

# **AVIONICS DESIGN SERVICES LTD.**

PO. BOX 151,  
Midland, ONTARIO,  
L4R 4K8. Ph. 705-527-6095

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Date: 6<sup>th</sup> of October 2009

**RE: Zenair Zodiac CH 650 Structural Test to ASTM-SLSA**


To Whom It May Concern,

I, Catalin Voicu, hereby affirm that I witnessed the Load Test to ASTM-SLSA carried out on the Zenair Zodiac CH 650 design in Midland, Ontario and completed on September 28, 2009.

I understand that my capacity as an official observer was to ensure accurate reporting of the witnessed events. I am aware that the test results will be forwarded to third parties interested in the design of this aircraft.

Therefore, and for these reasons, I hereby certify that I have verified the above listed Structural Test Report prepared by Zenair Ltd. and attest that the figures, measurements and photographs presented within the report accurately reflect the data I saw being collected and recorded during the witnessed test. The test article conformity, performed by Zenair Ltd., is not covered by this letter.

Sincerely,

  
Catalin Voicu, P. Eng.  
Professional Engineers Ontario  
License 100079521

ENC: Zenair Zodiac CH 650 Structural Test to ASTM-SLSA (21 pages dated and signed)



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**Zenair Zodiac CH 650**  
**Structural Test to ASTM-SLSA**

Test Witnessed By: Catalin Voicu

A handwritten signature in black ink, appearing to read "Catalin Voicu", with a long horizontal stroke extending to the right.

Report Prepared By: Zenair Ltd

Test Completion Date: September 28, 2009



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**Object:**

The object of this Test is to prove the structural integrity of the Zenair Zodiac 650 for the following Load case:

The Wing Structure and Fuselage attachment structure is capable of reacting the Positive Design Load Case corresponding to ASTM-SLSA at 6g at Vd=290km/h=180mph, aileron deflected.

**Positive Design Loads applied to the Wing Structure**

The following Loads and their distribution over each wing:

Limit Design Applied Load Per Wing	=	759 Kilograms
Ultimate Design Applied Load Per Wing	=	1140 Kilograms
Exceeding Ultimate Applied Load Per Wing	=	74 Kilograms
Correction of total weight of shingles	=	+18 Kilograms
Total weight applied to both wings	=	2,446 Kilograms (5,381.20 lbs)

**Test Set Up**

The Test Specimen consisted of a fuselage, both port and starboard wings. Both wings were loaded and the applied load was reacted at the fuselage as shown below.

Prior to the start of the test, the specimen was set up with the fuselage being set at 0 Degrees corresponding to 6 deg. of wing incidence.

The load was applied using roofing shingles which are pliable and formed to the contour of the wing. The dimensions of the shingle are 340 mm wide by 1,000 mm long.

A Portion of the Load was reacted at the Seat Structure for the set-up of this Reaction (S).

The Vertical deflection was measured from the floor to the following positions:

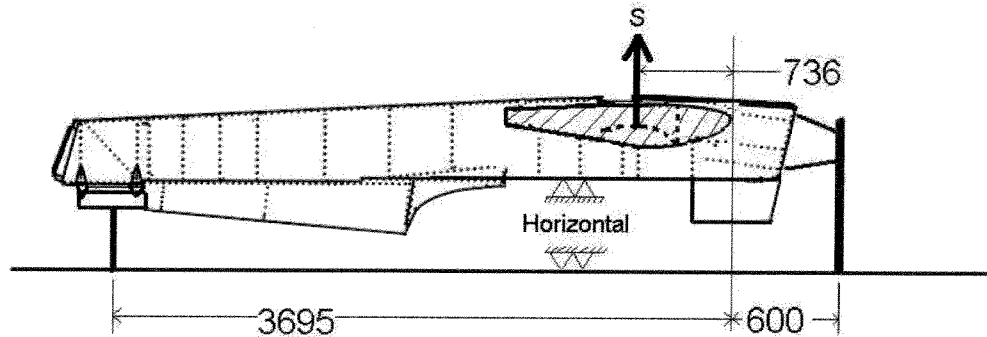
Wing Leading edge at the Root and Wing Tip.  
Rear Spar at the Root and Wing Tip.

Setting the zero reference point for Measured Deflections. Load was added to wings (759 kg) and Measured Deflections taken as per line 1 (a) on Table #4. Load was removed and Measured Deflections taken as per line 2 (Zero Load) on Table #4. Zero reference points for the remainder of the test was established. Limit load test was than started.



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### **Test Procedure**

#### **Limit Load Case**

Load was applied up to Limit Load totalling 759 Kilograms per wing as per Table #1A and Table #1B for position, and Table #2 for applied weights. Deflection Measurements were taken before the load was removed. See Table #4 line 3 (a).

When the load was completely removed the Deflection Measurements were again taken. Line 4 on Table #4.

#### **Ultimate Load Case**

After the Limit Load was removed from the wings and the Deflection Measurements taken, Limit Load was re-applied. See Table #4 line 5 (a).

Load was then applied as per Table 2, line b, c, and c. Ultimate Load totalling 1140 Kilograms per wing as per Table #1A and Table #1B for position, and Table #2 for applied weights. Deflection Measurements were taken at lines b, c, and d.

