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ALLOY INSIGHTS



DUPLEX STAINLESS STEELS

How do they compare?

Duplex stainless steels offer an extremely valuable combination of properties – primarily high strength and corrosion resistance. This, combined with good fabrication properties and pricing that is not as sensitive to nickel as are the austenitic grades, has resulted in the increased utilsation of these metals. We compare some of the more common duplex grades. The data presented is from ASTM Standards or the data sheets of reputable mills.

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Gauteng: T: + 27 (0)11 466 2480 or **E:** sales@multialloys.co.za
Western Cape: T: + 27 (0)21 982 1060 | **E:** sales-cape@multialloys.co.za

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Compositions

For duplex stainless steels to attain their favourable properties the target is to have a microstructure with approximately equal amounts of austenite and ferrite. This requires a balanced composition which in turn means good control of those elements that promote the formation of each phase viz austenite and ferrite.

Table 1

Type	Grade	% Cr	%Ni	%Mo	%C	%Cu	%Mn	%N	Other
Early Duplex	**3RE60** UNS S31500 / W Nr 1.4417	18.0-19.0	4.3-5.2	2.5-3.0	0.03*		1.2-2.0	0.05-0.10	Si: 1.4-2.0
Lean Duplex	**LDX2101** UNS S32101 / W Nr 1.4162	21.0-22.0	1.35-1.70	0.1-0.8	0.04*	0.1-0.8	4.0-6.0	0.20-0.25	
	Alloy 2304 UNS S32304 / W Nr 1.4362	21.5-24.5	3.0- 5.5	0.05-0.60	0.03*	0.05-0.60	2.5*	0.05-0.20	
Standard Duplex	**Alloy 2205** UNS S31803 / W Nr 1.4462	21.0-23.0	4.5-6.5	2.5-3.5	0.03*		2.0*	0.08-0.20	
	Alloy 2205 UNS S32205 / W Nr 1.4462	22.0-23.0	4.5-6.5	3.0-3.5	0.03*		2.0*	0.14-0.20	
Super Duplex	**Alloy 2507** UNS S32750 / W Nr 1.4410	24.0-26.0	6.0-8.0	3.0-5.0	0.03*	0.5*	1.2*	0.24-0.32	
	S32760 UNS S32760 / W Nr 1.4501	24.0-26.0	6.0-8.0	3.0-4.0	0.03*	0.5-1.0	1.0*	0.20-0.30	W: 0.5-1.0
	Alloy 255 UNS S32550 / W Nr 1.4507	24.0-27.0	4.5-6.5	2.9-3.9	0.04*	1.5-2.5	1.5*	0.10-0.25	

Physical properties

The physical properties of the duplex grades are very similar to each other as shown below. The thermal conductivity is higher than that of the austenitic grades and the coefficient of thermal expansion is lower. These physical properties combined with the strength and corrosion resistance of the duplex grades is advantageous for heat exchanger applications.

Table 2

	Density (kg/dm^3)	**Youngs Modulus** (GPa) [at 20°C]	**Coefficient of Thermal Expansion** ($10^{-6}/K$) [20-100°C]	**Thermal Conductivity** (W/[mxK])
Alloys 2101, 2304	7.7	205	13.0	15
3RE60, Alloys 2304, 2205, 2507, 32760	7.8	200	13.0	15
Alloy 255	7.8	199	11.1	14.2

Mechanical properties

The high strengths of duplex stainless steel grades are an important feature of this family of alloys. This has expanded the use of stainless steels in to structural applications for which other stainless steels would not be suitable or cost effective. In other instances, it enables design in stainless steel with thinner section thus enabling weight saving.

Table 3

Grade	Mechanical Properties*			
	UTS (MPa)	**0.2% Proof** (MPa)	**Elong** (%)	**Hardness**
3RE60	630	440	30	30HRC
LDX2101	650	450	30	-
Alloy 2304	600	400	25	32HRC
Alloy 2205 (S31803)	620	450	25	31HRC
Alloy 2205 (S32205)	655	450	25	31HRC
Alloy 2507	795	550	15	32HRC
S32760	750	550	25	-
Alloy 255	760	550	15	32HRC

*: From ASTM A240; ASTM A789 for 3RE60

Corrosion resistance

The corrosion resistance attributes of the duplex grades are primarily their pitting and crevice corrosion resistance and stress corrosion cracking resistance. The general corrosion resistance of a specific grade will reflect its actual alloy content eg the presence of small amounts of copper are advantageous in resisting corrosion in sulphuric acid.

Table 4

	SCC Test 1 (ASTM G123)	**SCC Test 2** (ASTM G36)	**PRE****	**Temperature (°C)*** **			
				Sulphuric Acid Concentration (%)			
				10	20	40	60
3RE60	*	*	27	60	40		
LDX2101	No SCC	SCC	26	55			
Alloy 2304	No SCC	SCC	26	70	20		
Alloy 2205	No SCC	SCC	35	81	60		
Alloy 2507	No SCC	SCC	43	90	78	30	
S32760	No SCC	SCC	42	100	78	48	40
Alloy 255	*	*	40	92	82	75	58

* No Comparative data

** PRE = %Cr+3.3(%Mo+0.5(%W))+16%N

*** Temperature at which 0.1mm/yr corrosion rate is reached in commercial sulphuric acid at the concentrations given (read from iso corrosion curves)

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Applications	
3RE60	Popular for use in heat exchangers as an upgrade to carbon or low alloy steel.
LDX2101	A low alloyed general purpose duplex grade displaying high strength and used widely in structural applicatioxans as a substitute for coated carbon steel.
Alloy 2304	A lean alloy grade used selectively in structural applications. It has good resistance to localised and uniform corrosion as well as stress corrosion cracking.
Alloy 2205	The most popular duplex grade. It combines high strength with good resistance to uniform and localised corrosion and stress corrosion cracking. It is used for a wide range of equipment in a variety of industries.
Alloy 2507	As a duplex stainless steel this grade has similar properties to Alloy 2205. The strength is however greater as is its resistance to localised and uniform corrosion and stress corrosion cracking.
S32760	A super duplex grade with higher strength and corrosion resistance than Alloy 2205. Often used in desalination plants, scrubbers, and a variety marine / offshore equipment.
Alloy 255	A copper containing super duplex grade with useful resistance to sulphuric and phosphoric acid over a range of conditions.

Application by industry
Water treatment and desalination
Pollution control
Pulp and paper
Marine and offshore
Chemical and petro-chemical
Mineral processing and recovery
Construction and civil engineering

Application by equipment
Tanks and pressure vessels
Heat exchangers and water heaters
Piping systems
Fasteners
Impellers, shafts and mixers
Bridges, bus shelters and similar public use structures

FOR A MORE COMPREHENSIVE REVIEW OF DUPLEX STAINLESS STEELS

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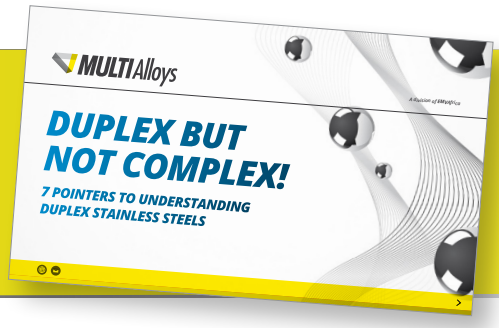

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