



ATI Richburg Operations,
4374 Lancaster Highway,
Richburg, SC 29729
US

CERTIFICATE OF TEST
Cert No. 162930 Rev. 1



FEB 13 2018

Tina Coletti
Tina K. Coletti
Certification Auditor
Date : February 02, 2018

Batch - 169646
Heat - L7K20 ✓
Ingot - 1 ✓

| | | | |
|-------------------------|---------------------|----------------|---------------------------|
| Customer Name & Address | Purchase Order No ✓ | Sales Order No | Sales Order Line No |
| | 28-227050-001 | 91791 | 1.1 |
| Size (in) ✓ | Cross section ✓ | No Pcs ✓ | Weight (lbs) ✓ |
| 1.2500 | Round | 30 | 1,498 |
| | | | Alloy ✓ |
| | | | ATI VascoMax® C-350 Alloy |

✓ Specifications

| Spec Name | Rev | Class | Compliance Condition |
|-------------|----------|----------|----------------------|
| AMS 6515 | A | | Compliant |
| ASQR-01 | 10 | | Compliant |
| DMI-350 | 11/27/12 | | Compliant |
| EN 10204 | 10-2004 | | Compliant |
| F-14 | D | | Compliant |
| F-17 | C | | Compliant |
| F-17 SUPP A | B | | Compliant |
| MIL-S-46850 | D AM.2 | TYPE=III | Compliant |
| MIL-S-46850 | D AM.2 | TYPE=IV | Compliant |
| PWA 300 | BP | | Compliant |

Remarks:
Material certified in accordance with EN 10204 Type 3.1.

✓ As Shipped Condition

| Heat Treat | Heat Treat Cycles | Hot Work Type |
|-------------------|--|---------------|
| Solution Anneal | Heat To 1700 F Hold 1 Hr(s) Rapid Air Cool Heat To 1500 F Hold 1 Hr(s) Rapid Air Cool | Rolled |
| Surface Finish | | |
| Centerless Ground | | |

Melt Method Details

| Primary Melt | Facility | Address |
|-----------------------|-------------------------|--|
| Vacuum Induction Melt | ATI Lockport Operations | ATI Lockport Operations 695 Ohio Street, Lockport, NY 14094 US |
| Remelt | Facility | Address |
| Vacuum Arc Remelt | ATI Lockport Operations | ATI Lockport Operations 695 Ohio Street, Lockport, NY 14094 US |

Conversion Method Details

| Conversion Type | Facility | Address |
|-----------------|-------------------------|---|
| Rolling | ATI Richburg Operations | ATI Richburg Operations 4374 Lancaster Highway, Richburg, SC 29729 US |

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✓ CHEMISTRY

| Piece ID | T1 | T3 | B4 |
|---------------|-----------------------|-----------------------|-----------------------|
| Sample Source | Top | Middle | Bottom |
| Test Facility | ATI Monroe Operations | ATI Monroe Operations | ATI Monroe Operations |
| Elements UOM | Method | | |
| C % | CS | <0.01 | <0.01 |
| Mn % | XRF | 0.02 | 0.02 |
| Si % | XRF | <0.01 | <0.01 |
| P % | XRF | 0.005 | 0.004 |
| S % | CS | <0.001 | <0.001 |
| Ni % | XRF | 18.43 | 18.46 |
| Co % | XRF | 12.35 | 12.36 |
| Mo % | XRF | 4.73 | 4.74 |
| Ti % | XRF | 1.44 | 1.44 |
| Al % | XRF | 0.09 | 0.10 |
| Cr % | XRF | 0.08 | 0.08 |
| Cu % | XRF | 0.01 | 0.01 |
| Fe % | XRF | BAL | BAL |

Remarks:
 CS = Combustion/IR Detection
 GAS = Inert Gas Fusion
 XRF = X-Ray Fluorescence

Remarks:
 Certified maximum additions: B = 0.003, Zr = 0.020, Ca = 0.050
 Test Methods: C/S/O/N = ASTM E1019 (2011); XRF = ASTM E572 (2013), ASTM E1085 (2016), ASTM E2465 (2013); OES = ASTM E415 (2017), ASTM E1086 (2014), ASTM E3047 (2016); ICP = ASTM E2594 (2009/2014); Mass Spec. = ASTM E2823 (2017); GFAA = ASTM E1834 (2011)

MECHANICAL

Test Specimen Heat Treatment(s)

Plant: 700F, 1hr, RAC - 1500F, 1hr, RAC
 Laboratory: 950F, 6hrs, AC

✓ Tensile

| Piece ID | Sample Direction | Sample Location | Test Temperature | Ultimate Strength (ksi) | .2% Yield Strength (ksi) | 4D-Elongation (%) | Reduction of Area (%) | Initial Gage Length (in) | Initial Diameter (in) | Crosshead Speed | Strain Rate (in/in/min) | Test Facility |
|----------|------------------|-----------------|------------------|-------------------------|--------------------------|-------------------|-----------------------|--------------------------|-----------------------|-----------------|-------------------------|---------------------------------|
| 1 | L | C | ROOM | 365.3 | 354.9 | 7.1 | 36.8 | 2.000 | 0.5018 | 0.05 | 0.003 | Westmoreland Mechanical Testing |
| 2 | L | C | ROOM | 366.0 | 355.9 | 8.8 | 36.5 | 2.002 | 0.5016 | 0.05 | 0.003 | Westmoreland Mechanical Testing |
| 3 | L | C | ROOM | 366.6 | 355.7 | 8.0 | 37.0 | 2.000 | 0.4994 | 0.05 | 0.003 | Westmoreland Mechanical Testing |

Remarks:
 L = Longitudinal
 C = Center
 ASTM E8/E8M (2016a)
 Elongation determined after fracture.

