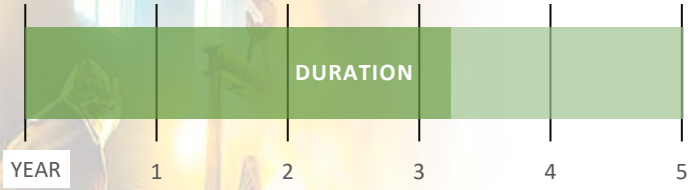
Properties vs. Section Thickness - High Alloy Elongation Structural Alloys

Paul Brancaleon, NADCA

Emergent Metal Casting Technologies (EMCS)

AMC Technology Review

June 24-25, 2026



Overview

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Needs and Benefits

- This project will provide DoW / DLA and die casters with measured properties related to specific section thicknesses of production castings, which will allow them to reduce weight and improve performance of structural die cast parts.
- Focused on structural die castings made from higher integrity aluminum. Current high integrity structural die cast alloys do not have published mechanical property data for the various cast wall thicknesses being produced.

Progress

- Die castings from Aural 2, C611 and A365 Structural Alloys have been selected to excise specimens. The casting selection has been completed and the alloy chemistry has been verified.

Industry Transition

- Incorporation into NADCA Product Specification Standards
- Presentations to industry at NADCA Committee Meetings and NADCA Die Casting Congress

Cost Share

- $195,420 provided of $367,000 proposed (33% of total project cost proposed)

Needs

Description

- Within the structural die castings, there are alloys that are solution heat treatable and able to be welded that exhibit enhanced tensile strength, yield strength, and have higher elongation properties than those made from standard die cast alloys.
- This project will provide DoW, DLA and die casters with measured properties related to specific section thicknesses of production castings which will allow them to reduce weight and improve performance of structural die cast parts.

Objective

- Establish typical mechanical properties for various section thicknesses of production structural die castings for better design guidance, resulting in lighter, higher performing die cast parts. This project will focus on structural die castings made from higher integrity aluminum with high pressure, high vacuum die cast processes.
- Incorporate into NADCA Product Specification Standards

This information will…

- Reduce casting wall thickness, reduce casting weights, decrease cycle times and reduce scrap.

Benefits

- Reduce casting wall thickness by up to 20%
  - From standard wall thickness of 7-9 mm to 3-5 mm for optimum mechanical properties
- Reduce casting weight by up to 20% by wall thickness reductions.
- Decrease casting cycle times by up to 15% by thinner walls, less casting weight with the same or better mechanical properties.

  - **<u>Improve the quality and reduce cost</u>**
    - Design for minimum wall based on developed specifications
    - Provide design data for low iron, heat-treated castings for higher performance applications

Die Castings for Military Applications

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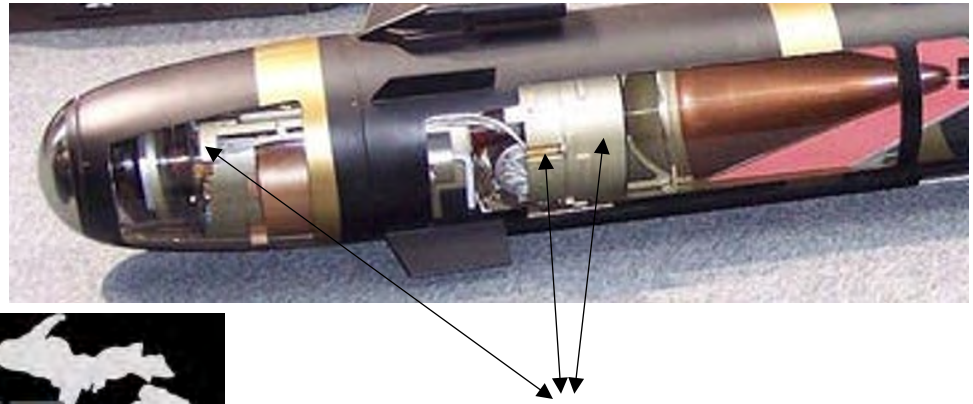
AGM-114 Hellfire



Hellfire II Missile Die Castings

Project Plans

1. Alloy Selection
   - Select alloys from most common alloys to heat treatable alloys to represent a broad selection across the die cast industry
2. Casting selection for As-Cast cross sections for tensile test bars
3. Characterize the tensile test bars
   - Use X-ray and CT Scanning to determine casting and tensile test bar quality prior to mechanical testing
4. Mechanically test tensile bars for Tensile, Yield and Elongation
5. Record mechanical data to be published in the NADCA Specifications and Standards for High Integrity & Structural Die Castings

Technical Progress:
Structural Castings

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- Five specific alloys have been identified

Alloy	Composition (%)									
	Si	Cu	Mg	Fe	Mn	Zn	Sr	Ti		Other
Aural 2	**9.5-11.5**	**0.05**	**0.28-0.33**	**0.25**	**0.3-0.65**	**0.07**	**0.05**	**0.10**	**-**	**0.05**
Aural 5	6.5-9.5	0.03	0.06	0.13-0.2	0.3-0.6	0.03	0.05	0.02-0.06	-	0.05
Alcoa C611	4.0-7.0	0.01	0.15-0.25	0.15	0.4-0.8	-	0.1-0.03	0.01	-	0.05
Silafont 36	9.5-11.5	0.03	0.1-0.5	0.15	0.8	0.08	0.05	0.04-0.15	-	0.05
A365	9.5-11.5	0.05	0.15-0.5	0.15	0.5-0.8	0.05	0.01-0.02	0.15	-	0.05

- All five will be tested in the as cast and heat-treated condition

Technical Progress:
Structural Castings

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- Aural 2, C611 and A365 - Completed

Alloy	Composition (%)									
	Si	Cu	Mg	Fe	Mn	Zn	Sr	Ti		Other
Aural 2	**9.5-11.5**	**0.05**	**0.28-0.33**	**0.25**	**0.3-0.65**	**0.07**	**0.05**	**0.10**	**-**	**0.05**
Aural 5	6.5-9.5	0.03	0.06	0.13-0.2	0.3-0.6	0.03	0.05	0.02-0.06	-	0.05
Alcoa C611	4.0-7.0	0.01	0.15-0.25	0.15	0.4-0.8	-	0.1-0.03	0.01	-	0.05
Silafont 36	9.5-11.5	0.03	0.1-0.5	0.15	0.8	0.08	0.05	0.04-0.15	-	0.05
A365	9.5-11.5	0.05	0.15-0.5	0.15	0.5-0.8	0.05	0.01-0.02	0.15	-	0.05

Technical Progress:
Structural Castings

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- Aural 5 is being Tested for 2026

Alloy	Composition (%)									
	Si	Cu	Mg	Fe	Mn	Zn	Sr	Ti		Other
Aural 2	**9.5-11.5**	**0.05**	**0.28-0.33**	**0.25**	**0.3-0.65**	**0.07**	**0.05**	**0.10**	**-**	**0.05**
Aural 5	6.5-9.5	0.03	0.06	0.13-0.2	0.3-0.6	0.03	0.05	0.02-0.06	-	0.05
Alcoa C611	4.0-7.0	0.01	0.15-0.25	0.15	0.4-0.8	-	0.1-0.03	0.01	-	0.05
Silafont 36	9.5-11.5	0.03	0.1-0.5	0.15	0.8	0.08	0.05	0.04-0.15	-	0.05
A365	9.5-11.5	0.05	0.15-0.5	0.15	0.5-0.8	0.05	0.01-0.02	0.15	-	0.05

Aural 2, T7, 2.5mm

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Technical Progress:

