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16. Abstract

This study was performed by the FAA to assess the material properties and mechanical behavior of next-generation aluminum lithium (Al-Li) alloys being used in aerospace structures through comparisons made to conventional aerospace aluminum alloys (AAs). The latest generation of Al-Li alloys purports to offer a significant weight savings over conventional aerospace aluminums resulting in significant use in recent aircraft and aerospace applications. The current public data provided for these alloys are limited and do not provide a comprehensive understanding of the strengths and weaknesses of these materials. Because previous generations of Al-Li alloys displayed material behaviors that limited their use for aerospace applications, it is necessary to understand the properties of these new alloys and identify if any unique behaviors exist.

Two Al-Li alloys were considered as a case study, namely Al-Li 2198-T8 and 2196-T8511 alloys used for skin and extrusion applications, respectively. Several properties were assessed and compared with the baseline AA 2024-T3/351 and 7075-T6 alloys, including static properties, fatigue and fatigue crack-growth behavior, and supplemental properties. This volume (volume 4 of 4) provides in-depth detail on the supplemental tests. The supplemental properties tests were included to evaluate the material's response to certain external influences, specifically corrosion, fire, and manufacturing processes. Naval Air Systems Command (NAVAIR) performed a slow strain rate tension test with specimens submerged in a 5% NaCl solution to look at susceptibility to environmentally assisted cracking. The FAA William J. Hughes Technical Center performed a flammability and burn-through test, where the alloys were subjected to direct contact with an open flame to evaluate the reaction of Al-Li to fire. Fatigue Technology Inc. performed cold expansion and installation of interference fit fasteners to specimens which were then inspected by the FAA William J. Hughes Technical Center and Drexel University to evaluate the materials' responses to common manufacturing practice in the aerospace industry. The results of the NAVAIR test showed no impact on tensile strength at strain rates down to 10^{-6}/s. The flammability test showed the Al-Li 2198-T8 alloy displayed no evidence of ignition or excess smoke compared to the baseline AA 2024-T3 aluminum. The Al-Li also registered a burn through time that was 50% longer compared to the baseline at the same material thickness. The fastener hole process test showed no indication of cracking or other damage for any of the materials due to the open hole processing.

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LIST OF ACRONYMS

AA	Aluminum alloys
Al-Li	Aluminum lithium
CX	Cold expansion
EAC	Environmentally assisted cracking
FAA WJHTC	Federal Aviation Administration William J. Hughes Technical Center
FTI	Fatigue Technology Inc.
IFF	Interference fit fastener
NAVAIR	US Navy Naval Air System Command
SSRT	Slow strain rate testing

EXECUTIVE SUMMARY

This study was performed by the FAA to assess the material properties and mechanical behavior of next-generation aluminum lithium (Al-Li) alloys being used in aerospace structures through comparisons made to conventional aerospace aluminum alloys (AAs). The latest generation of Al-Li alloys purports to offer a significant weight savings over conventional aerospace aluminums resulting in significant use in recent aircraft and aerospace applications. The current public data provided for these alloys are limited and do not provide a comprehensive understanding of the strengths and weaknesses of these materials. Because previous generations of Al-Li alloys displayed material behaviors that limited their use for aerospace applications, it is necessary to understand the properties of these new alloys and identify if any unique behaviors exist.

Two Al-Li alloys were considered as a case study, namely Al-Li 2198-T8 and 2196-T8511 alloys used for skin and extrusion applications, respectively. Several properties were assessed and compared with the baseline AA 2024-T3/351 and 7075-T6 alloys, including static properties, fatigue, and fatigue crack growth behavior; and supplemental properties. This volume (volume 4 of 4) provides in-depth detail on the supplemental tests. The supplemental properties tests were included to evaluate the material's response to certain external influences, specifically corrosion, fire, and manufacturing processes. Naval Air Systems Command (NAVAIR) performed a slow strain rate tension test with specimens submerged in a 5% NaCl solution to look at susceptibility to environmentally assisted cracking. The FAA William J. Hughes Technical Center performed a flammability and burn-through test, where the alloys were subjected to direct contact with an open flame to evaluate the reaction of Al-Li to fire. Fatigue Technology Inc. performed cold expansion and installation of interference fit fasteners to specimens which were then inspected by the FAA William J. Hughes Technical Center and Drexel University to evaluate the materials' responses to common manufacturing practice in the aerospace industry. The results of the NAVAIR test showed no impact on tensile strength at strain rates down to 10^{-6}/s. The flammability test showed the Al-Li 2198-T8 alloy displayed no evidence of ignition or excess smoke compared to the baseline AA 2024-T3 aluminum. The Al-Li also registered a burn through time that was 50% longer compared to the baseline at the same material thickness. The fastener hole process test showed no indication of cracking or other damage for any of the materials due to the open hole processing.