#### **Exceeding Ultimate Load Case**

After Deflection Measurements were taken at Ultimate, 2 shingles were added to each station as per Table #3A – Starboard wing and Table #3B – Port wing, for applied weights and locations. Shingles were weight after completion of test with total weights shown on Table #3A and #3B.

#### **Applied Loads**

The load location definition for each wing is shown on Table #1A and 2A. Applied weights are on Table #2 for up to Ultimate. Table #3A and 3B for Past Ultimate shows applied weight and location of weights.



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### **Weight Confirmation of Shingles After Test**

All shingles (per wing) up to Ultimate Load were placed on a wood skid and weighted, as to confirm the total weight.

Total weight of shingles for Port wing was 1,148 kg (weight of skid removed).

Total weight of shingles for Starboard wing was 1,150 kg (weight of skid removed).

### **Conclusions**

#### **Limit Load**

Limit Load was applied with no signs of local deformation in the aircraft structure. When the load was removed there was no permanent deformation in the structure when inspected.  
The Limit test was considered successful.

#### **Ultimate Test**

Ultimate Load was applied and held for longer than 60 seconds, with no visible permanent deformation in the structure when inspected.  
The Ultimate load test was considered successful.

#### **Exceeding Ultimate Load**

Weights exceeding Ultimate Load was applied and held for more than 30 seconds, with no visible permanent deformation in the structure when inspected.  
Exceeding Ultimate Load test was considered successful.

#### **Inspection**

Inspection of airframe after removing weights and removing wings from fuselage.  
Spar bolts were bent and bolt holes at wing root area were elongated. No other deformation was noticed in the wings or fuselage.

#### **Total Weight**

Total weight on both wings was 1150 + 1148 + 74 + 74 for a total of 2,446 kg (5,381.20 lbs).

#### **Failure**

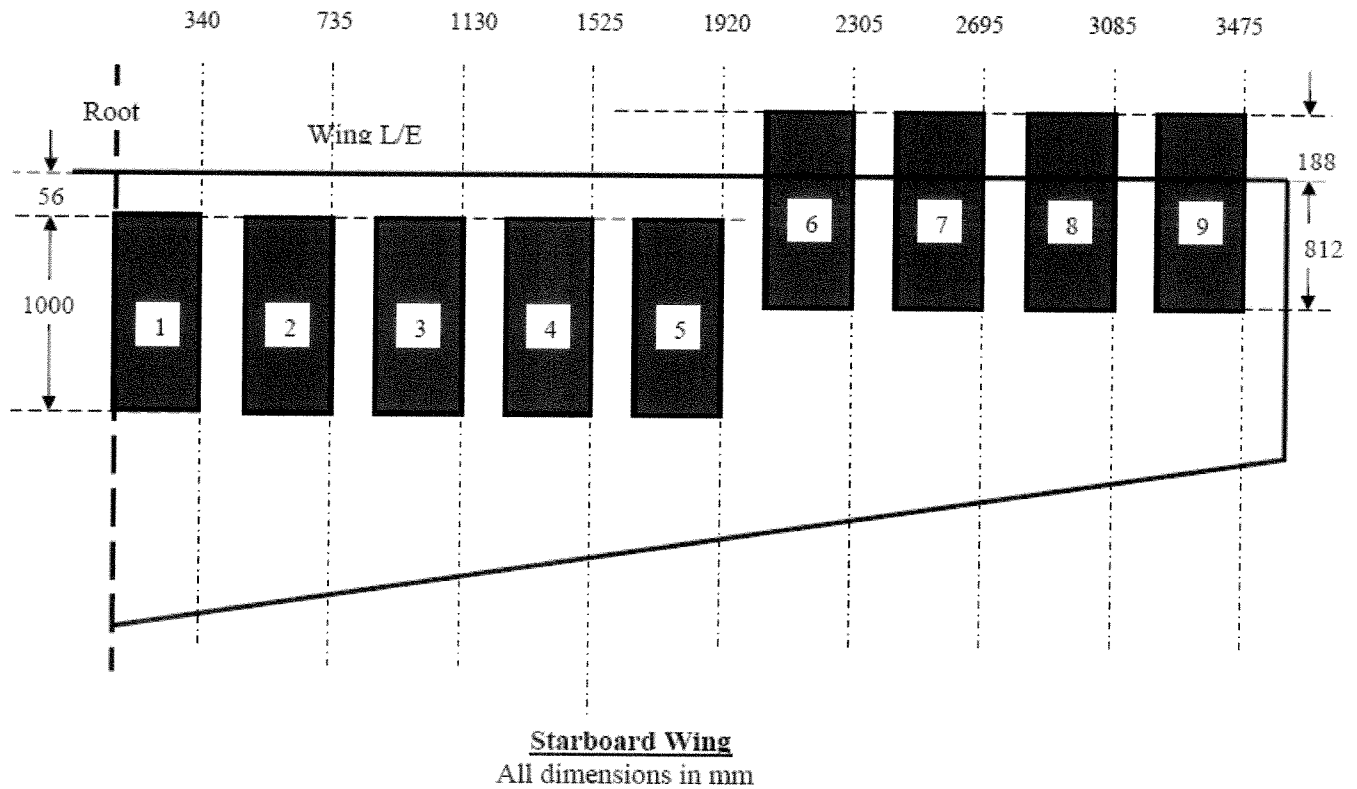
Test did not show any failures or permanent deformation in the airframe. However, inspection of the spar bolts at root were slightly bent and bolt holes slightly elongated.



