

Duplex Stainless Steel



The
Strength of
reliability





JSL STAINLESS Leading the way through innovation and Integration

The evolution of JSL Stainless Ltd. from a single-unit Stainless Steel manufacturer in Hisar, Haryana to the largest Stainless Steel manufacturer of India and the only fully integrated Stainless Steel manufacturer rests on the strong foundation of its roots of historic proportions. As part of the renowned O. P. Jindal Group, the company has always stood for making quality steel at a cost effective structure. Formerly known as JSL Limited, the company has always added fresh dimensions of innovation and integration to its multi-directional growth as a multi-location and multi-product conglomerate.

JSL Stainless Ltd. is a globally recognized producer of stainless steel flat products in Austenitic, Ferritic, Martensitic and Duplex grades. Its product range includes Ferro Alloys, Stainless Steel Slabs & Blooms, Hot Rolled Coils, Plates, Cold Rolled Coils and specialty products such as Razor Blade Steel, Precision Strips and Coin Blanks.

Through forward and backward integrations and some astute growth plans both on domestic and international fronts, JSL Stainless Ltd. has made significant investments into its capacity expansions. The positive response of its prestigious line of customers has always inspired the company to constantly add value to its products and services with continuous innovation.

With an extensive distribution network of its Service Centers and Warehouses in both domestic and overseas markets, JSL Stainless Ltd. is well equipped to serve its customers from its Stainless Steel manufacturing facilities at Hisar and Odisha.

Attuned to the future, JSL Stainless Ltd. has expanded its band width of business spectrum into newer grounds of Energy, Minerals & Mines, Public Infrastructure, Lifestyle Products, Media and many more to fall in line in course of time, to be in touch with lives of millions of people.



Innovating to meet your specific requirements

A key feature of JSL Stainless is its close understanding of the customers we serve. This inspires us to constantly innovate and add value to our products and services.



Achieving seamless forward and backward integration allows us to provide our customers with cost-effective solutions through superior, value-added products.



JSL Stainless has the expertise

Our definition of leadership goes much beyond the confines of market share. To us it mean setting new benchmarks and constantly changing and adapting to the change of time. Making our products and ourselves future friendly.



"We believe in managing change rather than allowing change to manage us. An open mind and a constant search for a better way of doing things have led us to achieve continuous innovation in both product development as well as our production processes. As a leader, this has proved to be a valuable differentiator that has kept us consistently ahead in the market place"



Harness the power of a leader



Innovation in our production process and product development plays a key role in sustaining our leadership positions



Whatever the application, Duplex Stainless Steel offers you the greatest competitive advantage.



This assurance of quality is backed by JSL Stainless technical expertise. It is here that by sharing resources, expertise, skills, research findings and experience between our specialist divisions, we can bring you the most suited solutions for your requirement. The market approach adopted as keynote in JSL culture ensures that innovation is customer focused.

Duplex Stainless Steel

“Duplex stainless steels (DSSs), alloys with a mixed microstructure of about equal proportions of austenite and ferrite, have existed for more than 70 years. The first generation duplexes were ferrous alloys of chromium, nickel and molybdenum. In 1960s, with the advent of AOD, the second generation alloys were developed by addition of nitrogen in the steel which improved the corrosion resistance and weldability of these alloys. The 1980s saw the development of super duplex grades for highly aggressive offshore and petrochemical industries. This was followed by developing lean duplex grades containing lower alloy content for less critical applications.

The Product range of JSL Stainless Ltd. encompasses entire range from lean duplex to super-duplex stainless steel.

Since the 1990s, duplex stainless steels have been gaining ground over austenitics. Cost of Nickel being one of the factors; Improved metallurgical techniques, improved weldability and greater availability of products have also played a role in cementing the importance of duplex stainless steels. Duplex Stainless steels are now universally accepted as a reliable solution for corrosion related issues in a number of process industries, where life cycle costs and environmental factors are gaining prominence.”

The duplex structure gives this family of stainless steel a combination of attractive properties:

Strength: Duplex stainless steel are about twice as strong as regular austenitic or ferritic stainless steel.

Toughness & Ductility: Duplex Stainless Steel have significantly better ductility than Ferritic grades & inferior to Austenitic Stainless Steel but toughness of Duplex Stainless Steel is better than both Ferritic & Austenitic stainless steel.

Corrosion resistance: As with all stainless steel, corrosion resistance depends mostly on the composition of the stainless steel. For chloride pitting and crevice corrosion resistance, their chromium, molybdenum and nitrogen content are most important.

Stress corrosion cracking resistance: Duplex stainless steel show very good stress corrosion cracking (SCC) resistance, a property they have “inherited” from the ferritic side.

