



## AM 350®

### Stainless Steel: Precipitation Hardening

(UNS S35000)

#### INTRODUCTION

AM 350® Precipitation Hardening Alloy (S35000) is a chromium-nickel-molybdenum precipitation hardening stainless steel used for applications requiring high strength and excellent weldability along with corrosion resistance.

The S35000 alloy has been available for many years and has found application in a variety of aerospace applications and especially in edge welded bellows applications that require high strength. Non-aerospace applications include use in precision seals, in couplings for semiconductor processing equipment, and in high vacuum systems. AM 350® precipitation hardening alloy may be formed in a soft austenitic condition and hardened to a high strength level by low temperature heat treatments. The low temperature allows minimum distortion compared to conventional quench and temper hardening processes.

#### PRODUCT FORMS

AM 350® precipitation hardening alloy is furnished as sheet and strip. In most forms, the material is furnished in the annealed condition.

#### SPECIFICATIONS & CERTIFICATES

The AM 350® Precipitation Hardening Alloy (S35000) is covered by the following specifications.

##### Specification: Product Form

AMS 5548: Sheet and Strip

ASTM A 693: Plate, Sheet and Strip

ASME SA 693: Plate, Sheet and Strip

##### Typical Composition (wt.%)

Carbon: 0.09

Manganese: 0.80

Silicon: 0.30

Chromium: 16.5

Nickel: 4.3

Molybdenum 2.75

Nitrogen: 0.10

Iron: Balance

#### CORROSION RESISTANCE

Tests have shown that the corrosion resistance of AM 350® alloy is comparable to that of Type 316 stainless steel in most media. In general, the corrosion resistance of AM 350® alloy is superior to that of the other precipitation hardenable stainless steels as well as being superior to the hardenable 400 series stainless steels.

## Technical Data Sheet

### WELDABILITY

The AM 350® precipitation hardening alloy is weldable by conventional inert gas methods. The precipitation hardening reaction in the alloy is independent of the presence of aluminum or titanium, which are reactive elements. For this reason, AM 350® alloy welds much more readily than other precipitation hardenable stainless steels. Inert gas methods should be used to protect against the loss of chromium or changes in carbon content.

As-welded AM 350® alloy will be substantially austenitic and will exhibit mechanical properties which are roughly equivalent to annealed (Condition H) material. The ductility of the weld eliminates the need for preheating and post-weld annealing procedures required for the conventional and age hardenable martensitic alloys. To produce high-strength welds, however, full post-weld heat treatment (solution annealing plus austenitic conditioning, transformation and precipitation hardening) is necessary.

### PHYSICAL PROPERTIES

	Condition H	Condition SCT 850	Condition DA
<b>Density</b> lb/in <sup>3</sup> kg/m <sup>3</sup>	0.286 7920	0.282 7810	0.277 7670
<b>Linear Coefficient of Thermal Expansion</b> Units of 10 <sup>-6</sup> /°F (10 <sup>-6</sup> /°C) Temperature Range: 70-200°F (21-93°C)	8.4 (15.2)	6.3 (11.3)	5.6 (10.1)
<b>Magnetic Permeability</b>	12	18	18
<b>Thermal Conductivity</b>	Approximately 9.2 Btu-ft/hr-ft <sup>2</sup> -°F (15.9 W/m-K) in the hardened conditions in the range 70-300°F (20-150°C)		
<b>Electrical Resistivity</b>	Approximately 80 microhm-cm in annealed or hardened conditions		

Elastic Modulus and Modulus of Rigidity (Room Temperature Values)			
	Condition H	Condition SCT 850	Condition DA
<b>Modulus of Elasticity</b> 10 <sup>6</sup> psi (GPa)	29 (200)	29 (200)	29 (200)
<b>Modulus of Rigidity</b> 10 <sup>6</sup> psi (GPa)	11 (75)	11 (75)	11 (75)



