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REPORT A-33162

FLYING WIRE TEST, Aerocet Model 5850 Series Floats (DeHavilland DHC-2 Aircraft)

September. 20, 2019

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REVISION RECORD

REV	DATE	DESCRIPTION	PAGES	RELEASED
0	9/20/2019	Initial Release	All	

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1. ABSTRACT

Aerocet, Inc. performed a series of tensile tests on AN676 Ø3/8" Streamline Tie Rods ("Flying Wires") in order to establish the approximate loads required to achieve recoil buckling when attachment components fail under load. Flying wires were attached to a hydraulic ram and a test specimen or "pull fuse" which broke at a predicted load and the results were observed. This report describes the process and the results of that testing sequence.

2. APPLICABILITY

This is applicable to Aerocet Model 5850 Series Floats, specifically the AN676 Streamlined Flying Wires (56-15170 Tie Rod Assembly) Installation.

3. REFERENCES

No.	Reference	Revision	Date
1.	56-15170 Tie Rod Assembly Installation	B	9/4/2012
2.	SL05-56-15145 Service Letter	--	10/08/2012
3.	Tensile Specimen, Tie Rod Test	--	--
4.	Flying Wire Test Fixture	--	--
5.	56-15190 Tie Rod Assembly	B	3/02/2010
6.	56-15191 Streamlined Tie Rod	A	7/18/2006
7.	FW-ART405-25 Structural Substantiation for Installation of Aerocet 5850 Twin Seaplane Floats on DeHavilland, DHC-2 Beaver	I/R	8/30/2019
8.	AN676	3	6/15/1967

4. LOADS

Tension loads (lbf.) were arbitrarily determined from lowest at 2,500 lbf. and sequentially increased to attain the ultimate load for the installation 5,179.8 lbf. rounded to 5,200 lbf. for this test. Thereafter, loads were arbitrarily set sequentially increasing until attaining the rated tie rod load of 10,000 lbf.

Loads to be applied using hydraulic ram testing device in tensile direction until a failure is observed. An Ashcroft Pressure Gauge (Tool# Q-8600) rated at 0-5000 psi, Accuracy Grade 3A $\pm$.25%, Calibration Due Dated 7/30/2020 was used to monitor and record pressure.

The hydraulic ram has a 2.501 cubic inch area. The tension (lbf) value is determined by multiplying the maximum psi by hydraulic ram cubic inch area as shown in the following equation:

$$psi \times hyd. ram area (2.501) = lbf.$$

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5. PROCEDURES

Test Specimens (pull fuses) were made from 6061-T6 aluminum and 4130 alloy steel, which were constructed in accordance with each of six variations depicted in Test Specimen, Tie Rod Test Drawing. The test specimens were designed to fail at an approximate tensile load to record buckling to the flying wire at each interval during recoil. Test Specimens were validated using Instron Testing Equipment to measure ultimate tensile load of the material. (See Appendix A) With the actual material strength (ksi) established, the pull test specimens were then created or modified to achieve ultimate tensile strengths of 2500, 3850, 5200, 7000, 9000, and 11000 lbf.

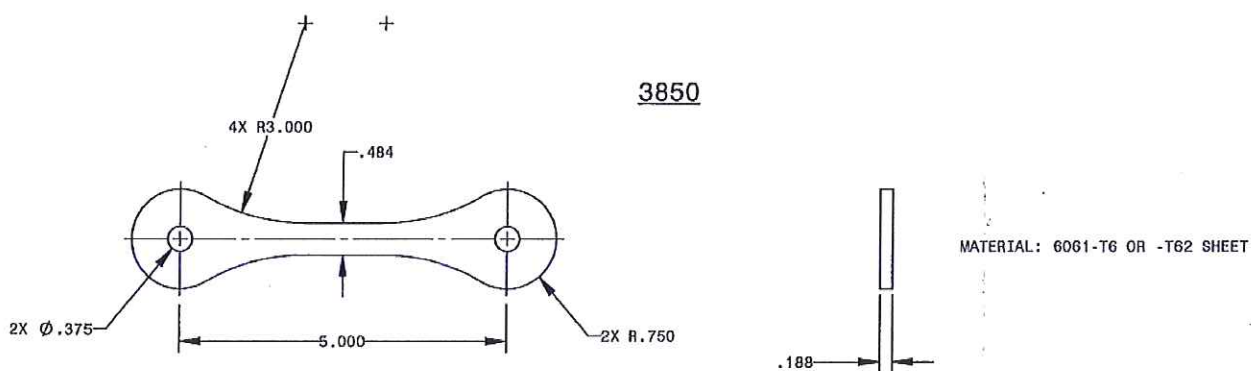


Figure 1 - Showing typical test specimen and eventual "pull fuse" shape

Note: Figure 1 shows a typical test specimen. Coupons were milled on CNC or Manual Mill machines, based upon availability. Configuration of those done on manual mill were simplified shapes, having a carefully controlled waist cross section in accordance with the desired breaking load. Where testing showed higher than estimated material strength, the waist area was further reduced to ensure a break at the desired load. This affects the results of the tests in no adverse way because those are based upon the actual pressures/loads achieved.

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ADAPTATION TO INSTRON TESTING MACHINE

Tensile load was applied through a specially designed, welded adapter which threaded to the Instron.

