

6.1 Introduction

This section describes the procedures for establishing the empty mass and the empty mass moment of the sailplane. Procedures for calculating the mass and moment are also provided.

A list of equipment installed is part of the currently valid inspection and weighing record.

As the C.G. position is of vital importance for a safe flight, the limits laid down must on no account be exceeded.

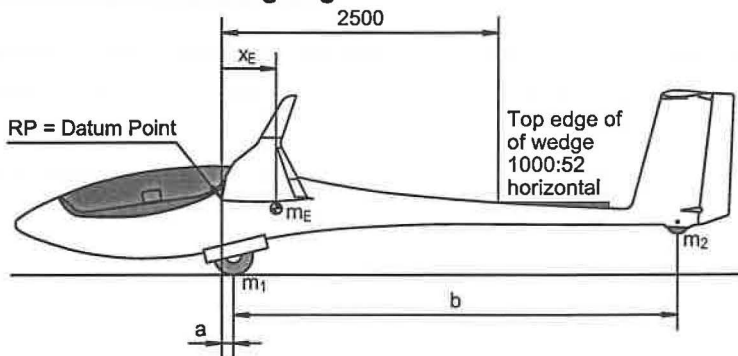
It is especially important after repairs, re-finishing and the fitting of additional equipment to ensure that the empty mass C.G. remains within permissible limits. If this cannot be proved by calculation, the aircraft must be re-weighed.

6.2 Weighing Procedures

The Datum (Reference) Point (German: **BezugsPunkt = BP**) for weighing and calculation of the C.G. is the **wing leading edge** at the root rib.

Prior to weighing, level the sailplane, so that a wedge 1000:52 on the tail boom in front of the fin is horizontal (see fig. 6.2-1). The weighing is best done on two scales (accurate to 1kg at least for the main wheel and 0.1kg for the tail wheel).

Fig. 6.2-1 Attitude for Weighing



Position of empty mass C.G. x_E :

$$x_E = \frac{m_2 * b}{m_E} + a \quad \text{aft of Datum}$$

Empty mass m_E :

$$m_E = m_1 + m_2$$

The weighing is done with 18m-outer wings rigged. In addition, the plane must be in the following condition:

1. landing gear extended
2. flight instruments fitted and canopy closed
3. seat backrest and seat cushion or equivalent in place
4. with aircraft log book and Flight Manual in place
5. without fin ballast (battery), if supplied
6. without removable trim ballast in the front cockpit, if supplied
7. without parachute
8. without oxygen bottle, if supplied

6.3 Weighing Record

The weighing results must be stated in a weighing record which includes a list of equipment fitted at the time, and which must be incorporated in the aircraft service record and in the Flight Manual, section 6)

6.4 Basic Empty Mass and Moment

The empty mass and the empty mass moment can be established by weighing as described under 6.2, or may be taken from the currently valid inspection report.

The maximum and minimum permissible cockpit load in the pilot seat can be determined with the diagram overleaf.

As the in-flight-c.g. is closer to the limits with 18m-wings mounted, the glider has to be weighed with 18m wingtips. Diagram 6.4.1 gives the information necessary for the mass and balance form.

The empty mass diagram for the 15 m-outer wings is only specified for sheer completeness (fig. 6.4-2). For this diagram, the glider has to be weighted with 15m-outer wings.

Admitted In-flight CG position behind Datum point:

	18 m	15 m
front flight CG position	217 mm 8,54 inch	213 mm 8.38 inch
rear flight CG position	330 mm 12.6 inch	335 mm 13.1 inch