Cost: Duplex stainless steel have lower nickel and molybdenum contents than their austenitic counterparts of similar corrosion resistance. Due to the lower alloying content, duplex stainless steel can be lower in cost, especially in times of high alloy surcharges. Additionally, it may often be possible to reduce the section thickness of duplex stainless steel, due to its increased yield strength compared to austenitic stainless steel. The combination can lead to significant cost and weight savings compared to a solution in austenitic stainless steel.

These Grades are categorized in follows:

Regular Duplex	Lean Duplex	Super Duplex
<ul style="list-style-type: none"> • UNS S32205 (2205, EN 1.4462) • UNS S31200 	<ul style="list-style-type: none"> • UNS S32101 (2101, EN 1.4162) • 2102 • UNS S32304 (2304) 	<ul style="list-style-type: none"> • UNS S32750 (2507, EN 1.4410) • UNS S32550 (EN 1.4507) • UNS S32760 (EN 1.4501)



Regular Duplex

UNS S32205

The 2205 is the most widely used of the duplex stainless steel occupying more than 80% of the duplex stainless steel market. The 2205 alloy provides better corrosion resistance in various environments where 316L is generally used with an added advantage of its higher yield strength. All 2205 alloys are metallographically examined to ensure that the as shipped product is free from presence of detrimental phases such as sigma. It is often used in the form of welded pipe or tubular components. The alloy has also been applied as a formed and welded sheet product in environments where resistance to general corrosion and chloride stress corrosion cracking is important.

Grade	UNS No	C%	Cr%	Ni%	Mo%	N%	Mn%
J31803	S31803	≤0.03	21.0-23.0	4.5-6.5	2.5-3.5	0.08-0.2	≤2.0
J2205	S32205	≤0.03	22.0-23.0	4.5-6.5	3.0-3.5	0.14-0.20	≤2.0

SPECIFICATION EQUIVALENTS:

- UNS31803, UNS32205, EN1.4462
- ASTM A182, A240, A276, A789, A790 and A815

Mechanical properties (as per ASTM 240):

Grade	YS (MPa)	UTS (MPa)	% Elongation	Hardness(BHN)
J31803	450 min.	655 min.	25 min.	293 max.
J2205	450 min.	620 min.	25 min.	293 max.

Typical values of mechanical properties:

Grade	YS (MPa)	UTS (MPa)	% Elongation	Hardness(BHN)
J31803	550	750	35	228
J2205	530	720	37	220

GENERAL CHARACTERISTICS:

1. PREN value 34 (Pitting Resistance Equivalent Number: $\%Cr + 3.3*\%Mo + 16*\%N$)
2. It is an extra Low Carbon Duplex Stainless steel.
3. Its yield strength is nearly twice that of the Austenitic Stainless Steel.
4. It has good weldability with minimal inter-granular corrosion in as welded condition.
5. It has high resistance to SCC in chloride and in hydrogen sulfide containing environments.
6. Exhibits high resistance to corrosion fatigue, pitting and crevice corrosion and erosion-corrosion.

MACHINABILITY:

- Cutting procedures with high speed steel tools are same as for AISI 316.
- With carbide tipped tools, the cutting speeds should be 40% less than for AISI 316 in roughing operations and 20% less for finish machining.

FABRICABILITY

- Nearly twice the force is required to initiate plastic deformation compared to those required for AISI 304L and 316L.
- Plastic deformation proceeds as easily as in austenitic stainless steel beyond yield strength.
- It can be cold bent to 25% deformation without requiring subsequent heat treatment.
- Bending should be followed by annealing if the service conditions are prone to SCC.
- Hot bending may be carried out in the range 950-1100 deg C and should be followed by quench annealing.
- Normal expanding methods can be used while expanding its tubes, but higher initial force is required and it should be completed in a single operation.

WELDABILITY:

- It is welded easily by Manual Metal Arc Welding (MMAW) using covered electrode, Gas Tungsten Arc Welding (GTAW), Gas Metal Arc Welding (GMAW).
- Heat input should be in the range of 0.5-2.5kJ/mm
- Interpass temperature should be held to 150 deg C max.
- Preheat or postweld heat treatment is normally not required.
- Typical Filler metals are overalloyed with nickel like E2209.
- Welding with carbon steels, other stainless steel and nickel alloys is readily achieved.

CORROSION RESISTANCE:

- Has better general corrosion resistance as compared to AISI 316L and 317L
- Welded joints easily pass inter-granular corrosion testing as per ASTM A262 Practice E-Strauss Test.
- Better resistance to pitting and crevice attack than 304 and 316 at higher temperatures and chloride contents.
- The combined high strength, hardness and corrosion resistance provide J2205 with superior corrosion fatigue and erosion/corrosion resistance.

