ATI Aerospace

Mission Critical Metallics®

Development of ATI 425® Alloy Flat Rolled Products

ITA 2010

Orlando FL
October 5, 2010

Luis Ruiz-Aparicio, PhD

Outline

- ATI 425® Alloy Introduction
- Cold-Rolled & Annealed Coil
  - Processing
  - Mechanical & Product Properties
- Cold-Rolled & Annealed Sheet/Coil Attributes
  - Quality Advantages
  - Manufacturing Advantages
  - Performance Advantages
- Summary

ATI 425® Alloy

INTRODUCTION

Overview

ATI 425® Alloy

- An α/β titanium alloy that can be processed to a balance of properties comparable to Ti-6Al-4V
- Formulation utilizes higher O & Fe containing recycle streams
  - US Patent No. 5,980,655
- Specifications
  - AMS 6946B (Aerospace)
  - ASTM B265-08 (Grade 38)

Element	Min (wt%)	Max (wt%)
Al	3.5	4.5
V	2.0	3.0
Fe	1.2	1.8
O	0.20	0.30
C	--	0.08
N	--	0.03
H	--	0.015
Other (each)	--	0.10
Other (total)	--	0.30
Ti	balance	

ATI 425® Alloy

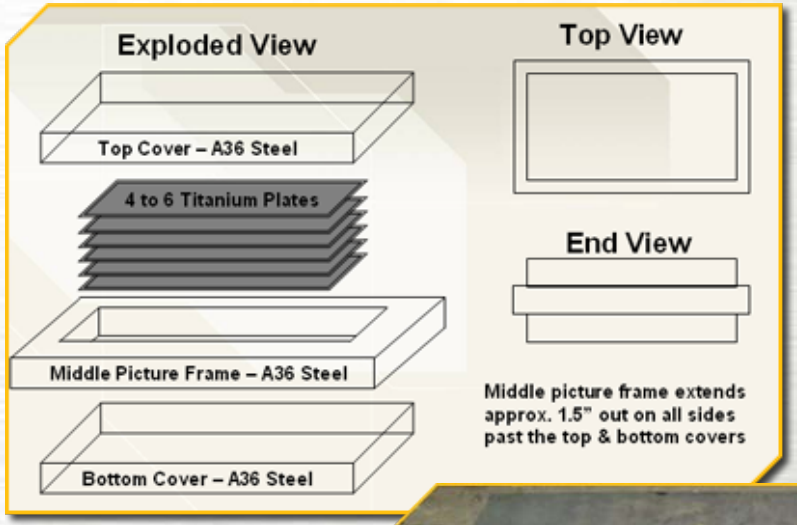
CR&A COIL PROCESS & PRODUCT

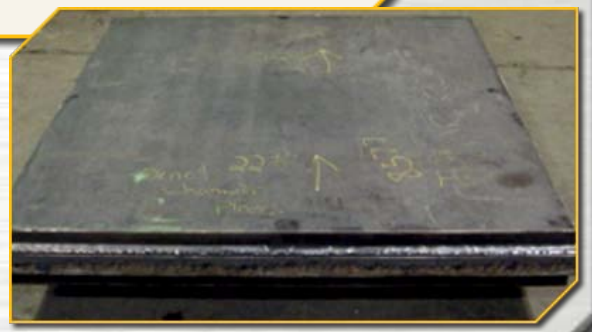
ATI 425® Alloy – Process Comparison
Continuous Coil vs. Pack Roll Sheet

ATI 425® Alloy - Revolutionary Titanium Alloy

Continuous Processing
High-Speed Production
Superior Yields

Today's Industry Standard: Ti 6-4





Labor Intensive
Non Productive
High Rejection Rate

J. E. Nordheim et al
US Patent 2,985,945
May 1961; Filed Feb 1954

ATI 425® Alloy Processing

Vacuum Melting

↓

Hot Working

↓

Cold Rolling

↓

Anneal

↓

CR&A Coil

↓

C-T-L Sheet

AMS 6946: 0.020” → 0.156”
(0.5 to 4 mm)

EXPANDED GAUGE RANGE

0.002” → 0.187”
(0.05 mm →4.75 mm)