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Table 1A

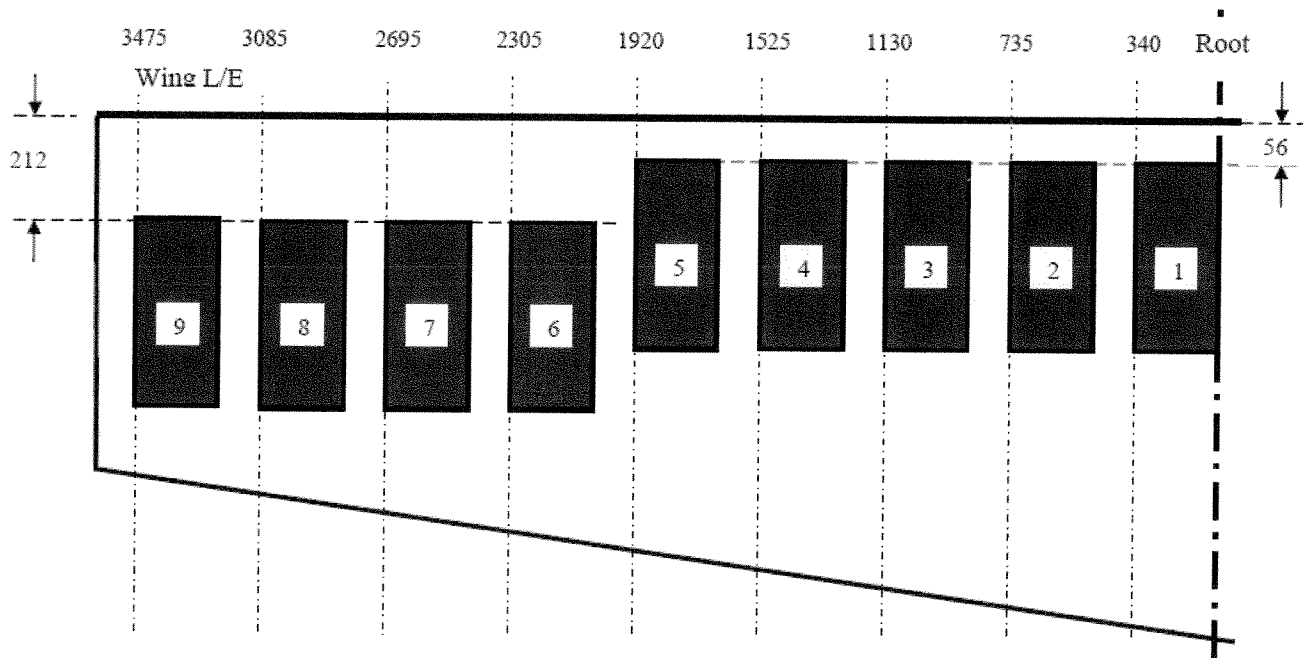




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**Table 1B**



**Port Wing**  
All dimensions in mm





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**Table #2 – Applied Loads up to Ultimate**

	Root								Tip	
Wing Stations	1	2	3	4	5	6	7	8	9	
										Totals
a) Limit Load	65	70	110	110	110	71	71	72	80	759
b)	20	25	35	35	35	20	20	25	30	245
c)	7	5	15	15	15	10	10	6	5	88
d)	5	5	6	6	6	5	5	5	5	48
Totals	97	105	166	166	166	106	106	108	120	
Ultimate Load										<b>1140</b>

(Loading from the root in kg)

**Table #3A Starboard – Weights and location past Ultimate**

	Root								Tip
	1	2	3	4	5	6	7	8	9
# of Shingles	2	2	2	2	2	2	2	2	2
# of Shingles	2	2	2	2	2	2	2	2	2
Extra Weight									11.8 kg
Weight in kg	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	18.7

**Total weight past Ultimate: 74 kg**

**Table #3B Port – Weights and location past Ultimate**

	Root								Tip
	1	2	3	4	5	6	7	8	9
# of Shingles	2	2	2	2	2	2	2	2	2
# of Shingles	2	2	2	2	2	2	2	2	2
Extra Weight									11.8 kg
Weight in kg	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	18.7

**Total weight past Ultimate: 74 kg**



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**Table #4 Measured Deflections**

Applied Load		Port Wing				FUSELAGE	Starboard Wing			
Measurement Position		Tip Rear Spar mm	Tip L/E mm	Root Rear Spar mm	Root L/E mm		Root L/E mm	Root Rear Spar mm	Tip L/E mm	Tip Rear Spar mm
		D	C	B	A		A	B	C	D
1 (a)	<b>759 kg.</b>	<b>538</b>	<b>619</b>	<b>959</b>	<b>995</b>		<b>993</b>	<b>958</b>	<b>603</b>	<b>541</b>
2	Zero Load	624	695	965	998		998	965	690	630
3 (a)	<b>759 kg. Limit</b>	<b>538</b>	<b>619</b>	<b>959</b>	<b>994</b>		<b>992</b>	<b>958</b>	<b>602</b>	<b>540</b>
4	Zero Load	623	695	965	998		998	965	690	631
5 (a)	<b>759 kg. Limit</b>	539	619	960	995		993	960	602	541
b	<b>1,004 Kg</b>	<b>505</b>	<b>591</b>	<b>958</b>	<b>994</b>		<b>990</b>	<b>957</b>	<b>560</b>	<b>499</b>
c	<b>1,092 Kg</b>	<b>490</b>	<b>578</b>	<b>957</b>	<b>993</b>		<b>988</b>	<b>955</b>	<b>545</b>	<b>483</b>
d	<b>1,140 Kg Ultimate</b>	480	569	956	992		987	954	535	473
e	Zero Load	609	680	964	997		997	964	667	608

