Design of a system for measuring the weight and balance of sailplanes

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# Sailplane specifications

## 1.1 General data

<table>
<thead>
<tr>
<th>Model</th>
<th>Manufacturer</th>
<th>Year</th>
<th>Type</th>
<th>Span (m)</th>
<th>Length (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASK 13</td>
<td>Schleicher</td>
<td>1966</td>
<td>Two seater</td>
<td>15.4</td>
<td>8.18</td>
</tr>
<tr>
<td>ASK 21</td>
<td>Schleicher</td>
<td>1979</td>
<td>Two seater</td>
<td>17.0</td>
<td>8.35</td>
</tr>
<tr>
<td>ASW 20</td>
<td>Schleicher</td>
<td>1977</td>
<td>Single seater</td>
<td>15.0</td>
<td>6.80</td>
</tr>
<tr>
<td>DG-1000S</td>
<td>DG Flugzeugbau</td>
<td>2000</td>
<td>Two seater</td>
<td>20.0</td>
<td>8.57</td>
</tr>
<tr>
<td>G102 Astir CS</td>
<td>Grob</td>
<td>1974</td>
<td>Single seater</td>
<td>15.0</td>
<td>6.47</td>
</tr>
<tr>
<td>G103 Twin II</td>
<td>Grob</td>
<td>1980s</td>
<td>Two seater</td>
<td>17.5</td>
<td>8.18</td>
</tr>
<tr>
<td>Ka 6E</td>
<td>Schleicher</td>
<td>1955</td>
<td>Single seater</td>
<td>15.0</td>
<td>6.66</td>
</tr>
</tbody>
</table>

Table 1: Sailplanes' general data.

## 1.2 Weight and balance

### 1.2.1 Weights

<table>
<thead>
<tr>
<th>Model</th>
<th>Empty weight (kg)</th>
<th>Maximum weight (kg)</th>
<th>Maximum weight of non-lifting parts (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASK 13</td>
<td>295</td>
<td>481</td>
<td>322</td>
</tr>
<tr>
<td>ASK 21</td>
<td>380</td>
<td>600</td>
<td>410</td>
</tr>
<tr>
<td>ASW 20</td>
<td>255</td>
<td>454</td>
<td>235</td>
</tr>
<tr>
<td>DG-1000S</td>
<td>415</td>
<td>750</td>
<td>469</td>
</tr>
<tr>
<td>G102 Astir CS</td>
<td>255</td>
<td>450</td>
<td>240</td>
</tr>
<tr>
<td>G103 Twin II</td>
<td>380</td>
<td>580</td>
<td>400</td>
</tr>
<tr>
<td>Ka 6E</td>
<td>190</td>
<td>300</td>
<td>190</td>
</tr>
</tbody>
</table>

Table 2: Empty weights, maximum weights and maximum non-lifting parts weights.

### 1.2.2 Weight distribution

<table>
<thead>
<tr>
<th>Model</th>
<th>Representative front weight (G1) (kg)</th>
<th>Representative rear weight (G2) (kg)</th>
<th>Max. G1 (kg)</th>
<th>Max. G2 (kg)</th>
<th>Min. G1 (kg)</th>
<th>Min. G2 (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASK 13</td>
<td>295.4</td>
<td>4.6</td>
<td>318.2</td>
<td>272.1</td>
<td>7.9</td>
<td>1.8</td>
</tr>
<tr>
<td>ASK 21</td>
<td>360.4</td>
<td>14.6</td>
<td>389.4</td>
<td>334.1</td>
<td>15.9</td>
<td>10.6</td>
</tr>
<tr>
<td>ASW 20</td>
<td>225.8</td>
<td>39.2</td>
<td>251.6</td>
<td>202.6</td>
<td>46.2</td>
<td>34.4</td>
</tr>
<tr>
<td>DG-1000S</td>
<td>387.8</td>
<td>52.2</td>
<td>430.2</td>
<td>345.3</td>
<td>59.8</td>
<td>48.5</td>
</tr>
<tr>
<td>G102 Astir CS</td>
<td>218.4</td>
<td>31.6</td>
<td>249.5</td>
<td>196.9</td>
<td>36.5</td>
<td>24.9</td>
</tr>
<tr>
<td>G103 Twin II</td>
<td>359.1</td>
<td>20.9</td>
<td>382.9</td>
<td>337.4</td>
<td>22.6</td>
<td>17.1</td>
</tr>
<tr>
<td>Ka 6E</td>
<td>174.6</td>
<td>25.4</td>
<td>196.4</td>
<td>163.5</td>
<td>29.5</td>
<td>22.4</td>
</tr>
</tbody>
</table>

Table 3: Sailplanes' weight distributions (front and rear weighing points).

---

1 By representative we indicate those weights used for all uncertainty calculations.
1.3 Distances and angles

<table>
<thead>
<tr>
<th>Model</th>
<th>L1 (m)</th>
<th>L2 (m)</th>
<th>Datum transversal position $Y_0$ (m)</th>
<th>Rear weighing point height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASK 13</td>
<td>4.80</td>
<td>-0.41</td>
<td>0.622</td>
<td>0.682</td>
</tr>
<tr>
<td>ASK 21</td>
<td>4.61</td>
<td>-0.59</td>
<td>0.400</td>
<td>0.489</td>
</tr>
<tr>
<td>ASW 20</td>
<td>4.16</td>
<td>0.00</td>
<td>0.314</td>
<td>0.295</td>
</tr>
<tr>
<td>DG-1000S</td>
<td>5.18</td>
<td>-0.11</td>
<td>0.363</td>
<td>0.659</td>
</tr>
<tr>
<td>G102 Astir CS</td>
<td>4.09</td>
<td>-0.11</td>
<td>0.322</td>
<td>0.507</td>
</tr>
<tr>
<td>G103 Twin II</td>
<td>4.34</td>
<td>-0.50</td>
<td>0.374</td>
<td>0.405</td>
</tr>
<tr>
<td>Ka 6E</td>
<td>4.49</td>
<td>0.00</td>
<td>0.619</td>
<td>0.227</td>
</tr>
</tbody>
</table>

Table 4: Relevant distances (estimated).

<table>
<thead>
<tr>
<th>Model</th>
<th>Estimated vertical CG position $^2$ (m)</th>
<th>Levelling angle $\theta_0$ (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASK 13</td>
<td>0.730</td>
<td>3.15</td>
</tr>
<tr>
<td>ASK 21</td>
<td>0.693</td>
<td>2.98</td>
</tr>
<tr>
<td>ASW 20</td>
<td>0.572</td>
<td>2.58</td>
</tr>
<tr>
<td>DG-1000S</td>
<td>0.800</td>
<td>1.89</td>
</tr>
<tr>
<td>G102 Astir CS</td>
<td>0.628</td>
<td>2.48</td>
</tr>
<tr>
<td>G103 Twin II</td>
<td>0.629</td>
<td>2.29</td>
</tr>
<tr>
<td>Ka 6E</td>
<td>0.540</td>
<td>5.14</td>
</tr>
</tbody>
</table>

Table 5: CG vertical position and levelling angle (in flight position).