Structural Castings C611 Alcoa Structural alloy

- Large Structural Castings
- Die Cast Machine Size is 6100 Ton to 9100 Ton
- Automotive Applications
- Alloy C611™
- Process – High pressure Die Cast

C611 Alloy

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Rear Side of Mega Casting. Note Scale on casting

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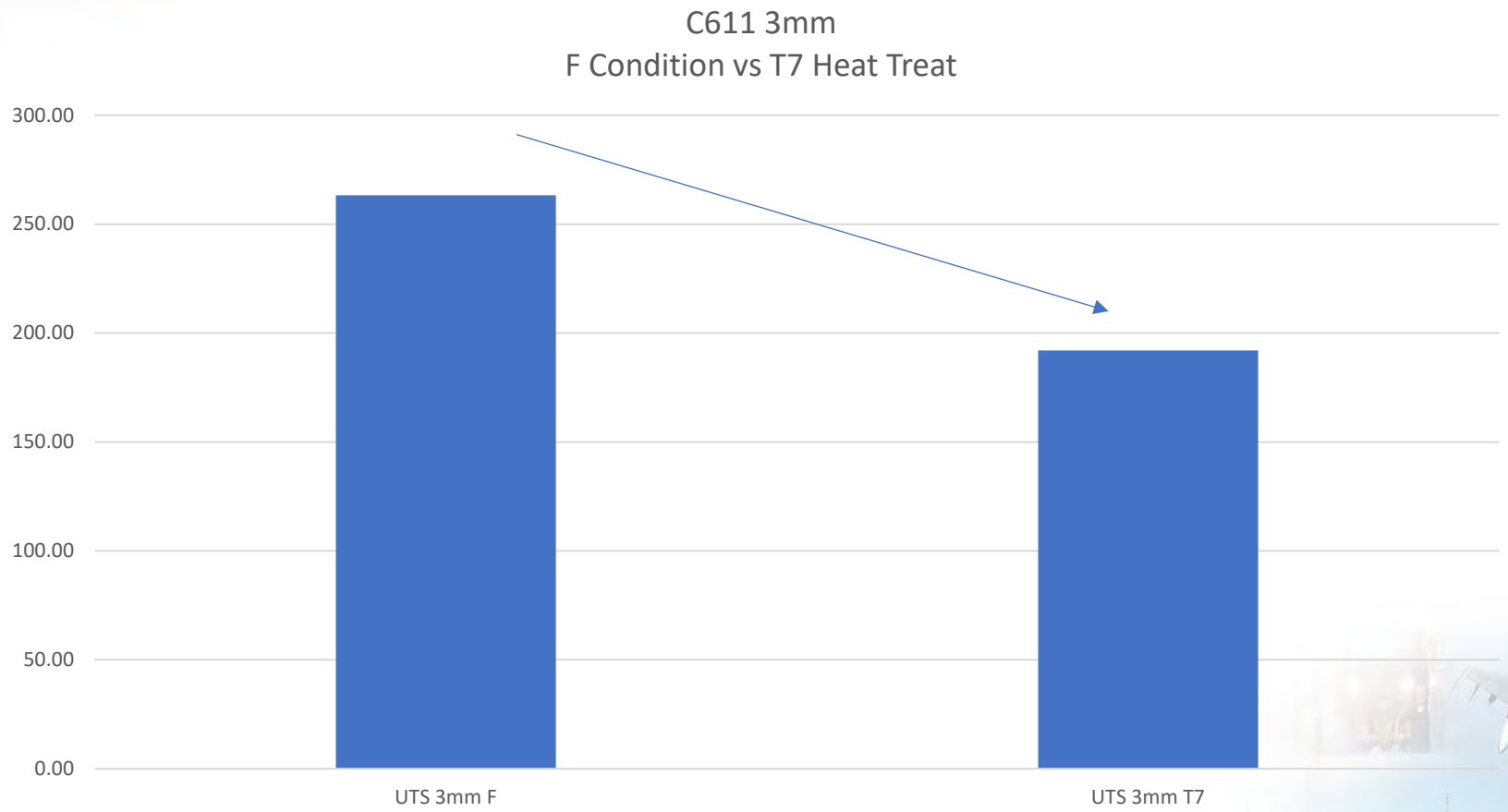
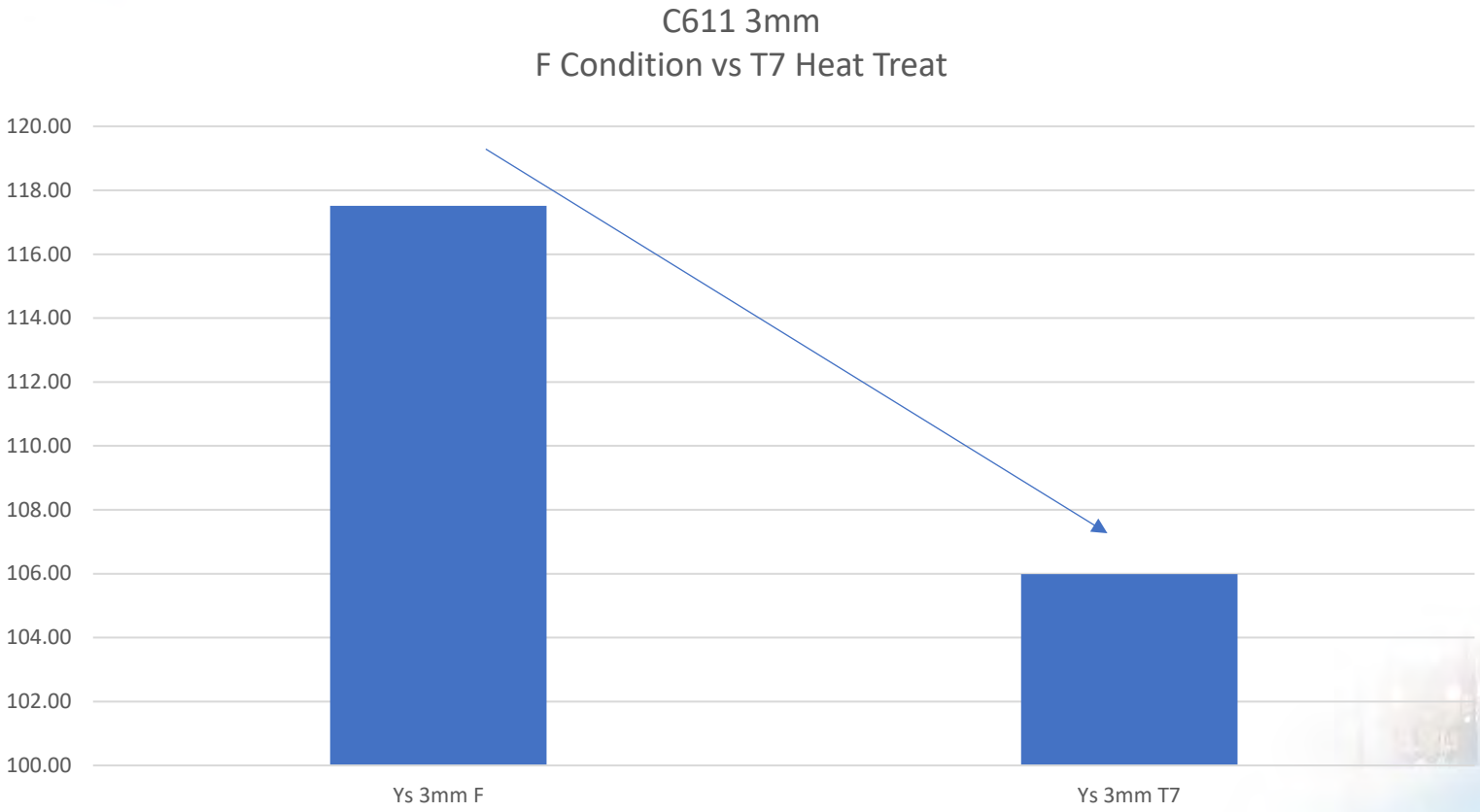
C611 Alloy