**Reaction Applied to seat structure (S) during the Loading Sequence**

At an Applied Load of 759 kg (Limit Load), the Seat Reaction (S) was 600 kg.

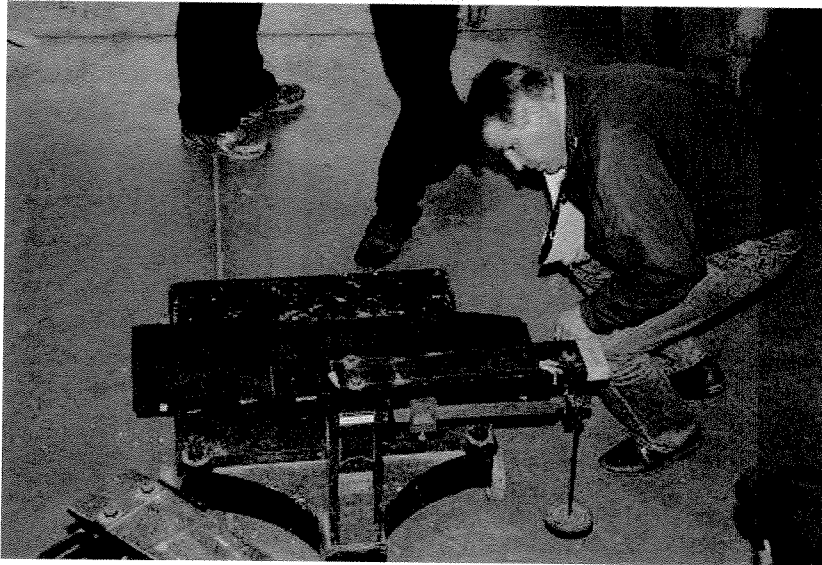
At an Applied Load of 1,140 kg (Ultimate Load), the Seat Reaction (S) was 880 kg.

At an Applied Load of 1,140 kg, Seat Reaction (S) was taken to 1,000 kg for 30 seconds. Seat Reaction (S) was then reduced to 880 and test continued to Table #3A/3B.



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Confirming the weights before starting test



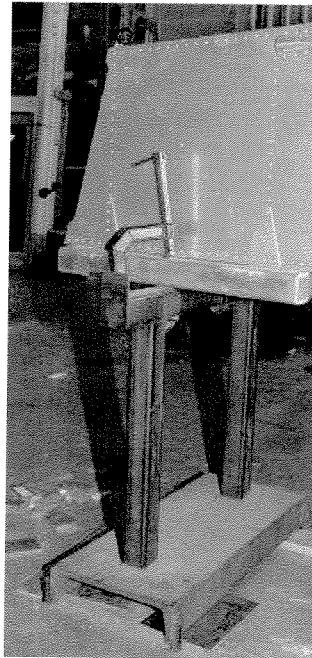
Seat area representing "S" load for 2 people

A handwritten signature in black ink, located at the bottom right of the page.



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**Fuselage is supported at the rear fuselage as shown above**



**Fuselage is supported at the engine mount as shown above**

A handwritten signature in black ink, located at the bottom right of the page.

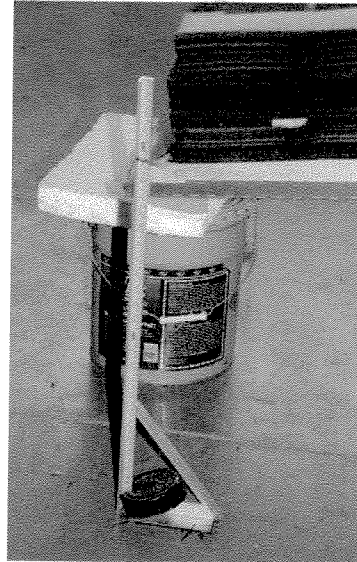


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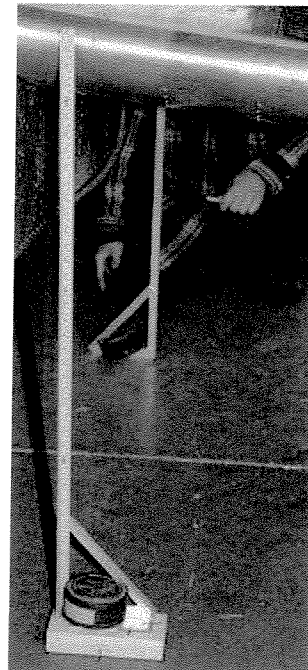
Location of Deflection measurement B  
Root Rear Spar