APPLICATIONS:

- Chemical Industries
 - Pumps, fans, centrifuges, sulphur melting coils, chemical tanks
- Pulp & Paper Industries
 - Digester in sulphate and sulfite plants, blow tanks, blow lines
- Petrochemical Industries
- Power Generation Industries
- Oil & Gas Industries
- Desalination
- Architecture and Construction
- Food Processing Equipment
- Biofuels plant
- Cargo tanks for ships and trucks



UNS S31200

CHEMISTRY:

Elements	%C	%Mn	%S	%P	%Si	%Ni	%Cr	%Mo	%N
Min	-	-	-	-	-	5.5	24.0	1.2	0.14
Max	0.03	2.0	0.03	0.045	1.0	6.5	26.0	2.0	0.20

GENERAL CHARACTERISTICS:

- Highly resistant to SCC in Chloride containing media and sulfidic environments.
- Yield strength is nearly twice that of Austenitic Stainless Steel.
- Better machinability than austenitic stainless grades.
- Has considerable formability and toughness.
- Can be welded by TIG, MIG or MAW methods.
- Max operating temperature is 300 °C.

MECHANICAL PROPERTIES:

Property	ASTM 240 S31200 Minimum	Typical values
YS (MPa)	450	485
TS (MPa)	690	851
% Elongation	25%	31%
Hardness(BHN)	293 Max.	235



WELDABILITY :

- Can be welded by TIG, MIG and MAW methods
- Preheating or post welding treatments should not be used
- Heat input should be minimized by using small diameter electrodes and low welding current.
- Best corrosion resistance after welding is obtained by pickling or grinding & pickling.

CORROSION RESISTANCE:

- General corrosion resistance is better than to AISI 316L
- Its high chromium content makes it resistant to strongly oxidizing media and superior to that of 304L and 316L
- Its low carbon content and balanced structure make it resistant to intergranular attack after welding
- It highly resists SCC in chloride containing media and sulfidic environments.

APPLICATIONS:

Suitable for material for equipment which comes in contact with sour gas or sour oil and other chloride containing media

- Equipments for processing and pipelines for transporting sour gas and sour oil,
- Internals and shells for evaporators in desalination plants,
- Dryers for chloride-containing products,
- Fishmeal production,
- Distillery & Breweries

Lean Duplex

UNS S32101

Lean duplex stainless steel possesses the high strength coupled with corrosion resistance comparable to austenitic grades like 316L. They have a stable cost owing to low nickel and molybdenum contents. They can easily substitute standard austenitic grades like 304, 304L and even 316L in most environments.

CHEMISTRY:

UNS	EN	C%	Cr%	Ni%	Mo%	N%	Mn%	Cu%
S32101	1.4162	≤0.04	21.0-22.0	1.35-1.7	0.1-0.8	0.2-0.25	4.0-6.0	0.1-0.8

Specification Equivalents:

UNS: S32101, EN 1.4162

Mechanical properties (as per ASTM 240):

YS (MPa)	UTS (MPa)	% Elongation	Hardness(BHN)
450min.	650min.	30min.	290max.

Typical values of mechanical properties:

YS (MPa)	UTS (MPa)	% Elongation	Hardness(BHN)
485	690	36	220

2102

	C%	Cr%	Ni%	Mo%	N%	Mn%	Cu%
2102	≤0.03	20.5-23.5	1-2	0.1-1.0	0.15-0.27	2-3	≤0.5

Typical values of mechanical properties:

YS (MPa)	UTS (MPa)	% Elongation	Hardness(BHN)
540	750	34	230



UNS S32304

UNS	EN	C%	Cr%	Ni%	Mo%	N%	Mn%	Cu%
S3204	1.4362	≤0.03	21.5-24.5	3.0-5.5	0.05-0.6	0.05-0.2	≤2.50	0.05-0.6

Specification Equivalents:

- UNS: S32304, En 1.4362
- ASTM: A240, A276, A480, A789, A790

Mechanical properties (as per ASTM 240):

YS (MPa)	UTS (MPa)	% Elongation	Hardness(BHN)
400min.	600min.	25min.	290max.

