Duplex, Super Duplex, and Super Austenitic Stainless Steels for Fisher® Valves

High Alloy Stainless Steels

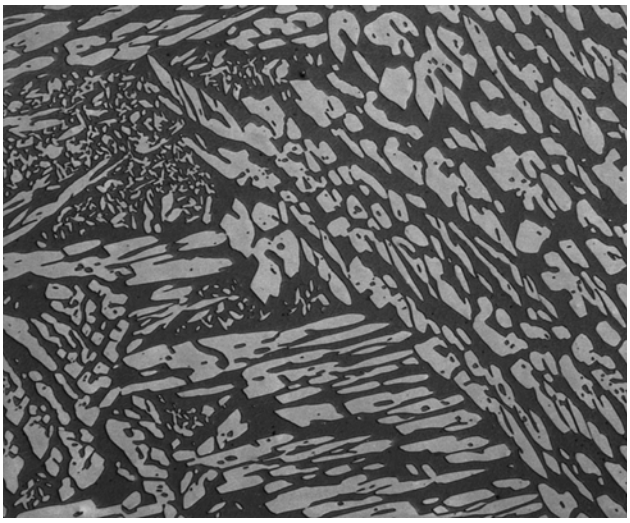
For many years, the 300 series stainless steels (SST) have been the workhorse alloys for corrosive applications. For severe applications, the nickel-base alloys were the next step up in corrosion resistance. The cost differential, however, was great (four to ten times, or more). In recent years, duplex and superaustenitic SSTs have started to fill this void as cost-effective alternatives.

High alloy SSTs are similar to the 300 series SSTs whereas they are iron base with significant additions of chromium, nickel, and molybdenum. To produce a duplex SST, the alloy chemistry is adjusted by increasing the chromium and molybdenum and reducing the amount of nickel, see the following figure. These changes result in both ferrite and austenite phases present in approximately equal amounts. By contrast, the 300 series SSTs are generally fully austenitic. Superaustenitic SST's have the same structure as the common 300 series alloys, but have higher levels of elements such as chromium, nickel, molybdenum, copper and nitrogen.

High alloy SST's are often used where chlorides or sour gas are encountered. Industries include pulp and paper, chemical, oil and gas, power, desalination, and marine.

Advantages of high alloy stainless steels are:

- Superior stress corrosion cracking resistance and corrosion resistance in chloride environments compared to the standard austenitic materials such as S31600.
- Yield strengths significantly higher or even double that of annealed 300 series SST.
- Duplex SST's have inherently better resistance to stress corrosion cracking than 300 series single-phase alloys, because at least one of the phases is often resistant to cracking in a given environment.



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Photomicrograph of a Typical Cast Duplex Stainless Steel

High alloy SST's are commonly ranked by an empirical formula to calculate their pitting resistance equivalency number [PREN = %Cr + 3.3%Mo 0.5%W + 30%N]. Higher PREN's correlate to improved resistance to pitting corrosion. See table 1. The standard duplex SST grades have a PREN of 30-40. Superduplex SST grades have a PREN of greater than 40.

Another measure of corrosion resistance is the critical pitting temperature (CPT). Tests are conducted to the requirements of ASTM G48 practice A; 6% ferric chloride. A series of tests are run at increasing temperatures. The CPT is the minimum temperature at which pitting corrosion occurs. See table 1.

A third measure of corrosion resistance is the threshold temperature for chloride stress corrosion cracking (SCC) in 4% sodium chloride. Again a series of tests are run at increasing temperatures until SCC occurs. See table 1.

Because the nickel content of a duplex SST is lower than S31600, one would expect the prices to be slightly lower. However, the opposite is true for two reasons:

- Duplex SSTs are produced in much lower volumes than the 300 series SSTs.
- The higher strength of the duplex and special processing requirements increase cost.

Table 1. Measures of Resistance to Pitting and Stress Corrosion Cracking. These are typical values, not for specification purposes.

MATERIAL	PREN(4)	CPT(1)		SCC(1)	
		°C	°F	°C	°F
S31600 CF8M	26 28	15(3)	60(3)	55(3)	130(3)
S31803 Duplex CD3MN Duplex	35 35	30(3)	85(3)	150(3)	300(3)
S32760 Super Duplex CD3MWCuN Super Duplex	44 44	70(3)	160(3)	250+(3)	480+(3)
S31254 Super Austenitic CK3MCuN Super Austenitic	43 45	70(3)	160(3)	250+(2,3)	480+(2,3)

1. NACE Corrosion 94 Conference Paper by R. Francis, The Performance of Duplex Stainless Steels in Chemical Environments, NACE Corrosion 94.
2. Estimated by Emerson Process Management.
3. Due to elemental segregation and other factors, the cast grades may have lower threshold values than the wrought grades.
4. These are typical mid-range values; not for specification purposes.

