the new Basic Weight calculated. If such changes in the aircraft equipment warrant it, the aircraft shall be re-weighed and a new L36 completed.

MAINTENANCE PERSONNEL

(b) When the C of G limits are shifted to the critical ranges by a weight change, an entry shall be made in the L14 Aircraft Maintenance Record set. The aircraft will remain unserviceable until such times as the critical condition is rectified or the aircraft weighed and found to be within the C of G limits.

LOADING PERSONNEL

(c) Personnel responsible for the loading of the aircraft shall refer to this form to obtain the C of G index prior to loading of the aircraft.

BASIC WEIGHT CHECK LIST

5 The Basic Weight Check List consists of a check-off list for all fixed operating equipment items (e.g. machine guns, cameras etc.) which:

- (a) Have a definite location in the aircraft.
- (b) Are, or at some time will be, installed.
- (c) Are an alternate installation for standard equipment. In addition, the weight of each item is given in pounds, its location, from the reference point (arm) in inches and the moment calculated.

6 Items will be listed according to their compartment location. For example A - nose B - pilot's compartment etc. Equipment within each compartment should be listed consecutively e.g. equipment in compartment "A" to be listed as A-1, A-2 A-3 etc.

7 The column "Delivery Equipment" may be used by the manufacturer/contractor to check off the items in the aircraft at the time of delivery. User units should consider the check list an inventory and X all items.

presently installed in the "In Aircraft" column. Any items not installed, designated with an O in the same column.

NOTE

When an aircraft is weighed, items which have been previously tallied with an X but are temporarily removed must be listed in column 2 of the L36. (When such basic weight items are replaced after the aircraft weighing, they must not be recorded in the L38 since they have already been calculated).

Some Basic Check Lists itemize optional equipment such as wheels, skis, flotation gear, float ladders etc. When an aircraft is weighed, only that equipment which is necessary for its present configuration should be considered. It is obvious that the balance of optional check list items which are not required must not be listed in column 2 of the L36. Subsequent changes to the configuration as weighed, by substitution of the optional items, must be recorded in the L38 unless it is considered necessary to re-weigh the aircraft.

PART 4

BALANCE COMPUTER (COX & STEVENS)**GENERAL**

1 The purpose of these descriptions and instructions is to provide a means for determining the basic index on an applicable load adjuster when provided with the aircraft basic weight and total moment.

DESCRIPTION**GENERAL**

2 The balance computer has an appearance similar to the widely used mathematical slide rule. The balance computer, however, adds and subtracts moments. Each loading scale represents a combination of weight and moments or the effect of load (weight) placed in a given location. In agreement with all standard aeronautical drafting practices, the left end of the balance computer represents the nose of the aircraft and the right end represents the tail. Consequently, loading any items that cause the indicator hairline to move to the left tends toward a forward center of gravity position, and loading any item that causes the indicator hairline to the right tends toward an aft center of gravity position.

BASE

3 The base of the balance computer contains grooves in which the slide and the indicator move back and forth. The far (top) side of the face shows the balance ranges; the rear (bottom) side shows the index scale. On the back of the base is a plan view of the fuselage showing the compartmentation and centroids with a corresponding reference scale in inches. On the portion under the slide is a grid consisting of horizontal and sloping vertical lines with the horizontal lines representing gross weight and the

sloping lines representing percent of MAC or inches from reference datum. The forward and aft sloping limits are marked in red. The loading range may be thought of as representing that short section of the aircraft in which the C of G may be located for all conditions of safe flight. Dangerous flight conditions exist if the C of G falls beyond the loading range.

CAUTION

When the C of G falls within the critical flight conditions, the applicable -8 EO for the specific aircraft must be checked, the -8 EO of the specific aircraft being the final authority for C of G limits.

SLIDE

4 The top face of the flat sliding portion of the balance computer has loading scales for use in adjusting the C of G position. They are designed to fit the requirements of specific aircraft models. The various loading scales are used to compute the effect on the C of G when such items as fuel, bombs, crew and cargo are loaded in various parts of the aircraft. The reverse side of the slide usually shows scales with the weight plotted against moment/constant. These scales are used to rapidly determine the index for a particular basic condition of weight and moment.

INDICATOR

5 The indicator is a rectangular piece of transparent plastic, with a hairline perpendicular to the scales, and is used to make the balance computer setting. The

hairline indicates a C of G position in relation to the balance limits. In all operations on the balance computer, the indicator hairline is used to line up the settings.

DEFINITIONS

6 In order to obtain a reading on the balance computer, the following definitions should be understood:-

INDEX

(a) "Index" as a term used in connection with the balance computer is a value expressing the combined effect of weight and moment.

SIMPLIFIED MOMENT

(b) "Simplified moment" is the moment (inch-pounds) divided by a constant. Its purpose is to make the numerical size of a moment smaller. The constant may be 100, 1000, 10000, etc., depending on the size of the particular aircraft. The constant to be used with the specific aircraft computer normally appears on the left hand end on the back face of the slide.

EXAMPLE

$$\text{Simplified moment} = \frac{\text{moment}}{\text{constant}} = \frac{4,500,000}{1,000} = 4,500$$

BASIC INDEX

(c) "Basic index" is that location on the balance computer index scale, expressed numerically, which represents the C of G location of the aircraft in its basic condition. Whenever any change is made to the aircraft basic condition which adds, subtracts or moves weight and thereby changes the basic C of G location, the basic index must be determined as per paragraph 7.

DETERMINATION OF BASIC INDEX BY BALANCE COMPUTER

7 The basic weight and moment/constant scales are on the back of the slide. Since the range of weight and moment/constant is so great as to require scales two, and frequently three, times the length of the slide, they have been divided into sections. No complications are involved, however, in finding basic index when basic weight is located on one section of the compound scale and moment/constant on another.

BASIC INDEX DETERMINATION SETTINGS

8 The operations involved in determining the basic index by use of balance computer settings are as follows:-

METHOD 1

(a) Move indicator until hairline is over the arrow at zero index.

(b) Move slide until the basic weight is under hairline.

(c) Move indicator until hairline is over basic weight moment/constant. If this is not possible, proceed to determine basic index as per Method 2.

(d) Read basic index at intersection of hairline with index scale.

METHOD 2

(e) Move indicator until hairline is over the arrow at zero index.

(f) Move the slide until the basic weight is under the hairline.

(g) Move indicator to the right until hairline is over the final moment/constant

figure at right hand end of the same scale on which the basic weight occurs.

(h) Move slide to the right until the mark for the same moment/constant that resulted from procedure (g) is under

hairline on next scale below.

(j) Move indicator until hairline is over actual basic moment/constant.

(k) Read basic index at intersection of hairline with index scale.