1. INTRODUCTION

This report is the fourth of four volumes detailing an effort sponsored by the FAA to conduct a comparative evaluation of the latest generation of aluminum lithium (Al-Li) alloys [1–3]. The primary objective of this effort was to gain a better understanding of the overall mechanical behavior of the 3rd generation Al-Li alloys relative to traditional aerospace aluminum alloys (AA). As Al-Li continues to gain more widespread use in primary aircraft structure [4], it is necessary to develop a better knowledge base on the material to ensure its safe implementation. The program test matrix consisted of eight tests grouped into three main categories: static, fatigue and fatigue crack growth, and supplemental. This volume contains detailed information on the supplemental tests conducted by the Naval Air System Command (NAVAIR), the FAA William J. Hughes Technical Center (FAA WJHTC), Fatigue Technology Inc. (FTI), and Drexel University. The three tests included under the supplemental designation are: 1) environmentally assisted cracking (EAC) using slow strain-rate testing (SSRT), 2) flammability resistance, and 3) fastener hole processing. The EAC and flammability tests focused on the Al-Li 2198-T8 sheet material compared to its baseline AA 2024-T3 aluminum, whereas the fastener hole processing work additionally included the Al-Li 2196-T8511 and AA 7075-T6 alloys. An overview of the tests covered in this volume is shown in table 1.

Table 1. Supplemental properties test overview

Test Name and Standard	Materials Tested	Variables*	Output	Performing Organization
EAC using SSRT ASTM G129	2198-T8 2024-T3	t_s (in): 0.125 θ: 45° S: 10^{-5}/s, 10^{-6}/s	Tensile strength	NAVAIR
Flammability and Burn Resistance AC 25.856-2A		t_s (in): 0.071, 0.125, 0.25	Burn-through time	FAA WJHTC
Fastener Hole Process Test	2198-T8 2196-T8511 2024-T3/351 7075-T6	t_s (in): 0.071, 0.125, 0.25 P: CX, IFF	Inspection results	FTI FAA WJHTC Drexel University

* Variable definitions:

t_s = Typical sheet thickness for the Al-Li 2198-T8 and AA 2024-T3, inches
θ = Grain orientation, degree from L (rolling) direction
S = Strain rate
P = Process; cold expansion (CX) or interference fit fastener (IFF)

Sections 2.1–2.3 detail each test listed in table 1 with additional data available in appendix A. The Al-Li alloys used in these tests were produced by Constellium and the baseline aluminums were purchased through commercial retailers. All materials were tested at the thicknesses supplied with no additional surface machining.

2. TEST DESCRIPTION

2.1 ENVIRONMENTALLY ASSISTED CRACKING

EAC using SSRT was studied by NAVAIR per ASTM G129 [5] to determine the corrosion resistance of the material under a gradually increasing tensile strain. The specimens were machined at one thickness (0.125 inch) and one grain orientation (45 degree) for both the Al-Li 2198-T8 and clad AA 2024-T3 alloys. The 45 degree grain orientation was chosen because it produced the lowest tensile strength from the static properties tests and was considered the critical orientation. The specimen geometry used was the subsized tension dog bone per ASTM E8 [6] (figure 1). The clad AA 2024-T3 specimen machined edges were left untreated during the tests.