Giga Casting made in a 9000 ton die cast machine. The part weis in at 160 lbs

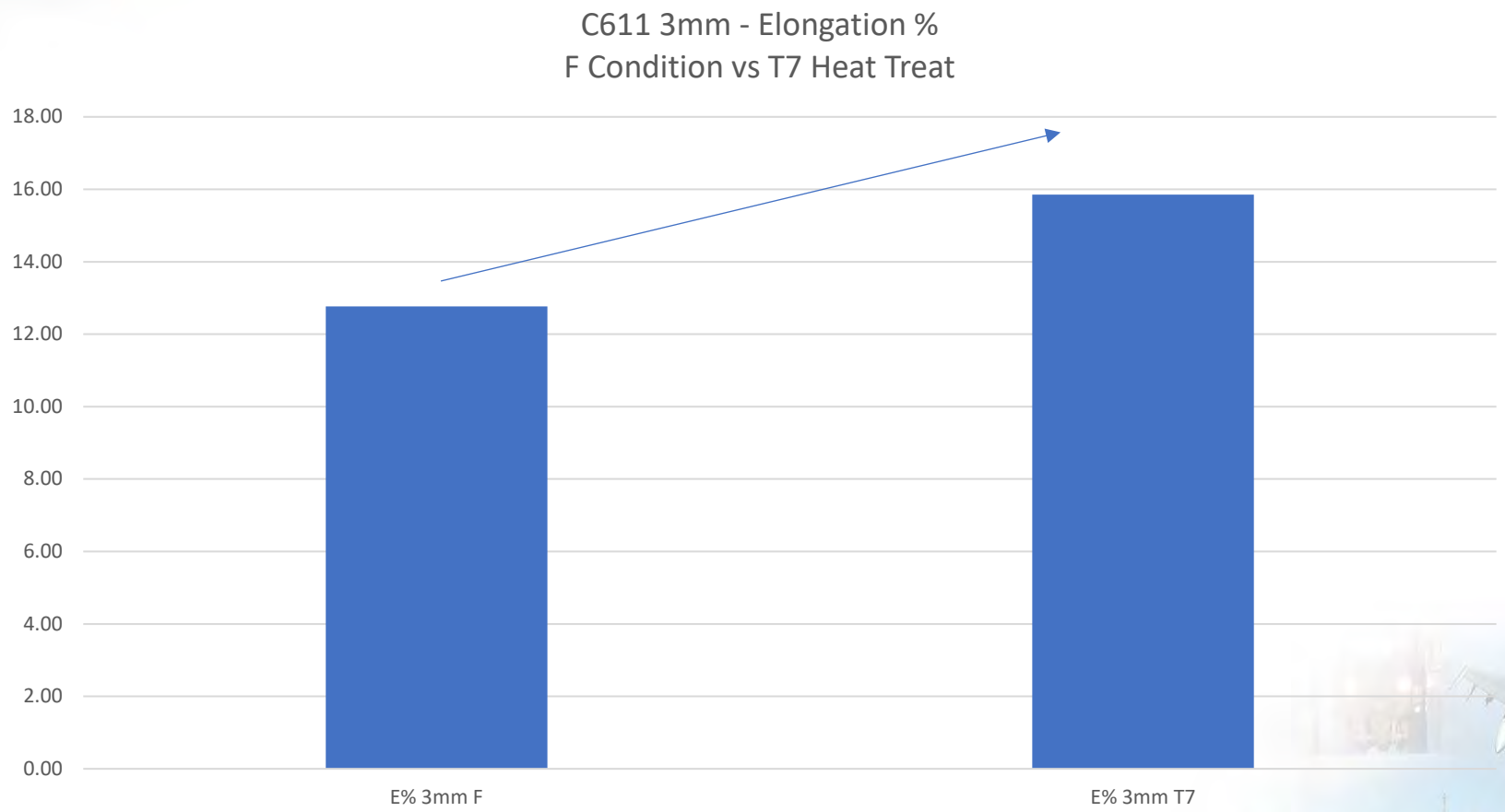
UTS C611 – F vsT7-HT



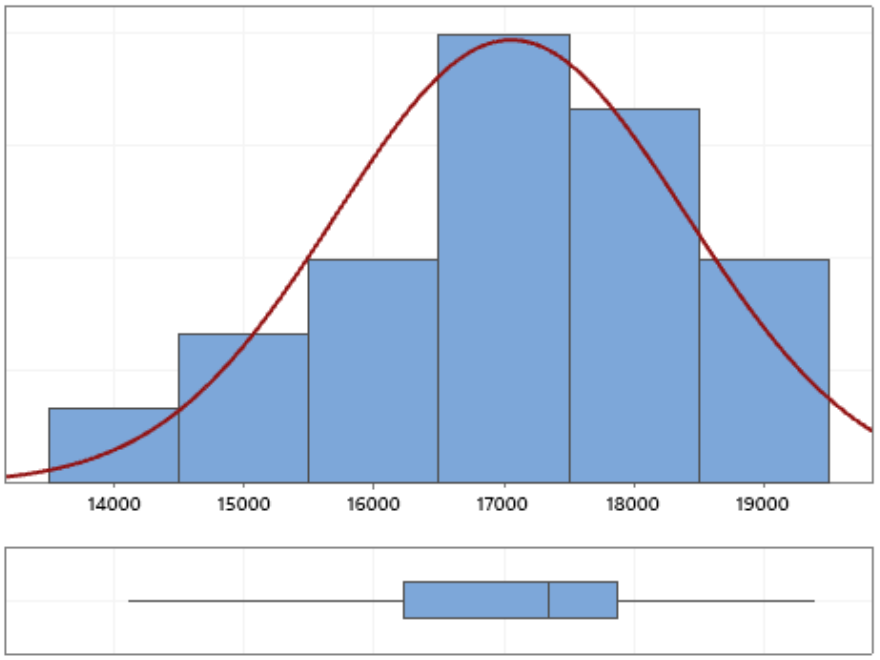
Ys C611 – F vsT7-HT



E%- C611 – F vsT7-HT



C611 As Cast 3mm Thickness Ys



Anderson-Darling Normality Test

A-Squared	0.32
P-Value	0.512
Mean	17055
StDev	1347
Variance	1815237
Skewness	-0.563282
Kurtosis	0.078509
N	20
Minimum	14100
1st Quartile	16225
Median	17350
3rd Quartile	17875
Maximum	19400