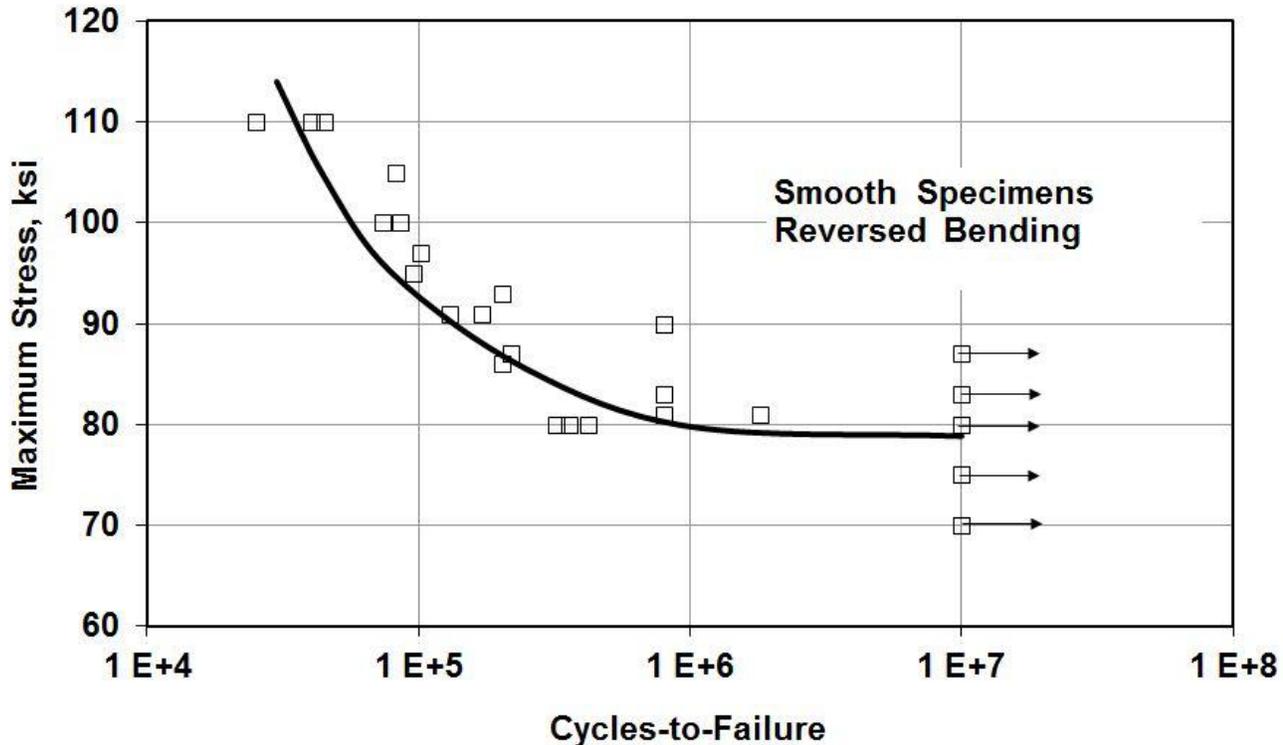
Technical Data Sheet

MECHANICAL PROPERTIES

Room Temperature Properties (Typical Values) (Sheet and Strip)				
		Condition H	Condition SCT 850	Condition DA
0.2% Yield Strength	psi (MPa)	70,000 (480)	200,000 (1380)	160,000 (1100)
Ultimate Tensile Strength	psi (MPa)	150,000 (1035)	220,000 (1520)	190,000 (1310)
Elongation (percent)		30	9	10
Hardness		20	46	42
Rockwell Hardness Scale		C	C	C

FATIGUE

Results of fatigue tests of three heats of AM 350® alloy condition SCT sheet are shown in the following graph.



Data are typical, are provided for informational purposes, and should not be construed as maximum or minimum values for specification or for final design, or for a particular use or application. The data may be revised anytime without notice. We make no representation or warranty as to its accuracy and assume no duty to update. Actual data on any particular product or material may vary from those shown herein. TM is trademark of and ® is registered trademark of ATI Properties, Inc. or its affiliated companies. © The starburst logo is a registered trademark of ATI Properties, Inc. © 2012 ATI. All rights reserved.

Allegheny Technologies Incorporated  
1000 Six PPG Place  
Pittsburgh, PA 15222-5479 U.S.A.  
www.ATImetals.com



## Technical Data Sheet

### HEAT TREATMENT

Typically, the AM 350® precipitation hardening alloy is furnished in the annealed condition, Condition H. In this condition, the material possesses an austenitic structure, although it has several percent delta ferrite. As an austenitic material, the AM 350® precipitation hardening alloy possesses a relatively low strength. This is the condition in which formability is easiest.

To develop the high precipitation hardened strength of the alloy by heat treatment, starting from Condition H, heat treatments are done to accomplish two necessary steps. The first is a heat treatment which allows the relatively stable austenite of Condition H to transform to martensite (Austenite Conditioning and Transformation). The second is a precipitation hardening heat treatment to further strengthen the material. The austenite is easier to transform to martensite using a lower temperature heat treatment. For this reason, Condition DA uses a 1400°F (760°C) heat treatment to produce a martensite transformation around room temperature, and this is followed by a precipitation hardening heat treatment at 1050°F (565°C). If Condition SCT 850 is desired, the austenite conditioning heat treatment is conducted at ~1700°F (~925°C). In this case, the martensite transformation is not complete until the material is held for some time at -100°F (-73°C). When the transformation is complete, the material is precipitation hardened at 850°F (455°C) to Condition SCT 850.

Because the precipitation hardening reaction can be driven past peak strength by high temperature or excessive time at the aging temperature, higher temperature or longer time precipitation hardening heat treatments produce lower strength levels.

When AM 350® precipitation hardening alloy with an austenitic structure is cold worked by substantial deformation, a transformation to martensitic structure results from the deformation. In this condition, Condition C, the material may be precipitation hardened directly by heat treatment at 800°F (482°C) to condition CRT 800.

