CHAPTER

08

LEVELLING AND WEIGHING

CONTENT

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GENERAL

The airplane weighing is carried out when lifted by fuselage jacks or when placed with landing gear upon balances. The reason of weighing is to verify airplane mass, determine airplane empty weight, determine airplane C-G position, or to determine difference that may occur since the last weighing.

The levelling is made with airplane lifted by jaks. The reason of levelling is to determine possible changes in airplane geometrical characteristics.

AIRPLANE WEIGHING

The airplane weighing is carried out in case of equipment modification that may influence airplane mass or C-G position after extensive repairs including the part replacement, after airplane new painting, etc.

Mandatory conditions of airplane weighing:

1) The airplane should be weighed in shut hangar. No works should be done with weighed airplane.
2) Preparation of airplane for weighing:
   a) Drain fuel from airplane fuel system
   b) Replenish lube system to maximum
   c) Replenish braking fluid to airplane brake system
   d) Set front seat to very fwd position
   e) Shut cockpit canopy
   f) Make sure the airplane is completed including final paint.

AIRPLANE WEIGHING WITH FUSELAGE JACKS

Procedure of airplane weighing when lifted with fuselage jacks

1) Set the airplane to level position by means of fuselage jacks (sections 07-11-00; 07-12-00), being placed upon the balances. Use for longitudinal airplane levelling the NiB 2 and 3 being upon rear fuselage section and in lateral direction use NiB 6 upon port and starboard wings (Fig. 08-3).

2) Fill the measured data into the Levelling Record (Fig. 08-1)

   a) Results of weighing (average of three weights):
   M_1 - weight including fwd jack being indicated by balance
   M_2 - weight including rear jack being indicated by balance
   M_3 - mass of fwd jack
   M_4 - mass of rear jack

   b) Distance of supported points L

3) Calculate:

   a) Mass of empty airplane
   $M = (M_1 + M_2) - (M_3 + M_4)$ kg (lb)

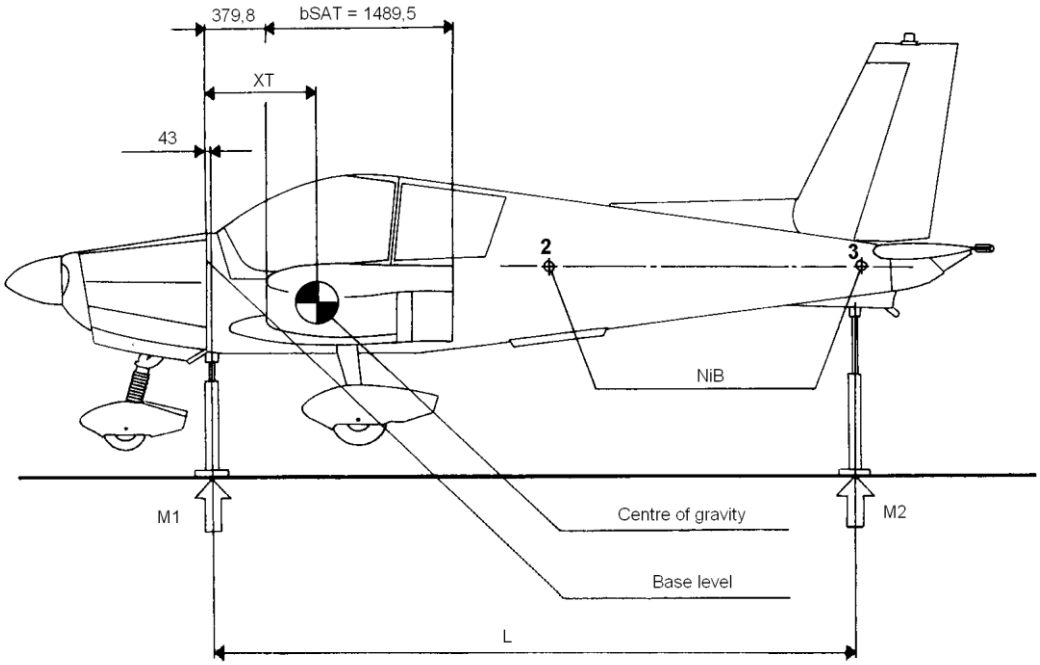
   b) C-G arm
   $$X_T = L \cdot \left(\frac{M_2 - M_4}{M} \right) + 0{,}043 \text{ m}$$
   or
   $$X_T = L \cdot \left(\frac{M_2 - M_4}{M} \right) + 1.693 \text{ in}$$