Location of Deflection measurement D  
Tip Rear Spar



Location of Deflection measurement C  
Tip L/E

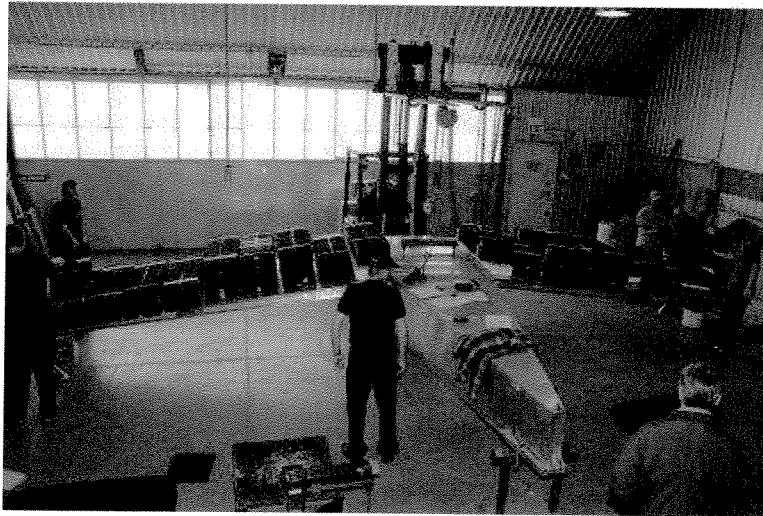


Location of Deflection measurement A  
Root L/E

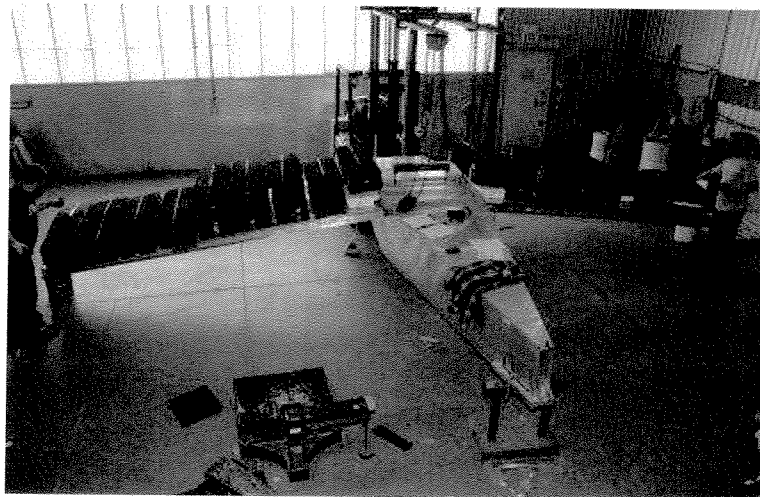


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Loading the final 5 kg per wing for Ultimate Load



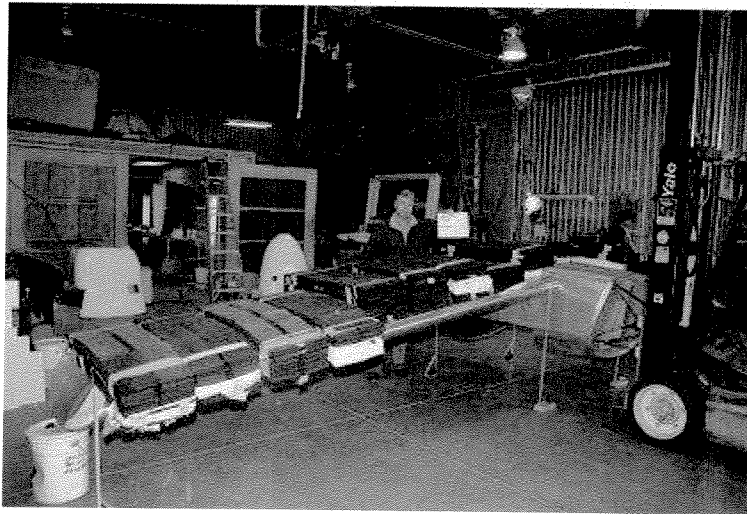
Loading the final 11.8 Kg of extra weight past Ultimate Load for a total load per wing of 1,214 kg

A handwritten signature in dark ink, appearing to be "G. J. R." or similar, located at the bottom right of the page.

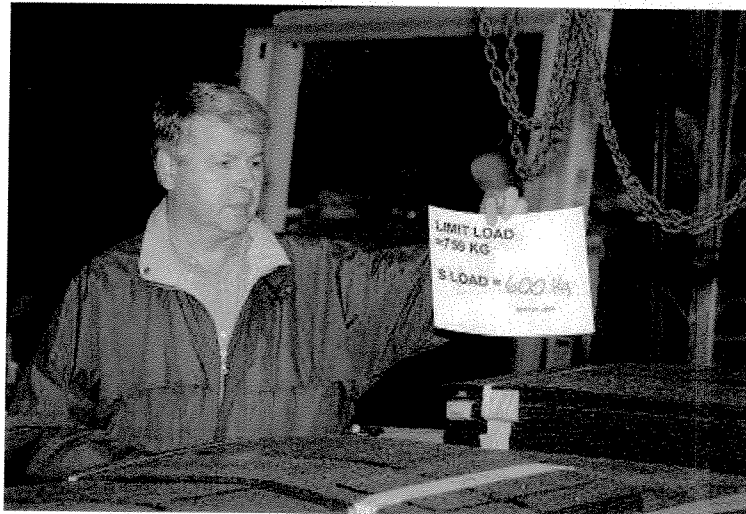


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**Limit Load Applied to the Aircraft**



