MOLY FERRITIC STAINLESS STEELS

Unity	AISI	UNS	EN
U-434	434	S43400	1.4113
U-436	436	S43600	1.4526
U-444	444	S44400	1.4521

Technical Brochure

www.columbusstainless.co.za

COLUMBUS STAINLESS [Pty] Ltd

Introduction

Moly ferritic stainless steels are chromium stainless steels alloyed with Molybdenum, and can be stabilised with niobium and/or titanium.

Annealed moly ferritics are ductile and can be formed using a large variety of roll forming or mild stretch bending operations as well as the more common drawing and bending operations. They do not harden excessively during cold working.

Being ferritic, they are not susceptible to stress corrosion cracking.

The steels have limited weldability and should not be used in the as-welded condition for dynamic or impact loaded structures. Moly ferritics can undergo grain growth in the heat affected zone of weldments, which may adversely affect the mechanical properties in these zones.

Applications involving welded moly ferritics are thus generally limited to a maximum thickness of 2.5mm. Edge welds are not recommended for applications using moly ferritics.

They are unsuited for use in cryogenic applications as brittle fracture could occur at sub-zero temperatures.

U-434 is a low carbon, molybdenum containing ferritic stainless steel. With 16% chromium and 1% molybdenum, the steel has better corrosion resistance than U-430. U-434 has excellent polishing characteristics and is therefore used in applications such as automotive trim.

U-434 also has good formability and corrosion resistance and this makes it suitable for applications such as dishwashers, kitchen-ware and restaurant equipment, architectural applications (except in coastal environments), nitric acid plant equipment, etc.

U-436 is a low carbon, niobium stabilised, molybdenum containing ferritic stainless steel. With 16% chromium and 1% molybdenum, the steel has better corrosion resistance than U-1.4509.

Niobium stabilisation improves the steel's resistance to sensitisation in the weld heat affected zone and improves the steel's creep resistance at high temperatures. U-436 has similar formability to U-1.4509 and is used in applications such as automotive exhaust systems and trim, cladding, domestic appliances, etc.

U-444 is a low carbon, dual stabilised, molybdenum containing ferritic stainless steel. With 18% chromium and 2% molybdenum, the steel has good pitting resistance and crevice corrosion resistance, similar to U-316L.

U-444 is thus suitable for roofing and cladding in marine environments, as well as hot water tanks and geysers, heat exchanger tubing and food processing equipment.

Product range

The latest revision of the Product Catalogue should be consulted, as the product range is subject to change without notice.

The Product Catalogue is available from the Technical Department or can be found at www.columbusstainless.co.za

Specifications and tolerances

Columbus Stainless (Pty) Ltd supplies the moly ferritics to ASTM A240 and EN 10088-2.

Columbus Stainless (Pty) Ltd normally supplies material to the following tolerances:

HOT ROLLED
ASTM A480M
ISO 9444 - material processed as coil
ISO 18286 - material processed as plate

COLD ROLLED
ASTM A480M
ISO 9445

Other specifications and tolerances may be available on request. Further information is available in the Product Catalogue, which can be obtained from the Technical Department or can be found at www.columbusstainless.co.za

Further information

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Disclaimer

Chemical composition

In accordance with ASTM A240 and EN 10088-2.

Unity	C	Si	Mn	P	S	N	Cr	Mo	Nb	Ni	Others
U-434	0.08	1.0	1.0	0.040	0.015		16.0 18.0	0.90 1.25			
U-436	0.08	1.0	1.0	0.040	0.015	0.04	16.0 18.0	0.80 1.25	7x(C+N)+0.1 0.8		
U-444	0.025	1.0	1.0	0.040	0.015	0.03	17.5 19.5	1.80 2.50		1.0	Ti: 4x(C+N)+0.2 0.8

- *Compositions are ranges or maximum values.*
- *Stabilisation may be by use of titanium or niobium or zirconium. For ASTM A240, Ti+Nb>4x(C+N)+0.2. For EN 10088-2, according to the atomic mass of these elements and the content of carbon and nitrogen, the equivalence shall be the following: Nb (% by mass) = Zr (% by mass) = 7/4 Ti (% by mass) (i.e. when replacing Ti with Nb, nearly double (1.75) the Nb is needed).*

Mechanical properties

In accordance with ASTM A240 and EN 10088-2.