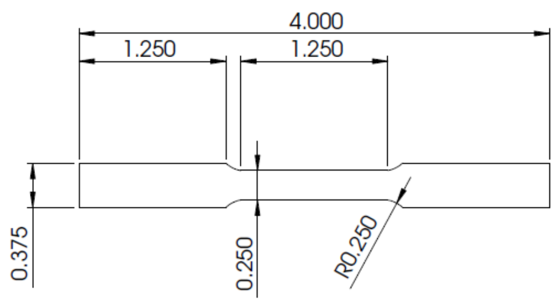

Figure 1. NAVAIR EAC specimen geometry

Tests were run at three strain rates (10^{-5}/s, 10^{-6}/s, and 10^{-7}/s) to determine if rate has an effect on the material properties. An aqueous 5% NaCl solution was used to create the corrosive environment during the test. Duplicates were also conducted at lab air conditions as a baseline. The tests were run until specimen failure. Information on load, elongation, and duration was recorded. The 10^{-7}/s tests were not completed because of issues maintaining constant power supply throughout the tests, which could last around 6 weeks per specimen.

2.2 FLAMMABILITY

Testing was conducted by the FAA Fire Safety Branch at the FAA WJHTC to determine flame penetration, flammability, and burn resistance of the Al-Li 2198-T8 material. The specimens were machined at three thicknesses (0.071 inch, 0.125 inch, and 0.25 inch) into simple rectangular sections (16 inches x 24 inches). Grain directions were inconsequential to this test.

The test was performed using a NexGen 6 gal/hr open flame oil burner specified by AC 25.856-2A [7]. A rendering of the test setup is shown in figure 2. Each specimen was exposed to direct flame contact until complete burn through of the specimen was observed. The flame was calibrated using seven thermocouples to ensure a steady-state temperature of approximately 1800˚F was achieved. Each specimen was mounted on a support stand, which was mounted on a cart and track system to allow the entire setup to be moved into position following the burner calibration. Each test was recorded and observed for any significant events, such as smoke, ignition, melting, or burn through. The tests were timed using a handheld stopwatch to record the time of occurrence for each event.

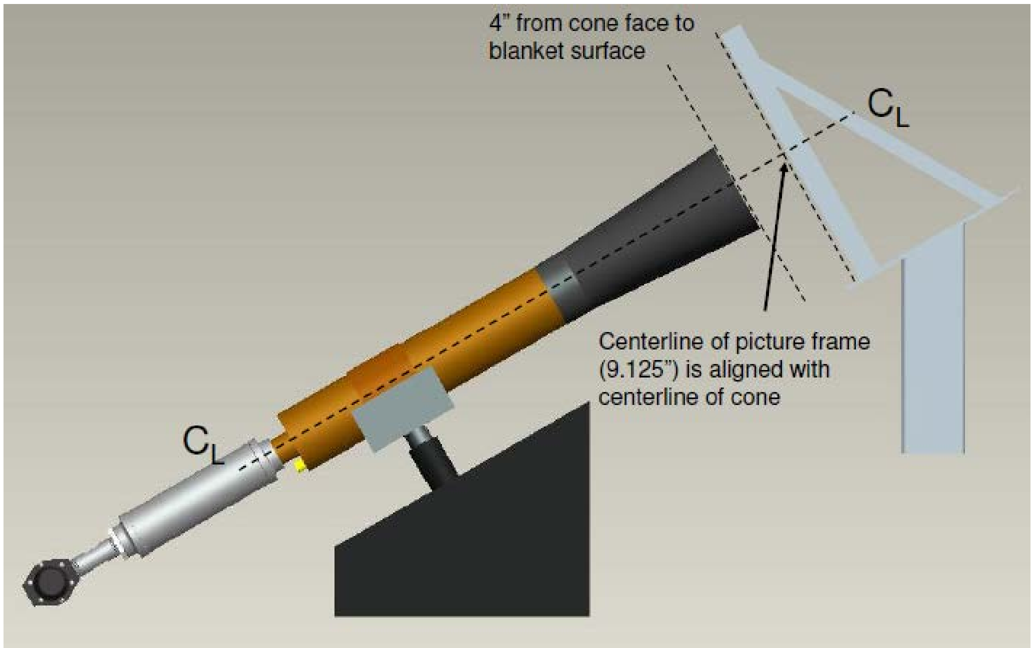

Figure 2. FAA William J. Hughes Technical Center flammability test setup

2.3 FASTENER HOLE PROCESSING

CX of holes and IFFs are common manufacturing techniques used in the aerospace industry to improve fatigue life of fastened joints. Each method works by creating a small compressive region in the material immediately surrounding the hole. This compressive region then requires a higher tensile force to be applied before the overall stress at the hole reaches the point where cracks can initiate and grow. It was important to evaluate the Al-Li alloys’ responses to such processing because certain materials can be susceptible to cracking and other damage as a result of this type of processing.