   c) Static moment
   $S = M \cdot X_T$ kgm (lbin)

   d) C-G position of empty airplane
   $$\overline{X_T} = \left(\frac{X_T - 0{,}3798}{1{,}4895} \right) \cdot 100 \text{ \% SAT} \quad (X_T \text{ in metres})$$
   or
   $$\overline{X_T} = \left(\frac{X_T - 14.953}{58.642} \right) \cdot 100 \text{ \% SAT} \quad (X_T \text{ in inches})$$

4) Record (M; X_T; S; X_T) calculated data to the Record of Weighing (Fig. 8-1).

5) Compare calculated data with that issued in Flight Manual, Chapter 6 and with data of issued manufacturer label upon floor of upper cargo bay. Correct different data issued in Flight Manual and manufacturer label



Name	Marking	Measured data
Fwd balance reading including fwd jack mass	M_1	kg (lb)
Rear balance reading including rear jack mass	M_2	kg (lb)
Mass of fwd jack	M_3	kg (lb)
Mass of rear jack	M_4	kg (lb)
Airplane empty weight	M	kg (lb)
Distance of support points	L	m (in)
Arm	X_T	m (in)
Static moment of airplane	S	kgm (lbin)
C-G position of empty airplane	$\overline{X_T}$	% SAT

date _____ Made out by _____ Approved by _____

Fig. 08-1 Record on weighing with airplane lifted by jacks

EFFECTIVITY: All

AIRPLANE WEIGHING ON LANDING GEAR

Procedure of airplane weighing when on landing gear

1) Set the airplane longitudinally to level position (Fig. 08-2) according to levelling points NiB 2 and NiB 3 upon rear fuselage section to maintain the allowance of these points from levelling plane (NiB 2 – NiB 3) within ± 10 mm.

Recommendation

The approximate setting of airplane to level position may be adjusted by pressing upon rear fuselage down and inserting the balance under the nose wheel. Accurate level setting is made by partial deflation of nose or main landing gear tires.

2) Record data of airplane weighing into the Weighing Record (Fig. 08-2)

a) výsledky vážení (průměrné hodnoty ze tří vážení):
M_1 ... reading of fwd balance that is under nose wheel
M_2 ... reading of left balance that is under the port landing gear wheel
M_3 ... reading of right balance that is under the starboard landing gear wheel

b) distance:
A ... between datum plane and axis of main landing gear
B ... between axis of nose wheel and axis main landing gear wheels

Recommendation

a) Suspend plumb bobs in airplane axis, i.e. from the front side of firewall (datum plane) and from beam of auxiliary tailskid. Place rope that passes under the tips of both plumb bobs all along the lenght of airplane.

b) Place rope so that it is in main landing gear axis.

c) Measure the distance between main landing gear axis and tip of plumb bob suspended from front side of firewall.

d) Measure the distance between nose wheel axis and main landing gear axis.

3) Calculate:

a) Mass of empty airplane

$M = M_1 + M_2 + M_3$ kg (lb)

b) C-G arm

$$X_T = A - \frac{B \cdot M_1}{M}$$ m (in)

c) Airplane static moment

$S = M \cdot X_T$ kgm (lbin)