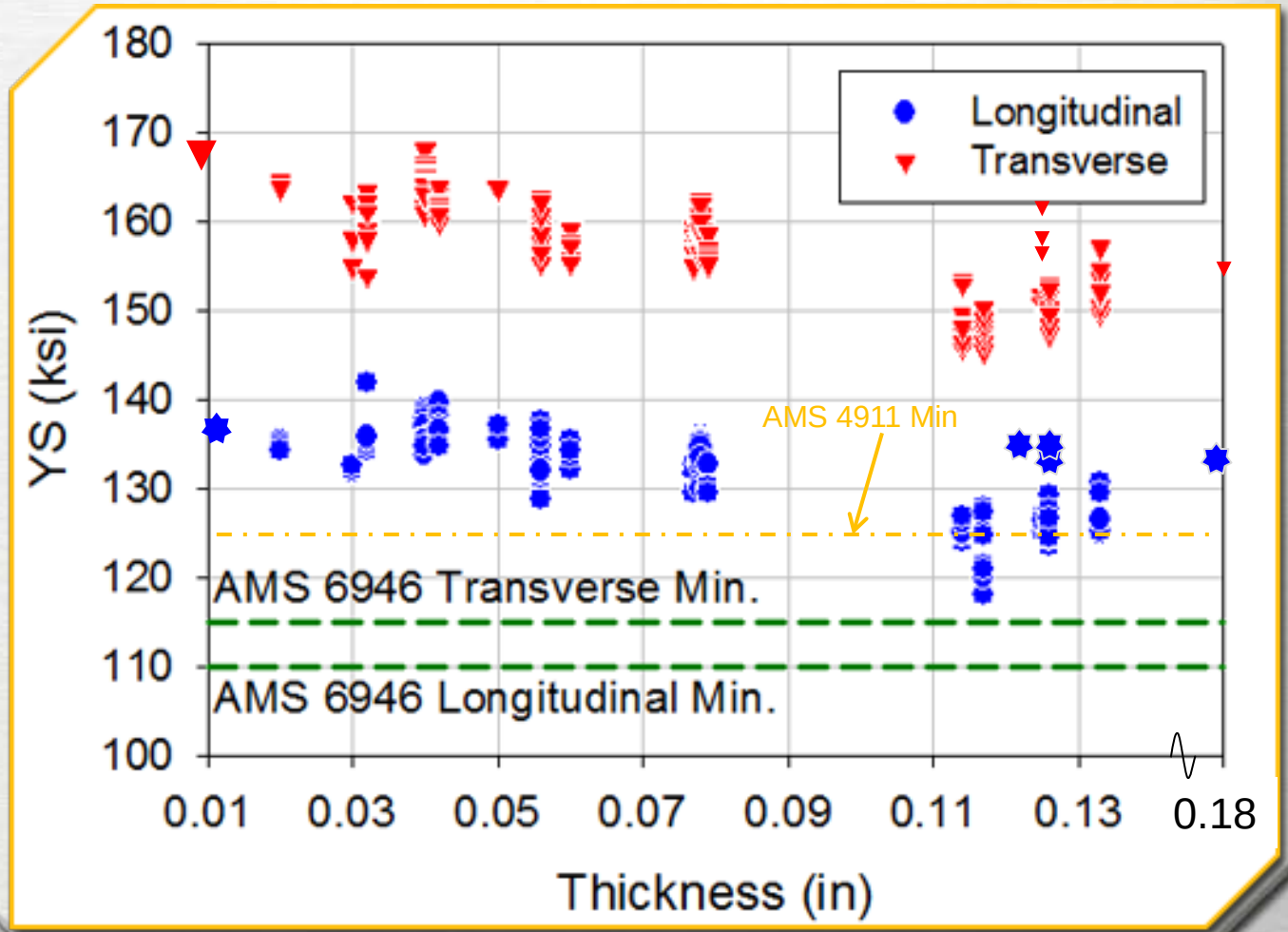
Mechanical Properties

ATI 425® Alloy Sheet

Product comparable to Ti-6Al-4V pack rolled sheet

Tensile Yield Strength

Data in MMPDS 2010 Handbook *(Approved April 2010)*

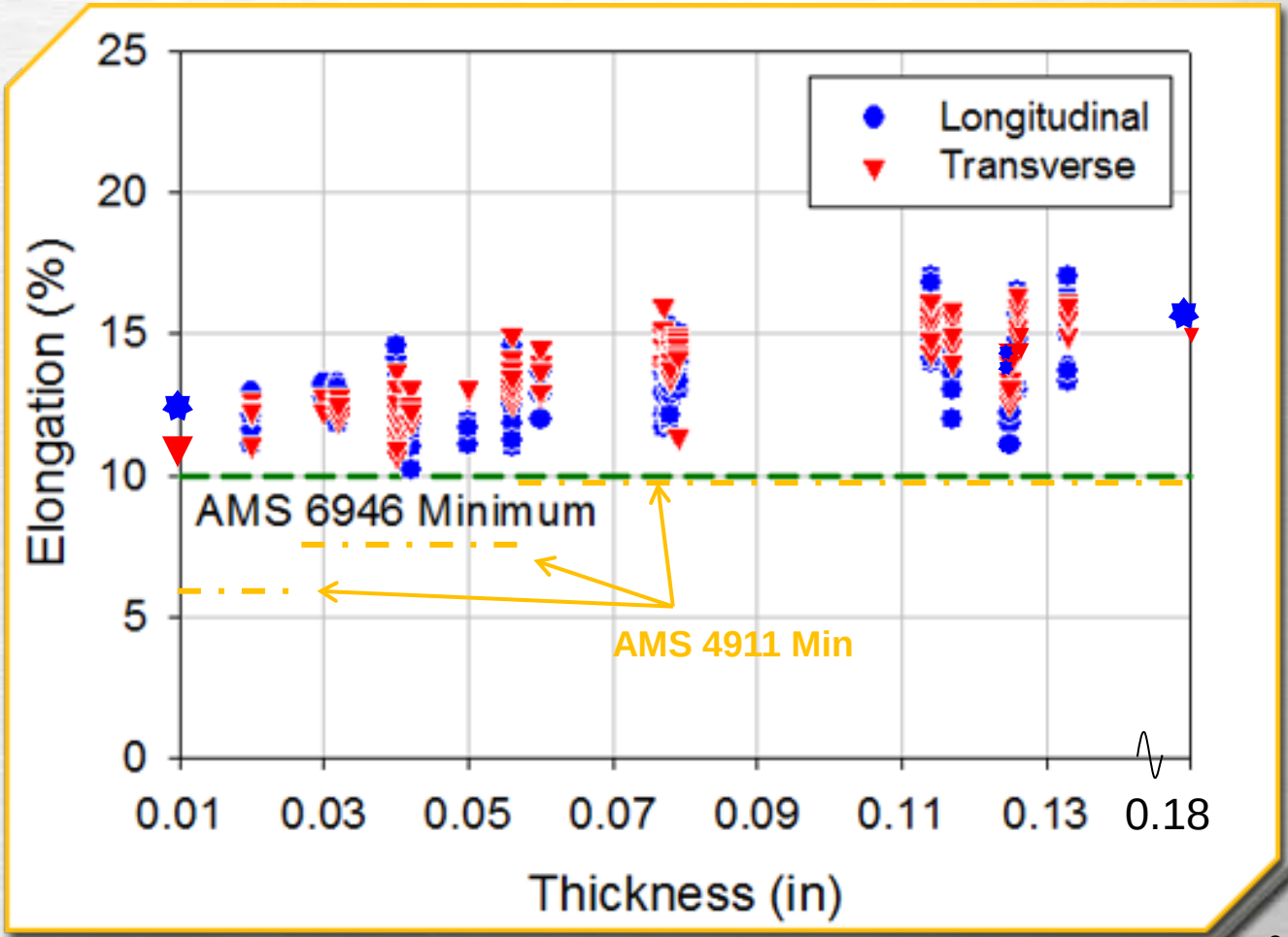


Mechanical Properties