2.3.1 Specimen Processing

The specimen processing was performed by FTI with an overview of the materials used and number of holes processed, as shown in table 2. The materials were supplied in small rectangular blanks to which FTI machined the holes and performed the subsequent processing. The holes were all bored to maintain tight tolerances for the original diameters.

Table 2. Fastener Hole Processing Test Matrix

Material	Thickness (inch)	Interference Fit Holes	Cold Expansion Holes	Total
2198-T8	0.071	3	3	6
	0.125	3	3	6
	0.25	3	3	6
2024-T3/351	0.071	3	3	6
	0.125	3	3	6
	0.25	3	3	6
2196-T8511	0.06	3	3	6
	0.12	3	3	6
	0.145	3	3	6
7075-T6511	0.063	3	3	6
	0.125	3	3	6
	0.16	3	3	6
			Total:	72

The CX holes shown in figure 3(a) were initially machined to 0.235 inch (+0.0000/-0.0005) in diameter and expanded by approximately 5%. A split sleeve method was used to create the CX. In this process, the following procedures are performed:

1. A lubricated split sleeve is inserted on to a mandrel.
2. The mandrel and sleeve are inserted into the hole.
3. The mandrel is drawn through the sleeve radially expanding the hole.
4. The sleeve is removed.
5. The hole is typically reamed to the final size.

For this program, the final step to ream the hole was skipped so that any damage in the immediate vicinity of the hole was not lost. Additionally, the split of the sleeve was oriented at the three major grain orientations (L, 45 degree, and LT) to determine if there were any directional responses present.

The IFF holes shown in figure 3(b) were initially machined to 0.246 inch (+0.000/-0.0005) in diameter. The desired interference was 0.003 inch, so all fasteners were measured before installation and matched with an appropriate hole to give the proper interference. The fasteners used were NAS1578A4T5 and were installed using a rivet gun and back-up plate.

Figure 3. Fastener hole processing specimens: Al-Li 2198-T8; 0.25″ thick; (a) cold expansion; (b) interference fit fasteners

2.3.2 Specimen Inspection

Once processed by FTI, the specimens were inspected by the FAA WJHTC and Drexel University for damage and cracking. Inspections by the FAA WJHTC were performed on every specimen using an Olympus 500D eddy current unit with a number of probes as detailed in table 3. Drexel University inspected only the CX specimens. Those inspections involved high magnification examinations of the outer surfaces as well as sectioning and inspection of the hole surfaces, all using a Zeiss Supra 50 VP scanning electron microscope (SEM).

Table 3. Fastener hole processing: Eddy current inspection information

Probe Type	Model Number	Specimens Inspected	Type of Inspection
Pencil Probe	M7L905-60 50-500 kHz	All	Surface inspection around open holes and fasteners
Ring Probe	RR026-2/TF 100 Hz – 10 kHz	IFF	Top/bottom surface inspection around fasteners
Rotating Probe	BPM-14/TF 7/32 50-500 kHz	CX	Inspection of internal hole surfaces

3. TEST RESULTS

3.1 ENVIRONMENTALLY ASSISTED CRACKING

EAC using SSRT was conducted by NAVAIR per ASTM G129 [5]. The results presented in figure 4 showed little to no effect from the environment on the ultimate tensile strength of both materials. There appeared to be no effect on strain rate in the results. The 10^{-7}/s tests were abandoned because of issues related to the length of those tests. The results for the Al-Li 2198-T8 were also comparable to the results from the static tests (Volume 2) and even showed slightly higher ultimate strength and elongation.