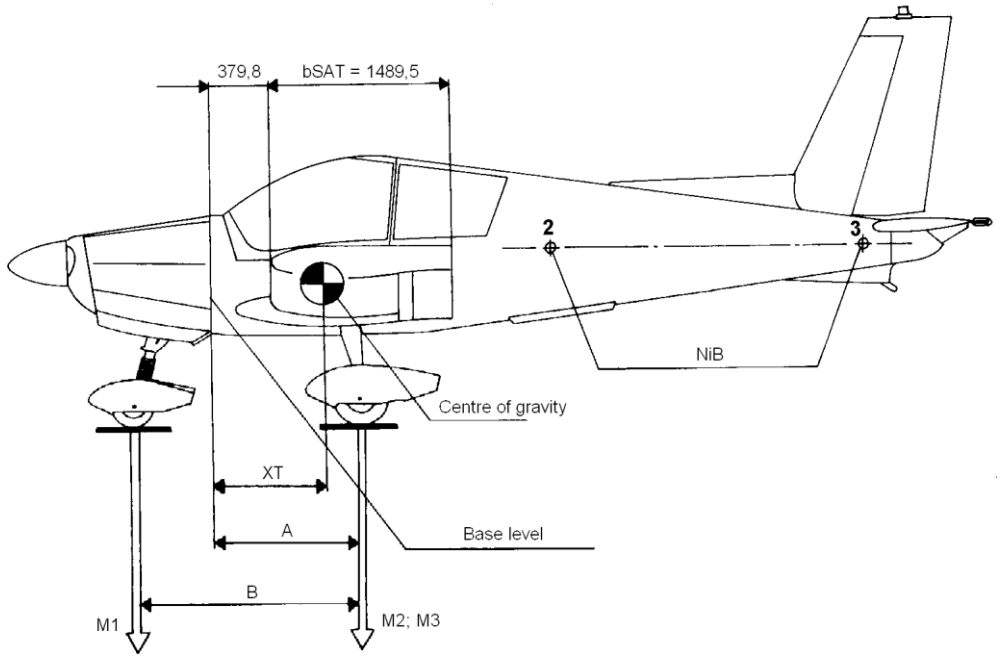
d) C-G position of airplane

$$\overline{X_T} = \left(\frac{X_T - 0{,}3798}{1{,}4895}\right) \cdot 100 \quad \% \text{ SAT} \qquad (X_T \text{ in metres})$$

$$\overline{X_T} = \left(\frac{X_T - 14.953}{58.642}\right) \cdot 100 \quad \% \text{ SAT} \qquad (X_T \text{ in inches})$$

4) Record (M; X_T; S; $\overline{X_T}$) data to the Record of Weighing (Fig. 08-2)

5) Compare calculated data with that issued in Flight Manual, Chapter 6 and upon manufacturer label that is on the floor of upper cargo bay. Correct different data in Flight Manual and label.



Name	Marking	Measured Data
Reading of fwd balance	M_1	kg (lb)
Reading of balance under port main landing gear	M_2	kg (lb)
Reading of balance under starboard main landing gear	M_3	kg (lb)
Airplane empty weight	M	kg (lb)
Distance between datum plane and axis of main landing gear	A	m (in)
Distance between axis of nose and main landing gear wheels	B	m (in)
Arm	X_T	m (in)
Airplane static moment	S	kgm (lbin)
C-G position of empty airplane	$\overline{X_T}$	% SAT

date | Made by | Approved by

Fig. 08-2 Record on weighing with airplane standing upon landing gear wheels

AIRPLANE LEVELLING

The airplane levelling is made after vital part replacement that may influence airplane geometrical characteristics, after excessive airplane overload or in the other cases that may influence data checked during levelling.

Survey of works to be done:

Reason of airplane levelling and adjustment	Range of airplane levelling and adjustment				
	Fig. 08-5				
	Table 1	Table 2; 3	Table 4	Table 5	Table 6
	Lenght of mount bolts	Vertical distances	Direct distances	Adjustment of control surfaces and flaps	Convergen-ce of main landing gear
- replacement/installation of mount bolts	o	---	---	---	---
- wing installation without mount reaming	---	---	---	ailerons, flaps	---
- wing installation after wing mount reaming	---	NiB 4;5;6;7 NiB 5-4; 6-7; 6-4	A; B	ailerons, flaps	---
- replacement/installation of ailerons/flaps, flap control cables	---	---	---	ailerons, flaps	---
- replacement/installation of elevator/trim tab/ cables of pitch trimming	---	---	---	elevator / trim tab	---
- replacement/installation of rudder, rudder control cables	---	---	---	rudder	---
- stabilizer installation without mount reaming	---	---	---	elevator / trim tab	---
- replacement/installation of stabilizer with reaming of stabilizer mounts	---	NiB 8;9; 10; 11 NiB 8-9; 10-11; 11(L)-11(P)	A; C	elevator / trim tab	---
- replacement of main landing gear leg/wheel shaft; reaming the main landing gear suspension mounts	---	---	---	---	o
- overload in flight - flight through heavy turbulence	o	o	o	---	---
- overload during rough landing	o	o	o	o	o
- the other cases that may influence tha data checked during airplane levelling	Acc. to need, on-condition				