ATI 425® Alloy Sheet

Product comparable to Ti-6Al-4V pack rolled sheet

Tensile Elongation



Data in MMPDS 2010 Handbook *(Approved April 2010)*

ATI 425® Alloy

CR&A COIL/SHEET ATTRIBUTES

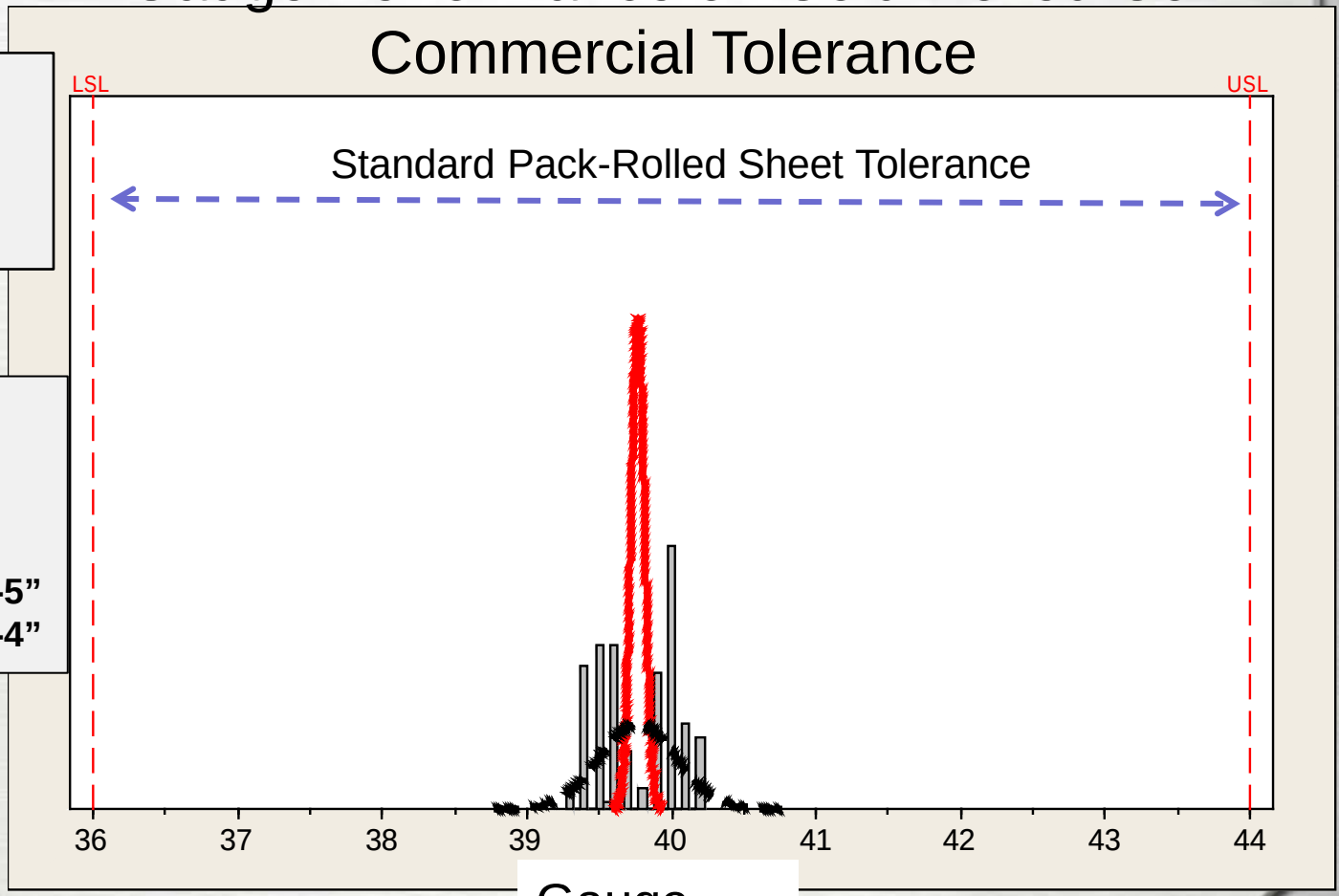
QUALITY MANUFACTURING PERFORMANCE

Quality Advantages

ATI 425® Alloy Sheet

Precision Gauge Tolerance System **leads to tight gauge control**

Gauge Performance on Cold Rolled Coil



Statistics
- # Coils: 5
- Mean: 0.0398”
- Std. Deviation
  - **Coil-to-Coil: 4.6E-5”**
  - **Overall: 2.6E-4”**