95% Confidence Interval for Mean

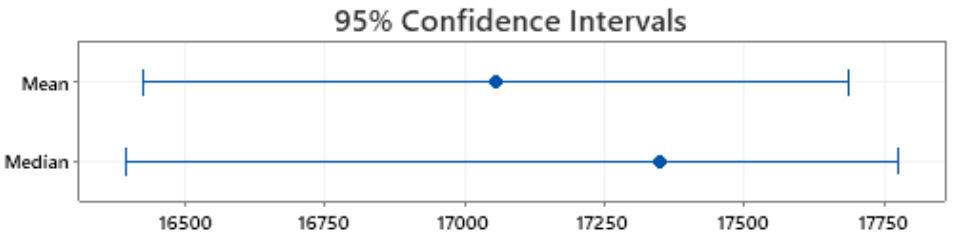
16424	17686

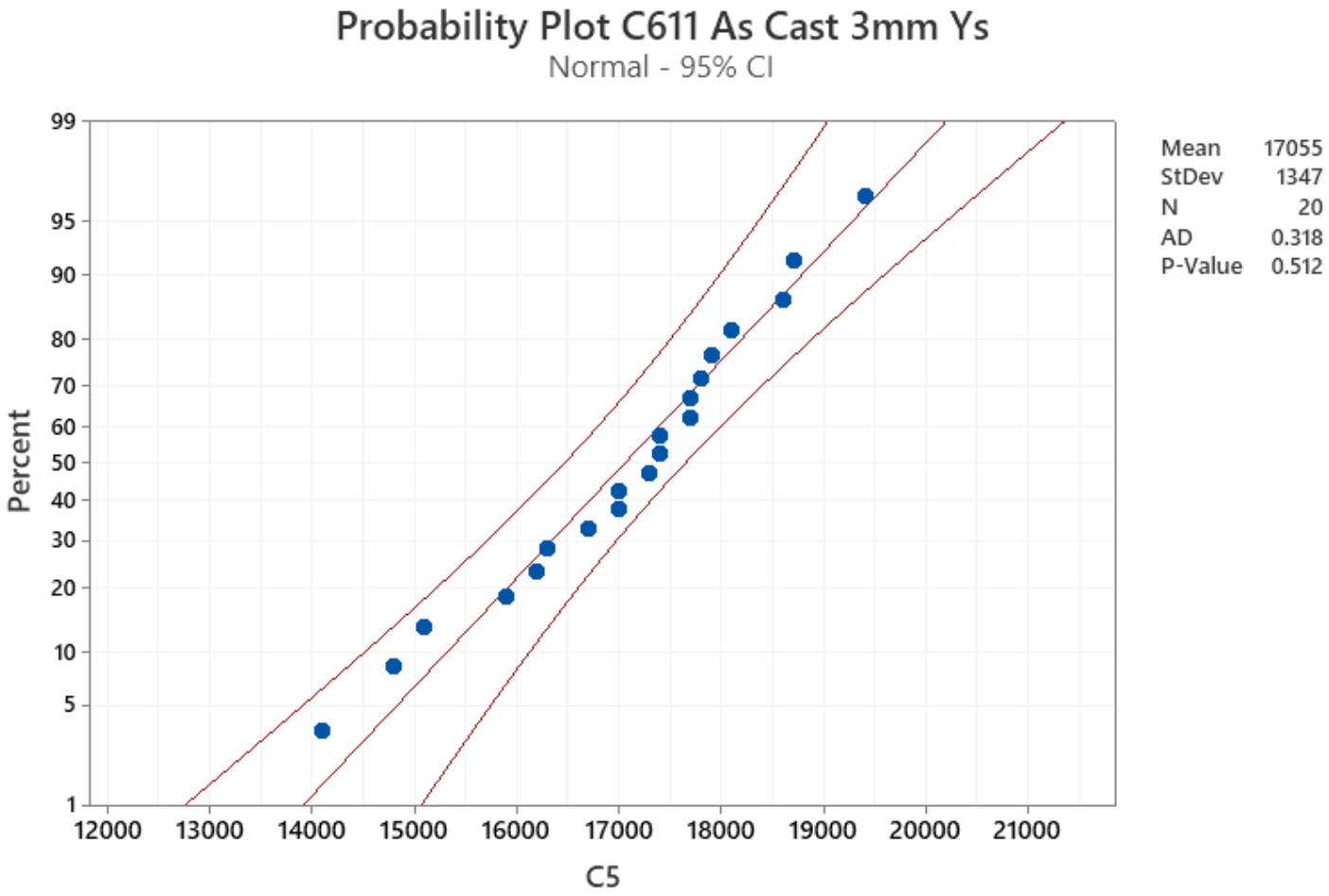
95% Confidence Interval for Median

16394	17776

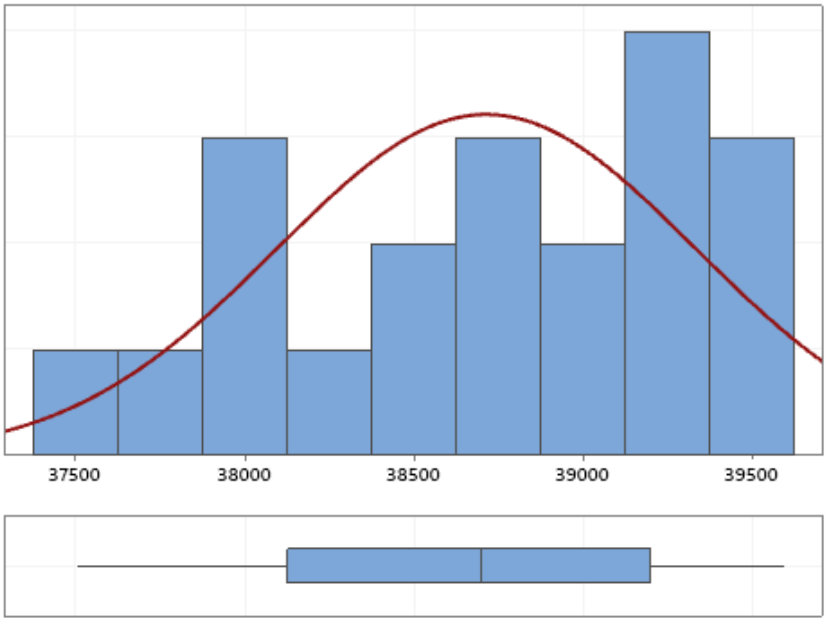
95% Confidence Interval for StDev

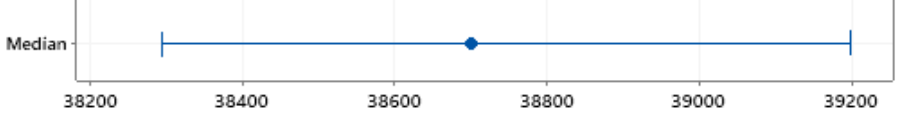
1025	1968



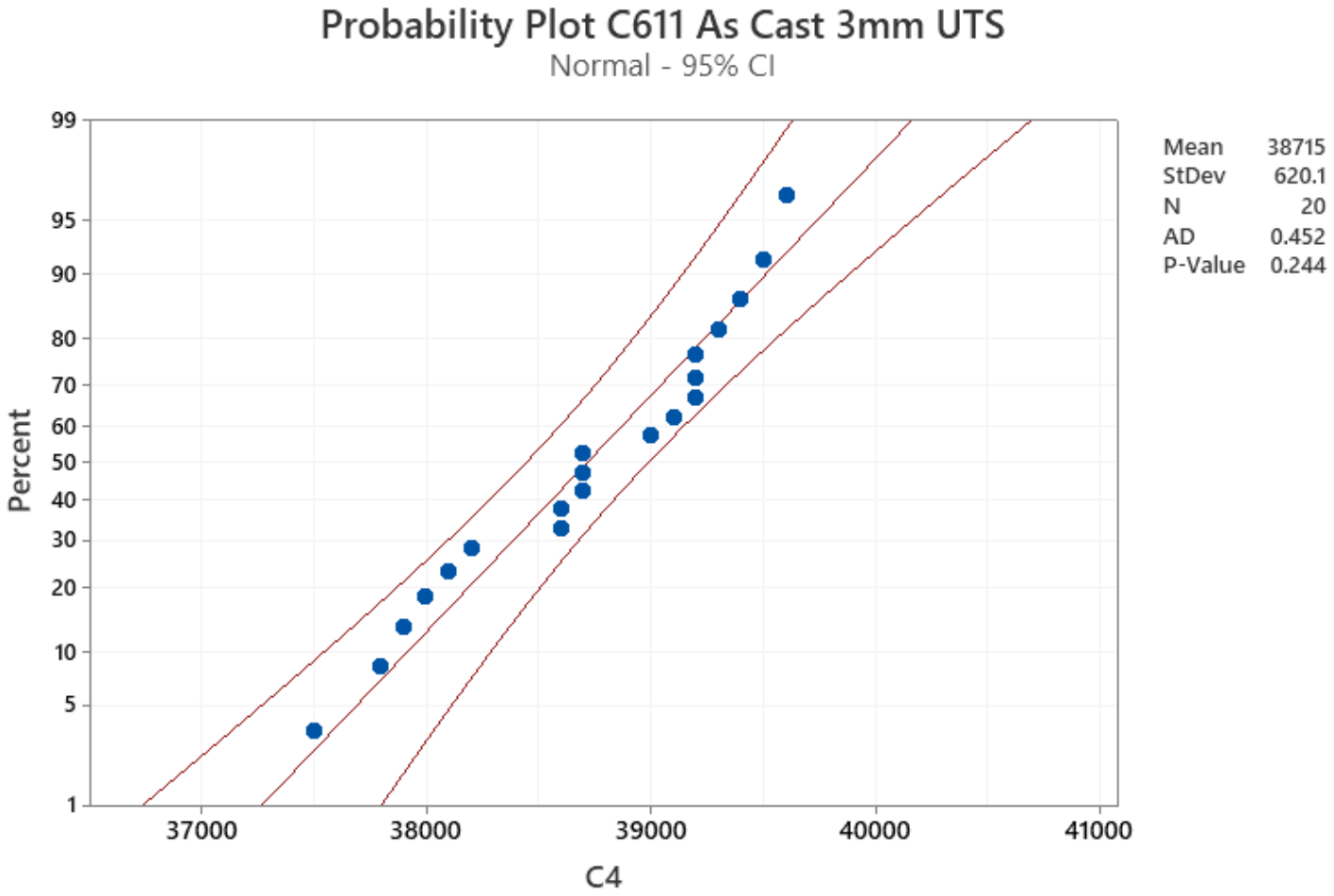

Probability Plot C611 As Cast 3mm Ys
Normal - 95% CI
Percent
99
95
90
80
70
60
50
40
30
20
10
5
1
12000
13000
14000
15000
16000
17000
18000
19000
20000
21000
C5
Mean 17055
StDev 1347
N 20
AD 0.318
P-Value 0.512

C611 As Cast 3 mm Thickness UTS

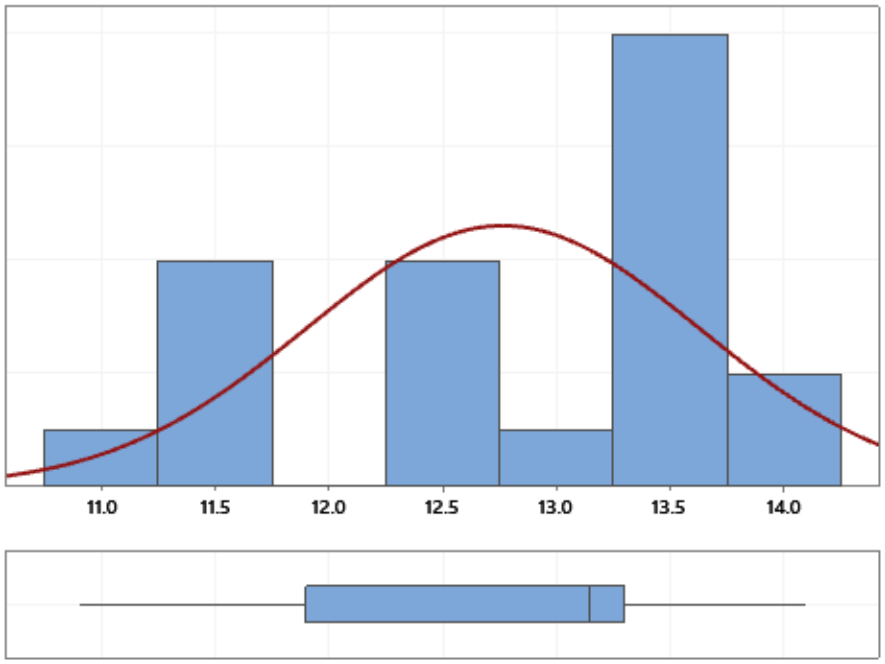


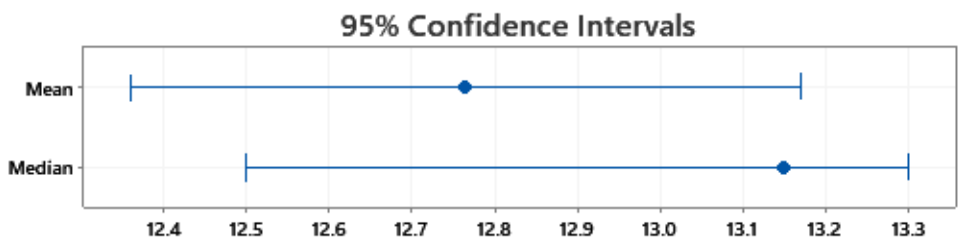


Anderson-Darling Normality Test	
A-Squared	0.45
P-Value	0.244
Mean	38715
StDev	620
Variance	384500
Skewness	-0.421343
Kurtosis	-0.938960
N	20
Minimum	37500
1st Quartile	38125
Median	38700
3rd Quartile	39200
Maximum	39600
95% Confidence Interval for Mean	
38425	39005
95% Confidence Interval for Median	
38294	39200
95% Confidence Interval for StDev	
472	906


Probability Plot C611 As Cast 3mm UTS
Normal - 95% CI
Percent
99
95
90
80
70
60
50
40
30
20
10
5
1
37000
38000
39000
40000
41000
C4
Mean 38715
StDev 620.1
N 20
AD 0.452
P-Value 0.244

C611 As Cast 3mm Elongation %





Anderson-Darling Normality Test

A-Squared	0.95
P-Value	0.013
Mean	12.765
StDev	0.865
Variance	0.748
Skewness	-0.488165
Kurtosis	-0.402154
N	20
Minimum	10.900
1st Quartile	11.900
Median	13.150
3rd Quartile	13.300
Maximum	14.100