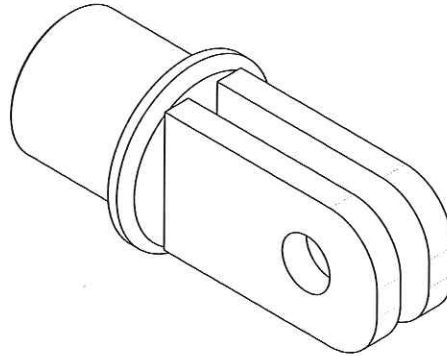


Figure 2 - Showing Welded Adapter

Results were recorded, including maximum load attained and a graphical plot from the data acquisition software.

Tensile strength for each test specimen (pull fuses) were determined using the following equation:

$$w \times t = a^2$$

$t = \text{sample thickness}$

$w = \text{sample width}$

Tensile value is determined by multiplying the maximum force by the area:

$$\text{Max Load (lbf)} \div a^2 = \text{tensile strength (psi)}$$

DATA HANDLING:

Raw data exported from the test machine was saved in .csv files. Data can be made available upon request, however, the intent of testing the test specimens (pull fuses) with the Instron was to establish tensile strength and determine when they are expected to break under load. Actual forces were verified using test video showing the maximum psi, which was then converted to lbf.

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ADAPTION TO TESTING FIXTURE

Tensile load was applied through specifically designed test fixture, which affixed the flying wire statically at one end and pull back ram at the other. The test specimen (pull fuse) was installed between the fixture static mount and streamlined flying wire. The fixtures are shown in the pre-test condition, which is relaxed (no load). The actual tests were performed with the wire taut and mounted vertical. In (Figure 3) illustrates actual flying wire orientation during test procedure. The wire orientation is critical so that the recoil is not affected by the beam (test fixture).