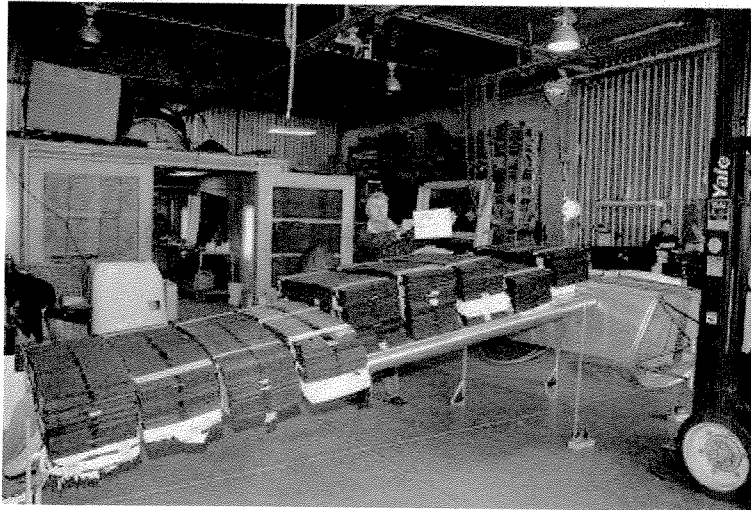
**Limit Load Applied to the Aircraft Per Wing**



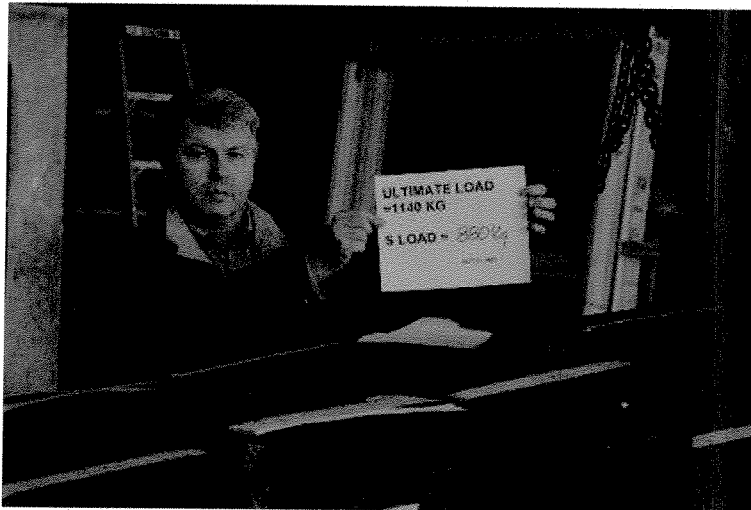


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**Ultimate Load Applied to the Aircraft**



**Ultimate Load Applied to the Aircraft Per Wing**

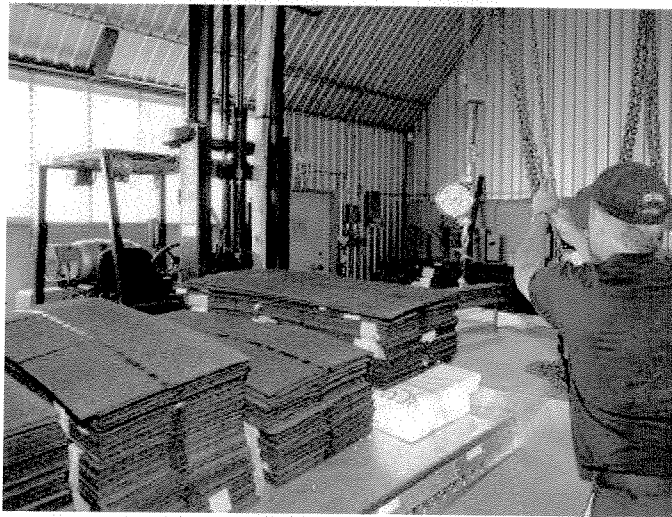
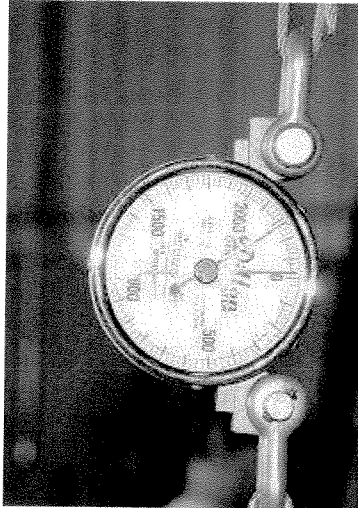
A handwritten signature in ink, located at the bottom right of the page.