95% Confidence Interval for Mean

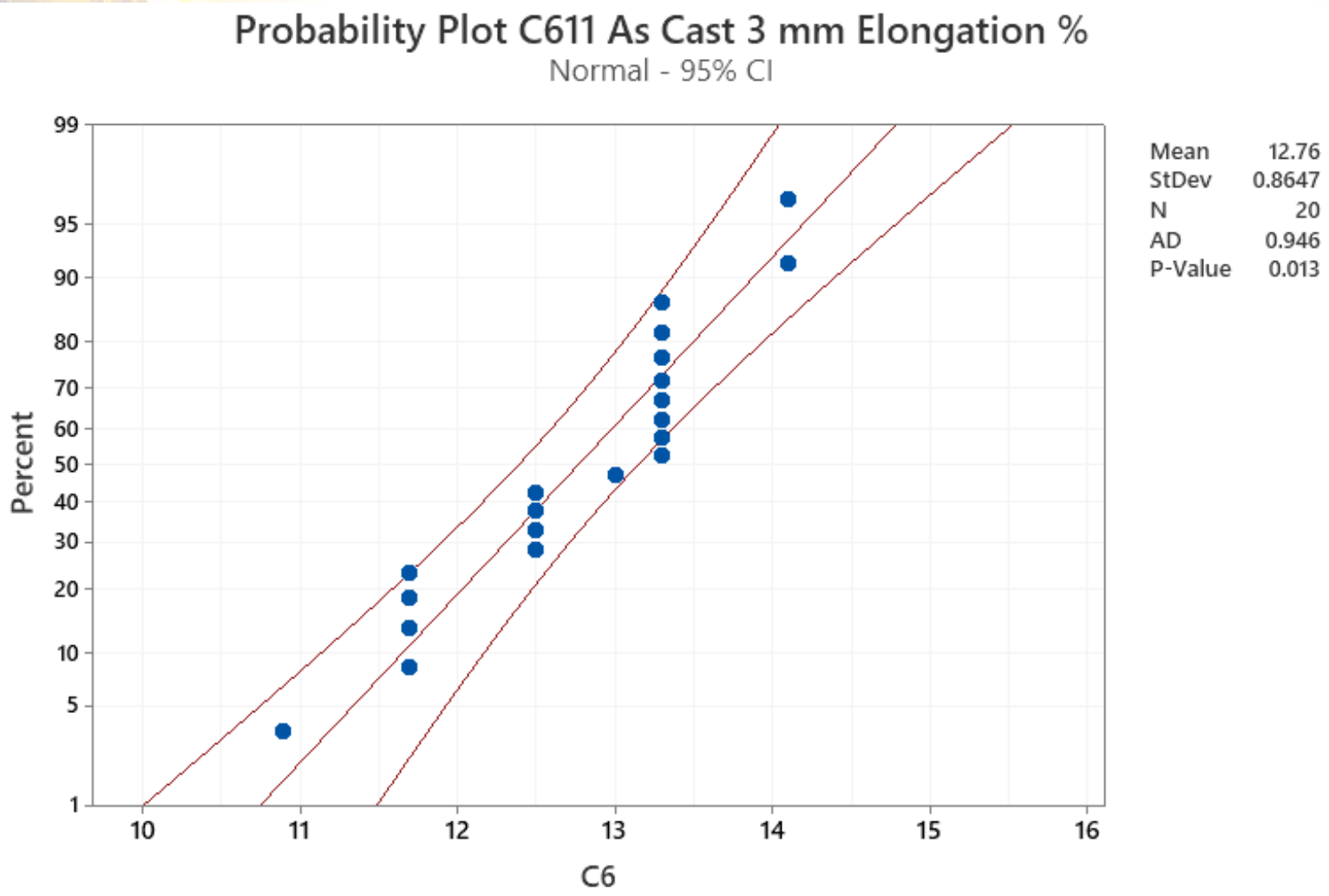
12.360 13.170

95% Confidence Interval for Median

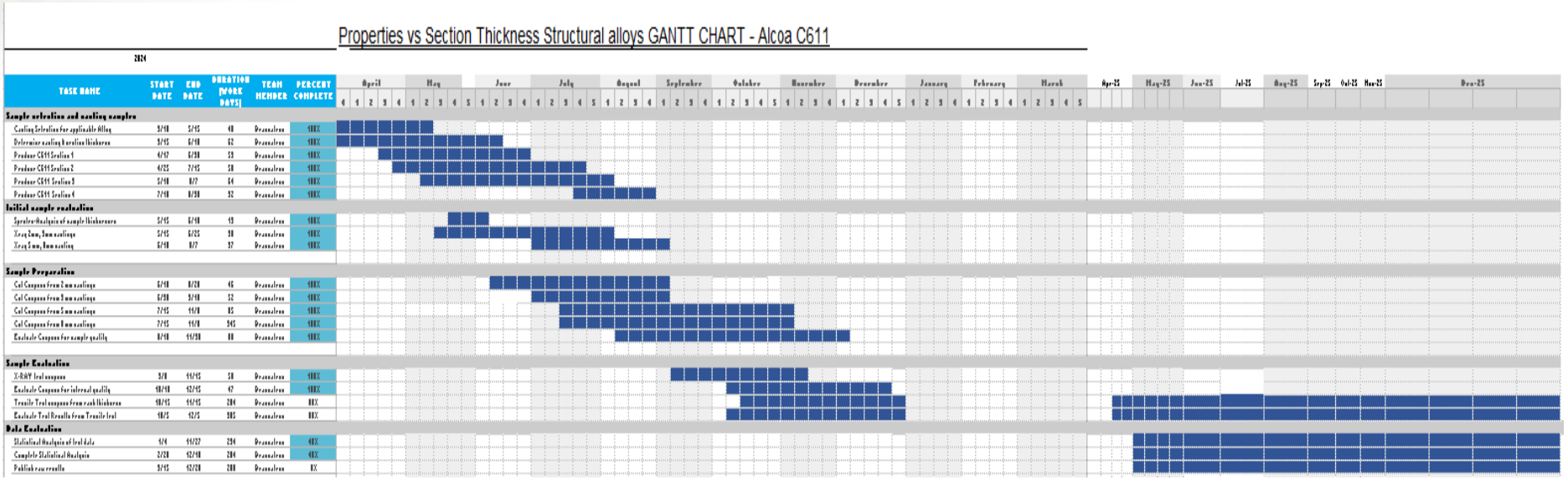
12.500 13.300

95% Confidence Interval for StDev

0.658 1.263


Probability Plot C611 As Cast 3 mm Elongation %
Normal - 95% CI
Percent
99
95
90
80
70
60
50
40
30
20
10
5
1
10
11
12
13
14
15
16
C6
Mean 12.76
StDev 0.8647
N 20
AD 0.946
P-Value 0.013

C611 Gantt Chart



Technical Progress:

Structural Castings A365 Structural alloy

- Structural Casting alloy
- Die Cast Machine Size is 900 Ton to
- Automotive Applications
- Alloy A365
- Process – High pressure Die Cast

Casting Selection for 2025 A365 Alloy

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Casting Selection for 2025 A365 Alloy