Typical values of mechanical properties:

YS (MPa)	UTS (MPa)	% Elongation	Hardness(BHN)
480	665	30	215

GENERAL CHARACTERISTICS:

- 2101, 2102 and 2304 have a PREN value around 24.
- These lean duplex alloys provide a good strength, formability and economy with slightly less corrosion resistance than reference duplex alloy 2205 in various acidic environments.
- Possess good drawing and welding characteristics.
- have excellent chloride SCC resistance and high cyclic oxidation resistance upto 970 deg C.
- Exhibits high ductility (superplasticity) at high temperatures (above 920 deg C) making them readily formable (formability is better than the ferritic grades but not as good as the austenitics).
- Have considerably higher resistance to sigma formation compared to than other duplex stainless steel and some heat resistant steel.
- Optimised with respect to strength, maintenance, ductility and long term cost efficiency.

FABRICABILITY:

LDSS can be successfully cold-bent and expanded to the same extent as other duplex stainless steel. Because of the higher strength and lower ductility of duplex grades, greater loads and more generous bend radii are required for forming compared to conventional austenitic materials. It is suggested that bend radii of at least two times the metal thickness be used when forming duplex stainless steel. Allowances will also need to be made for a larger springback than is seen with lower strength materials.

WELDABILITY:

Commercially available filler metals, which are over alloyed with nickel, are suggested for welding lean duplex alloys. Such filler metals (for example, AWS E2209 or E2507) contain more nickel than the base metal in order to produce a phase balance within the weld that is approximately the same as that of the base metal. Weld procedures for LDSS alloy have been developed using Gas Tungsten Arc Welding (GTAW), Gas Metal Arc Welding (GMAW), Submerged Arc welding (SAW), and Flux Cored Arc Welding (FCAW) and Plasma Arc Welding (PAW). Root treatment can be given using Gas Tungsten Arc Welding (GTAW) for welding thicker sections.

CORROSION RESISTANCE:

1. Plain and welded samples of lean duplex alloys were exposed for over 1000 hours in a salt fog cabinet as per ASTM B117. No signs of rust or pitting were observed.
2. 2101, 2102 and 2304 show more resistance to SCC than austenitic grades like Types 304 and 316. When U-bend specimens of LDSS were immersed in a boiling 26% NaCl solution for 1000 hours they did not crack.

APPLICATIONS:

- Power Generation
 - Rotors impeller shafts
- Desalination Plants
 - Preheater shell and tube plates, Evaporator chamber
- Pulp & Paper
 - Storage tanks
- Oil and Gas
 - Pressure vessels, flue gas cleaner
- Food and Beverage Industries
 - Storage containers for wine, Fruit juices, Ethanol, Silos
- Potash Industry
 - chutes, bins, fans, blowers
- Construction Industries
 - Bridges
- Tanker truck hot cargo containers
- Waste water treatment systems



Super Duplex

UNS S32507

Super duplex Stainless steel, which combines high strength and excellent corrosion resistance in many environments; have found applications in chemical and process industries. Pulp mills, offshore systems, flue gas desulphurization units. Localized corrosion resistance of Super-duplex Steel is close to what is achieved with 6% Mo super-austenitic grades. This corrosion resistance is obtained with doubling of yield strength and decrease in amount of costly alloying elements like Ni and Mo, thus resulting in significant cost reductions.

UNS	C%	Cr%	Ni%	Mo%	N%	Mn%	Cu%	W
S32750	≤0.03	24.0-26.0	6.0-8.0	3.0-5.0	0.24-0.32	≤1.20	≤0.5	-
S32760	≤0.03	24.0-26.0	6.0-8.0	3.0-4.0	0.20-0.30	≤1.00	0.5-1.0	0.5-1.0

Specification Equivalents:

- UNS: S32750, En 1.4410
- UNS: S32760, EN 1.4501
- ASTM: A240, A480, A789, A790



Mechanical properties (as per ASTM 240):

Grade	YS (MPa)	UTS (MPa)	% Elongation	Hardness(BHN)
UNS S32750	550 min.	795 min.	15 min.	310 max.
UNS S32760	550 min.	750 min.	25 min.	270 max.

Typical values of mechanical properties:

Grade	YS (MPa)	UTS (MPa)	% Elongation	Hardness(BHN)
UNS S32750	585	826	25	260
UNS S32760	640	820	35	240

GENERAL CHARACTERISTICS:

- Super Duplex stainless steel exhibits PREN value higher than 40.
- Combines most desirable characteristics of both super-ferritic and super-austenitic steel
- Has excellent resistance to chloride SCC, pitting, crevice and general corrosion and carbide related inter-granular corrosion.
- Possesses high strength & impact strength.
- Has high thermal conductivity and a lower coefficient of thermal expansion compared to super austenitic steel.