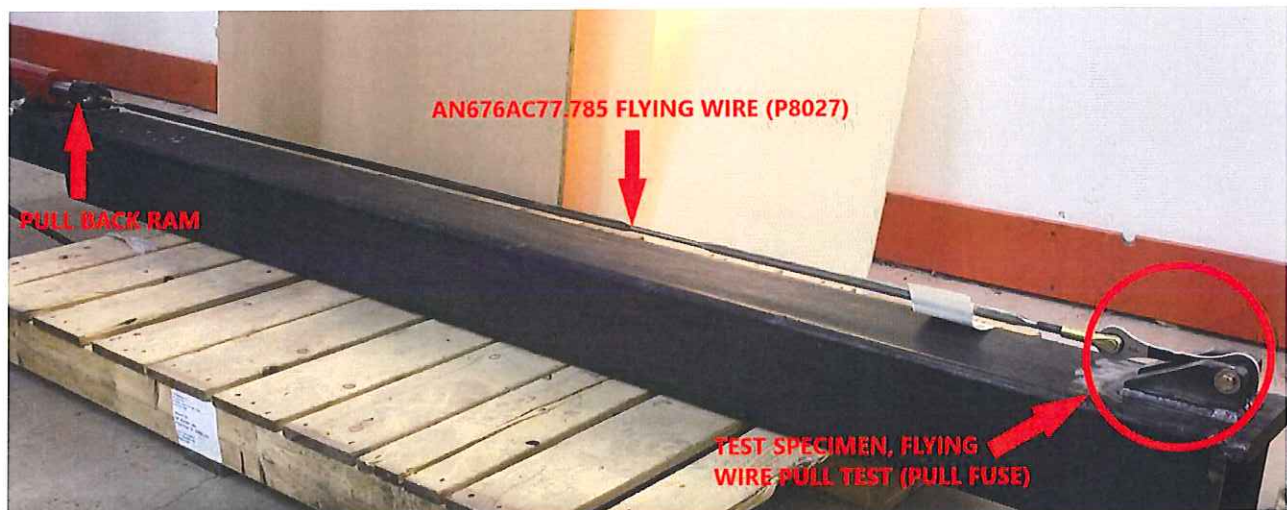


Figure 3 – Showing Test Fixture Set-up



Figure 4 – Showing Test Fixture Set-up

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6. RESULTS

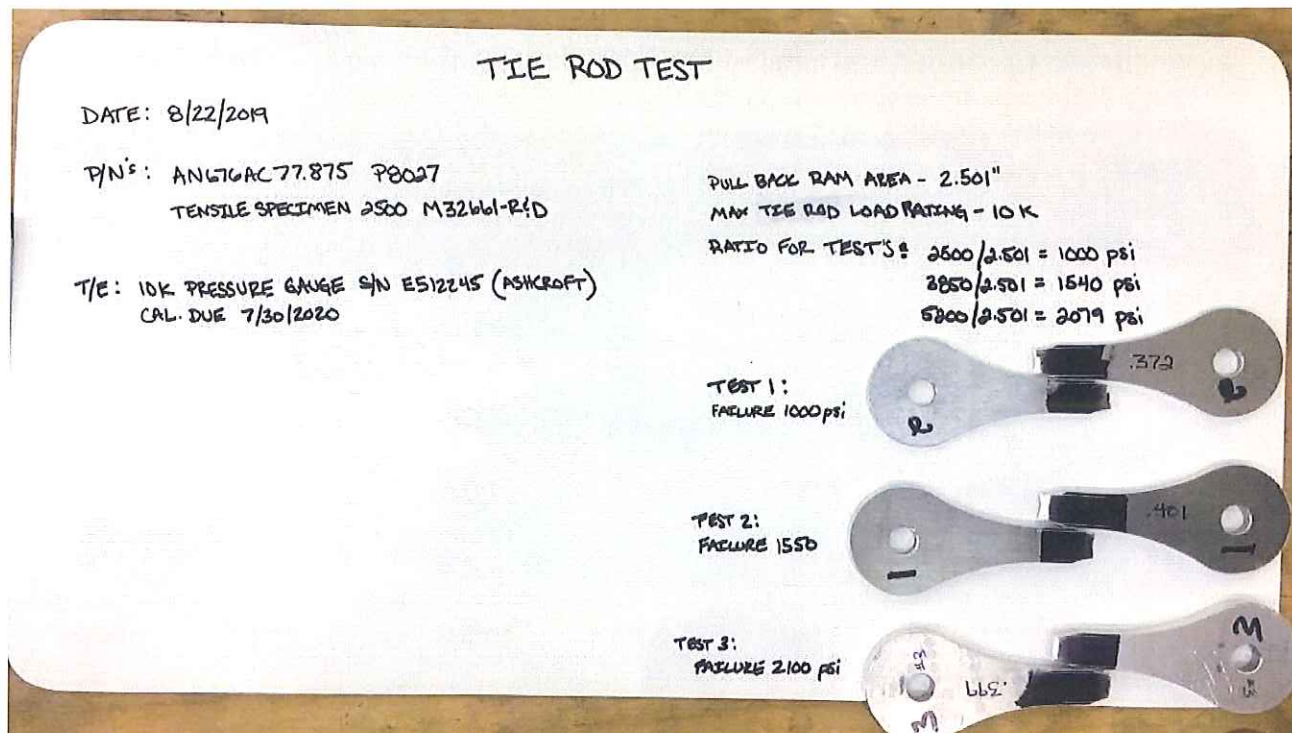
The results were recorded and entered into spreadsheets as file number Tests 1 thru 6. A summary of the results is shown in Table 1.

Test Specimen (Pull Fuse)	Test Specimen (width)	Test Specimen (material)	Max Load (psi)	Max Load (lbf) (calculated)	Results (AN676 flying wire)
1	.372"	6061-T6	1,000	2,500	No damage evident.
2	.401"	6061-T6	1,550	3,877	No damage evident.
3	.399"	6061-T6	2,100	5,252	No damage evident.
4	.464"	4130	2,800	7,002	Slight deformation (bow) to flying wire.
5	.592"	4130	3,600	9,003	Slight deformation (bow) to flying wire.
6	.723"	4130	4,000	10,004	Buckling caused by recoil occurred approx. 12" from end of wire.

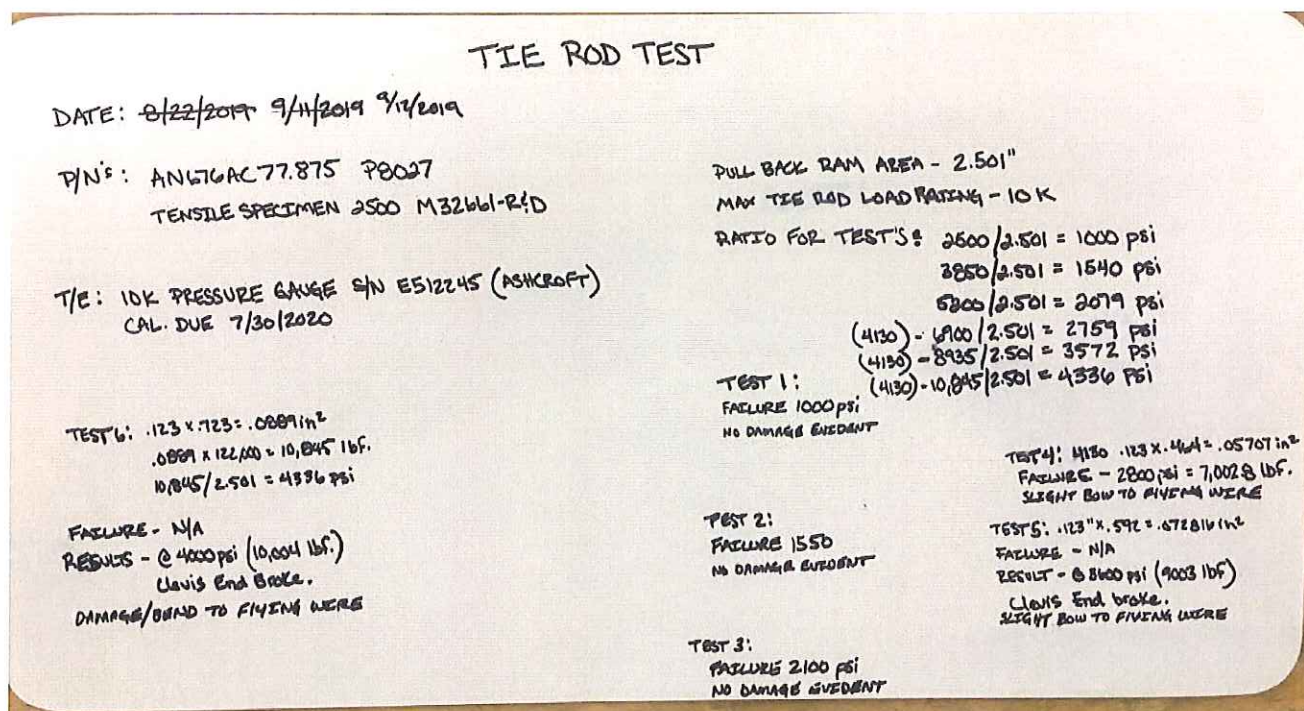
Table 1 - Showing Test Result Values

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Storyboard - Tests 1, 2, and 3:



Storyboard - Tests 1, 2, 3, 4, 5, and 6:



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TEST 1:



Figure 5 – Showing Test Specimen (Pull Fuse) Failure at 1000 psi (2500 lbf.)

