Technical Data Sheet

ATI Datalloy 2® Alloy

INTRODUCTION

ATI Datalloy 2® ESR alloy is a Cr-Mn-N non-magnetic Electro Slag Remelted (ESR) stainless steel. It has been specially developed to exhibit enhanced resistance to both pitting and galvanic corrosion. It is suitable for use in critical non-magnetic drill string components including MWD tools, LWD tools, Stabilisers and Compressive Service Drill Pipe.

Datalloy 2 ESR alloy has been designed to be used in place of standard Cr-Mn steels, in situations where increased corrosion resistance and 'high strength' characteristics are required. Also the chemistry of Datalloy 2™ ESR ensures that galvanic corrosion caused by coupling to dissimilar metals is resisted.

The increased nickel content of Datalloy 2 ESR alloy does not adversely affect its resistance to Stress Corrosion Cracking or its galling performance.

Datalloy 2 ESR alloy complies, as a minimum, to the mechanical property requirements of API 7-1.

The material is also available in a "High Strength" condition with a guaranteed minimum of 140 ksi 0.2% yield strength.

Chemical Composition

	C	Si	Mn	Cr	Mo	Ni	N
Typical	0.03	0.30	15.1	15.3	2.1	2.3	0.4

STRUCTURE

Datalloy 2 ESR alloy is a highly stable, austenitic stainless steel with a homogeneous, low segregation, ultra clean structure and has a maximum magnetic permeability of 1.005.

A combination of controlled hot forging and cold working generates the high yield strengths required in oilfield service. Datalloy 2 ESR alloy cannot be hardened by heat treatment.

Forging parameters are carefully designed to produce optimum pitting corrosion resistance through microstructural control.

Physical Properties

Modulus of Elasticity	200 GPa	30.0 x 10^6 psi
Poisson's Ratio	0.4	0.4
Coefficient of Thermal Expansion	16 x 10^{-6} m/m/K°	8.89 x 10^{-6} in/in/F°
Resistivity	680 µΩmm	26.8 µΩin
Thermal Conductivity	0.035 W/mK°	6.74 X 10^{-5} BTU (IT) in/sec/ft²/F°
Density	7.87 g/cm³	0.283 lbs/in³
Relative Magnetic Permeability	1.005 max	1.005 max

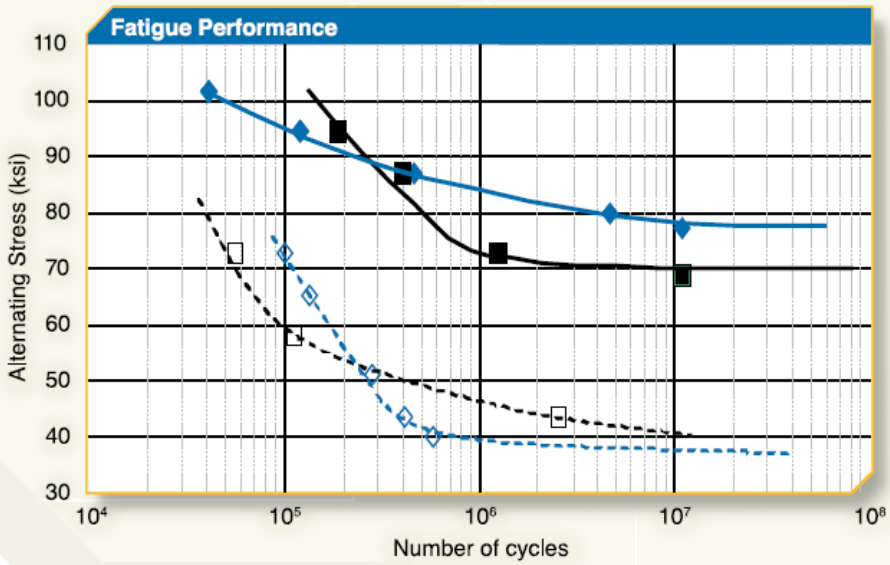
Allegheny Technologies Incorporated
1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
www.ATImetals.com

Mechanical Properties - Standard Strength							
Size		0.2% Yield (ksi)	UTS (ksi)	Elongation (%)	R of A (%)	Long. CVN @RT (J)	Hardness (HB)
>7" Dia	Min	110	120	18	50	160	300
	Typical	148	166	24	68	198	352
<7" Dia	Min	100	110	20	50	150	300
	Typical	138	157	28	71	224	347
>9.5" Dia	Min	100	110	20	50	150	300
	Typical	139	157	26	70	214	353