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**"S" reading at Ultimate in Lbs at 2,200 lbs (1,000 kg)**  
**(reduced to 880 kg after 30 seconds)**

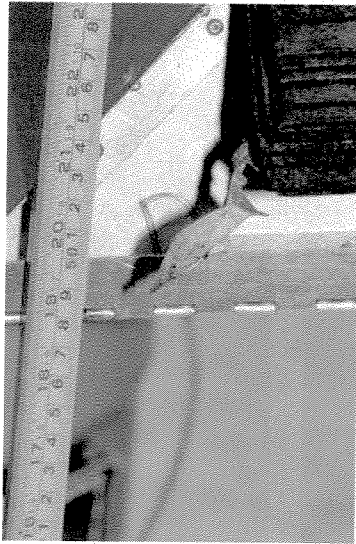




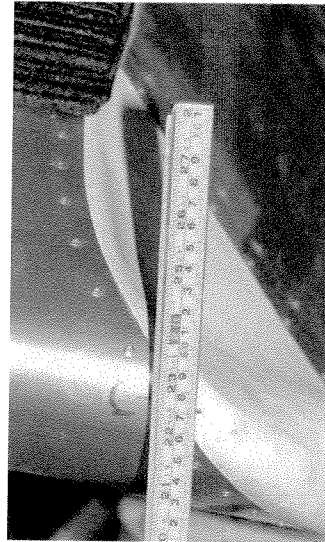
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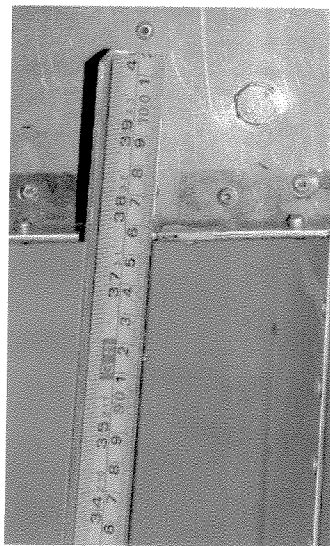
**Following photos are of the Measured Deflections at Ultimate Load**



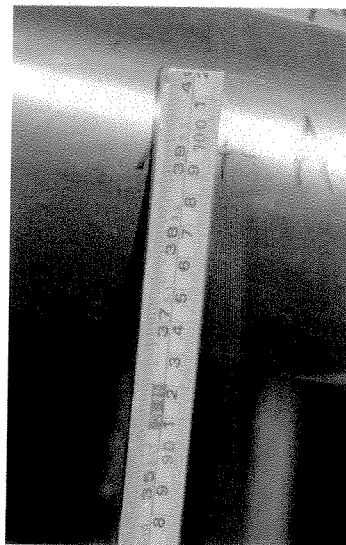
**Port wing O/B rear spar D  
With weight**



**Port wing O/B front spar C  
With weight**



**Port wing I/B rear spar B  
With weight**



**Port wing I/B front spar A  
With weight**

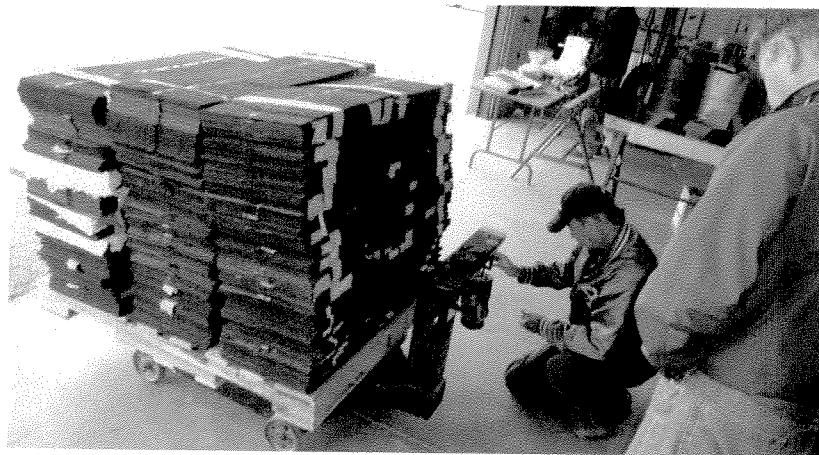


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**Weighing total weight of Port wing for Ultimate. Total weight is 1,148 kg**



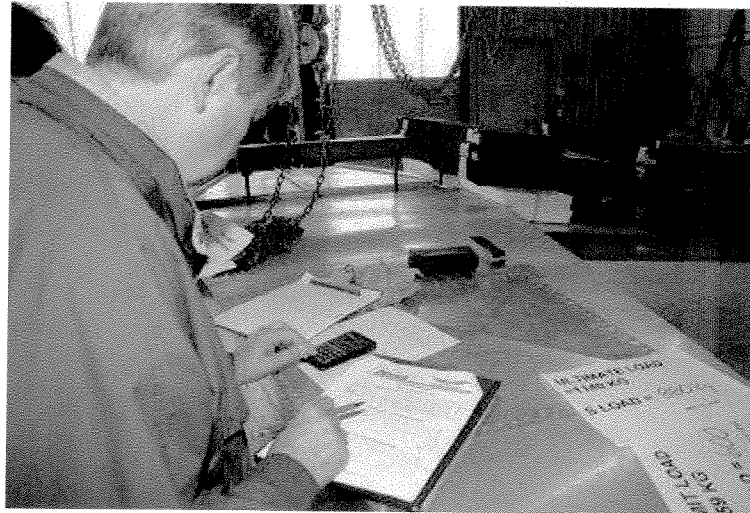
**Weighing total weight of Starboard wing for Ultimate. Total weight is 1,150 kg**

A handwritten signature in black ink, consisting of a stylized, cursive script.