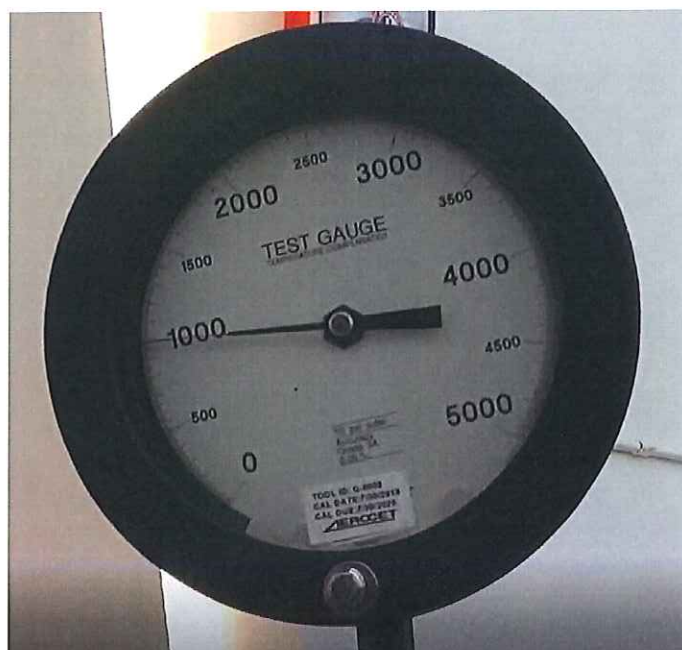


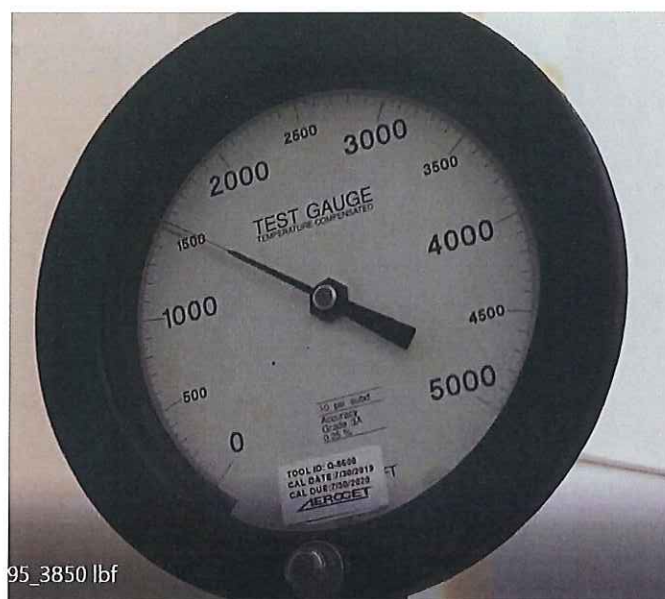
Figure 6 – Test 1 Showing Max (psi) During Test

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TEST 2:



Figure 7 – Showing Test Specimen (Pull Fuse) Failure at 1550 psi (3877 lbf.)



95_3850 lbf

Figure 8 – Test 2 Showing Max (psi) During Test

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TEST 3:

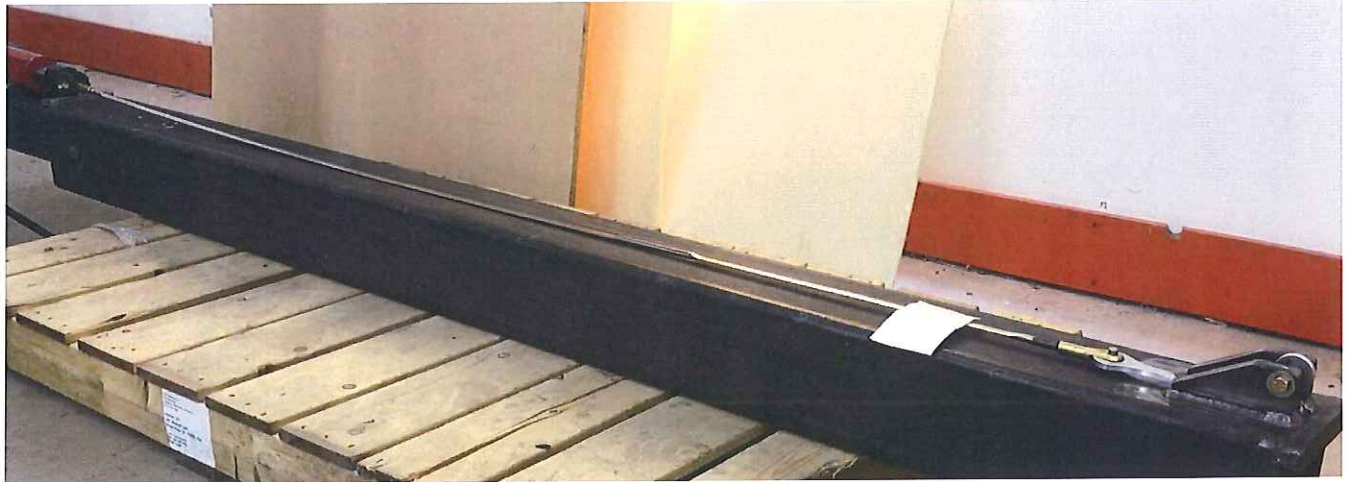


Figure 9 – Showing Test Specimen (Pull Fuse) Failure at 2100 psi (5252 lbf.)