1.4 Other specifications

<table>
<thead>
<tr>
<th>Model</th>
<th>Tyre pressure (bar)</th>
<th>Tyre contact area (m$^2$)</th>
<th>Tyre diameter (mm)</th>
<th>Tyre width (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASK 13</td>
<td>2.413</td>
<td>0.0129</td>
<td>354</td>
<td>122</td>
</tr>
<tr>
<td>ASK 21</td>
<td>2.700</td>
<td>0.0141</td>
<td>354</td>
<td>122</td>
</tr>
<tr>
<td>ASW 20</td>
<td>2.500</td>
<td>0.0099</td>
<td>354</td>
<td>122</td>
</tr>
<tr>
<td>DG-1000S</td>
<td>2.500</td>
<td>0.0169</td>
<td>380</td>
<td>146</td>
</tr>
<tr>
<td>G102 Astir CS</td>
<td>2.533</td>
<td>0.0097</td>
<td>354</td>
<td>122</td>
</tr>
<tr>
<td>G103 Twin II</td>
<td>2.500</td>
<td>0.0150</td>
<td>436</td>
<td>155</td>
</tr>
<tr>
<td>Ka 6E</td>
<td>2.413</td>
<td>0.0080</td>
<td>330</td>
<td>124</td>
</tr>
</tbody>
</table>

Table 6: Main wheel tyres data.

$^2$ Measured from the ground when the sailplane is in flight position and the main wheel is touching the ground.
2 Sailplane manuals information

In this section, you will find the pages of the sailplanes’ manuals which provide the necessary data used in this project.

2.1 ASK 13 [1]

---

### AS - K 13 Flight Manual

#### 1. Operating Limitations

**Air speeds:**

- Max. speed: 125 mph, 108 kts
- Rough air: 87 mph, 75 kts
- Aero tow: 87 mph, 75 kts
- Auto and winch tow: 62 mph, 53 kts

**Weights:**

- Empty weight: 650 lbs
- Max. weight: 1060 lbs
- Max. weight of non lifting parts: 710 lbs

**Category:** 2 BVLS

**Limit load factor:**

- Up: 4.0
- Down: -2.0

**Safety factor:** 2.0

---

*Approval of translation has been done by best knowledge and judgement. In any case the original text in German language is authoritative.*
Center of gravity position in flight:

<table>
<thead>
<tr>
<th></th>
<th>Tangente to rib Nr. 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leveling means</td>
<td>horizontal</td>
</tr>
<tr>
<td>Datum</td>
<td>wing leading edge rib 3</td>
</tr>
<tr>
<td>Max. forward</td>
<td>2,75 behind datum point</td>
</tr>
<tr>
<td>Max. rearward</td>
<td>9,7</td>
</tr>
</tbody>
</table>

Weak link in the tow cable:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Winch tow</td>
<td>max. 2350 lbs</td>
</tr>
<tr>
<td></td>
<td>min. 1850 lbs</td>
</tr>
<tr>
<td>Aero tow</td>
<td>max. 1580 lbs</td>
</tr>
<tr>
<td></td>
<td>min. 1060 lbs</td>
</tr>
</tbody>
</table>

2. Operating Directions:

Winch tow:

Max. tow speed is 62 mph.

Attention. In winch tow pulling the stick back means increase of speed. When lifting off ease the stick somewhat to overcome a light tendency to pitch up. Best attitude in climb is with stick normal. Winch tow on the belly hook only.
With pushed and pulled stick the ailerons are some what zoomed.

The controls have stops:

Rudder control: Fixed stop at the lower hinge.

Aileron control: Fixed stop at two hard wood pieces down the front seat.

Elevator control: Backward – fixed stop at the front edge of the seat, forward – fixed stop at the ground board.

Airbrakes:
Backward: Adjustable stop at the horizontal pushrod, stops against the main bulkhead frame.
Forward: Fixed stop, cross shaft lever stops at a tube piece.

6) Weights and Center of Gravity Positions:
   After repairs, after installing of additional equipment, after new painting etc. there should be watched that the empty weight center of gravity is within the limits. If necessary balance weights are to be installed.

<table>
<thead>
<tr>
<th>Empty weight</th>
<th>616</th>
<th>638</th>
<th>660</th>
<th>682</th>
<th>705</th>
<th>lbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>center of gravity position</td>
<td>max. 21,45</td>
<td>21,06</td>
<td>20,68</td>
<td>20,3</td>
<td>20,0</td>
<td></td>
</tr>
<tr>
<td>behind datum point.</td>
<td>min. 19,3</td>
<td>18,7</td>
<td>18,2</td>
<td>17,7</td>
<td>17,2</td>
<td></td>
</tr>
</tbody>
</table>

Leveling means: Tangente to rib 3 horizontal.
Datum: wing leading edge rib 3.

Also by condensing water considerable quantities of humidity can enter the interior of the glider.

Strong sun irradiation will affect the finish by time, therefore the glider should not be exposed to the sun more than necessary. The treatment of the finish with good waxes and polishing material will increase the durability and improve the surface, an important fact for performance. The advantages of the laminarprofil can only be achieved by a smooth surface.

Sealing of gaps with adhesive tape will also cause some gain of performance. However at the cockpit caution is necessary, when parachute bail out shall be possible.

Cleaning of the plexiglas canopy only with suitable cleaners. If not available use pure water. Soft cloth (gloves cloth). In no case rub with hard cloth dry on plexiglass.

Lubrication of bearings:

So far as possible, the ball bearings are covered and therefore need no special maintenance. Only the bearings at the wing root, where the rigging connections do not allow a suitable protection, must be cleaned with gasoline when dirty and greased again.

The control surface bearings are to be dismantled and greased at the annual overhauls.

Wheel: Tube pressure 35 psi.

The c.g. hock especially is exposed to dirt and needs often cleaning and ciling.
GL - Leergewicht; empty weight.
Gr - Gewicht am vorderen Auflagerpunkt; weight at the front support.
Gz - Sporn gewicht; weight of tail skid.
R - Schwerpunkt rücklage; center of gravity position.

<table>
<thead>
<tr>
<th>G1</th>
<th>G2</th>
<th>L1</th>
<th>L2</th>
<th>A</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>280</td>
<td>280</td>
<td>300</td>
<td>310</td>
<td>320</td>
<td>kg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>R</th>
<th>Vorderste Schwerpunktlage; most forward position of Gz; Gz empty min.</th>
<th>490</th>
<th>425</th>
<th>462</th>
<th>444</th>
<th>439</th>
<th>mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hintere Schwerpunktlage; most rearward position of Gz; Gz empty max.</td>
<td>545</td>
<td>535</td>
<td>525</td>
<td>516</td>
<td>508</td>
<td>mm</td>
</tr>
</tbody>
</table>
2.2 ASK 21

Flight Manual SCHLEICHER ASK 21

I.5 DESCRIPTION

The ASK 21 is designed to meet the needs of modern gliding training. It has an all fiberglass sandwich structure.

Midwing with T-tail, tandem seat arrangement, airbrakes on upper wing only.

The glider is stressed for aerobatics (inverted flight included).

Technical Data

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Span</td>
<td>17.00 m = 55.74 ft</td>
</tr>
<tr>
<td>Length</td>
<td>8.35 m = 27.4 ft</td>
</tr>
<tr>
<td>Height</td>
<td>1.53 m = 5.02 ft</td>
</tr>
<tr>
<td>Aspect ratio</td>
<td>16.1</td>
</tr>
<tr>
<td>Wing area</td>
<td>17.95 m² = 192.95 sqft</td>
</tr>
<tr>
<td>Max. all up weight</td>
<td>600 daN = 1320 lbs</td>
</tr>
<tr>
<td>Max. wing loading</td>
<td>33.4 daN/m² = 6.84 lbs/sqft</td>
</tr>
</tbody>
</table>

Airfoil: Wortmann FX 502 196 (inner wing)
Wortmann FX 60 -126 (wing tip)

Winch Tow: Weak Link 1000 daN
Aero Tow : Weak Link 600 daN

March 9, 1983

11
Airspeed indicator markings (IAS)

Red line (max. permissible airspeed):
151,2 kts = 174,0 mph = 280 km/h

Yellow arc (caution range):
97,2 - 151 kts = 112 - 174 mph = 180 - 280 km/h

Green arc (normal range):
43,0 - 97 kts = 50 - 112 mph = 80 - 180 km/h

Yellow triangle (approach speed):
49,0 kts = 56,0 mph = 90 km/h

II.5 CREW
: 2 persons

Minimum crew : 1 person (min.weight 70 daN = 154 lbs

Caution: Solo flights may only be conducted from the front seat!