EFFECTIVITY: All

Conditions to be maintained during airplane levelling:

The airplane should be leveled in shut hangar. Exceptionally it may be leveled in calm weather in the open upon flat, leveled concrete area.

Procedure of airplane levelling:

NOTE

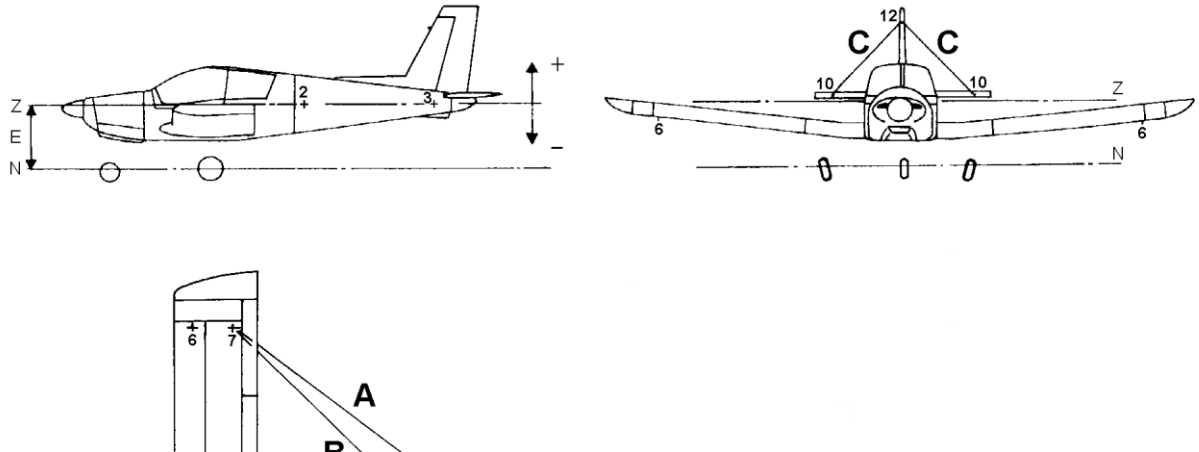
Measure all the data three times and fill the calculated average of these three measurement to the Airplane Levelling Record.

1) Measure the lenght of suspension bolts joining the fuselage rear section to airframe (section 53-30-00) and fill the measured data to the Table 1 of Airplane Levelling Record (Fig. 8-5).
   a) In case of suspension bolts installation measure their lenght before and after installation. Record calculated differences (L_2 - L_1).
   b) Measure the lenght of installed suspension bolts and compare the measured data with that recorded in the Airplane Levelling Record.
2) Lift the airplane by fuselage jacks (section 07-11-00, 07-12-00) and set it to level position. Use for levelling along longitudinal axis NiB 2 and 3 upon rear fuselage section and NiB 6 upon L.H. side and R.H. side wings for levelling along lateral axis (Fig. 8-3).
3) The height of Levelling plane, i.e. the plane of theodolite. Should be set at least 600 mm below airplane datum plane that is determined by NiB 2 and 3.
4) Place theodolite such a way that it enables measurement on both sides of airplane. It is inconvenient to place theodolite behind the airplane.
5) Prepare theodolite for measurement, measure all the data and fill the distances of NiB 2 through 11 on both sides of airplane from the levelling plane to the Airplane Levelling Record (fig. 8-5).