Mechanical Properties - High Strength							
Size		0.2% Yield (ksi)	UTS (ksi)	Elongation (%)	R of A (%)	Long. CVN @RT (J)	Hardness (HB)
>7" Dia	Min	140	155	20	50	140	250
	Typical	148	166	25	69	208	358
<7" Dia	Min	140	155	20	50	140	250
	Typical	145	164	26	70	217	358
>9.5" Dia	Min	135	150	20	50	140	250
	Typical	145	163	26	70	221	357

FATIGUE

Fatigue testing was performed using a Wöhler rotating bend test configuration, tested at 4000 cycles per minute. The strengths of the materials used are as below.



- ♦ Datalloy 2™ ESR
- ■ AG17™
- ◇ Notched Datalloy 2® ESR
- □ Notched AG17™

Material	0.2% Yield Strength
Datalloy 2TM ESR	105 ksi
Staballoy AG17™	116 ksi

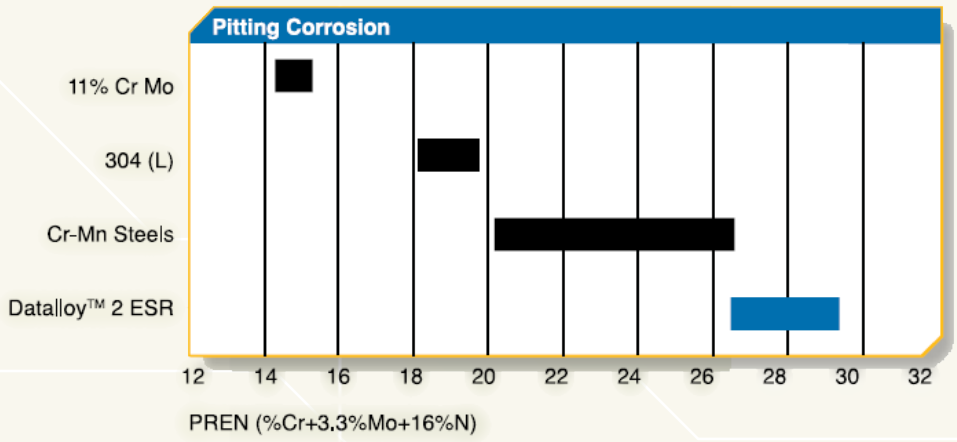
Allegheny Technologies Incorporated
1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
www.ATImetals.com

In rotating bend Wöhler type fatigue tests, higher strength Datalloy 2 ESR alloy with 0.2% yield strengths in excess of 140 ksi, has been shown to have a fatigue endurance limit in excess of approximately 70 ksi.

PITTING CORROSION

Pitting is caused by adverse localized conditions. Corrosion rate is dependent on the differential between oxidants in the pit and the supply of oxidants to the area around the pit. Thus highly oxidized muds, or stagnant muds which form deposits that deprive localized area of oxidant, generate more aggressive environments.

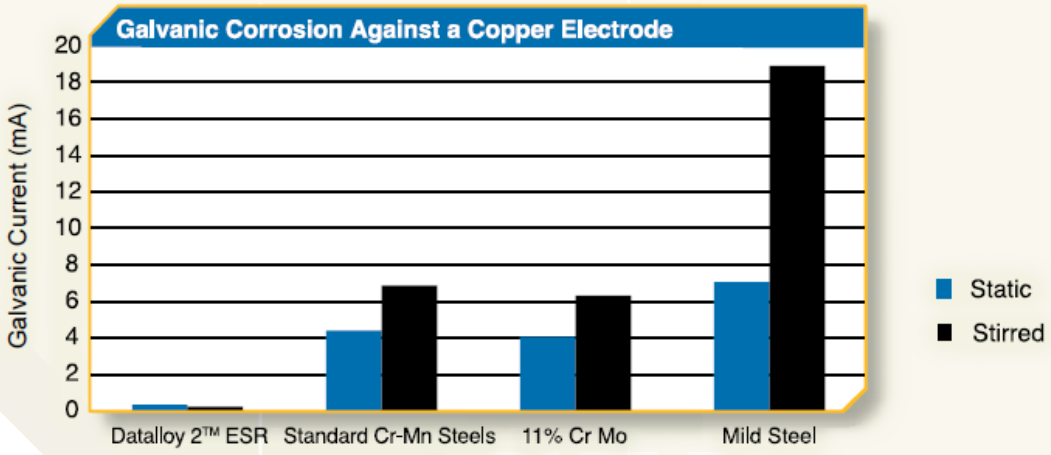
One widely adopted indicator of pitting resistance is the PREN or pitting resistance equivalent number. This number is a calculation based on chemical analysis, this figure together with material cleanliness is commonly accepted as providing a good indication of pitting resistance. Higher values indicate increased resistance to pitting corrosion.