Table 2. High Alloy SST Grades

Grade	Typical Composition	Cast Equivalent	Forged Equivalent	Plate Equivalent
S31803 Duplex CD3MN Duplex (commonly called 2205)	22% chromium, 5% nickel, 3% molybdenum	ASME SA995 Grade CD3MN or 4A	ASME SA182 Grade F51	ASME SA240 S31803
S32760 Super Duplex CD3MWCuN Super Duplex (UNS J93380)	25% chromium, 7% nickel, 3.5% molybdenum, and traces of tungsten and copper	ASME SA351 Grade CD3MWCuN or 6A	ASME SA182 Grade 55	ASME SA240 S32760
S31254 Super Austenitic CK3MCuN Super Austenitic (commonly called 254SMO	20% chromium, 18% nickel, 6% molybdenum, 1% copper	ASME SA351 Grade CK3MCuN	ASME SA182 Grade F44	ASME SA240 S31254

Table 3. Compliance of High Alloy SST Grades with NACE Specifications

Grade	NACE MR0175-2002	NACE MR0175/ISO 15156	NACE MR0103
S31803 Duplex CD3MN Duplex	Wrought form only acceptable to 28 HRC hardness	Wrought and cast acceptable with some environmental restrictions	Offered only as block-forged bodies. Welding is prohibited(1)
S32760 Super Duplex CD3MWCuN Super Duplex	Both wrought and cast acceptable with some restrictions	Wrought and cast acceptable with some environmental restrictions	Offered only as block-forged bodies. Welding is prohibited(1)
S31254 Super Austenitic CK3MCuN Super Austenitic	Wrought and cast acceptable with some restrictions	Wrought acceptable with environmental restrictions. Cast acceptable to 100 HRB without environmental restrictions.	Wrought and cast acceptable without restrictions to 35 HRC hardness

1. The duplex SST welding restrictions in NACE MR0103 are very restrictive and cost prohibitive. Forged valves are offered with no welding permitted. Cast valves are not offered by Emerson Process Management at this time.

Preferred Grades for Fisher Valves

A summary of the varieties of high alloy SST's is shown in table 2. In an effort to increase volumes and control cost, we have standardized our offerings. To provide the optimum properties and the best value to our customers, we have standardized on:

- S31803 and CD3MN Duplex
  (best cost)
- S32760 and CD3MWCuN Super Duplex
  ("middle" cost)
- S31254 and CK3MCuN Super Austenitic
  (higher cost)

Our preferred grades are superior materials. By concentrating on specific grades, we can keep your costs lower and provide you materials in a more efficient manner.

S31803, CD3MN Duplex

S31803 contains approximately 22% chromium, 5% nickel, and 3% molybdenum. S31803 is commonly called 2205 and is the most widely used duplex stainless steel. It is produced by most stainless steel producers because it is not protected by any patents. It combines high strength, ductility, and hardness with resistance to corrosion, stress corrosion cracking, and erosion. Because it has a slightly lower alloy content, its corrosion resistance is not as good as the superduplex SST.

ASME SA995 grade CD3MN or 4A is the cast equivalent of S31803. Grade F51 per ASME SA182 is the forged equivalent. ASME SA240 S31803 is the plate equivalent.

Only the wrought form of S31803 is approved for use in sour environments per NACE MR0175-2002 to 28 HRC maximum. Both the wrought and cast forms are acceptable per NACE MR0175/ISO 15156 with certain environmental restrictions. This duplex SST is only being offered to the requirements of NACE MR0103 as block-forged bodies with welding prohibited. Castings are not offered due to welding restrictions contained in the specification.

S31803 is limited to 316°C or 600°F by the ASME Boiler and Pressure Vessel Code. S31803 and CD4MCu suffer embrittlement when exposed to temperatures above the limit.

S31803 is listed in ASME B16.34. CD3MN is not listed in ASME B16.34; it is Fisher-rated.

S32760, CD3MWCuN Super Duplex

This material is a superduplex stainless steel. Its corrosion resistance is superior to other duplex stainless steels because its alloy content is higher. It has a high PREN (pitting resistance equivalency number) for superior resistance to chloride pitting and stress corrosion cracking.

S32760 contains approximately 25% chromium, 7% nickel, 3.5% molybdenum, and traces of tungsten and copper.

ASME SA351 and SA995 grade CD3MWCuN or 6A is the cast equivalent of S32760. The UNS number is J93380. Grade F55 to ASME SA182 is the forged equivalent. ASME SA240 S32760 is the plate equivalent.

Both the wrought and cast forms are acceptable per NACE MR0175-2002 and NACE MR0175/ISO 15156 with certain environmental restrictions. Superduplex is only being offered to the requirements of NACE MR0103 as block-forged bodies with welding prohibited. Castings are not offered due to welding restrictions contained in that specification.

S32760 is limited to 316°C or 600°F by the ASME Boiler and Pressure Vessel Code. These alloys suffer embrittlement when exposed to temperatures above the limit.

S32760 and CD3MWCuN are listed in ASME B16.34.

S31254, CK3MCuN Super Austenitic

This material is a superaustenitic stainless steel. Its corrosion resistance is higher than the duplex grades because its alloy content is higher. It has a high PREN (pitting resistance equivalency number) for superior resistance to chloride pitting and stress corrosion cracking.

S31254 contains approximately 20% chromium, 18% nickel, 6% molybdenum, and 1% copper.

ASME SA351 grade CK3MCuN is the cast equivalent of S31254. The UNS number is J93254. Grade F44 to ASME SA182 is the forged equivalent. ASME SA240 S31254 is the plate equivalent.

Both the wrought and cast forms are acceptable per NACE MR0175-2002 and NACE MR0175/ISO 15156 with certain environmental restrictions. It is acceptable to NACE MR0103 to 35 HRC without environmental restrictions.

S31254 is limited to 300°C or 750°F by the ASME Boiler and Pressure Vessel Code. These alloys suffer embrittlement when exposed to temperatures above the limit.

S31254 and CK3MCuN are listed in ASME B16.34.

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