Unity	Rm (MPa)	$Rp_{0.2}$ (MPa)	El (%)	Max BHN
U-434	450 to 630	280	22	
U-436	480 to 560	300	25	
U-444	420 to 640	320	20	217

- *Minimum values, unless max or range is indicated.*
- *The table assumes certification to both ASTM A240 and EN 10088-2.*

Properties at elevated temperatures

The properties quoted below are typical of annealed moly ferritics. These values are given as a guideline only, and should not be used for design purposes.

Short time elevated temperature tensile strength (MPa)

Unity	100°C	200°C	300°C	400°C	500°C	600°C	700°C
U-434	500	485	470	450	400	290	130
U-436	460	400	350	310	260	200	120
U-444	500	460	440	420	380	300	160

Short time elevated temperature 0.2% proof stress (MPa)

Unity	100°C	200°C	300°C	400°C	500°C	600°C	700°C
U-434	300	290	280	260	220	160	60
U-436	280	250	230	200	170	130	80
U-444	370	330	310	295	270	220	130

Short time elevated temperature elongation (%)

Unity	100°C	200°C	300°C	400°C	500°C	600°C	700°C
U-434	28	27	24	17	12	14	27
U-436	28	27	23	20	19	23	35
U-444	30	28	26	23	21	20	22

Maximum recommended service temperature

Unity	Continuous (°C)	Intermittent (°C)
U-434	730	870
U-436	730	870
U-444	850	950

- *In oxidising conditions*

Physical properties

The values given below are for 20°C, unless otherwise stated.

		U-434	U-436	U-444
Density (kg/m^3)		7 740	7 700	7 750
Modulus of Elasticity in Tension (GPa)		210		220
Modulus of Elasticity in Torsion (GPa)		65		65
Specific Heat Capacity (J/kg K)		460	440	430
Thermal conductivity at	100°C (W/m K)	26.1	26.3	26.8
	500°C (W/m K)	26.3	27.0	27.1
Electrical Resistivity (x10^{-9} Ω m)		650	580	570
Mean Coefficient of Thermal Expansion from	0 to 100°C (x10^{-6} K^{-1})	10.4	10.9	10.8
	0 to 300°C (x10^{-6} K^{-1})	11.0	11.9	11.6
	0 to 500°C (x10^{-6} K^{-1})	11.3	12.4	11.9
	0 to 700°C (x10^{-6} K^{-1})	12.1	13.4	12.5
Melting Range (°C)		1 480 1530	1 530 1 405	1480 1 495
Magnetic		Yes	Yes	Yes

Thermal processing and fabrication

ANNEALING

Annealing is achieved by heating to the following temperatures for 90 minutes per 25mm thickness (3.5min/mm) followed by air quenching. Controlled atmospheres are recommended in order to avoid excessive oxidation of the surface.

	U-434	U-436	U-444
Annealing Temperature (°C)	820 to 920	750 to 850	870 to 970

STRESS RELIEVING

Stress relieving after welding is not normally required. Should this be necessary, temperatures between 200°C and 300°C are recommended for 60 minutes per 25mm thickness (2.5min/mm).

HOT WORKING

Uniform heating of the steel in the range of 950°C to 1 050°C is required. The finishing temperature should be below 750°C and the steel should be cooled rapidly between 550°C and 400°C to prevent 475 embrittlement. Extended holding times above 1 000°C should be avoided as excessive grain growth may occur and ductility may be detrimentally affected.

All hot working operations should be followed by annealing and then pickling and passivating to restore the mechanical properties and corrosion resistance.

COLD WORKING

Moly ferritic stainless steels have good formability characteristics with useful mechanical properties. Their good ductility allows them to be readily formed by bending and deep drawing. They do not undergo significant work hardening when cold formed. U-434 is slightly more prone to roping than the other moly ferritics.