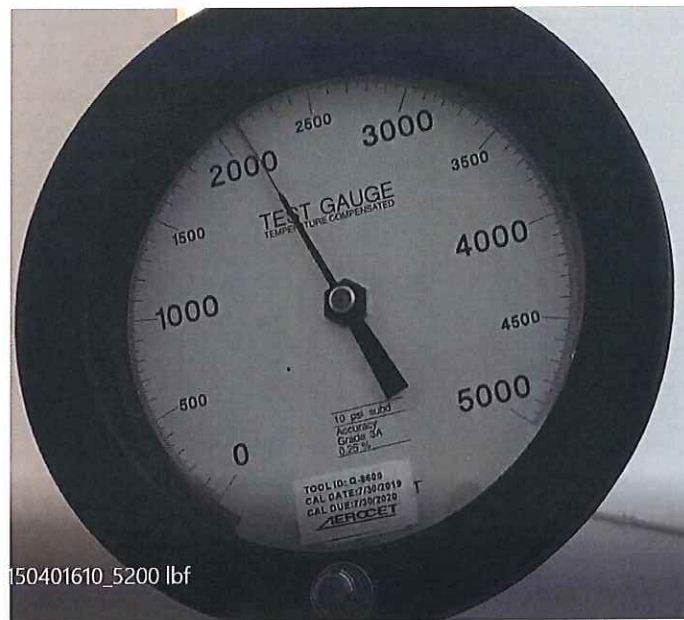


Figure 10 – Test 3 Showing Max (psi) During Test

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TEST 4:



Figure 11 – Showing Test Specimen (Pull Fuse) Failure at 2800 psi (7002 lbf.)



Figure 12 – Showing Test Specimen (Pull Fuse) Failure at 2800 psi (7002 lbf.)



Figure 13 – Showing Test Specimen (Pull Fuse) Failure at 2800 psi (7002 lbf.)

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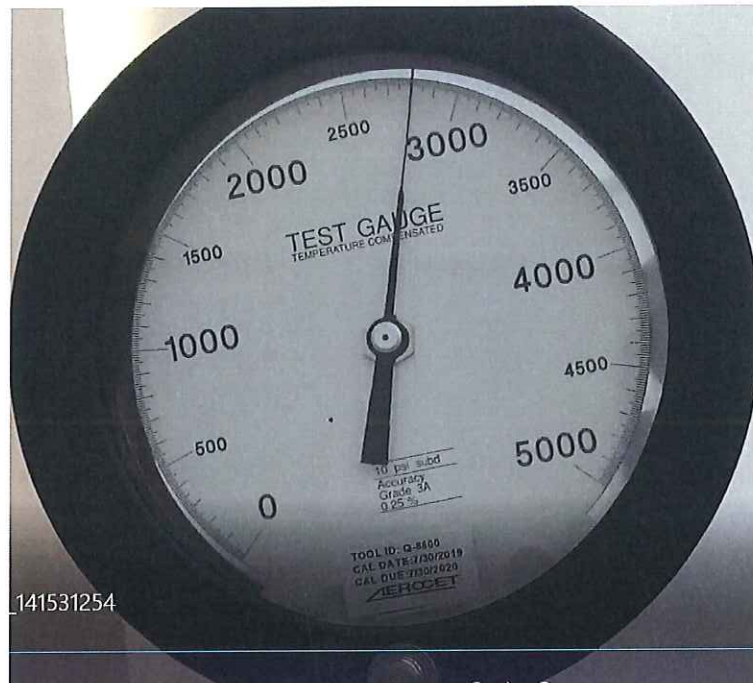


Figure 14 – Test 4 Showing Max (psi) During Test

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TEST 5:



*Figure 15 – Showing Test Specimen (Pull Fuse) Failure at 3600 psi (9003 lbf.)
NOTE: Clevis end failed prior to pull fuse limit.*



*Figure 16 – Showing Test Specimen (Pull Fuse) Failure at 3600 psi (9003 lbf.)
NOTE: Clevis end failed prior to pull fuse limit.*

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Figure(s) 17 – Showing Test Specimen (Pull Fuse) Failure at 3600 psi (9003 lbf.)
 NOTE: Clevis end failed prior to pull fuse limit.