II.6 WEIGHTS

Empty weight approx. 792 lbs = 360 daN
Max. all up weight 1320 lbs = 600 daN
Max. weight of non lift producing members 902 lbs = 410 daN.
IV.2 DAILY INSPECTIONS

Prior to flight operations the following checks must be accomplished:

1.a. Open canopy! Check that the main pins are properly secured.

b. Check the proper connection of the ailerons and airbrakes through the access hole on the left side above the wing. Are the quick-release connectors secured with spring clips?

c. Check for foreign bodies!

d. Check the control circuits force and that all controls are free-moving. Apply full deflections and load the control circuits with fixed controls and airbrakes. Check the plastic tubes inside the S-shaped rudder pedal tubes for proper and tight fit.

e. Check tire pressure:
   - Nose wheel 2.0 bar (28 psi)
   - Main wheel 2.7 bar (38 psi)
   - Tail wheel (if installed) 2.5 bar (35.6 psi).

f. The condition and function of the tow release mechanism is to be checked. Actuate the tow release: does it snap back freely? Engage and disengage the ring pair. Check the automatic release of the G.S. towing hook with the ring pair which must release automatically backwards.

g. Check the wheel brake. Pull the airbrake lever; at the end of its travel an elastic resistance must be felt.

2.a. Check upper and lower wing surface for damages!

b. Ailerons: its condition, free-movingness and play is to be checked! Check also the pushrod connection.

c. Airbrake: its condition, fit and locking is to be checked.

3. Check the fuselage for damages, in particular also the bottom side.

4. Check that the tailplane is properly assembled and secured. Check also the pushrod connection! Secured with spring clips?
VI. CENTER OF GRAVITY (CG)

VI.1 WEIGHING PROCEDURE OF CG AT EMPTY WEIGHT
Prior to determining the CG in flight the CG at empty weight has to be established by weighing the glider. For this procedure the glider must be put on two pair of scales (one at the nose wheel and one at the tail skid).

NOTE: the glider must be set on the two pairs of scales very carefully in order to prevent that the scales get misaligned; (this could lead to erroneous results).

The Datum Line (DL) is situated at the wing leading edge of the straight center part of the wing.

Levelling means: wedge on rear top edge of fuselage 1000 : 52 horizontal.

Empty weight CG:
Weight at the nose wheel: lbs
Weight at the tailskid: lbs
Support point nose wheel: in
Support point tailskid: in

NOTE: determination of empty weight and empty weight CG must be done without any additional balance weights (e.g. trim cushion).

Be careful not to exceed the maximum weight of non lift producing parts when using maximum payload. The total weight of non lift producing units contains the individual weights of fuselage, elevator and maximum payload and must not exceed 410 daN = 920 lbs (the payload must be reduced accordingly).

March 9, 1981
Flight Manual Schleicher ASK 21

Weight and Balance Sheet

Datum Point Wing Leading Edge \( (B.P.) y = 0.4 \text{ m} \)

\[
\frac{G_2 \cdot L_1}{G_1 + G_2} - L_2
\]

With pilot C.G. arm = 1185 mm / 46.65 in
before datum point

Hatched area = permissible range

- max 90 kg Rear
- +110 kg Front

With pilot C.G. arm = 1250 mm / 49.21 in
= 80 mm / 3.15 in
before datum point

- max 30 kg Rear
- +110 kg Front

\( G_0 \) Empty Weight (kg)

March 3, 1983
The CG should be recalculated after repair, repainting or installation of additional equipment, but not later than 4 years after the last weighing. The empty weight, empty weight CG position and maximum load should be recorded after each weighing on page of the Flight Manual by a competent person.

VI.2 EMPTY WEIGHT CG POSITION

With the empty weight CG according to the below-mentioned limits and the pilot weights according to the load table, the in flight CG will be within the approved range.

<table>
<thead>
<tr>
<th>Empty Weight</th>
<th>CG Forward</th>
<th>CG aft</th>
</tr>
</thead>
<tbody>
<tr>
<td>dSN</td>
<td>lbs</td>
<td>mm</td>
</tr>
<tr>
<td>350</td>
<td>770</td>
<td>800</td>
</tr>
<tr>
<td>360</td>
<td>792</td>
<td>784</td>
</tr>
<tr>
<td>370</td>
<td>814</td>
<td>769</td>
</tr>
<tr>
<td>380</td>
<td>836</td>
<td>754</td>
</tr>
<tr>
<td>390</td>
<td>858</td>
<td>732</td>
</tr>
<tr>
<td>400</td>
<td>880</td>
<td>712</td>
</tr>
</tbody>
</table>

March 9, 1983
at increasing altitude, the critical flutter speed, however, is more or less determined by true airspeed for light aircraft, the following speed limits are valid for high altitude flights.

<table>
<thead>
<tr>
<th>Altitude</th>
<th>Max. Speed (indicated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>m s.l.</td>
<td>feet m.s.l.</td>
</tr>
<tr>
<td>0-3,000</td>
<td>0-10,000</td>
</tr>
<tr>
<td>5,000</td>
<td>16,400</td>
</tr>
<tr>
<td>7,000</td>
<td>23,000</td>
</tr>
<tr>
<td>9,000</td>
<td>29,500</td>
</tr>
<tr>
<td>11,000</td>
<td>36,000</td>
</tr>
<tr>
<td>13,000</td>
<td>42,600</td>
</tr>
</tbody>
</table>

If the above limited values are not exceeded, the true airspeed will be constantly 315 km/h above 3000 m / 10000 feet m.s.l. and thus is high enough to face the strongest wind in wave flight.

** Please note: Rough air, according to airworthiness requirements, is turbulence found in wave rotors, thunderstorm clouds, dust devils and when skimming mountain crests. An experienced pilot will know that he must be aware of even stronger turbulence in thunderstorms or in alpine regions.

Weights (masses)

Empty weight with min. equipment ~ 255kg / 565lbs.
Max. all-up weight 454kg / 1000lbs.
Max. weight of non lift producing 235kg / 518lbs.

Components.

Permissible water ballast max. 120kg / 265lbs (depending on cockpit load) or 32 USGals.

See table on page 20.
Weak link in towing line

600 kg (1320 lbs) for auto / winch and aerotow

In Flight Centre of Gravity

Datum point is the leading edge of the wing root rib (without the fillet of the wing - fuselage fairing).

The horizontal reference line is the centre line of the fuselage tail cone or a 1000 : 45 wedge template levelled out on the top side of the fuselage aft portion (see the page "Rigging Data" in the appendix).

In flight centre of gravity range is from 240 mm (9.45 inch) to 360 mm (14.17 inch) behind datum.

Cloud flying

The sailplane is suited for cloud flying.

Flights under icing conditions are not recommended, specially if the glider has been wet before climbing through the icing level. Experiences have shown that in the area of the rather narrow control gaps, any rain or condensation drops dry off relatively slowly and turn to ice when climbing above the freezing level. Therefore, one has to face a stiffening of the controls, leading to blocked controls in extreme cases.

Isolated climbs above the freezing level with a dry sailplane did not lead to any stiffening of the controls, even though the leading edges of wings and control surfaces showed severe icing.