   NOTE

   The NiB data above the datum plane are provided with (+) signs, while those below that plane are provided with (-) signs.
6) Fill the differences of measured data from Table 2 to Table 3 of airplane Levelling Record (Fig. 8-5). Compare calculated differences with permitted allowances.
7) Measure and enter the distances A, B and C from both sides of airplane to Table 4 of Airplane Levelling Record (Fig. 8-5). Calculate and record differences between L.H. side and R.H. side of airplane. Compare the differences with permitted allowances.
8) Check maximum deflections of control surfaces (Fig. 8-4) and record result of check to Table 5 of Airplane Levelling Record (Fig. 8-5).
   The TAKE-OFF (14^o) and LANDING (37^o) positions of flaps should be measured when flaps loaded with 100N force acting perpendircularly upon flap trailing edge upwards.
9) Check convergence of main landing gear wheels. Procedure of convergence measurement is issued in section 32-41-00 (INSPECTION / CHECK). Results of check should be filled in to Table 6 of Airplane Levelling Record (Fig. 08-5).

1



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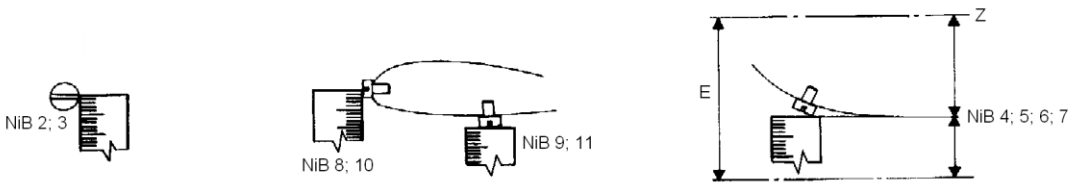

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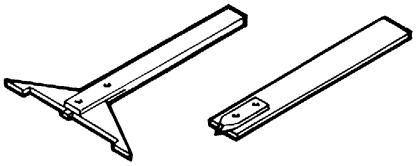
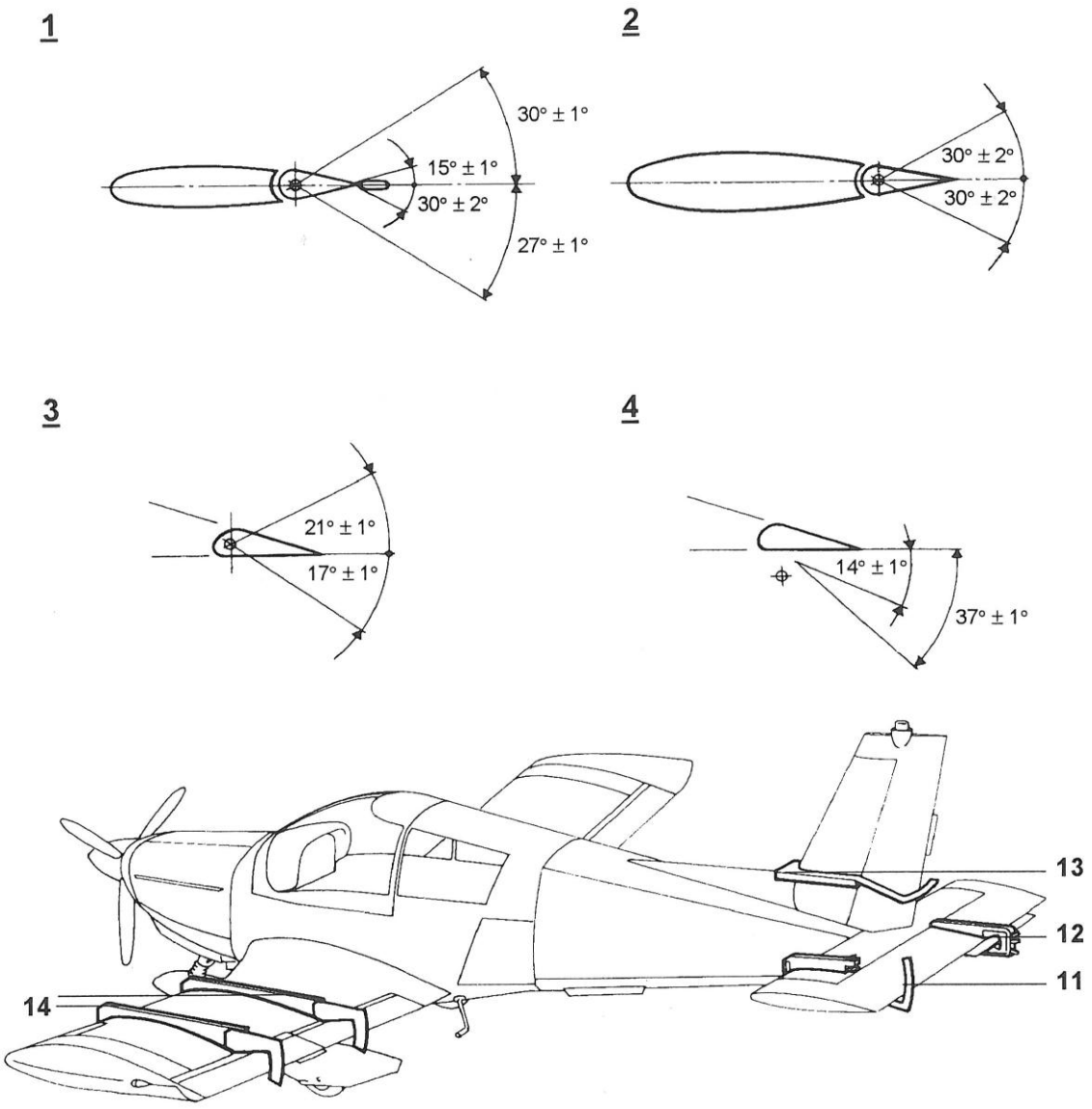