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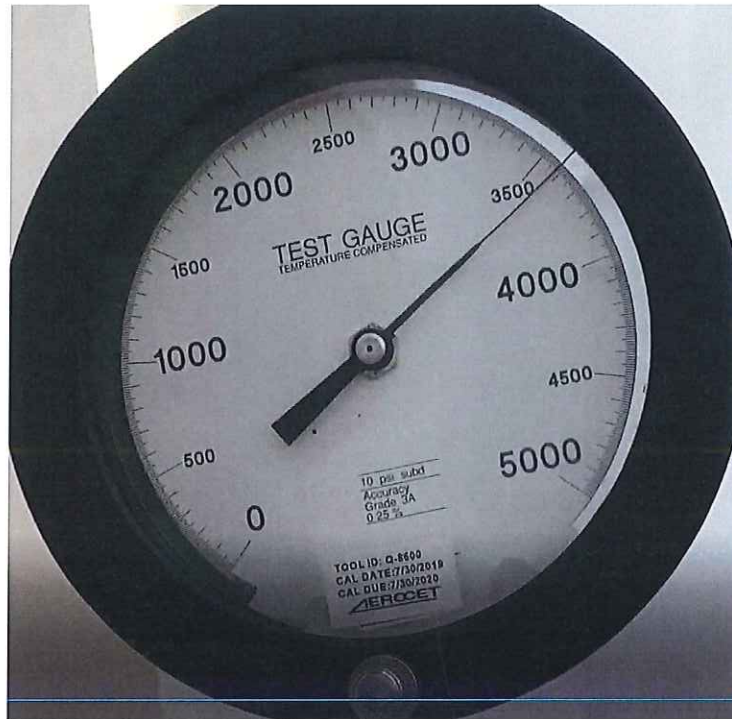


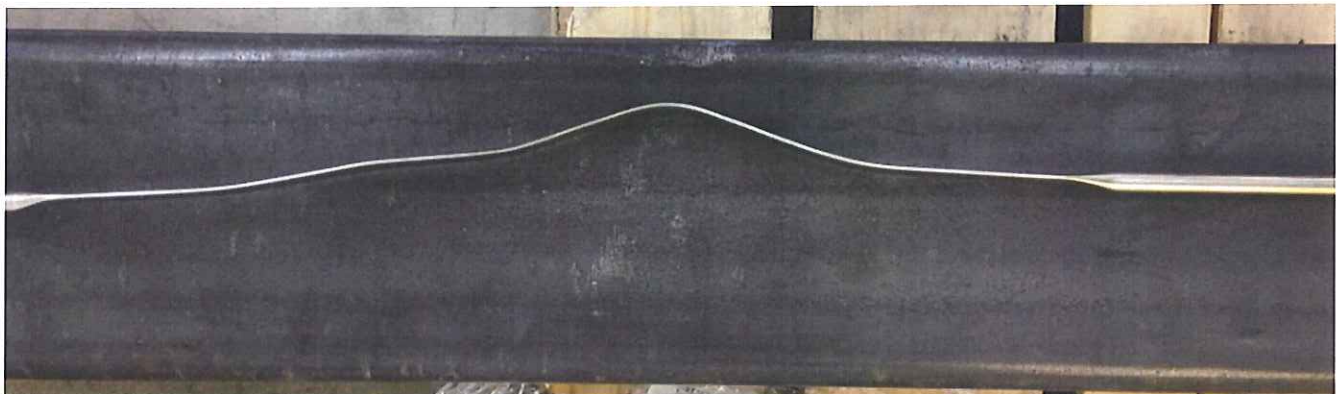
Figure 18 – Test 5 Showing Max (psi) During Test

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TEST 6:



*Figure 19 – Showing Test Specimen (Pull Fuse) Failure at 4000 psi (10,004 lbf.)
NOTE: Clevis end failed prior to pull fuse limit.*



*Figure 20 – Showing Test Specimen (Pull Fuse) Failure at 4000 psi (10,004 lbf.)
NOTE: Clevis end failed prior to pull fuse limit.*

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*Figure 21 – Showing Test Specimen (Pull Fuse) Failure at 4000 psi (10,004 lbf.)
 NOTE: Clevis end failed prior to pull fuse limit.*

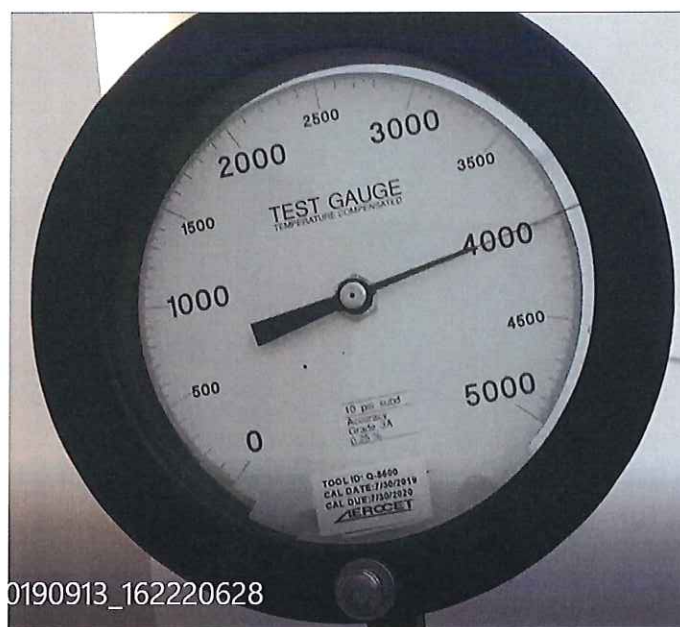


Figure 22 – Test 6 Showing Max (psi) During Test

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7. DISCUSSION

Most samples had an expected, predictable load vs. recoil buckling with a distinct failure. (Reference Tests 4, 5, & 6). Two test specimens (pull fuses) were not taken beyond initial failure points, as the clevis ends failed during the test. If the test specimen samples were reloaded, we suspect they would have failed within 11,000 lbf, given the time. Since the purpose of this testing was to record buckling caused by recoil at initial failure only, the data from all failures, expected or not, is included in the results.