Fig. 6.4-1 Diagram of Empty Mass C.G. Position with 18 m

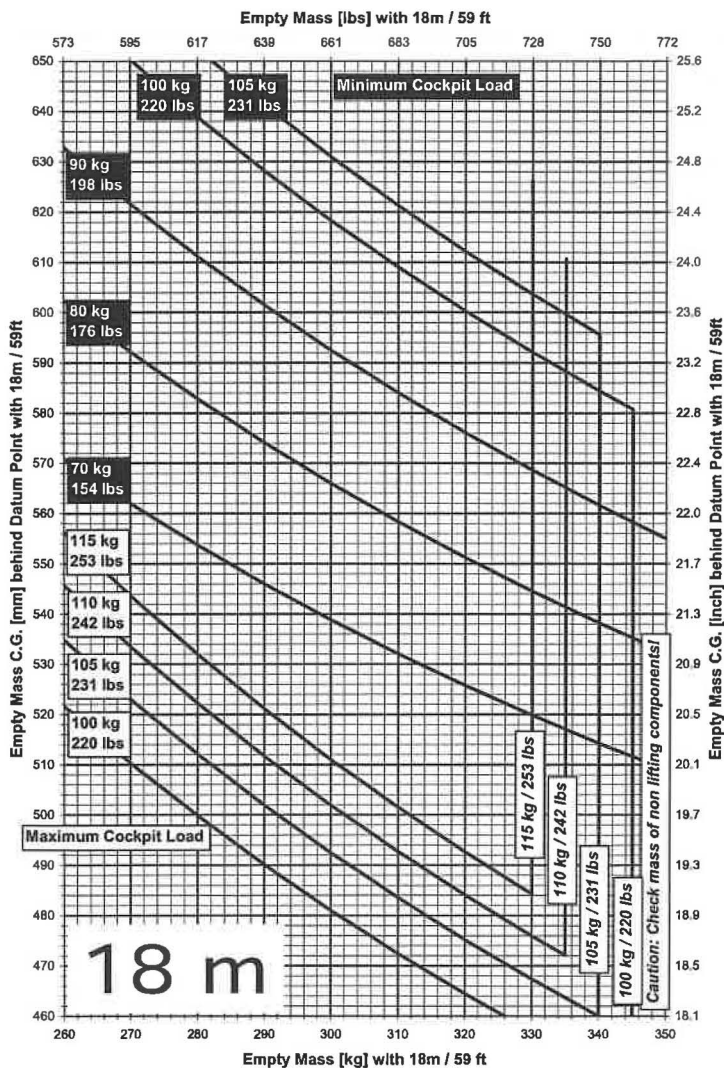
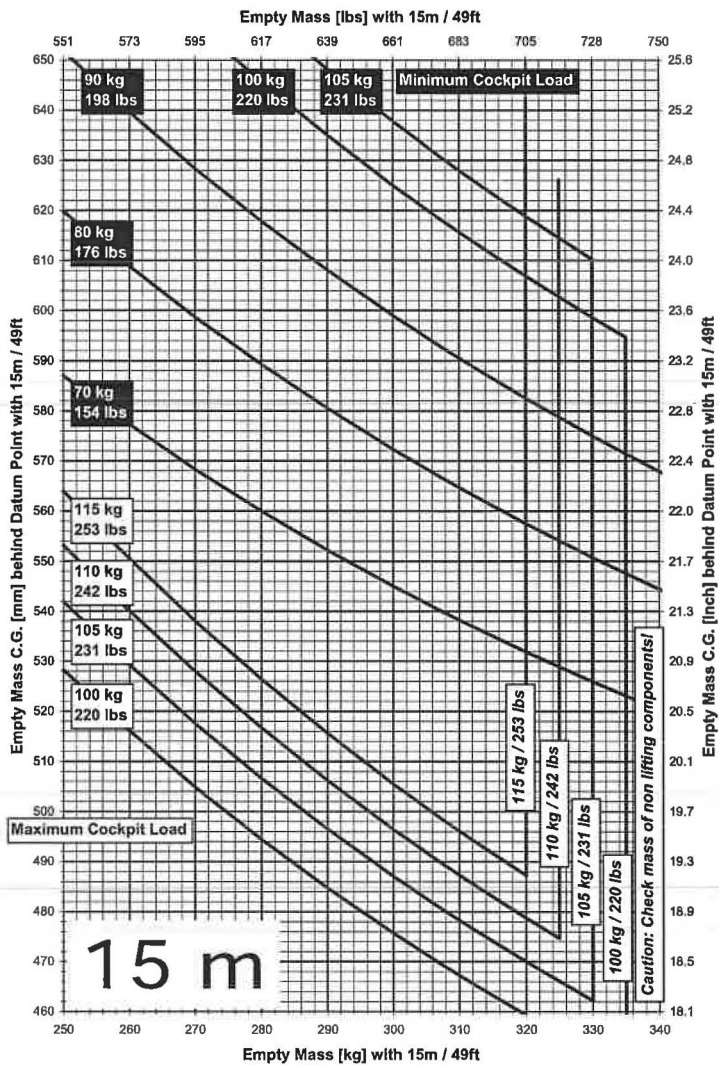


Fig. 6.4-2 Diagram of Empty Mass C.G. Position with 15 m



6.5 Mass of Non-Lifting Parts

The maximum permissible mass of non-lifting parts is **285 kg (627 lbs)**. These non-lifting parts include:

- Fuselage, horizontal and vertical tail
- Equipment fitted in fuselage as listed under 6.2
- Pilot and parachute (max. 115 kg = 253 lbs. max.)
- Baggage
- Equipment carried on board in flight but NOT weighed as under 6.2 (e.g. O₂)

6.6 Mass and Balance Form

The Mass and Balance form is included in Section 6 of the **Flight Manual**. After weighing the aircraft, the maximum and minimum permissible loads in the seat and the total useful load in the fuselage are entered in this Mass and Balance Form, using the diagram fig.6.4-1.