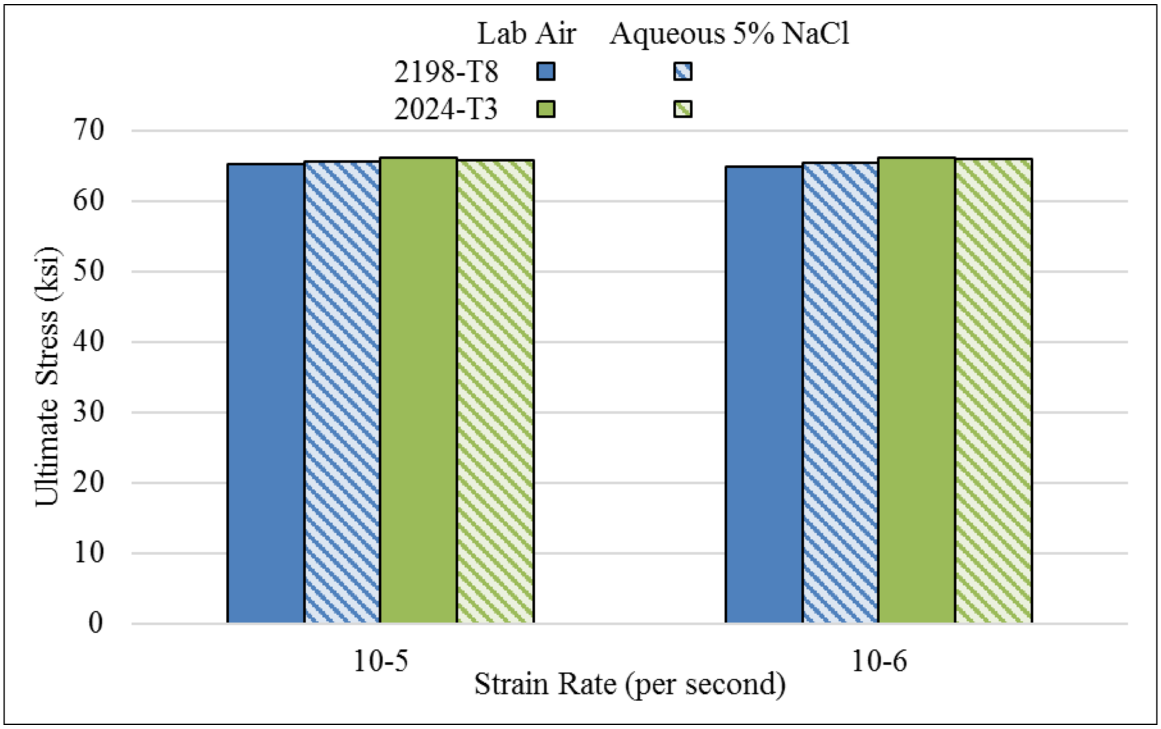

Figure 4. EAC results: Ultimate tensile strength comparison

3.2 FLAMMABILITY

The first test run used the 0.125 inch-thick AA 2024-T3 baseline material. The test lasted approximately 2 minutes and 8 seconds before a large portion of the material melted and fell toward the burner cone. Several masses of molten aluminum also fell to the sub frame area, though no additional flaming was seen. This type of performance is typical for an aluminum melt-through event. The specimen posttest can be seen in figure 5.

Figure 5. Flammability result: 0.125″ AA 2024-T3 specimen post test

The second test run used the 0.071 inch-thick Al-Li 2198-T8 material. This test lasted 1 minute and 52 seconds before a large portion melted and fell, similar to the baseline test. Again, there was molten material that fell to the subframe area where brief flames were seen. It was determined that this was not the Al-Li material self-igniting, but rather the surface of the catch material (honeycomb panel) igniting from the heat of the molten metal. The honeycomb panel was replaced with a sheet of 0.063 inch-thick aluminum to act as a new catch pan because of this reaction. The specimen posttest can be seen in figure 6.

Figure 6. Flammability result: 0.071″ Al-Li 2198-T8 specimen post test

The third test run was the 0.125 inch-thick Al-Li 2198-T8 material. This test lasted 3 minutes and 10 seconds, at which time a small amount of material melted and dripped from the test specimen and the burner was immediately turned off. Unlike the previous test, there were no signs of complete burn through. This type of reaction had not been observed previously when testing AAs. It appears that only a portion of the surface material melted, allowing enough material to be left behind, preventing a full thickness burn through. The material that melted and fell to the catch pan did not ignite, further suggesting that the reaction from the previous test was a result of the honeycomb panel igniting. The specimen posttest can be seen in figure 7.