1 ... survey of NiB location on the airplane
2 ... way of ruler placing to NiB
2.1 ... fuselage; 2.2 ... stabilizer; 2.3 ... wings
3 ... set of rulers, fixture number 002-619-1059

A ... distance between NiB 7 - 10
B ... distance between NiB 7 - 3
C ... distance between NiB 10 - 12
E ... distance of levelling plane from datum plane of airplane (min. 600 mm)
H ... distance of NiB from levelling plate
M ... distance of NiB from datum plane
N ... levelling plane
Z ... datum plane

Fig. 08-3 Airplane levelling

EFFECTIVITY: All



1 ... deflection of elevator and trim tab
2 ... deflection of rudder
3 ... deflection of ailerons
4 ... angles of flap extension

Recommended fixture:
11 ... elevator deflection template, fixture No. 33-Z 42-2254
12 ... trim tab deflection template, fixture No. 33-Z 42-2256
13 ... rudder deflection template, fixture No. 33-Z 42-2259
14 ... aileron deflection template and flap extension angles, fixture No. 33-Z 42-1851

Fig. 08-4 Deflection of control surfaces

Table 1 Lenght of suspension bolts

No. of suspension bolt	Lenght			Difference
	before installation L_1 (mm; in)	after installation		$L_2 - L_1$ (mm; in)
		$L_2 = L_1 {}^{+0,12}_{+0,14}$ (mm)	$L_2 = L_1 {}^{+0.0047}_{+0.0055}$ (in)	
1				
2				
3				
4				

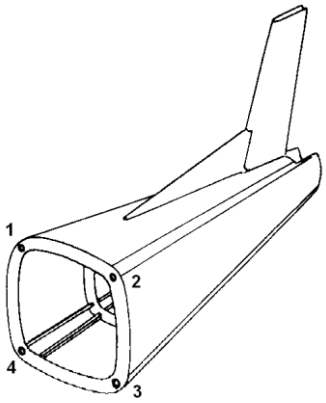


Table 2 Vertical distances (Fig. 08-3, items 1; 2)

APPLICABLE UP TO S/N 0014

NiB	Theoretic distance from Datum plane		Measured distance from levelling plane	
	mm	in	L.H. side (mm; in)	R.H. side (mm; in)
2	0	0		
3	0	0		
4	- 568,0	- 22.36		
5	- 554,5	- 21.83		
6	- 247,0	- 9.72		
7	- 287,0	- 11.30		
8	+ 125,2	+ 4.93		
9	+ 89,2	+ 3.51		
10	+ 125,2	+ 4.93		
11	+ 93,2	+ 3.67		