GALVANIC CORROSION

When two dissimilar materials come into contact it is possible that a galvanic cell will be set up, promoting corrosion in the least noble element of the couple. The resulting corrosion will usually be localized to the contact area and may be potentially catastrophic.

Datalloy 2 ESR alloy has been specifically designed to counteract this problem and, as the following graph shows, will resist attack even when coupled to pure copper.



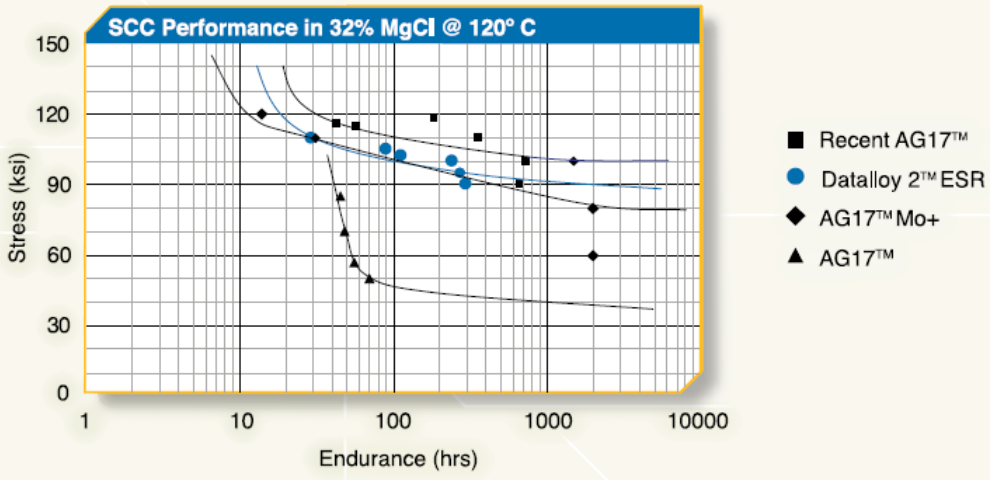
Allegheny Technologies Incorporated
1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
www.ATImetals.com

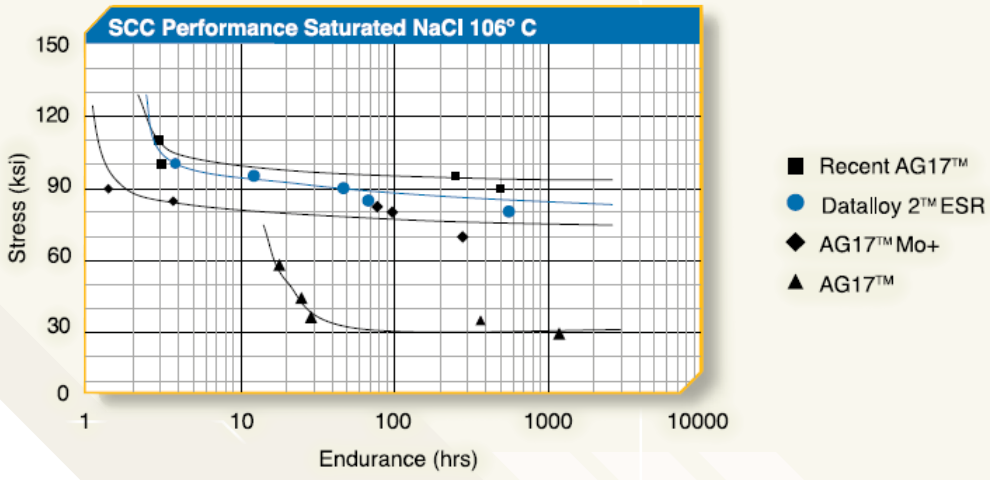
STRESS CORROSION CRACKING

Stress corrosion cracking (SCC) is caused by the combined action of stress and a corrosive medium. The stress can be externally applied or can arise from residual stresses introduced during manufacturing. It is also possible for loading and residual stresses to combine, giving a larger actual stress than is applied externally. There are two types of SCC: intergranular and transgranular.