Quality Advantages

ATI 425® Alloy Sheet

Tight Gauge Tolerance Control

Target Gauge (inch)	# Coils	Data Points	Average (inch)	Standard Deviation	Standard Pack-Rolled (1/2) Tolerance
0.078	5	1827	0.0771”	0.0004”	0.074-0.082"
0.040	5	24972	0.0398”	0.0003”	0.036-0.044"
0.030	3	1944	0.0295”	0.0008”	0.026-0.034"
0.020	2	468	0.0193”	.00001”	0.016-0.024"

Quality Advantages

ATI 425® Alloy Sheet

Precision Tolerance Sheet Advantage

Example: Aerospace Part at 0.180” gauge

Material: 0.180" x 48" x 144" Ti 6-4 Sheet					
AMS 2242 Gauge Tolerance: + / - (inches)	Range	Gauge	Width	Length	Weight
0.012	Maximum	0.192	48	144	212
	Nominal	0.180	48	144	199
	Minimum	0.168	48	144	186

Material: 0.180" x 48" x 144"ATI 425®*Alloy* Sheet					
ATI 425®*Alloy* Gauge Tolerance: + / - (inches)	Range	Gauge	Width	Length	Weight
0.001	Maximum	0.181	48	144	200
	Nominal	0.180	48	144	199
	Minimum	0.179	48	144	198

Average savings of **6-12 lb/piece** (3 - 6%)

Material: 0.169" x 48" x 144"ATI 425®*Alloy* Sheet					
ATI 425®*Alloy* Gauge Tolerance: + / - (inches)	Range	Gauge	Width	Length	Weight
0.001	Maximum	0.170	48	144	188
	Nominal	0.169	48	144	187
	Minimum	0.168	48	144	186

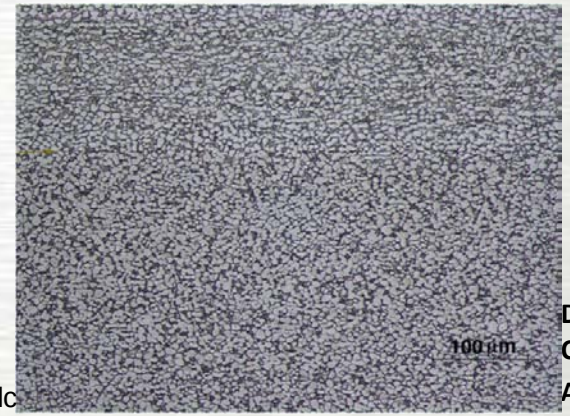
Average savings grow larger to **19-22 lb/piece** (10 - 12%)

Quality Advantages

ATI 425® Alloy Sheet

Improved Surface Finish

- Process delivers improved surface finish
  - No Grinding Required
    - Gauge Uniformity
  - Limited Pickling
  - Enhances Diffusion Bonding Process



Diffusion Bond Couple
ATI 425® Sheet

Courtesy of Aeromet Int. Plc

Quality Advantages

ATI 425® Alloy Sheet

"Endless" Sheet Lengths

- Coil instead of individual sheet
  - Monolithic parts, capability to reduce joints
  - Similar superior quality in each sheet

ATI 425® Alloy

CR&A COIL/SHEET ATTRIBUTES

QUALITY **MANUFACTURING** PERFORMANCE

Manufacturing Advantages ATI 425® Alloy Sheet

Distinctive Cold Formability

- ATI 425® Alloy offers better bending and spring-back Behavior than Ti 6-4
- Improves fabrication productivity

Bending Device:
V-block and Mandrel

GAUGE	DIRECTION	BEND	ANGLE
0.125" (3.2 mm)	Long	2.5T	105°
	Trans	3.6T	105°
0.040 (1 mm)	Long	2.2T	105°
	Trans	3.7T	105°
0.012 (0.3 mm)	Long	0.83T	135°
	Trans	0.83T	135°

Manufacturing Advantages

Welding Capability

- ATI 425® Alloy has been welded successfully by modern & traditional techniques
  - Laser
  - Friction Stir
  - Electron Beam
  - Autogenous Gas W Arc
  - W Inert Gas + Wire