This will ensure that the in-flight C. G. will always be within safe and approved limits, as long as the load limitations are observed.

Trim ballast mounted in the fin increases the minimum cockpit load. For safety reasons, if removable trim ballast in the fin is provided, the Mass and Balance Form must show the elevated minimum cockpit load.

Then, a placard near the **Mass and Balance Form** of the cockpit has to point out, that in the **Flight Manual Section 6.2** a lower minimum cockpit load **without** tail ballast is registered.

EXAMPLES:

(1) A weighing with 18 m according to Section 6.2 resulted in following values:

- m_E

=

289 kg

(637 lbs)

(empty mass)
- x_E

=

534 mm

(21,0 inch)

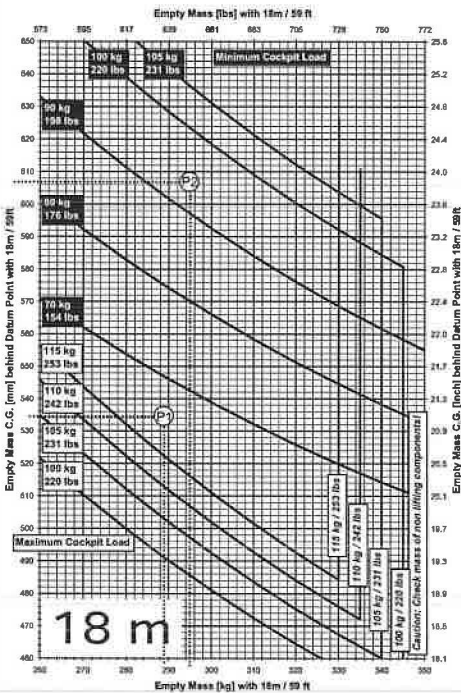
(empty mass C.G.)
- m_{nlp}

=

125 kg

(276 lbs)

(mass of non lifting parts)



Refer to figure 6.4-1:

The measured point P1 lies under the line with 70 kg (154 lbs.) min. cockpit load in the seat and over the line of the max. cockpit load of 115 kg (253 lbs.).

The point is quite far from the right, so the cockpit load is not limited by the maximum mass of non lifting parts:

$285\text{kg} - 125\text{kg} = 160\text{kg}$

The sailplane is within the necessary limits and can be flown by a pilot with a weight between 70 kg to 115 kg (154 lbs to 253 lbs) including parachute.

The amount of water, which may be loaded, depending on the span, can be obtained from the tables in Flight Manual Section 6.3.

- (2) A second weighing with a removable trim ballast of 6 kg (13,23 lbs) in the fin showed:

$$\begin{aligned}
 m_E &= 295 \text{ kg} \quad (650 \text{ lbs}) \quad (\text{empty mass}) \\
 x_E &= 607 \text{ mm} \quad (23,9 \text{ inch}) \quad (\text{empty mass C.G.}) \\
 m_{nlp} &= 131 \text{ kg} \quad (289 \text{ lbs}) \quad (\text{mass of non lifting parts})
 \end{aligned}$$

In the diagram, point P2 is **above** the line of minimum cockpit load of "90 kg (198 lbs)" but below the line of 100 kg (220 lbs.). A value of 94 kg can be measured. Therefore, the "Mass and Balance Form" placard in the cockpit must show a min. cockpit load of 94 kg (207 lbs.), for pilot incl. parachute and the following placard must be fixed in addition:

Reduced minimum Cockpit Load
without Trim Ballast in the Fin:
 see Flight Manual Page 6.4 !