Flights with water ballast above freezing level should be avoided because of the risk of icing-up of the tank ventilation.
After landings on wet, muddy ground or in dusty fields the landing gear must be cleaned. For this purpose one removes the seat pan in order to get good access with a vacuum cleaner and to facilitate a thorough cleaning job.

The tyre pressure should be between 2,5 to 2,7 Bar (35 to 38 psi) for 790 lbs. all up weight. At maximum all up weight (when water ballast is used) 3,2 to 3,4 Bar (45.5 to 48 psi).

If the tyre pressure is too low, the tyre deforms to such a degree during landings that the landing gear doors will be destroyed.

The skidplate has to be removed in time or should be protected against excessive wear by welding several stellite beads on to it.

The rubber tailskid has been designed such that it will shear off under strong side loads. It can be glued on again or repaired with contact cement. It is important to cover the gap from rubber skid to fuselage in order to prevent any peeling and catching of long grass.

The towing hooks are especially exposed to soil and dirt and require frequent cleaning and oiling. For this purpose remove the fibreglass seat pan.

Lubrication of the Bearings

Most ball bearings are, so far as possible, covered and, therefore, will normally require no special care for a longer period of time.

The control hinge bearings must be dismantled and re-lubricated at the annual inspection.
Empty Weight X_c of G Position

Empty Weight C. of G. Positions and Limits
## 2.4 DG-1000S [4]

**Flight manual DG-1000S**

### Technical data

<table>
<thead>
<tr>
<th></th>
<th>m</th>
<th>18</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Span</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Wing area</strong></td>
<td>m²</td>
<td>16.72</td>
<td>17.53</td>
</tr>
<tr>
<td><strong>Aspect ratio</strong></td>
<td>/</td>
<td>19.38</td>
<td>22.82</td>
</tr>
<tr>
<td><strong>Length</strong></td>
<td>m</td>
<td>8.57</td>
<td></td>
</tr>
<tr>
<td><strong>Fuselage height</strong></td>
<td>m</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td><strong>Fuselage width</strong></td>
<td>m</td>
<td>0.73</td>
<td></td>
</tr>
<tr>
<td><strong>Span of the horizontal tailplane</strong></td>
<td>m</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td><strong>Waterballast Wings</strong></td>
<td>max. kg (l)</td>
<td>160</td>
<td>160</td>
</tr>
<tr>
<td><strong>Waterballast fin</strong></td>
<td>max. kg</td>
<td>6.2</td>
<td></td>
</tr>
<tr>
<td><strong>Trim ballast fin</strong></td>
<td>max. kg</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td><strong>Empty mass with basic instruments</strong></td>
<td>approx. kg</td>
<td>411</td>
<td>415</td>
</tr>
<tr>
<td><strong>Wing loading (with one Pilot 80kg)</strong></td>
<td>approx. kg/m²</td>
<td>29.4</td>
<td>28.2</td>
</tr>
<tr>
<td><strong>max. take off mass (max. TOW)</strong></td>
<td>kg</td>
<td>750</td>
<td>750</td>
</tr>
<tr>
<td><strong>max. wing loading</strong></td>
<td>kg/m²</td>
<td>44.9</td>
<td>42.8</td>
</tr>
<tr>
<td><strong>Aerobatics</strong></td>
<td>unlimited</td>
<td>simple</td>
<td>Category „A“</td>
</tr>
<tr>
<td><strong>max. TOW for aerobatics</strong></td>
<td>kg</td>
<td>630</td>
<td>630</td>
</tr>
<tr>
<td><strong>max. speed</strong></td>
<td>km/h</td>
<td>270</td>
<td>270</td>
</tr>
</tbody>
</table>

*Options will increase the empty mass accordingly!
Flight manual DG-1000S

1.5 three view drawing

Issued: March 2002
2.4 Mass (weight)

Category „Aerobatic“:
- Maximum take off weight: 630 kg 1389 lbs.
- Maximum landing weight: 630 kg 1389 lbs.

Category „Utility“:
with waterballast:
- Maximum take off weight: 750 kg 1653 lbs.
- Maximum landing weight: 750 kg 1653 lbs.

without waterballast: Maximum take-off and landing mass = W_{NL,P} + W_{wings}

\[ W_{NL,P} = \text{Maximum mass of the non lifting parts (see below)} \]
\[ W_{wings} = \text{actual mass of the wings} \]
- Maximum weight of the non lifting parts = 469 kg 1034 lbs.

Caution: It is recommended to dump the waterballast before landing on airfields. Dump the ballast before an outlanding in any case.

Maximum mass in baggage compartment: 15 kg 33 lbs.

Caution: Heavy pieces of baggage must be secured to the baggage compartment floor (screwing to the floor or with belts). The max. mass secured on one half of the floor (left and right of fuselage centre line) should not exceed 7.5kg (16.5 lbs.).

Ballast
1. Maximum waterballast
   - in the wings: 160 kg 353 lbs.
   - in the fin: 6.2 kg 13.7 lbs.

2. Maximum mass in the trim-ballast box in the fin: 12 kg 26.5 lbs.

The max. take off mass is not to be exceeded with 1. and 2. together.

Warning: Follow the loading procedures see section 6.
2.13 Tyre Pressure
Main wheel 2,5 bar (36 psi)
Nose wheel (if installed) 2,5 bar (36 psi)
Tail wheel 4,0 bar (58 psi)

2.14 Waterballast (Option)
Max. capacity 80 l (21.1 U.S. gal) per wing.
Filling the water ballast is only allowed with a filling system which enables
determination of the exact amount of ballast filled, e.g. water gauge or calibrated
canisters. Only symmetrical loading is allowed.
After filling, balance the wings by dumping enough water from the heavy wing,
see 4.2.2.
Flight with leaking watertanks is prohibited, as this may result in asymmetrical
loading condition.

Warning: Follow the loading chart, see section 6.8.
The max. take off weight must not be exceeded.

2.15 Fin tank (Option)
Warning: As it is dangerous to fly with empty wing tanks while ballast is
resting in the fin, it is prohibited to fill water into the fin tank if there is any
risk of icing. The flight conditions must comply with the following table:

<table>
<thead>
<tr>
<th>min. ground temperature</th>
<th>°C</th>
<th>13,5</th>
<th>17</th>
<th>24</th>
<th>31</th>
<th>38</th>
</tr>
</thead>
<tbody>
<tr>
<td>°F</td>
<td>56</td>
<td>63</td>
<td>75</td>
<td>88</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>max. flight altitude</td>
<td>m</td>
<td>1500</td>
<td>2000</td>
<td>3000</td>
<td>4000</td>
<td>5000</td>
</tr>
<tr>
<td></td>
<td>ft</td>
<td>5000</td>
<td>6500</td>
<td>10000</td>
<td>13000</td>
<td>16500</td>
</tr>
</tbody>
</table>

In addition the outside air temperature OAT gauge is to be watched.
The OAT should not be lower than 2°C (36°F)!

2.16 Trim ballast box in the fin
A box for ballast (trim-weights) is installed in the fin. It can be used to
compensate the mass of the rear pilot and as a trim-possibility for heavy pilots.
Warning: Follow the loading chart see 6.8.7.
Tape the cover of the fin ballast box with tape min. 19mm (3/4 in.)
wide prior to each flight.

Issued: September 2003  TN 413/2   LBA app.  2.11
Flight manual DG-1000S

6.1 Introduction
This section contains the payload range within which the sailplane may be safely operated.
A procedure for calculating the in-flight C.G. is also provided.

A comprehensive list of all equipment available for this sailplane is contained in
the maintenance manual.

