An Introduction to Super-Duplex Stainless Steels

Super-Duplex Stainless Steels and their characteristics

The first-generation Duplex stainless steels were developed more than 70 years ago in Sweden for use in the sulfite paper industry. Duplex alloys were originally created to combat corrosion problems caused by chloride-bearing cooling waters and other aggressive chemical process fluids.

Called Duplex because of its mixed microstructure with about equal proportions of ferrite and austenite, Duplex stainless steels are a family of grades, which range in corrosion performance depending on their alloy content. The term “Super-Duplex” was first used in the 1980’s to denote highly alloyed, high-performance Duplex steel with a pitting resistance equivalent of >40 (based on Cr% + 3.3Mo% + 16N%).

With its high level of chromium, Super-Duplex steel provides outstanding resistance to acids, acid chlorides, caustic solutions and other environments in the chemical/petrochemical, pulp and paper industries, often replacing 300 series stainless steel, high nickel super-austenitic steels and nickel-based alloys. The chemical composition based on high contents of chromium, nickel and molybdenum improves intergranular and pitting corrosion resistance. Additions of nitrogen promote structural hardening by interstitial solid solution mechanism, which raises the yield strength and ultimate strength values without impairing toughness. Moreover, the two-phase microstructure guarantees higher resistance to pitting and stress corrosion cracking in comparison with conventional stainless steels.

From the introduction of its first-generation, Duplex steel has seen a steady increase in popularity. Recently, the production of high-strength, corrosion resistant super-duplex coil has been implemented in the marine and chemical industries, architecture and mast riggings, wire lines, lifting and pulley equipment and well service strands. In fact, development of wire processing techniques has enabled the production of steel wires down to 1mm in diameter.

The various Alloys

Super-Duplex falls under the Duplex stainless steel grouping.

Duplex stainless steels are graded for their corrosion performance depending on their alloy content. Today, modern Duplex stainless steel can be divided into four groups:

- Lean Duplex such as 2304, which contains no deliberate Mo addition;
- 2205, the work-horse grade accounting for more than 80% of duplex usage;
- 25 Cr duplex such as Alloy 255 and DP-3;
- Super-Duplex; with 25-26 Cr and increased Mo and N compared with 25 Cr grades, including grades such as 2507, Zeron 100, UR 52N+, and DP-3W

Composition of Duplex Stainless Steels[a]

The table lists the duplex stainless steels covered in ASTM specifications for plate, sheet, and bar products.

UNS Number Duplex Grades	Type[b]	C	Mn	P	S	Si	Cr	Ni	Mo	N	Cu	Other
S31200	...	0.030	2.00	0.045	0.030	1.00	24.0-26.0	5.5-6.5	1.20-2.00	0.14-0.20	...	...
S31260	...	0.03	1.00	0.030	0.030	0.75	24.0-26.0	5.5-7.5	2.5-3.5	0.10-0.20	0.20-0.80	W0.10-0.20
S31803	...	0.030	2.00	0.030	0.020	1.00	21.0-23.0	4.5-6.5	2.5-3.5	0.08-0.20	...	
S32001	...	0.030	4.0-6.0	0.040	0.030	1.00	22.0-23.0	1.00-3.00	0.60	0.05-0.17	1.00	
S32205	2205	0.030	2.00	0.030	0.020	1.00	19.5-21.5	4.5-6.5	3.0-3.5	0.14-0.20	...	
S32304	2304	0.030	2.50	0.040	0.030	1.00	21.5-24.5	3.0-5.5	0.05-0.60	0.05-0.20	0.05-0.60	
S32520	...	0.030	1.50	0.035	0.020	0.80	24.0-26.0	5.5-8.0	3.0-4.0	0.20-0.35	0.50-2.00	
S32550	255	0.04	1.50	0.040	0.030	1.00	24.0-27.0	4.5-6.5	2.9-3.9	0.10-0.25	1.5-2.5	
S32750	2507	0.030	1.20	0.035	0.020	0.80	24.0-26.0	6.0-8.0	3.0-5.0	0.24-0.32	0.50	
S32760	...	0.030	1.00	0.030	0.010	1.00	24.0-26.0	6.0-8.0	3.0-4.0	0.20-0.30	0.50-1.00	c
S32900	329 d	0.06	1.00	0.040	0.030	0.75	23.0-28.0	2.5-5.0	1.0-2.0	...	...	
S32950	...	0.03	2.00	0.035								

a) Weight percent, maximum unless otherwise noted.
b) Unless otherwise indicated, a common name, not a trademark, widely used, not associated with any one producer, as listed in ASTM A 240.
c) W 0.50-1.00; Cr+3.3Mo+16N=40 min.
d) AISI designation

Benefits

- High strength,
- High resistance to pitting, crevice corrosion resistance.
- High resistance to stress corrosion cracking, corrosion fatigue and erosion,
- Excellent resistance to chloride stress-corrosion cracking
- High thermal conductivity
- Low coefficient of thermal expansion
- Good sulfide stress corrosion resistance,
- Low thermal expansion and higher heat conductivity than austenitic steels,
- Good workability and weldability,
- High energy absorption.

Applications

- Heat exchangers, tubes and pipes for production and handling of gas and oil,
- Heat exchangers and pipes in desalination plants,
- Mechanical and structural components,
- Power industry FGD systems,
- Pipes in process industries handling solutions containing chlorides,
- Utility and industrial systems, rotors, fans, shafts and press rolls where the high corrosion fatigue strength can be utilized,
- Cargo tanks, vessels, piping and welding consumables for chemical tankers.
- High-strength, highly resistant wiring.

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