8. CONCLUSION

Based upon these results, the AN676 flying wires are adequate to handle the design loads that we anticipate in the directions that we have considered at this time. Furthermore, the recoil forces required to achieve buckling to the flying wires is over 9,000 lbf. based on our test results. The buckling from recoil was minimal through 7,000 lbf.

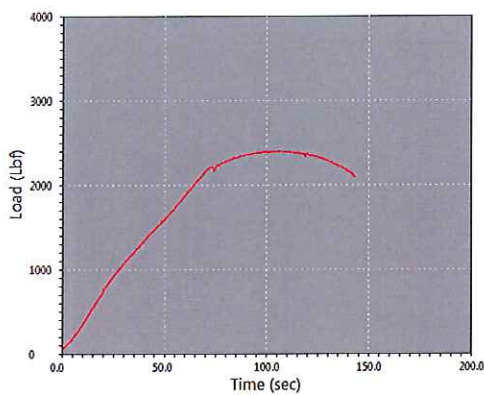
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APPENDIX A1

TEST# 1: Instron Validation Test Specimen



RESULTS

Date:
Time:
Specimen ID#:
Direction:
Specimen Type:

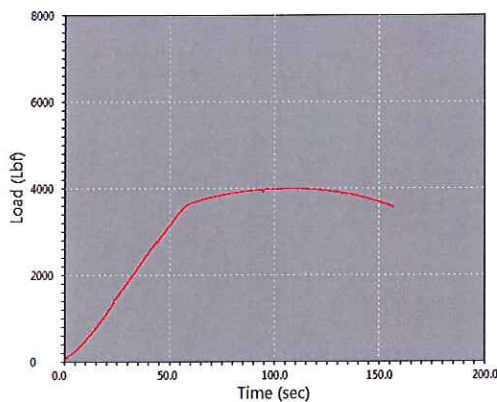
08/21/19
15:14:53
6-6-2018
TENSION
None

Status:

PASS

M32661 R&D (2500)
Test Specimen #1
TARGET - 2500 lbf.
RESULT (MAX) - 2401 lbf.
RESULT (FAILURE) - 2091 lbf.
Specimen Width - .375"

TEST# 2: Instron Validation Test Specimen



RESULTS

Date:
Time:
Specimen ID#:
Direction:
Specimen Type:

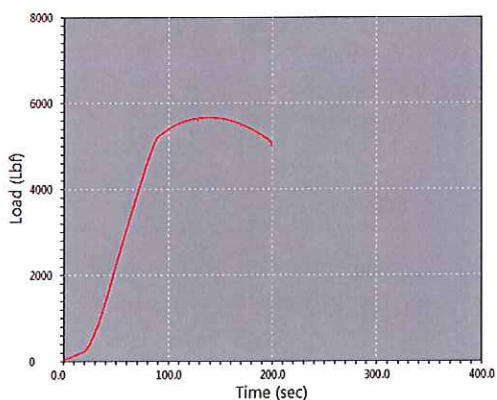
08/21/19
15:39:19
6-6-2018
TENSION
None

Status:

PASS

M32662 R&D (3850)
Test Specimen #3
TARGET - 3850 lbf.
RESULT (MAX) - 3993 lbf.
RESULT (FAILURE) - 3531 lbf.
Specimen Width - .400"

TEST# 3: Instron Validation Test Specimen



RESULTS

Date:
Time:
Specimen ID#:
Direction:
Specimen Type:

08/21/19
15:50:01
6-6-2018
TENSION
None

Status:

PASS

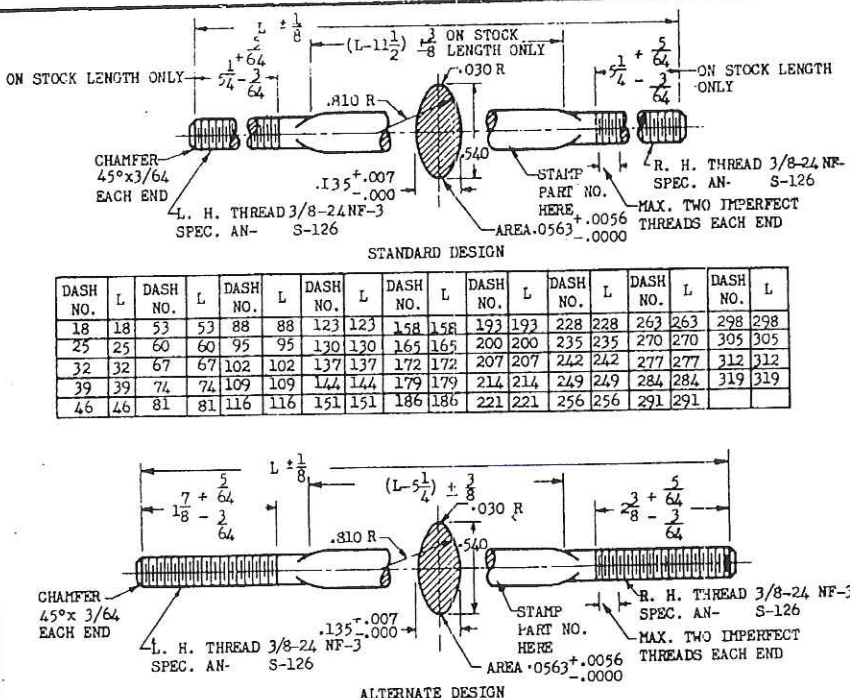
M32263 R&D (5200)
Test Specimen #1
TARGET - 5200 lbf.
RESULT (MAX) - 5662 lbf.
RESULT (FAILURE) - 4954 lbf.
Specimen Width - .400"