WELDING

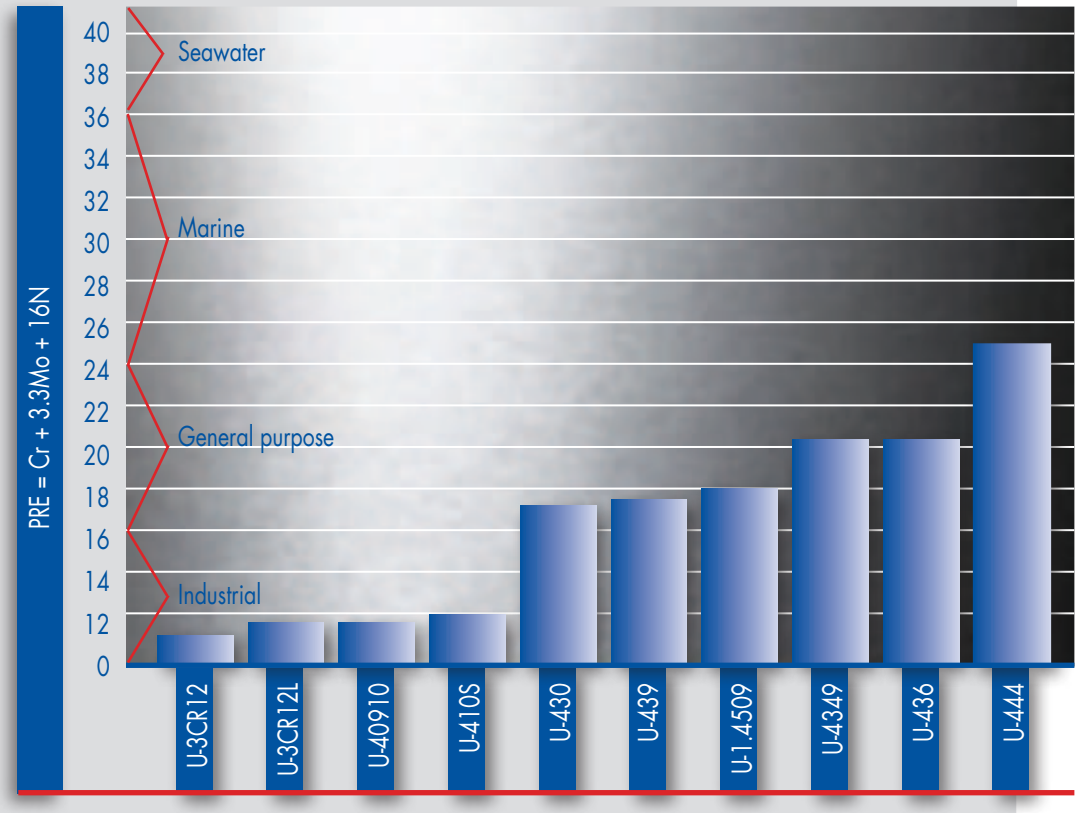
The moly ferritic stainless steels are prone to grain growth in the heat affected zone of weldments. As such, the tensile, fatigue and toughness properties in the welded condition are relatively poor. They should thus not be used for applications where tensile or dynamic loading will be experienced.

The moly ferritics are generally limited to a combined thickness in the welded condition of 2mm for U-434, 2.5mm for U-436 and 3mm for U-444. Edge welds are not recommended.

The use of austenitic filler metals such as types 308L, 309L or 316L will improve the ductility of welds to some extent but all welding procedures should nevertheless endeavour to maintain minimum heat inputs.

The weld discolouration should be removed by pickling and passivating to restore maximum corrosion resistance.

Corrosion resistance



The above diagram summarises the corrosion resistance of the ferritic stainless steels produced at Columbus. For the moly ferritic stainless steels, the corrosion resistance is a function of the chromium and molybdenum contents. In common with the other ferritic stainless steels, the moly ferritics are not susceptible to Stress Corrosion Cracking (SCC).

U-434 and U-436 have similar general corrosion resistance to U-430. Their pitting resistance is, however superior to U-430 but not as good as U-304. U-434 and U-436 thus have good resistance to rural and industrial atmospheres but in marine atmosphere environments, staining may occur, unless they are regularly washed.

U-444 has good resistance to a wide variety of corrosive environments. With 18% chromium and 2% molybdenum the steel has good uniform and pitting corrosion resistance, similar to U-316L in most environments. U-444 is thus suitable for use in marine atmospheres.