6.2 Weighing procedures
See maintenance manual DG-1000S.
Datum: Wing leading edge at the rootrib.
Reference line: aft fuselage centre line horizontal.
The weighing is to be executed with all tanks emptied, without ballast in the
trim ballast boxes in the fin and in the cockpit (optional), but with fin battery
Z110.

6.3 Weighing record
The result of each C.G. weighing is to be entered on page 6.7. If the min.
cockpit load has changed this data is to be entered in the cockpit placard as well.
When altering the equipment, the new data can be gathered by a C.G.
calculation (see section 6.9).
The actual equipment list is enclosed in the maintenance manual.

6.4 Basic empty mass and C.G.
Actual data see page 6.7. With the empty weight C.G. and the cockpit loads in
the limits of the diagram on page 6.8, the in-flight C.G. limits will not be
exceeded.

Issued: March 2002
6.5 Mass of all non-lifting parts (WNLP)
The max. mass of all non-lifting parts is 469 kg (1034 lbs.).

WNLP is to be determined as follows:
WNLP = WNLP empty + cockpit load (pilots, parachute, baggage, trim ballast, waterballast in the fin, removable items of equipment etc.).
WNLP empty = Total empty weight incl. permanently installed equipment minus weight of the wings.

6.6 Max. mass (weight)
Category A „Aerobic“
   Maximum take off weight: 630 kg 1389 lbs.
   Maximum landing weight: 630 kg 1389 lbs.

Category „Utility“ with waterballast:
   Maximum take off weight: 750 kg 1653 lbs.
   Maximum landing weight: 750 kg 1653 lbs.

without waterballast: Maximum take-off and landing mass = \( W_{NL, P} + W_{wings} \)
\( W_{NL, P} \) = Maximum mass of all non lifting parts (see above)
\( W_{wings} \) = actual mass of the wings

6.7 Useful loads
Max. load without waterballast
   = max. weight without waterballast - empty weight

Max. load with waterballast
   = max. weight with waterballast - empty weight

The data is recorded on page 6.7.
6.8.9  Empty weight C.G. limits (for 6.4)
Flying Limitations

Airspeed Limits (I.A.S.)

<table>
<thead>
<tr>
<th>Condition</th>
<th>km/h</th>
<th>mph</th>
<th>kts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never exceed (VNE)</td>
<td>250</td>
<td>155</td>
<td>135</td>
</tr>
<tr>
<td>In rough air (VB)</td>
<td>250</td>
<td>155</td>
<td>135</td>
</tr>
<tr>
<td>Manoeuvring (VA)</td>
<td>170</td>
<td>105</td>
<td>92</td>
</tr>
<tr>
<td>On aerotow (VT)</td>
<td>170</td>
<td>105</td>
<td>92</td>
</tr>
<tr>
<td>On winch tow (Vw)</td>
<td>120</td>
<td>74</td>
<td>64</td>
</tr>
<tr>
<td>Airbrakes</td>
<td>250</td>
<td>155</td>
<td>135</td>
</tr>
<tr>
<td>Gear extended</td>
<td>250</td>
<td>155</td>
<td>135</td>
</tr>
</tbody>
</table>

A.S.I. Colour Code

33 – 92 kts — Green Border — 60–170 km/h
92 – 135 kts — Yellow Border — 170–250 km/h
At 135 kts — Red Strip — bei 250 km/h

Weights

<table>
<thead>
<tr>
<th>Condition</th>
<th>lbs</th>
<th>kp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empty Weight</td>
<td>circa 560</td>
<td>255</td>
</tr>
<tr>
<td>Maximum permitted weight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>without water-ballast</td>
<td>836</td>
<td>380</td>
</tr>
<tr>
<td>with water-ballast</td>
<td>990</td>
<td>450</td>
</tr>
<tr>
<td>Maximum permitted weight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>of non-supporting ports</td>
<td>528</td>
<td>240</td>
</tr>
</tbody>
</table>

Weak Link on Winch cable

Maximum Load

1100 | 500

Cloud Flying and simple Aerobatics

Permitted if water-ballast is not being carried
See pages 12 — 14

22. 5. 76
Classification Group
Standard Class (German N)

Centre of Gravity positions
- Levelling means with a 1000:40 Incidence Board set up horizontal on the top of the rear fuselage.
- Datum Line (D. L.) Front edge of wing at root
  - Maximum forward position of C. of G. 250 mm behind D. L. (9.84 in)
  - Maximum rearward position 425 mm behind D. L. (16.73 in)

Loading Limitations ASTIR CS
Empty weight of glider and maximum cockpit load, see page 7.
Minimum cockpit load: 154 lbs (70 kp)
The permissible all up weight must NEVER be exceeded.
Maximum all up weight
- without water-ballast 836 lbs (380 kp)
- with water-ballast 990 lbs (450 kp)
The weight of water-ballast is dependent on the cockpit weight (Pilot with parachute and luggage). See page 7.
Weight deficiencies should be corrected by securing or removing some ballast in the seat.
The C. of G. of the pilot with a parachute on lies 475 mm in front of the Datum Line.

22. 5. 76
Placards to be displayed in cockpit:

<table>
<thead>
<tr>
<th></th>
<th>kp</th>
<th>lbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum weight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>without water ballast</td>
<td>380</td>
<td>836</td>
</tr>
<tr>
<td>with water ballast</td>
<td>450</td>
<td>990</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Airspeed limits</th>
<th>km/h</th>
<th>m.p.h.</th>
<th>knots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never exceed</td>
<td>250</td>
<td>155</td>
<td>135</td>
</tr>
<tr>
<td>In rough air</td>
<td>250</td>
<td>155</td>
<td>135</td>
</tr>
<tr>
<td>Manoeuvering</td>
<td>170</td>
<td>105</td>
<td>92</td>
</tr>
<tr>
<td>On aerotow</td>
<td>170</td>
<td>105</td>
<td>92</td>
</tr>
<tr>
<td>On winch tow</td>
<td>120</td>
<td>74</td>
<td>64</td>
</tr>
<tr>
<td>Airbrakes</td>
<td>250</td>
<td>155</td>
<td>135</td>
</tr>
<tr>
<td>Gear extended</td>
<td>250</td>
<td>155</td>
<td>135</td>
</tr>
</tbody>
</table>

Payload (pilot and parachute)
The maximum weight must not be exceeded.

Minimum payload: 70 kp, 154 lbs.
Less weight must be compensated with ballast in the seat.

Placards to be displayed near undercarriage:

Weak links for towing
500 kp, 1100 lbs. max.
Tire: 2,5 Atm., 36 psi
4 Four piece safety harness
5 Weighted seat cushion at least 2\(\frac{1}{4}\)”, thick, or parachute
6 Loading limitations Chart
7 Flying limitations Placard
8 Flight Manual

**Weight and Center of Gravity positions**

When the new instruments are added and other changes in the weight of the glider made, the empty weight C. of G. position should be checked. If the limits of the empty weight C. of G. positions and the Loading Limitations Chart are adhered to, then the C. of G. of the loaded glider will lie within the permitted range.

Empty Weight (lbs) | Range of C. of G. positions (mm behind the Datum Line)
--- | ---
506 | 606 — 698
517 | 598 — 693
528 | 591 — 687
539 | 584 — 682
550 | 577 — 677
561 | 557 — 672
572 | 537 — 667
583 | 518 — 662
594 | 499 — 658
605 | 481 — 654

**Measurements**

Position of the glider whilst taking all measurements:

with a 1000:40 Incidence Board set up horizontal on the top of the rear fuselage.