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A365 Cut sections

A365 Alloy

A365 Ts, Ys, E%

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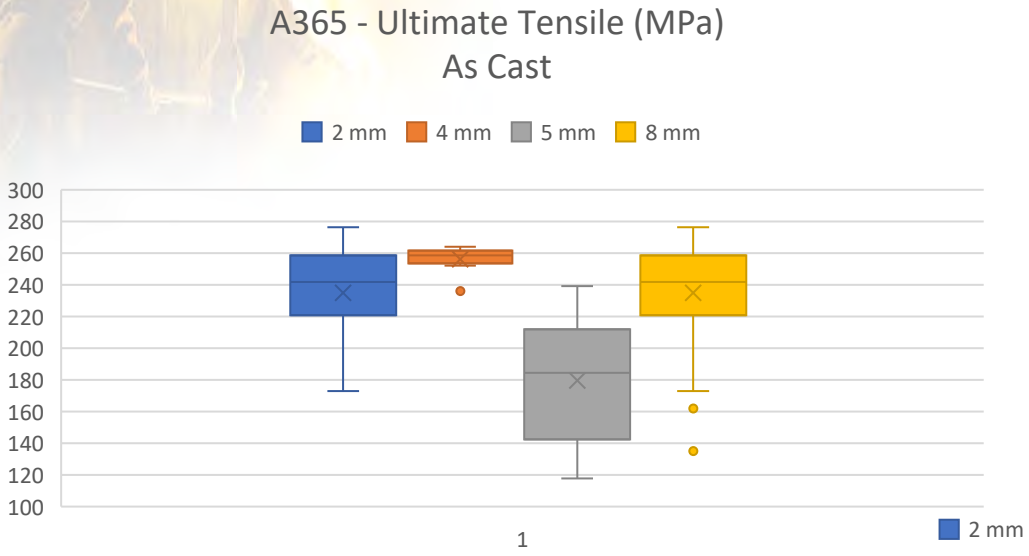
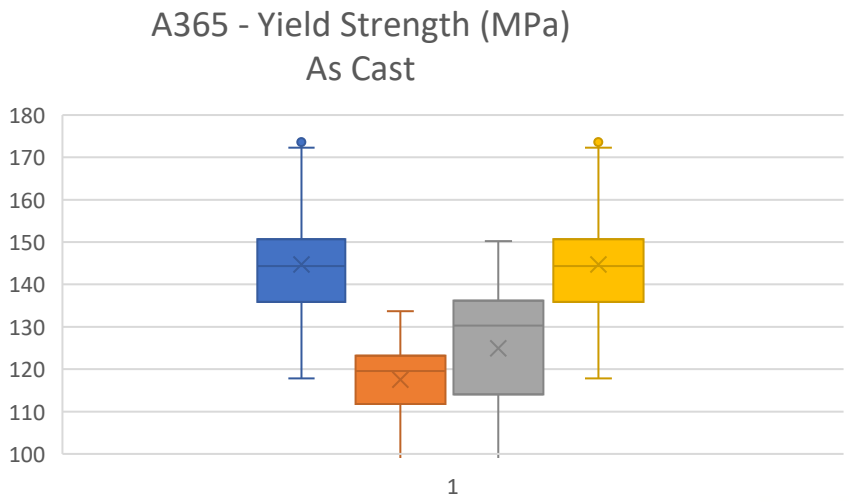
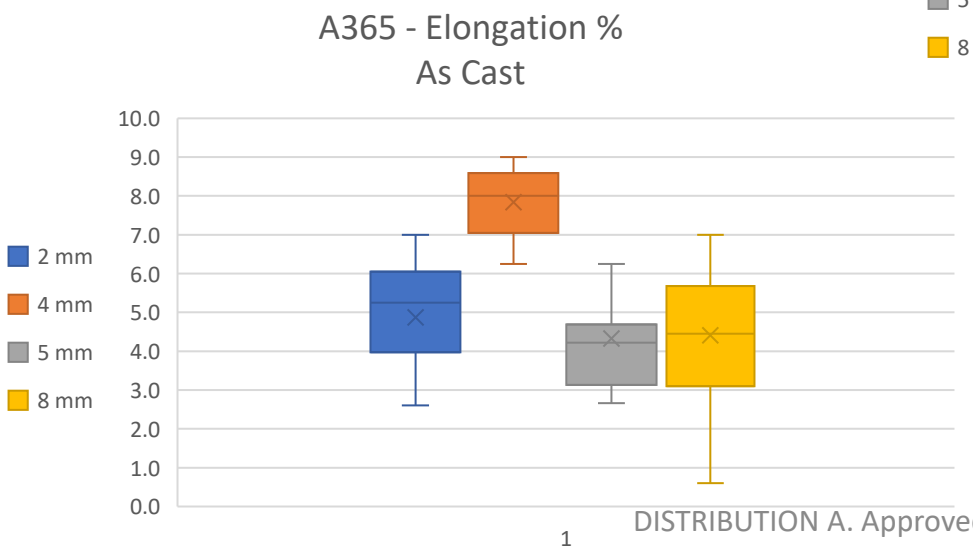
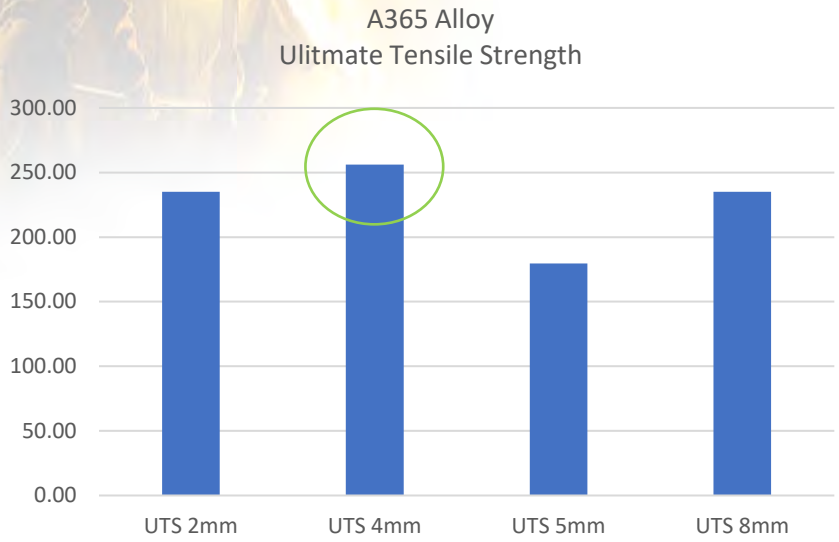
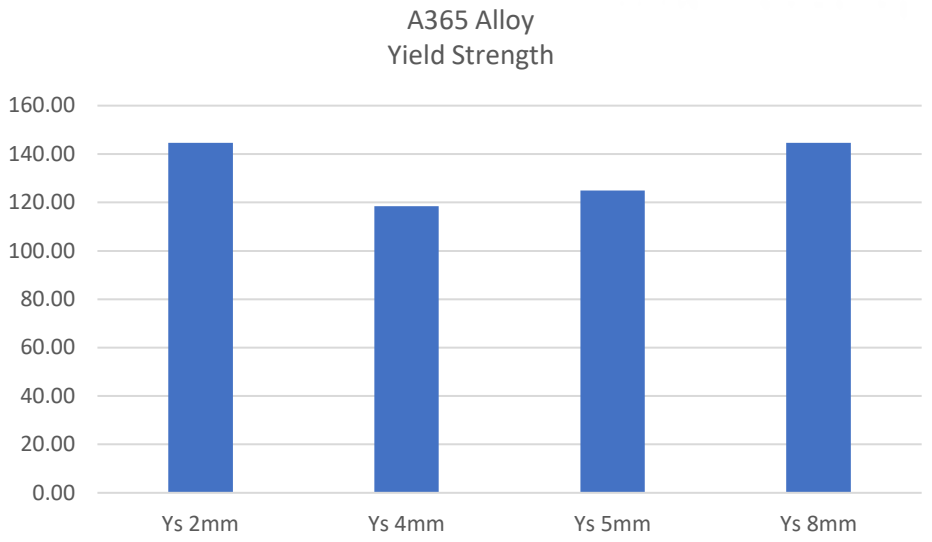