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APPENDIX A2

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STANDARD DESIGN

DASH NO.	L	DASH NO.	L	DASH NO.	L	DASH NO.	L	DASH NO.	L	DASH NO.	L	DASH NO.	L	DASH NO.	L	DASH NO.	L
18	18	53	53	88	88	123	123	158	158	193	193	228	228	263	263	298	298
25	25	60	60	95	95	130	130	165	165	200	200	235	235	270	270	305	305
32	32	67	67	102	102	137	137	172	172	207	207	242	242	277	277	312	312
39	39	74	74	109	109	144	144	179	179	214	214	249	249	284	284	319	319
46	46	81	81	116	116	151	151	186	186	221	221	256	256	291	291		

ALTERNATE DESIGN

TENSILE STRENGTH: 10000 LB.
 MATERIAL: CARBON STEEL. COR. RES. STEEL (SEE PROCUREMENT SPECIFICATION).
 FINISH: SEE PROCUREMENT SPECIFICATION).
 THREADS: MINIMUM THREAD FOR RIGID TERMINAL AND LOCK NUT 1-7/8.
 AIRPLANE MANUFACTURERS ARE PERMITTED TO INSTALL RODS WITH MINIMUM LENGTH OF THREADS AS INDICATED IN ALTERNATE DESIGN, ON AIRPLANES SUPPLIED ON GOVERNMENT ORDERS.
 LENGTH "L" SHALL BE THE NEAREST 25/100 AS 1825, 1850, 1875, 19, 1925 TO FIT, FIGURING 50% TAKE UP AND 50% LET OUT. TO FIND ROD LENGTH SUBTRACT 2-1/4 FROM LENGTH BETWEEN PIN CENTERS OF ASSEMBLY.
 CUT OFF EQUAL AMOUNT FROM EACH END OF STANDARD DESIGN STOCK SIZES FOR INTERMEDIATE LENGTHS. PART NO. SHALL INDICATE THE EXACT LENGTH OF ROD WITH LETTER "A" AFTER BASIC NO. FOR THE ALTERNATE DESIGN.
 RODS OF THE STANDARD DESIGN, WHICH WILL BE USED FOR REPLACEMENT PURPOSES, WILL BEAR THE SAME NO. AS THOSE OF THE ALTERNATE DESIGN, WITHOUT THE LETTER "A".
 FOR COR. RES. STEEL RODS INSERT "C" BEFORE DASH NO.
 EXAMPLE OF AN PART NO.: AN676A3050 = 3/8-24 ROD, 30-1/2 IN. LONG, ALT. DESIGN, CARBON STEEL.
 AN676-3050 = 3/8-24 ROD, 30-1/2 IN. LONG, STD. DESIGN, CARBON STEEL.
 AN676C3050 = 3/8-24 ROD, 30-1/2 IN. LONG, STD. DESIGN, COR. RES. STEEL.
 REMOVE ALL BURRS AND SHARP EDGES.
 DIMENSIONS IN INCHES. UNLESS OTHERWISE SPECIFIED, TOLERANCES ON FRACTIONS ±1/64. DECIMALS ±.005.
 (3) CANCELED AFTER 15 JUNE 1967.
 NO SUPERSEDING STANDARD.
 INACTIVE FOR DESIGN AFTER 30 JUNE 1953.
 NO SUPERSEDING AN STANDARD.
 FOR DEF. AND P. OF DR. G. STANDARDS, SEE ARMY BULLETIN NO. 17.

PROCUREMENT SPECIFICATION	ARMY-NAVY AERONAUTICAL STANDARD	AN676
AN-T-20	TIE ROD - STREAMLINE (3/8-24)	

ARMY AIR FORCES STOCK CLASSIFICATION: Q14-A

U.S. GOVERNMENT PRINTING OFFICE: 1967-301-509/171

SUPERSEDES FORMER ARMY AND NAVY STANDARD ISSUES OF AN676

APPROVED 9-2-42 REVISED 6-21-43 15 JUN 67

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RVSD:	--	Date:	--		Report No.:	A-33162
CHKD:	RB	Date:	9/20/2019		Revision:	0

APPENDIX A3

Aerocet Inc.	Fliegen Works Inc. 503 221-4001	FW-ART405-25	
Structural Substantiation for Installation of Aerocet 5850 Twin Seaplane Floats on DeHavilland, DHC-2 Beaver	8/30/2006	REV IR	PAGE 33

$MS_{Limit(tension)} = 10,000 / (1.15)(75\text{ksi}/125\text{ksi}) / 3453.2 - 1 = 51\%$
 $MS_{Ult(tension)} = 10,000 / 1.15 / 5179.8 - 1 = 68\%$

The fittings are AN665-80R and L, also rated at 10,000 lb. Acceptable by comparison.

The MS20392 5c21 clevis pins are rated at 16,160 lbs in double shear. Acceptable by comparison.

3,453.2	5,179.8
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The attachment lug is 56-15153 and is analyzed in the appendix. It has the following minimum margins:

$MS_{Bearing\ Ult} = 9600\text{ lb} / 1.15 / 5179.8 - 1 = 61\%$
 $MS_{Bearing\ Lim} = 8337\text{ lb} / 1.15 / 3453.2 - 1 = 109\%$