The Mass and Balance Form in the Flight Manual page 6.4 must be filled in according to the following example:

Date of Weighing	Empty mass ¹⁾ (18m)	Empty mass C.G. aft of RP ²⁾ (18m)	Pilot mass incl. parachute ¹⁾ (15&18m)		Total useful load in fuselage ^{1,3)} (15&18m)	Inspector's stamp and signature
			min	max		
xx.xx.xx	289 kg 637 lbs	534 mm 21.0 inch <u>without</u> trim-ballast in the fin	70 kg 154lbs	115 kg 253lbs	160 kg 353 lbs	
	295 kg 650 lbs	607 mm 23.9 inch <u>with</u> 6kg trim-ballast in the fin	94 kg 207lbs	115 kg 253lbs	154 kg 339 lbs	
						+++

- 1) For U.S.-registered sailplanes show lbs.
- 2) For U.S.-registered sailplanes show inches.
Other countries may use metric units
- 3) Total useful load in fuselage = 285 kg (628 lbs) less empty mass of non-lifting parts

6.7 Useful Load

The useful cockpit load is influenced and limited by various factors:

- (1) **Total mass of non-lifting parts:**
must not exceed 285kg (627lbs).
- (2) **In-flight C.G. position:** must remain in the range 217mm–330mm (8.54 – 12.6in.) behind datum point for 18m wing tips, respectively in the range 213mm–335mm (8.38–13.1in.) for 15m wing tips.
- (3) **Maximum Take-Off Mass:** must not exceed 600kg (1322lbs) with 18m wing tips respectively 550 kg (1212 lbs) with 15m wing tips.
This mainly affects the water ballast load.

Load in the baggage compartment

The mass of the baggage is calculated as follows:

max. mass of non-lifting parts	=	285 kg	(627 lbs.)
- weighed mass of non-lift. parts	=	xxx kg	(xxx lbs.)
- actual load in the seat	=	xx kg	(xxx lbs.)
- fuselage water ballast	=	xx kg	(xxx lbs.)
= permissible load in the baggage compartment	=	xx kg	(xx lbs.)

But do not exceed 5 kg (11 lbs.) in the baggage compartment besides the landing gear box and 12 kg (26.5 lbs.) in the baggage compartment behind the headrest.

Useful Load with 15m span

In comparison with the 18m outer wings, the set of 15m outer wings is approximately 10 kg (22 lbs) lighter. On the other hand the max. take-off mass with 15m span is reduced by 50kg (110lbs) compared to the 18m-configuration. Therefore the permissible water ballast mass with 15m span is 42 kg (92 lbs) lower as with 18m-outer wings. See the table in the Flight Manual, Section 6.3.

The permissible weight of the non-lifting parts does not change, nor does the load in the baggage compartment.

6.8 Calculation of in Flight Mass/C.G.

(1) How to determine **pilot mass arms**:

Pilot arm for calculations concerning the **rear** c.g. limit

565mm	(22.2 inch)	in front of the datum point for a	70kg	(154 lbs)	pilot including parachute
545mm	(21.5 inch)		90kg	(198 lbs)	
530mm	(20.9 inch)		105kg	(231 lbs)	

This is approximately correct with the backrest in the rear hinge position and can be expressed in a formula as (with x_p as pilot mass arm and m_p as pilot mass):

$$x_p [\text{mm}] = m_p [\text{kg}] - 635$$

or

$$x_p [\text{inch}] = 0.0179 m_p [\text{lbs}] - 25$$

Pilot arm for calculations concerning the **forward** c.g. limit

615mm	(24.2 inch)	in front of the datum point for a	70kg	(154 lbs)	pilot including parachute
590mm	(23.4 inch)		95kg	(209 lbs)	
580mm	(22.8 inch)		100kg	(220 lbs)	
550mm	(21.7 inch)		115kg	(253 lbs)	

If an exact pilot mass arm is needed, a weighing must be done with the pilot incl. parachute in place.

(2) Calculation of In-Flight C.G. Position

$$X_{C.G.} = \frac{X_E \cdot m_E + X_P \cdot m_P + X_W \cdot m_W + X_{O_2} \cdot m_{O_2} + X_G \cdot m_G + X_B \cdot m_B}{m_E + m_P + m_W + m_{O_2} + m_G + m_B}$$

X_E	(mm)	Empty mass C.G. position
m_E	(kg)	Empty mass
X_P	(mm)	Pilot mass arm
m_P	(kg)	Mass of the pilot incl. parachute
X_W	(mm)	Distance of the water ballast from datum point
m_W	(kg)	Mass of water ballast (1 liter = 1 kg or 2,2 lbs)
X_{O_2}	(mm)	Distance of the oxygen bottle from datum point in standard fitting location (if fitted)
m_{O_2}	(kg)	Mass of the oxygen bottle
X_G	(mm)	Distance of the baggage compartment from datum point
m_G	(kg)	Mass in baggage compartment
X_B	(mm)	Distance of the fin mounted battery from datum point (if fitted)
m_B	(kg)	Mass of battery or trim weight in the fin

Regard every mass and ballast (wing, tail, fuselage) separately with its own lever arm. The above formula can only be an example.