Intergranular SCC
Intergranular SCC is caused by microstructural sensitization of the steel. It has been largely eliminated in modern NMDC manufacture by strict analytical control during steelmaking. Material from all ATI products is tested to ASTM A262 practice E to ensure freedom from sensitization.

Transgranular SCC
Transgranular SCC can occur in the presence of chloride ions when the steel surface is subjected to a tensile stress. Good engineering practice can help to reduce the occurrence of this type of SCC, as can surface treatments which introduce compressive stresses. Transgranular SCC can occur in the presence of chloride ions when the steel surface is subjected to a tensile stress. Good engineering practice can help to reduce the occurrence of this type of SCC, as can surface treatments which introduce compressive stresses. Hammer or shot peening are optional treatments on Datalloy 2™ ESR products. Hammer peening can introduce compressive stresses into the surface of our collars to a depth greater than 0.100”. The peening treatment also has the benefit of improving fatigue resistance.

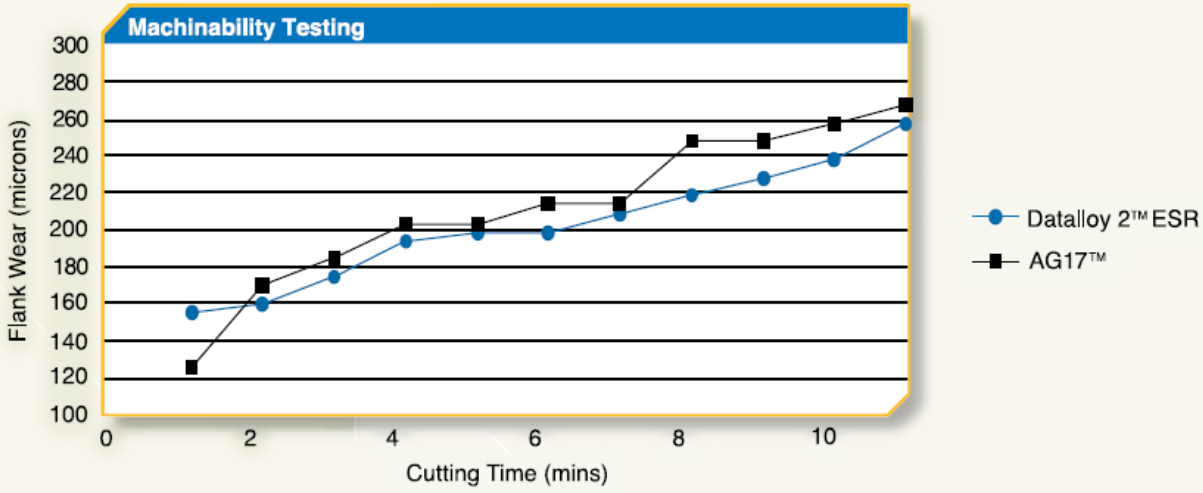




Allegheny Technologies Incorporated
1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
www.ATImetals.com

MACHINABILITY

Datalloy 2 ESR alloy exhibits comparable machineability to ATI products grade ATI Staballoy AG17™ alloy. The following graph shows the relative tip flank wear between the two materials. Tests were performed under specific accelerated wear conditions that are not recommended for normal use.



Austenitic steels are very ductile when compared to carbon and low alloy steels, so chip formation is far more difficult. Austenitic grades also work harden much more readily. These properties mean that cutting should be very positive and tools should not be allowed to dwell on the surface.

The cutting data below has been developed in collaboration with ATI.

The figures below are recommended for a tip life range from extended life to a maximum expected tip life of 30-minutes.