Courtesy Remmele Engineering

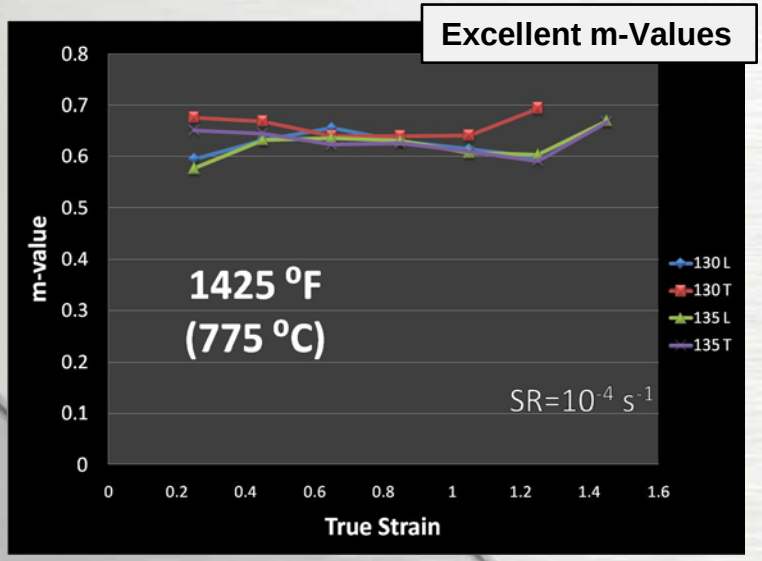
ATI Aerospace

Mission Critical Metallics®

Manufacturing Advantages ATI 425® Alloy Sheet

Exceptional Super Plastic Forming Characteristic

- **SPF Behavior at Lower T**
  - Increases Tool Life
  - Better Yield
  - Superior Operator Safety



ATI 425® Sheet 0.125" (3.2mm)

Parts SPF at 1500°F

0.080" (2mm)

ATI 425® Alloy

CR&A COIL/SHEET ATTRIBUTES

QUALITY MANUFACTURING **PERFORMANCE**

Performance Advantages ATI 425® Alloy Sheet

Weight Savings

- vs. 6-4 Ti
  - Improved tolerances
- vs. CP Ti
  - Higher strength

Cycle Time

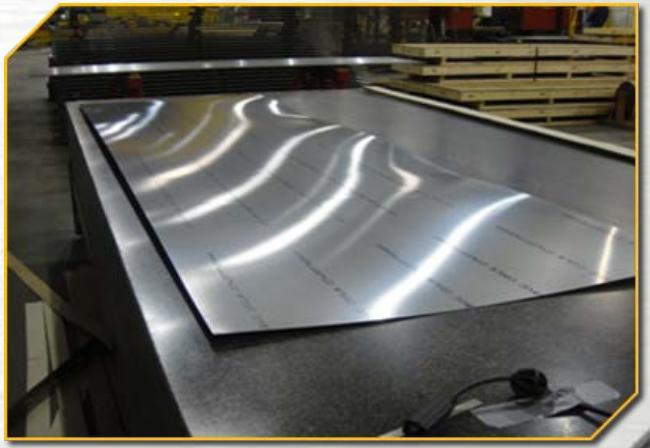
- Significantly shorter lead time as compared to pack-rolled sheet

ATI 425® Alloy

SUMMARY

ATI 425® Alloy – Product Comparison

Continuously Rolled ATI 425® Coil		Ti 6-4 Pack Rolled Sheet
• +/- .001″	**Gage Tolerance**	• +/- .008″
• Up to 2500 ft	**Sheet Length**	• 20 ft Max
• Up to 10,000 lbs	**Pack Weight**	• 500 lbs
• 16 weeks	**Cycle Time**	• Up to 52 Weeks
• Superior to Ti 6-4	**Ductility**	• Inferior to ATI 425® Alloy



Cold Rolled and Annealed ATI 425® Alloy

- It is a cold-rollable titanium alloy with higher ductility and strength comparable to Ti-6Al-4V

- ATI 425® Alloy offers:
  - Improved formability due to higher, room-temperature ductility and bending
  - Improved SPF capability- lower forming temperature, pressures
  - Improved DB capability- bonds similarly than FG Ti 6-4
  - Improved thickness tolerance over ground and pickled sheet
  - Cold-rolled surface finish with no grinding
  - Good weldability by conventional aerospace techniques

ATI 425® Alloy

THANK YOU