✓ Hardness

| Piece ID | Sample Direction | Sample Location | Hardness Value (Rockwell) | Hardness Type | Test Facility |
|----------|------------------|-----------------|---------------------------|---------------|---------------|
| 1 | T | MR | 61 | HRC | Acuren |
| 2 | T | MR | 61 | HRC | Acuren |
| 3 | T | MR | 60 | HRC | Acuren |

Remarks:
 T = Transverse
 MR = Mid-Radius
 ASTM E18 (2017*1)

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Test Specimen Heat Treatment(s)

Laboratory: 1700F, 1hr, AC - 1500F, 1hr, AC - 950F, 6hrs, AC

✓ **Charpy**

| Piece ID | Sample Direction | Sample Location | Test Temperature | Ft/Lbs Energy (ft/lbs) | Specimen Type | Striker Size | Test Facility |
|----------|------------------|-----------------|------------------|------------------------|---------------|--------------|---------------------------------|
| T-1 | L | MR | ROOM | 6 | V | 8 mm | Westmoreland Mechanical Testing |
| T-3 | L | MR | ROOM | 6 | V | 8 mm | Westmoreland Mechanical Testing |
| B-4 | L | MR | ROOM | 6 | V | 8 mm | Westmoreland Mechanical Testing |

Remarks:

L = Longitudinal
MR = Mid-Radius
ASTM E23 (2016b)

✓ **Fracture Toughness**

| Piece ID | Sample Direction | Test Temperature | K _{1C} (ksi(in) ^{3/2}) | Valid/Invalid | Number of Invalidities | Test Facility |
|----------|------------------|------------------|---|---------------|------------------------|---------------------------------|
| T-1 | C-R | ROOM | 30.3 | Valid | 0 | Westmoreland Mechanical Testing |
| T-3 | C-R | ROOM | 30.7 | Valid | 0 | Westmoreland Mechanical Testing |
| B-4 | C-R | ROOM | 30.9 | Valid | 0 | Westmoreland Mechanical Testing |

Remarks:

C-R = Circumferential-Radial
ASTM E399 (2012*3)

METALLOGRAPHY

As Shipped

Plant: 1700F, 1hr, RAC - 1500F, 1hr, RAC

✓ **Grain Size**

| Piece ID | Sample Direction | Sample Location | Uniform ASTM | Etchant | Magnification | Test Facility |
|----------|------------------|-----------------|--------------|----------|---------------|---------------|
| 4 | L | S-C | 7 | Zypherts | 100X | Acuren |

Remarks:

L = Longitudinal
S-C = Surface-Center
Average Grain Size Test Method = ASTM E112 (2013)

✓ **Hardness**

| Piece ID | Sample Direction | Sample Location | Hardness Value (Rockwell) | Hardness Type | Test Facility |
|----------|------------------|-----------------|---------------------------|---------------|---------------|
| 1 | T | MR | 35 | HRC | Acuren |
| 2 | T | MR | 37 | HRC | Acuren |
| 3 | T | MR | 35 | HRC | Acuren |
| 4 | T | MR | 35 | HRC | Acuren |

Remarks:

T = Transverse
MR = Mid-Radius
ASTM E18 (2017*1)

✓ **ASTM E45 Method D**

| Type A Thin (Sulfide) | Type A Heavy (Sulfide) | Type B Thin (Alumina) | Type B Heavy (Alumina) | Type C Thin (Silicate) | Type C Heavy (Silicate) | Type D Thin (Globular) | Type D Heavy (Globular) | Type E Thin (Ti Nitrides) | Type E Heavy (Ti Nitrides) | Test Facility |
|-----------------------|------------------------|-----------------------|------------------------|------------------------|-------------------------|------------------------|-------------------------|---------------------------|----------------------------|-----------------------|
| 0 | 0 | 0 | 0 | 0 | 0 | 0.5 | 0 | 0 | 0 | ATI Monroe Operations |

Remarks:

ASTM E45 (2013)

✓ **Macro**

| Test Facility | Etchant | Magnification |
|-----------------------|---------------------------------------|---------------|
| ATI Monroe Operations | Muriatic, Water and Hydrogen Peroxide | 1X |

Remarks:

Macrostructure evaluated in accordance with ASTM A604 (2007/2017) and is acceptable to Classes <1A, <2A, <3A and <4A.
Macrostructure evaluated in accordance with PWA MCL F-14 and found acceptable.

✓ **Inspection**

Remarks:

ATI Specialty Materials elects to certify magnetic particle testing as a periodic test as allowed by Para. 4.2.3 of AMS 2300 Rev. L. Periodic results for frequency and severity = 0/0.