Turning Operations	Tool Grade	Cutting Geometry	Depth of Cut (inches)	Cutting Speed Range (Feet/Minute)	Feed Rate Range (Inches/Rev)
Roughing*	SP0819	SNMG-150616E-4E	0.16	200 - 260	0.018 - 0.022
Semi-Finishing**	SP0819	CNMG-120408E-4E	0.06	250 - 265	0.008 - 0.012

* 75 degree approach angle on tip
** A surface finish of 60-80 CLA is achievable within these recommended ranges.

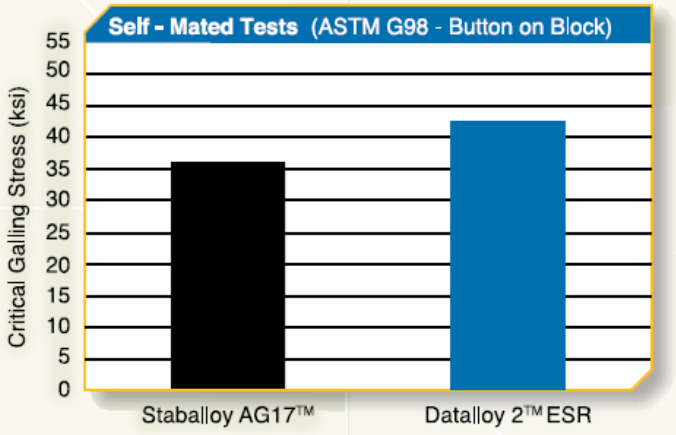
Allegheny Technologies Incorporated
1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
www.ATImetals.com

Milling Operations	Tool Grade	Cutting Geometry	Depth of Cut (inches)	Cutting Speed Range (Feet/Minute)	Feed Rate Range (Inches/Rev)
Roughing***	X500	ODMT-0605APEN-41	0.08 - 0.16	130 - 165	0.005 - 0.007
Semi-Finishing***	X500	ODMT-0605APEN-41	0.04 - 0.08	165 - 200	0.005 - 0.010
Finishing***	X500	ODET-0605APEN-44	0.008 - 0.04	180 - 215	0.003 - 0.005

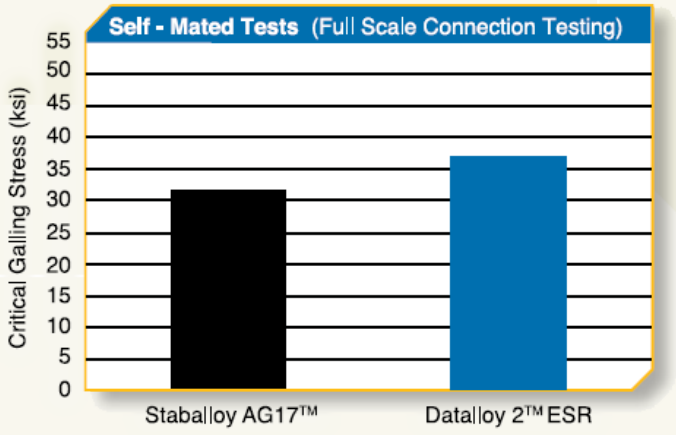
*** 45 degree approach angle on tip

GALLING RESISTANCE

Galling in the oil industry is defined as the seizure of, and damage to, threaded connections on tightening or untightening. Tests performed by ATI have shown that the intrinsic galling resistance of Datalloy 2™ ESR alloy is superior to that of other Cr-Mn steels.



Standard A.S.T.M. G98 test conditions.
Contact area = 123mm^2, no lubricant.
4 ½" IF connections.
Torque applied without lubrication.



On full-scale make and break tests using a typical proprietary lubricant, galling was prevented at stresses over 50% greater than the recommended make up stress.

QUALITY ASSURANCE

All collars meet API 7-1 specified mechanical properties and conditions as a minimum standard.

Each collar is mechanically tested, ultrasonically examined along its entire length, and tested for magnetic 'hotspots' using a Foerster EC Probe, with maximum deflection guaranteed less than ±0.05μT. Certification includes all relevant physical, chemical, mechanical, magnetic and ultrasonic results.

PRODUCT FORMS

Lengths of up to 31 feet and diameters from 4 to 12½ inches are supplied as standard, although longer lengths and other diameters may be ordered by arrangement. Material can be supplied solid, bored, semi-finished or fully machined to drawing. Datalloy 2™ ESR alloy is supplied in the strain hardened condition. Arrangements can be made to supply an annealed product, but at reduced strength levels.

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