Figure 7. Flammability result: 0.125″ Al-Li 2198-T8 specimen posttest

The final test used the 0.25 inch-thick Al-Li 2198-T8 material. It was decided to allow this test to run until complete burn through was observed because of the unexpected results from the 0.125inch-thick test. During the final test, two stages of failure were clearly observed at different times. First, the surface melt occurred at 5 minutes and 30 seconds. Second, the complete thickness burn through occurred at 5 minutes and 45 seconds. Once complete burn through occurred, large sections of the material fell forward toward the burner and onto the catch pan. Neither the melted surface material nor the large sections showed any signs of ignition. The specimen posttest can be seen in figure 8.

Figure 8. Flammability result: 0.25″ Al-Li 2198-T8 specimen post test

Overall, the Al-Li 2198-T8 material appeared to have a higher resistance to melt and burn through compared to the AA 2024-T3 baseline test. Neither material showed any sign of ignition or reignition once the molten material fell from the specimen. There was a noticeable difference in material surfaces after the tests were complete with all of the Al-Li 2198-T8 specimens displaying a white, blistered texture. Additionally, the thicker Al-Li specimens exhibited surface melt that is not typical of conventional AA and was not seen in the baseline material. When comparing the results for the two specimens tested at the 0.125 inch thickness, the Al-Li 2198-T8 material held up for approximately 1 minute longer than the baseline AA 2024-T3. A full comparison of the test times can be seen in table 4.

Table 4. Flammability results: Melt and burn through times

Material	Thickness	Melt Time	Burn Through Time
2024-T3	0.125″		2:08
2198-T8	0.071″		1:52
2198-T8	0.125″	3:10	
2198-T8	0.25″	5:30	5:45

3.3 FASTENER HOLE PROCESSING

The purpose of the fastener hole processing work was to determine if some common manufacturing techniques, namely cold expansion of holes and installation of IFFs, caused damage or otherwise negatively affected the Al-Li alloys. Through both destructive and non-destructive inspections, none of the materials showed any indication of cracking caused by the specified processes. This includes both the Al-Li alloys and baseline AAs at numerous thicknesses. No static or fatigue testing was performed on the specimens.

4. CONCLUSION

The test programs detailed in this report were conducted as a comparative study for a 3rd generation aluminum lithium (Al-Li) alloy (2198-T8 and 2196-T8511) against a traditional aerospace aluminum (2024-T3/351 and 7075-T6). Though the sample size is limited, this program was not meant to develop any design allowables or present the Al-Li alloy as a direct replacement for the traditional aluminum alloy (AA) tested. Rather, they were conducted to provide a broad, high-level look at the materials to determine if there are any unique behaviors in the Al-Li that may warrant further vetting as this material (and other Al-Li alloys) sees more widespread use in new aircraft design.

The results of the supplemental testing reported herein showed that the Al-Li alloys responded comparable to the baseline AAs. The EAC using SSRT showed no effect on ultimate tensile strength for either the Al-Li 2198-T8 nor AA 2024-T3 for the testing completed at 10^{-5}/s and 10^{-6}/s strain rates. The flammability tests did not produce any unusual smoking, burning, ignition, or reignition for the Al-Li 2198-T8 and AA 2024-T3. The Al-Li recorded an approximately 50% longer burn through time against the baseline aluminum when comparing identical thicknesses. Finally, the fastener hole processing test showed no cracking or other damage for any material after high-frequency eddy current and high-magnification visual inspections.

5. REFERENCES

1. FAA Report. (2018). Material Characterization of Aluminum Lithium Alloys used in Aerospace Applications – Volume 1 Overview. (DOT/FAA/ TC-18/21, V1).

2. FAA Report. (2018). Material Characterization of Aluminum Lithium Alloys used in Aerospace Applications – Volume 2 Static Properties. (DOT/FAA/TC-18/21, V2).