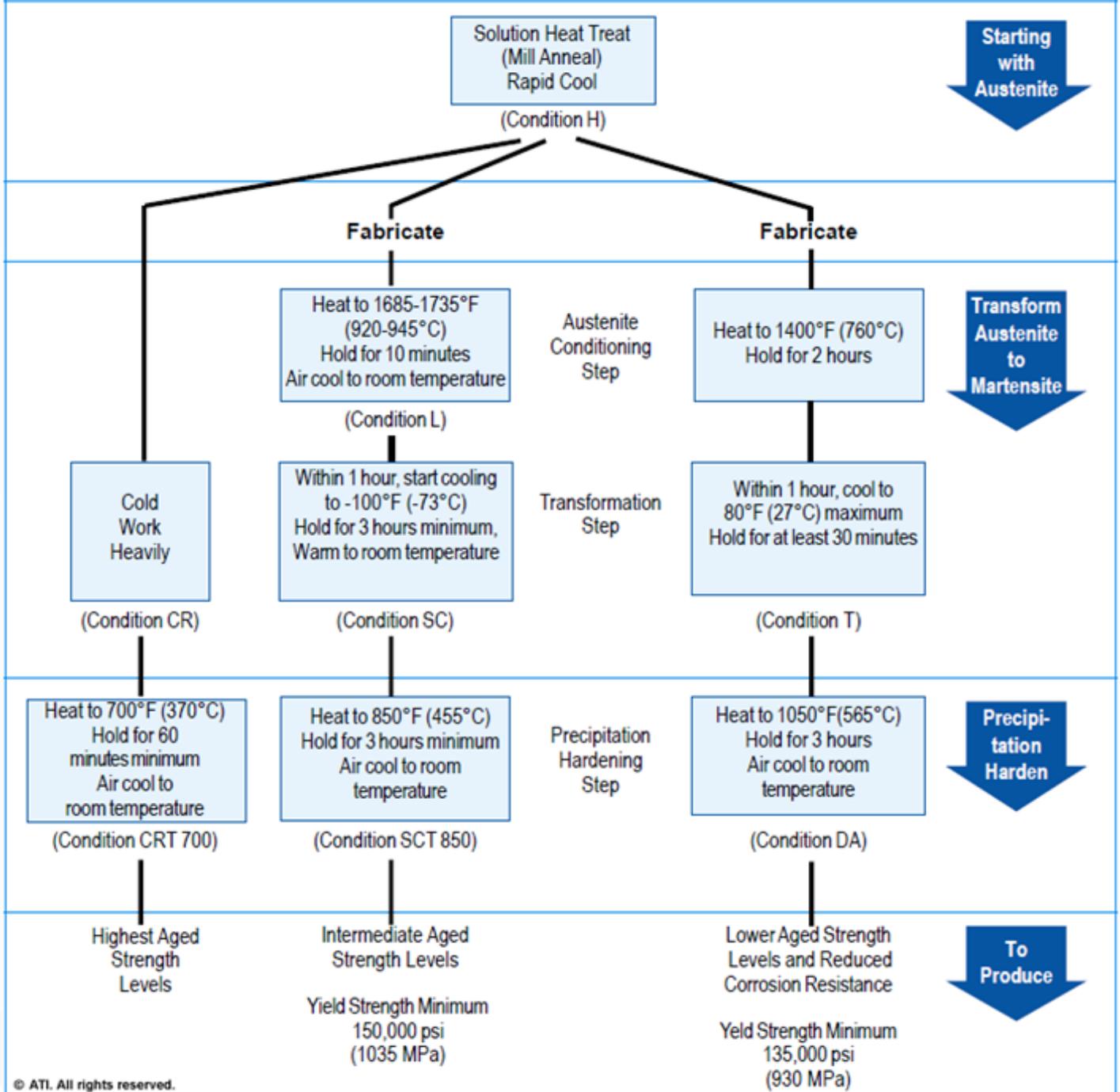
During heat treatment, AM 350® alloy expands approximately 0.0047 in/in from Condition H to the SCT 850 Condition and approximately 0.0049 in/in from Condition H to the DA Condition.

The heat treatments used for the AM 350® precipitation hardening alloy are summarized on the next page.



Technical Data Sheet

# Summary of Heat Treating AM 350® Precipitation Hardening Alloy



Data are typical, are provided for informational purposes, and should not be construed as maximum or minimum values for specification or for final design, or for a particular use or application. The data may be revised anytime without notice. We make no representation or warranty as to its accuracy and assume no duty to update. Actual data on any particular product or material may vary from those shown herein. TM is trademark of and ® is registered trademark of ATI Properties, Inc. or its affiliated companies. © The starburst logo is a registered trademark of ATI Properties, Inc. © 2012 ATI. All rights reserved.

Allegheny Technologies Incorporated  
1000 Six PPG Place  
Pittsburgh, PA 15222-5479 U.S.A.  
www.ATImetals.com