<table>
<thead>
<tr>
<th>Elevator</th>
<th>upwards</th>
<th>2.36 ± 0.23 in</th>
<th>60 ± 8 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>downards</td>
<td>2.13 ± 0.23 in</td>
<td>54 ± 6 mm</td>
<td></td>
</tr>
<tr>
<td>Rudder</td>
<td>left</td>
<td>7.09 ± 0.39 in</td>
<td>180 ± 10 mm</td>
</tr>
<tr>
<td>right</td>
<td>7.09 ± 0.39 in</td>
<td>180 ± 10 mm</td>
<td></td>
</tr>
<tr>
<td>Aileron</td>
<td>upwards</td>
<td>3.66 ± 0.39 in</td>
<td>93 ± 10 mm</td>
</tr>
<tr>
<td>downwards</td>
<td>1.89 ± 0.20 ln</td>
<td>48 ± 5 mm</td>
<td></td>
</tr>
<tr>
<td>Angles:</td>
<td>between the center line of the wing and the longitudinal axis of the fuselage</td>
<td>2°</td>
<td></td>
</tr>
<tr>
<td></td>
<td>between the cord of the tail-plane and the longitudinal axis of the fuselage</td>
<td>0°</td>
<td></td>
</tr>
</tbody>
</table>
FLUGZEUGLAGE BEI ALLEN MESSUNGEN: KEIL 900-40 AUF RUHRFRÜCHEN HORIZONTAL
MEASUREMENTS: 1000-40 INCIDENCE BOARD SET HORIZONTAL ON TOP OF REAR FUSELAGE

UP
OBEN 93±10

DOWN
UNTEN 48±5

ALLE MASSE IN mm
ALL MEASUREMENTS IN mm
Datum Line: Front edge of the wing at the root
Levelling means: With a 1000:40 Incidence Board set up horizontal on the top of the rear fuselage.

Weight on main-wheel \( G_1 = \) lbs
Weight on tail-skid \( G_2 = \) lbs
Empty Weight \( G_L = G_1 + G_2 = \) lbs
Displacement of main-wheel \( a = \) mm
Deplacement of tail-skid \( b = \) mm

Empty Weight C. of G.

\[
X = \frac{G_L \times b}{G_L} + a = \text{mm behind Datum Line}
\]

Maximum Load \( G = 836 - G_L = \) lbs

The measurements to determine the empty weight, the empty weight C. of \( G \), and the loading limitations should always be taken with the glider empty of waterballast.
2.6  G103 Twin II [6]
I. 5 Description

The "TWIN II" is a high performance two seater sailplane with a T-tail, fitted with a non-retractable tandem undercarriage and upper surface airbrakes.

This sailplane is manufactured using the latest techniques in industrial Glass fibre construction.

It is designed for training, high performance and simple aerobatic flying.

Technical Data:

- Span: 17.5 m (57.4 ft)
- Length: 8.18 m (26.8 ft)
- Height: 1.55 m (5.1 ft)
- Aspect Ratio: 17.1
- Maximum Flying Weight: 580 kg (1279 lbs)
- Maximum Wing Loading: 32.6 kg m\(^2\) (6.68 lbs ft\(^{-1}\))
- Wing Area: 17.8 m\(^2\) (191 ft\(^2\))

II. Operating Limitations:

II. 1 Airworthiness Group

Certification Basis: 14 CFR Sections 21.23 and 21.29 effective 1 February 1965; and Joint Airworthiness Requirements for Sailplanes and Powered Sailplanes (JAR-22), dated 1 April 1980.

II. 2 Permitted operating conditions:

1. VFR Day
2. Simple Aerobatics (Loops, Stall turns, Lazy eight, Chandelier and Spin).

II. 3 Minimum equipment

1. Air speed indicators reading to 300 km/hr (162 kts, 187 mph)
2. Altimeters
3. Full Harness Straps in front and back cockpit
4. Parachute or back cushion at least 7 cm (3 inch) thick for each occupant
5. Loading limit plaque in front and back cockpit
6. Flight Limits plaque
7. Flight Manual

17th March 1982

J. March 1982
II. 5 Weight limits

Empty weight ... about 380 kg (838 lbs)
Maximum flying weight ... 580 kg (1279 lbs)
Maximum permitted weight of non lifting parts 400 kg (882 lbs)

II. 7 Centre of gravity position

The approved range of centre of gravity positions during flight is 260 mm (10.24 inches) to 460 mm (18.11 inches) behind the datum line, equivalent to 24.7% to 43.6% of the M.A.C. of the wing.
A/c attitude: incidence board of 600/24 angle.
The datum line is the front edge of the wing at the wing root.
The approved centre of gravity range does not get exceeded by the payload distribution specified in the loading plan II. 8.
The exact position of the centre of gravity at flying weight can be calculated according to VI 5.

II. 8 Load scheme „TWIN II“

Minimum load in the front seat for all flight ... 70 kg (154 lbs)
Maximum load in the front seat ... 110 kg (242 lbs)
Maximum load in the back seat ... 110 kg (242 lbs)
Maximum load in the baggage compartment ... 10 kg (22 lbs)

The maximum flying weight of 580 kg (1279 lbs) must not be exceeded.
Trim weights must be used at the suspensions in front of stick bulkhead to compensate if the front seat load is lower than 70 kg (154 lbs). See page 74.

16th June 1982

25. Aug. 1982
II 9 Tow hooks and cable length
For Aerotow Nose hook "E 75" with modification 1-72.
For Winch launch, Safety back release hook "E 72" or "C 72".
Minimum aerotow cable length 40 m (130 ft)
Minimum launch cable length 600 m (1970 ft)

II 10 Weak link strength
Winch launch and aerotow max 754 daN, max 1662 lb

II.11 Tire Pressure

<table>
<thead>
<tr>
<th></th>
<th>6.00-6</th>
<th>260x85</th>
<th>210x65</th>
</tr>
</thead>
<tbody>
<tr>
<td>mainwheel</td>
<td>2.5-2.8</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>nosewheel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tailwheel</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

II. 12 Crosswinds
The maximum crosswind component approved for take off and landing
is 20 km/h (11 kts, 12 mph).

16th June 1982
V. 2 Determination of the Center of Gravity

The determination of the center of gravity is made with the glider supported on two scales at heights such that an incidence board of 60° : 24 angle is set horizontal on the back of the fuselage. (Position on the fuselage see sketch at page 23). The reference plane lies at the front of the wing at the root. The distances a and b are measured with the help of a plumb line. The empty weight is the sum of the two weights G₁ and G₂.

The Center of Gravity of the pilots is located:
1150 mm (45.3 inch) in front of the Datum Line (1. Seat)
40 mm (1.6 inch) behind the Datum Line (2. Seat)

17th March 1982
Procedure for determining C. of G. empty

Datum Line: Front edge of the wing at the root rib.

Level Means: With a 600.24 Incidence Board set up horizontal on the top of the rear fuselage.

Weight on main-wheel \( G_1 \) = kg / lbs
Weight on tail-skid \( G_2 \) = kg / lbs
Empty Weight \( G_L \) = \( G_1 + G_2 \) = kg / lbs
Distance to main-wheel \( a \) = mm / inches
Distance to tail-skid \( b \) = mm / inches

Empty Weight C. of G.

\[ X = \frac{G_2 \times b}{G_L} + a = \quad \text{mm / inches behind} \quad \text{Datum Line} \]

The measurements to determine the empty weight, the empty weight C. of G. and the loading limitations must always be taken with the glider empty.