APPLICABLE FROM S/N 0015

NiB	Theoretic distance from Datum plane		Measured distance from levelling plane	
	mm	in	L.H. side (mm; in)	R.H. side (mm; in)
2	0	0		
3	0	0		
4	- 568,0	- 22.36		
5	- 576,3	- 22.69		
6	- 247,0	- 9.72		
7	- 287,0	- 11.30		
8	+ 125,2	+ 4.93		
9	+ 89,2	+ 3.51		
10	+ 125,2	+ 4.93		
11	+ 93,2	+ 3.67		

Fig. 08-5 Airplane Levelling and adjustment record
(page 1 of 3)

EFFECTIVITY: All

Table 3 Actual differences of measured distances

APPLICABLE UP TO S/N 0014

Check	Distance between NiB	Theoretic difference		Allowance of difference		Difference of measured distance	
		mm	in	mm	in	L.H. side (mm; in)	R.H. side (mm; in)
Wing washout	5 - 4	13,5	0.53	± 3	± 0.12		
	6 - 7	40,0	1.57	± 3	± 0.12		
Dihedral	6 - 4	321,0	12.64	± 10	± 0.40		
Stabilizer washout	8 - 9	36,0	1.42	± 2	± 0.08		
	10 - 11	32,0	1.26	± 2,5	± 0.10		
Stabilizer setting	11(L)-11(P)	0	0	max. 15	max. 0.60		

APPLICABLE FROM S/N 0015

Check	Distance between NiB	Theoretic difference		Allowance of difference		Difference of measured distance	
		mm	in	mm	in	L.H. side (mm; in)	R.H. side (mm; in)
Wing washout	5 - 4	8,3	0.33	± 3	± 0.12		
	6 - 7	40,0	1.57	± 3	± 0.12		
Dihedral	6 - 4	321,0	12.64	± 10	± 0.40		
Stabilizer washout	8 - 9	36,0	1.42	± 2	± 0.08		
	10 - 11	32,0	1.26	± 2,5	± 0.10		
Stabilizer setting	11(L)-11(P)	0	0	max. 15	max. 0.60		

Table 4 Direct distances (Fig. 08-3, item 1)

Check	Distance	Actual data		Difference betwen L.H. side and R.H. side		
		L.H. side (mm; in)	R.H. side (mm; in)	Actual (mm; in)	Allowance	
					mm	in
Wing setting	A				max. 15	max. 0.60
	B				max. 15	max. 0.60
Tail unit setting	C				max. 15	max. 0.60

Fig. 08-5 Airplane Levelling and adjustment record
(page 2 of 3)

Table 5 Adjustment of control surfaces and flaps (Fig. 08-4)

Range of measurement	Deflection		Allowance	Actual deflection	
	position	Magnitude		L.H. side	R.H. side
Výškové kormidlo	Up	30^o	$\pm 1^o$		
	Down	27^o	$\pm 1^o$		
Vyvažovací ploška výškového kormidla	Up	15^o	$\pm 1^o$		
	Down	30^o	$\pm 2^o$		
Směrové kormidlo	Left / Right	30^o / 30^o	$\pm 2^o$ / $\pm 2^o$		
Křidélka	Up	21^o	$\pm 1^o$		
	Down	17^o	$\pm 1^o$		
Vztlakové klapky	Take-off	14^o	$\pm 1^o$		
	Landing	37^o	$\pm 1^o$		

Table 6 Convergence of main landing gear wheels (section 32-41-00, INSPECTION / CHECK)

Main landing gear	Tapered washer	Measured convergence	Design convergence
L.H. side			0° (+ 0° / - 1°)
R.H. side			

EVALUATION

Results of airplane levelling and adjustment in required allowances:	YES	NO
Differences, taken measures:		

date _____ Made by out _____ Approved by _____

Fig. 08-5 Airplane Levelling and adjustment record
(page 2 of 3)