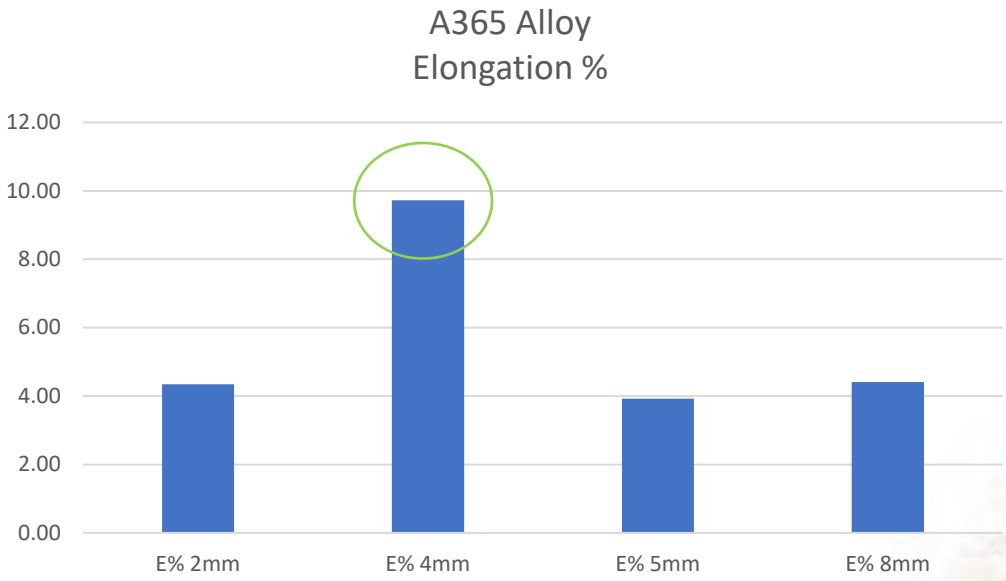


A365 Alloy





Ys is within 22 Mpa



A365 Gantt Chart

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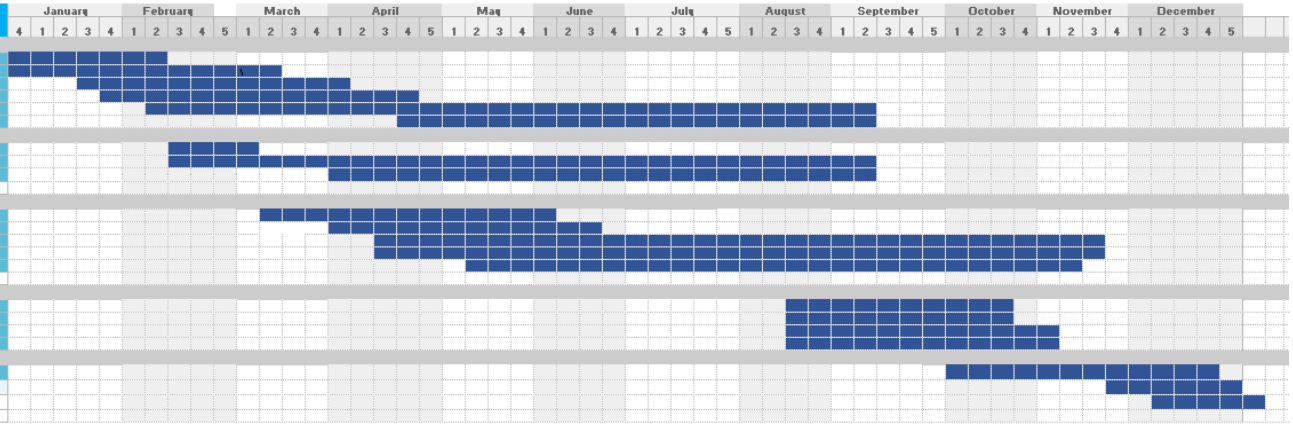
Properties vs Section Thickness Structural alloys GANTT CHART - A365

2025

TASK NAME	START DATE	END DATE	DURATION (WORK DAYS)	TEAM MEMBER	PERCENT COMPLETE
Sample selection and casting samples					
Casting Selection for applicable Alloy	1/6/2025	2/15/2025	30	Brancaleon	100%
Determine casting & section thickness	1/6/2025	3/15/2025	50	Brancaleon	100%
Produce A365 Section 1	1/21/2025	4/5/2025	54	Brancaleon	100%
Produce A365 Section 2	1/25/2025	4/21/2025	61	Brancaleon	100%
Produce A365 2 Section 3	2/10/2025	5/7/2025	63	Brancaleon	100%
Produce A365 2 Section 4	4/18/2025	5/30/2025	31	Brancaleon	100%
Initial sample evaluation					
Spectro-Analysis of sample thicknesses	2/15/2025	3/10/2025	16	Brancaleon	100%
Xray 2mm, 3mm castings	2/15/2025	5/5/2025	56	Brancaleon	100%
Xray 5 mm, 8mm casting	4/1/2025	5/7/2025	27	Brancaleon	100%
Sample Preparation					
Cut Coupons from 2 mm castings	3/10/2025	6/5/2025	64	Brancaleon	100%
Cut Coupons from 3 mm castings	3/30/2025	6/15/2025	55	Brancaleon	100%
Cut Coupons from 5 mm castings	4/15/2025	8/8/2025	84	Brancaleon	100%
Cut Coupons from 8 mm castings	4/15/2025	8/8/2025	84	Brancaleon	100%
Evaluate Coupons for sample quality	5/10/2025	9/15/2025	91	Brancaleon	100%
Sample Evaluation					
X-RAY test coupons	6/8/2025	8/15/2025	50	Brancaleon	100%
Evaluate Coupons for internal quality	7/10/2025	9/21/2025	52	Brancaleon	100%
Tensile Test coupons from each thickness	7/15/2025	11/5/2025	82	Brancaleon	100%
Evaluate Test Results from Tensile test	7/10/2025	11/5/2025	85	Brancaleon	100%
Data Evaluation					
Statistical Analysis of test data	10/4/2025	12/23/2025	57	Brancaleon	70%
Complete Statistical Analysis	11/23/2025	12/30/2025	27	Brancaleon	10%
Publish raw results	12/8/2025	1/10/2026	25	Brancaleon	0%



Transition Plan

- Promote alloys and properties
  - DCE Magazine article
  - Committee meetings
  - Chapter and company visits
  - Conferences/Die Casting Congress
  - Webinars and educational courses
- NADCA Product Specification Standards expanded with additional alloys and properties (web accessible, electronic, and hard copy format)

Leveraging

- Alloy compositions utilize and build on previous AMC and DOE research
- Collaborative work with LIFT (Lightweight Innovation For Tomorrow) to generate a larger property database
- Contributed data from Independent Research & Development (IR&D)
- Collaborative work with industry and researchers
- Project is not part specific, and alloys can be utilized wherever improved strength is beneficial

Project Metrics

Description	Baseline	Threshold	Goal	How Measured	Target Date	Progress	How Demonstrated
Mechanical properties for various thickness production die castings: One per year	As cast and heat-treated bar data	3 thicknesses from production castings (2mm, 4mm, 6mm)	4 thicknesses from production castings (2mm, 4mm, 6mm, 8-9mm)	ASTM E8 tensile tests	Aural 2: Dec '23 Aural 5: Dec '24 C611: Dec '25 Silfont 36: Dec 2026 Final alloy data A365 - Sept '27	Started Aural 2 casting selection and obtaining castings for specimens.	Mechanical properties generated
Updated NADCA Product Standards document	Very little data on production castings	Property data of production castings for 5 alloys in as cast condition	Property data of production castings for 5 alloys in as cast and H.T. condition	Number actually added to document	January 2028		Published in NADCA Structural alloy Standards

Acknowledgements

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Properties vs. Section Thickness - High Elongation Structural Alloys

DLA - POC: DLAR.DPR@dla.mil

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Problem:

- Available mechanical data from round as-cast tensile specimens do not accurately characterize production castings being manufactured throughout the industry resulting in differing properties

Objectives:

- Establish typical mechanical properties for various section thicknesses of production structural die castings made from high integrity aluminum with higher pressure, high vacuum die cast process

Benefits to Warfighter:

- Better design guidance for structural die castings will result in:
  - Lighter weight, higher quality die cast parts
  - Higher performance capabilities

Description of Project:

This project will create better design guidance for aluminum structural die castings by establishing typical mechanical properties for various section thicknesses of these castings resulting in lighter and higher performing parts.

Team: North American Die Casting Association, ATI

NADCA

ATI ADVANCED TECHNOLOGY INTERNATIONAL

Milestones / Deliverables:

- Mechanical property data including ultimate tensile strength, yield strength, and percent elongation for four section thicknesses across five alloys
- Characterized fracture surfaces
- Comparative statistical analysis for all alloys tested
- Integrate mechanical data into the NADCA Standard for High Integrity and Structural Die Casting Product Specification