Conversion

<table>
<thead>
<tr>
<th>from</th>
<th>to</th>
<th>multiply with</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg</td>
<td>lbs</td>
<td>2.2</td>
</tr>
<tr>
<td>mm</td>
<td>inches</td>
<td>0.0394</td>
</tr>
</tbody>
</table>

17th March 1982
If the limits of the empty weight C. of G. positions and the loading limitations chart are adhered to the C. of G. of the loaded glider will be within the permitted range.

<table>
<thead>
<tr>
<th>Empty Weight</th>
<th>Range of C. of G. behind Datum</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg</td>
<td>lbs</td>
</tr>
<tr>
<td>360</td>
<td>794</td>
</tr>
<tr>
<td>365</td>
<td>805</td>
</tr>
<tr>
<td>370</td>
<td>816</td>
</tr>
<tr>
<td>375</td>
<td>827</td>
</tr>
<tr>
<td>380</td>
<td>838</td>
</tr>
<tr>
<td>385</td>
<td>849</td>
</tr>
<tr>
<td>390</td>
<td>860</td>
</tr>
<tr>
<td>395</td>
<td>871</td>
</tr>
<tr>
<td>400</td>
<td>882</td>
</tr>
</tbody>
</table>

It should be noted that to make use of the maximum load the maximum admissible load for non-lifting parts must not be exceeded.

The weight of the non-lifting parts is the sum of the fuselage, tailplane and maximum load in the fuselage and must not exceed 400 kgs (882 lbs). Otherwise the maximum load permitted in the fuselage must be correspondingly decreased.

The Centre of Gravity should be recalculated after repair, repainting, the installation of additional equipment or when a period of 4 years has elapsed after the last weighing.

The empty weight, empty weight C. of G. position and maximum load, should be recorded after each weighing on page 9 of the Flight Handbook.

17 th March 1982
1. Operating Limitations

<table>
<thead>
<tr>
<th>Airspeed limits:</th>
<th>km/h</th>
<th>mph</th>
<th>kts</th>
</tr>
</thead>
<tbody>
<tr>
<td>max. airspeed</td>
<td>200</td>
<td>125</td>
<td>108</td>
</tr>
<tr>
<td>max. airspeed in gusty weather</td>
<td>140</td>
<td>87</td>
<td>75</td>
</tr>
<tr>
<td>airplane-tow</td>
<td>140</td>
<td>87</td>
<td>75</td>
</tr>
<tr>
<td>Auto-winch-tow</td>
<td>100</td>
<td>62</td>
<td>54</td>
</tr>
</tbody>
</table>

Weights:

<table>
<thead>
<tr>
<th>Empty weight:</th>
<th>approx. 190 kg</th>
<th>419 lbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum weight:</td>
<td>300 kg</td>
<td>660 lbs</td>
</tr>
<tr>
<td>max. weight of non-supporting structure</td>
<td>190 kg</td>
<td>419 lbs</td>
</tr>
</tbody>
</table>

Cloudflying is permissible (see page 7)

Category

2 BVG (German)

Airworthiness Requirements

Max. permitted positive load factor 4.0
Max. permitted negative load factor -2.0
Factor of safety 2.0
C.G. Range in Flight:

Leveling means: template 100 : 9 on top of fuselage horizontal
Datum: wing leading edge at rib 3
C.G. range: 180 to 383 mm, 7,1 to 15,0 in. behind datum.

Weak Links in the Tow Cable:

Winch-launch max. 635 kp 1400 lbs
min. 525 kp 1160 lbs
Airplane-tow max. 450 kp 990 lbs
min. 300 kp 660 lbs

2. Operating Instructions:

Winch-launching:

Maximum permissible winch-launch airspeed is 100 km/h, 62 mph, 54 kts.

Any slight tendency for the nose to pitch up can be controlled through appropriate stick operation. For optimum climb keep the stick in normal position. Attention: In winch-launching the speed will increase when you pull back the stick.

Airplane-tow

Max. permissible airplane-towing speed: 140 km/h, 87 mph, 75 kts. Use only textile ropes for airplane-tow. For release, pull the coupling knob all the way! Before every take-off check canopy and airbrakes for being locked.
If necessary, balance weights are to be installed. In each of these instances an examiner of the governmental aviation authority is to be called in.

<table>
<thead>
<tr>
<th>Empty weight</th>
<th>420</th>
<th>440</th>
<th>465</th>
<th>485</th>
<th>lbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>c.g. position</td>
<td>min.</td>
<td>20,8</td>
<td>20,2</td>
<td>19,5</td>
<td>19,0</td>
</tr>
<tr>
<td></td>
<td>max.</td>
<td>25,1</td>
<td>24,6</td>
<td>24,1</td>
<td>23,7</td>
</tr>
</tbody>
</table>

behind datum

Template 100 : 9 on fuselage horizontal
Datum: wing leading edge, rib 3.

If the empty weight c.g. position is within these limits, then it is guaranteed that the c.g. position in flight will be within allowable limits if the load in the cockpit is as specified in paragraph 6 below.

The c.g. position in flight has considerable influence on flight characteristics. For this reason, observance of the certified c.g. range is very important.

A displacement of the c.g. too far back may cause dangerous effects: Stalling and especially spinning behaviour (flat spinning) may worsen.
Strong solar radiation will affect the finish by time. Therefore the sailplane should not be exposed to the sun more than necessary. The use of good waxes and polishing materials will increase the durability of the finish and improve the surface, and consequently the flight performance. The advantages of the laminarprofile can only be achieved by a smooth surface.

Sealing the gaps and slots by means of adhesive tapes will also be of use for improving the performance. But do not seal the cockpit if parachute bail-out shall be possible.

Clean the plexiglass canopy only by means of appropriate cleansers. If not available use pure water. Only soft cloth should be used. Never run over the plexiglass with a rough dry cloth.

**Lubrication of Bearings**

So far as possible the ball bearings are sealed and therefore need no lubrication for a long period. The bearings at the wing root only, which cannot be sufficiently protected on behalf of rigging facilities, are to be cleaned with gasoline when dirty and lubricated again.

The control surface bearings are to be dismantled and greased at the annual overhauls.

**Tire pressure** 35 psi.

The tow coupling is especially exposed to dirt and needs a frequent cleaning and oiling.

The tail skid shoe has to be soled from time to time by welding on a new steel plate. But it should be removed for this work to prevent annealing of the spring.
$R = \frac{L_2 - A}{G_L} - A$

$\frac{G_1 + G_2}{G_L}$

$G_L$ = Leergewicht; empty weight.
$G_1$ = Gewicht am vorderen Auflagepunkt; weight at the front support.
$G_2$ = Sporn gewicht; weight at tail skid.
$R$ = Schwerpunkt rücklage; center of gravity position.

Grenzen der Leergewichtsschwerpunktlagen:
Empty weight - C. of Gr. - position limits:

<table>
<thead>
<tr>
<th>$G_L$ = Leergewicht; empty weight</th>
<th>180</th>
<th>190</th>
<th>200</th>
<th>210</th>
<th>220</th>
<th>kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>R (Vorderste Schwerpunkt lage, most forward position, min.)</td>
<td>550</td>
<td>530</td>
<td>513</td>
<td>497</td>
<td>482</td>
<td>mm</td>
</tr>
<tr>
<td>R (Hinterste Schwerpunkt lage, most rearward, max.)</td>
<td>652</td>
<td>638</td>
<td>625</td>
<td>613</td>
<td>603</td>
<td>mm</td>
</tr>
</tbody>
</table>
3 Manufacturers' weight and balance procedures

From the flight manuals of the selected sailplanes, we have gathered the instructions given by the manufacturers in order to measure the weight and balance of each aircraft. A summary of the specific instructions for each model is shown next:

- **Schleicher ASK 13:**
  - **Levelling:** there are two options: either the tangent to the wing’s rib number 3 has to be horizontal, or a 1000:55 wedge on top of the rear part of the fuselage must have its top side horizontal.
  - **Datum:** leading edge of the wing’s rib number 3.
  - **Other considerations:** the manual indicates the front support (forward of the main wheel) as the front weighing point. Nevertheless, this would require special equipment as the front scale should be elevated as well. Therefore, we have chosen the main wheel as the front weighing point.