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**Independent Inspector Catalin Voicu confirming total weights applied**



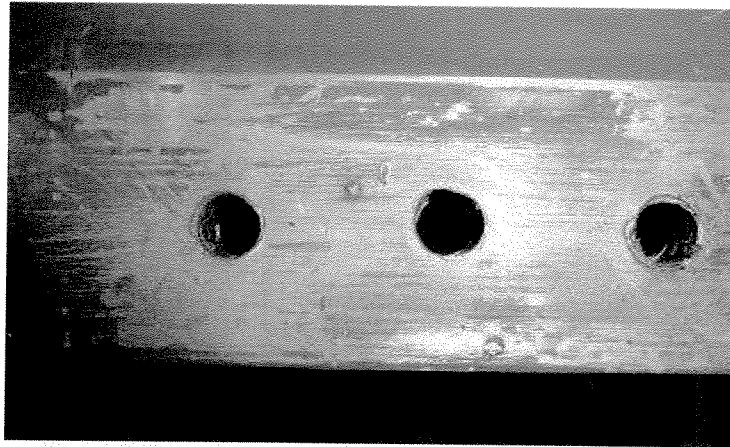
**Confirming airframe material thicknesses and inspecting general condition of airframe after test**

A handwritten signature in black ink, appearing to be "C. Voicu".

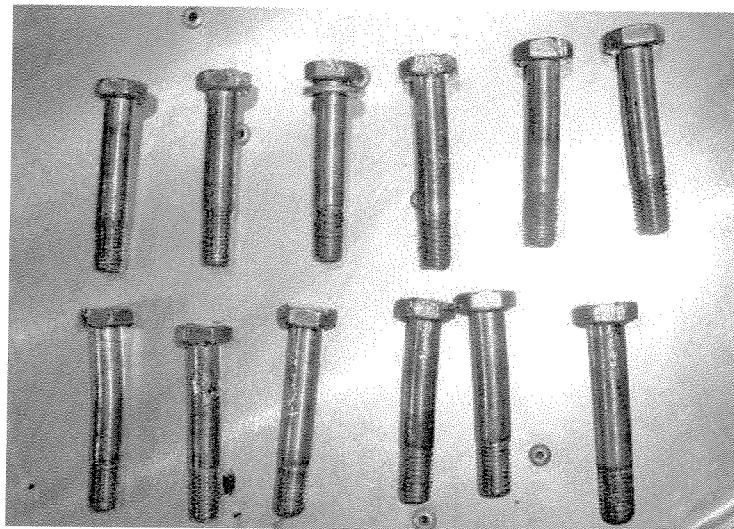


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**Wing root bolt holes after test. Holes are elongated**



**Spar bolts at wing root. Bolts are bent**

A handwritten signature or mark in the bottom right corner of the page.



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**Table #5**  
**Material thicknesses**

	Wings	Drawing specifications	Actual Specifications
6W3-1	Outboard wing spar web	t=0.040"	0.042
6W3-2	Front Upper Spar Doubler	1/4"x 1-1/2"	0.231"x1.495
6W3-3	Front Lower Spar Doubler	1/4"x 1-1/2"	0.231"x1.50
6W3-4	Rear Upper Spar cap	1/4"x 1-1/2"	0.232"x1.50"
6W3-5	Rear Upper Spar cap	1/4"x 1-1/2"	0.25"x1.501"
6W7-1	Rear Channel	t=0.025"	0.0245"
6W7-2	Root Doubler	t=0.063"	0.066"
	Spar bolt holes at root	5/16"	See photo
	Fuselage		
6W4-1	Center Spar Web Front	t=0.032"	0.031"
6W4-2	Center Spar Web Rear	t=0.032"	0.0315"
6W4-3	Center Spar Cap Top Rear	1/4"x 1-1/2"	0.247"x1.495"
6W4-3	Center Spar Cap Top Front	1/4"x 1-1/2"	0.251"x1.499"
6W4-3	Center Spar Caps Bottom Rear	1/4"x 1-1/2"	0.250"x1.496"
6W4-3	Center Spar Cap Bottom Front	1/4"x 1-1/2"	0.253"x1.494"
6B1-8	H.T. Attachment Bracket (rear)	t=0.063"	0.066"
6B1-9	H.T. Attachment Bracket (Front)	t=0.063"	0.065"
6B5-4	Rear Wing Channel Attach Plate	t=0.125	0.121"

**Extra material**

	Extruded L angle bolted to 6W3-2	1" x 1-1/2" x 1/8"	0.993"x1.497"x0.123"
	Center spar aluminium top doubler	t=0.063	0.065"
	Seat front bottom "L" angles	t=0.063	0.062"
	Wing root doubler at spar cap bolts	t=0.032	0.033"
	"L" angle at top of rear spar	t=0.040	0.039"
	Doubler plate at rear spar aileron rod hole	t=0.032	0.033"
	Gusset plate top of spar uprights	t=0.063	0.061"