3. FAA Report. (2018). Material Characterization of Aluminum Lithium Alloys used in Aerospace Applications – Volume 3 Fatigue Crack Growth Properties. (DOT/FAA/ TC-18-21, V3).

4. Prasad, N. E., Gokhale, A. A., and Wanhill, R. J. H. (2014). *Aluminum-Lithium Alloys: Processing, Properties, and Applications.* Waltham, MA: Elsevier.

5. ASTM Standard G129-00, ″Standard Practice for Slow Strain Rate Testing to Evaluate the Susceptibility of Metallic Materials to Environmentally Assisted Cracking,″ ASTM International, West Conshohocken, PA, 2013

6. ASTM Standard E8-16a, ″Standard Test Methods for Tension Testing of Metallic Materials″, ASTM International, West Conshohocken, PA, 2016

7. FAA. (2008, July). Advisory Circular 25.856-2A. *Installation of Thermal/Acoustic Insulation for Burnthrough Protection*. (AC 25.856-2A). Washington, D.C.: Government Publishing Office.

APPENDIX A—NAVAIR EAC USING SSRT DATA

Table A-1. Al-Li 2198-T8; 0.125″ thick; 45° grain orientation; EAC results

Specimen	Environment	Strain Rate (/sec)	Ult Strength (ksi)	Elongation %	Duration (hrs)
2198-SSR-125-45-10^{-5}-LA-1	Lab Air	10^{-5}	65.24	16.5%	3.0
2198-SSR-125-45-10^{-5}-LA-2			64.83		3.1
2198-SSR-125-45-10^{-5}-LA-3			65.40	20.3%	3.0
2198-SSR-125-45-10^{-6}-LA-1		10^{-6}	64.03	16.3%	27.5
2198-SSR-125-45-10^{-6}-LA-2			65.08	20.3%	30.1
2198-SSR-125-45-10^{-6}-LA-3			65.61	20.7%	30.1
2198-SSR-125-45-10^{-7}-LA-1		10^{-7}	65.48		
2198-SSR-125-45-10^{-5}-NaCl-1	5% Aqueous NaCl	10^{-5}	64.86		3.3
2198-SSR-125-45-10^{-5}-NaCl-2			66.11		3.3
2198-SSR-125-45-10^{-5}-NaCl-3			65.50		3.0
2198-SSR-125-45-10^{-6}-NaCl-1		10^{-6}	65.38		24.0
2198-SSR-125-45-10^{-6}-NaCl-2			65.31		27.9
2198-SSR-125-45-10^{-6}-NaCl-3			65.15		28.7
2198-SSR-125-45-10^{-7}-NaCl-1		10^{-7}	63.10		

Table A-2. Clad AA 2024-T3; 0.125″ thick; 45° grain orientation; EAC results

Specimen	Environment	Strain Rate (/sec)	Ult Strength (ksi)	Elongation %	Duration (hrs)
2024C-SSR-125-45-10^{-5}-LA-1	Lab Air	10^{-5}	66.03	20.7%	5.9
2024C-SSR-125-45-10^{-5}-LA-2			66.30	23.1%	5.7
2024C-SSR-125-45-10^{-5}-LA-3			66.02	22.4%	5.9
2024C-SSR-125-45-10^{-6}-LA-1		10^{-6}	66.28	23.4%	61.4
2024C-SSR-125-45-10^{-6}-LA-2			65.88	23.8%	65.2
2024C-SSR-125-45-10^{-6}-LA-3			66.14	23.5%	61.2
2024C-SSR-125-45-10^{-7}-LA-1		10^{-7}	66.09	20.4%	1008.0
2024C-SSR-125-45-10^{-5}-NaCl-1	5% Aqueous NaCl	10^{-5}	65.44		6.2
2024C-SSR-125-45-10^{-5}-NaCl-2			65.49		5.8
2024C-SSR-125-45-10^{-5}-NaCl-3			66.04		6.3
2024C-SSR-125-45-10^{-6}-NaCl-1		10^{-6}	65.44		59.4
2024C-SSR-125-45-10^{-6}-NaCl-2			65.86		61.6
2024C-SSR-125-45-10^{-6}-NaCl-3			66.46		61.3
2024C-SSR-125-45-10^{-7}-NaCl-1		10^{-7}	61.20		