- **Schleicher ASK 21:**
  - **Levelling:** a 1000:52 wedge on top of the rear part of the fuselage must have its top side horizontal.
  - **Datum:** leading edge of wing’s rib with transversal position \( y = 0.4 \) m.
  - **Other considerations:** the manual indicates the nose wheel as the front weighing point. However, we have chosen the main wheel (which is aft of the nose wheel) so that the front scale will not have to be elevated.

- **Schleicher ASW 20:**
  - **Levelling:** there are two options: the centre line of the fuselage tail cone has to be horizontal, or a 1000:45 wedge on top of the rear part of the fuselage must have its top side horizontal.
  - **Datum:** leading edge of the wing’s root (without the fairing).
  - **Other considerations:** apart from the levelling means, the datum and the allowed CG position range, the manufacturer does not provide any instructions for the weight and balance process.

- **DG Flugzeugbau DG-1000S:**
  - **Levelling:** the top of the rear part of the fuselage must have a slope of 1000:33.
  - **Datum:** leading edge of the wing’s root rib.
  - **Other considerations:** the manufacturer warns that the distances L1 and L2 should always be measured, as different weights might cause different deflections of the landing gear. For measuring L1, it is advised to measure the distance between main wheel and tail wheel centre lines.

- **Grob G102 Astir CS:**
  - **Levelling:** a 600:26 wedge (or “incidence board”) on top of the rear part of the fuselage must have its top side horizontal. The distance between the leading edge of the vertical tail plane has to be of 150 mm.
  - **Datum:** leading edge of the wing’s root rib.
  - **Other considerations:** the manufacturer also indicates the wheel’s centre point as the location of the point weight.

- **Grob G103 Twin II:**
- **Levelling**: a 600:24 wedge (or “incidence board”) on top of the rear part of the fuselage must have its top side horizontal. The distance between the leading edge of the vertical tail plane has to be of 150 mm.
- **Datum**: leading edge of the wing’s root rib.

- **Schleicher Ka 6E**:
  - **Levelling**: a 100:9 wedge (or “template”) on top of the rear part of the fuselage must have its top side horizontal.
  - **Datum**: leading edge of wing’s rib number 3.
4 Individual uncertainties

In this section, the uncertainties used in the propagations of uncertainties which depend on each sailplane model are shown. The definitions of each uncertainty are the following:

- $\epsilon_{d_L}$: uncertainty of the distance between the front point weight and the laser sensor, as used in the estimation of the uncertainty of $L_2$ with option A.
- $\epsilon_T$: uncertainty due to the tilt of the datum bar with respect to the transversal axis, as used in the calculation of the final error of the measurement of $L_2$.

<table>
<thead>
<tr>
<th>Model</th>
<th>$\epsilon_{d_L}$ (mm)</th>
<th>$\epsilon_T$ (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASK 13</td>
<td>$\pm 4.7$</td>
<td>$\pm 1.3$</td>
</tr>
<tr>
<td>ASK 21</td>
<td>$\pm 4.6$</td>
<td>$\pm 0.4$</td>
</tr>
<tr>
<td>ASW 20</td>
<td>$\pm 4.9$</td>
<td>$\pm 0.1$</td>
</tr>
<tr>
<td>DG-1000S</td>
<td>$\pm 4.5$</td>
<td>$\pm 0.4$</td>
</tr>
<tr>
<td>G102 Astir CS</td>
<td>$\pm 4.9$</td>
<td>$\pm 0.1$</td>
</tr>
<tr>
<td>G103 Twin II</td>
<td>$\pm 4.6$</td>
<td>$\pm 0.3$</td>
</tr>
<tr>
<td>Ka 6E</td>
<td>$\pm 5.1$</td>
<td>$\pm 2.4$</td>
</tr>
</tbody>
</table>

Table 7: Individual uncertainties for each sailplane.
5 Mathematical proofs

5.1 Dependency of the uncertainty of X1’ (or X2’) on the point weight G1 (or G2)

From the propagation of uncertainties:

\[ \epsilon_{X1'} = \left| \frac{\partial X1'}{\partial W1} \right| \epsilon_{W1} + \left| \frac{\partial X1'}{\partial W2} \right| \epsilon_{W2} + \left| \frac{\partial X1'}{\partial S1} \right| \epsilon_{S1} + \left| \frac{\partial X1'}{\partial S2} \right| \epsilon_{S2} = \]

Since \( \epsilon_{S1} = \epsilon_{S2} = 2 \) mm:

\[ = \left| \frac{\partial X1'}{\partial W1} \right| \epsilon_{W1} + \left| \frac{\partial X1'}{\partial W2} \right| \epsilon_{W2} + 2 \text{ mm} = \]

\[ = \frac{W2 \cdot (S1 - S2)}{(W1 + W2)^2} \cdot \epsilon_{W1} + \frac{W1 \cdot (S2 - S1)}{(W1 + W2)^2} \cdot \epsilon_{W2} + 2 \text{ mm} \]

And since \( \epsilon_{W1} = \epsilon_{W2} = 0.2 \) kg and \( S2 > S1 \):

\[ \epsilon_{X1'} = \frac{W2 \cdot (S2 - S1) + W1(S2 - S1)}{(W1 + W2)^2} \cdot 0.2 \text{ kg} + 2 \text{ mm} = \]

\[ = \left( \frac{W1 + W2}{(W1 + W2)^2} \right) \cdot (S2 - S1) \cdot 0.2 \text{ kg} + 2 \text{ mm} = \]

\[ = \frac{S2 - S1}{W1 + W2} \cdot 0.2 \text{ kg} + 2 \text{ mm} \]

Finally, since \( W1 + W2 = G1 \) and, in this case, \( S2 = 350 \text{ mm} \) and \( S1 = 0 \), we get:

\[ \epsilon_{X1'} = \frac{350 \text{ mm}}{G1} \cdot 0.2 \text{ kg} + 2 \text{ mm} \]

And the same is true for the rear weighing point:

\[ \epsilon_{X2'} = \frac{350 \text{ mm}}{G2} \cdot 0.2 \text{ kg} + 2 \text{ mm} \]

5.2 Partial derivatives of uncertainty calculations

The calculation of L2 with option A (explained in the Report) is defined as follows:

\[ L2' = \frac{a^2 - b^2 + L1^2}{2 \cdot L1'} \]

\[ L2 = L2' + d_L \]

Then, the total uncertainty of L2 can be calculated as:

\[ \epsilon_{L2} = \left| \frac{\partial L2}{\partial a} \right| \epsilon_a + \left| \frac{\partial L2}{\partial b} \right| \epsilon_b + \left| \frac{\partial L2}{\partial L1} \right| \epsilon_{L1'} + \left| \frac{\partial L2}{\partial d_L} \right| \epsilon_{d_L} \]

And the partial derivatives are the following:
\[
\frac{\partial L_2}{\partial a} = a L_1' \\
\frac{\partial L_2}{\partial b} = -b L_1' \\
\frac{\partial L_2}{\partial L_1'} = \frac{L_1'^2 - a^2 + b^2}{2 \cdot L_1'^2} \\
\frac{\partial L_2}{\partial d_L} = 1
\]
References