FABRICABILITY:

- It should be hot worked in the range of 1250-1000 deg C, followed by a solution anneal at 1100 deg C and rapid quench.
- It can be cold formed using methods similar to those commonly used for Stainless Steel. The primary difference is that the high yield strength makes it necessary to have higher forming forces, increased radius of bending, and increased allowance for springback.
- Deep drawing, stretch forming and similar processes are difficult to perform.

WELDABILITY:

- It possesses good weldability and can be welded to itself and other materials by Shielded Metal Arc Welding (SMAW), Gas Tungsten Arc Welding (GTAW), Plasma Arc Welding (PAW) or Submerged Arc Welding (SAW).
- Surfaces must be clean before welding.
- Preheating is not necessary, except to prevent condensation on cold metal.
- The recommended heat input should be nearly about 50KJ/in for SAW and 5 to 38 kJ for SMAW or GTAW.
- The interpass temperature should not exceed 135 deg C.
- The root should be shielded with commercial Ar or 90%N₂ / 10%H₂ purging gas for maximum corrosion resistance.

CORROSION RESISTANCE:

- It is highly resistant to carbide related inter-granular corrosion due to its low carbon content which greatly lowers the risk of carbide precipitation at the grain boundaries during heat treatment.
- Its critical pitting temperature (CPT) is superior to that of 904L.
- It has excellent resistance to crevice corrosion and SCC.
- Extremely resistant to uniform corrosion by organic acids such as formic and acetic acid and also to inorganic acids, especially those containing chlorides.
- Excellent corrosion resistance against highly corrosive acids like Sulphuric, Nitric, Phosphoric acids.

APPLICATIONS:

- Oil and gas industry.
- Petrochemical industries (polymerization reactor cycle pumps and pipework)
- Offshore platforms (heat exchangers, process and service water systems, fire-fighting systems, and injection and ballast water systems)
- Chemical process industries (heat exchangers and vessels)
- Desalination plants (high pressure RO-plant and seawater piping)
- Fertilizers (Recirculation tanks, sedimentation tanks, phosphate reactor recirculation pumps)
- Power industry FGD systems
- Utility & industrial scrubber systems (absorber towers, ducting, piping)
- Mining/ Extraction (hot slurry pipe work, acid leach mining)
- Sewage (critically important pipelines.)
- Engineering applications (pressure vessels,)



UNS S32550

Chemical Composition as per ASTM A 240

Elements	%C	%Mn	%S	%P	%Si	%Ni	%Cr	%Mo	%N	Cu
Min	-	-	-	-	-	4.5	24.0	2.9	0.10	1.5
Max	-0.04	1.5	0.03	0.04	1.0	6.5	27.0	3.9	0.25	2.5

GENERAL CHARACTERISTICS:

- It is a high strength super stainless steel.
- It combines high mechanical strength, ductility and hardness with excellent resistance to corrosion and erosion.
- Its corrosion resistance is superior to that of fully austenitic 304, 316 and 317L stainless steel under service conditions.
- It can be machined readily and hot worked or cold worked by conventional processes.
- It can be welded by several conventional processes.

SPECIFICATION EQUIVALENTS:

- EN 1.4507
- ASTM : A240, A479, A789 and A790
- ASME : SA 240, SA 479, SA 789, and SA 790
- AWS : A5.9 and A5.4
- NACE : MR-01-75

MECHANICAL PROPERTIES:

Property	ASTM 240 UNS S32550 Minimum	Typical values
YS (MPa)	550	605
TS (MPa)	760	835
% Elongation	15%	23%
Hardness (BHN)	302 Max.	242



UNS S32550



Fabricability:

- Can be readily machined using conventional techniques. In spite of being considerably harder than austenitics, the same practices can generally be employed.
- High speed tools are normally found to be satisfactory
- Machining speeds can often be substantially increased by the use of carbide-tipped tools.
- It has good hot working and cold working characteristics.
- It can be hot worked or cold worked by conventional processes.

Weldability:

- It can be welded successfully by GTAW, GMAW or SMAW process.
- It can be successfully joined to itself, and a variety of dissimilar combinations, both stainless and carbon steel dissimilar joints.

CORROSION RESISTANCE:

- It has outstanding resistance to corrosion and is superior to fully austenitic AISI Types 304, 316 and 317L stainless steels under most service conditions.
- It exhibits excellent resistance to sulfuric, phosphoric, nitric, hydrochloric and many other acids and salts, and other severely reducing acids and chemicals
- Highly resistant to acetic, formic and other organic acids and compounds.
- Particularly suitable for the higher concentrations and temperatures where pitting and preferential corrosion are common causes of failure with most conventional austenitic stainless steels in the presence of chlorides and other impurities has improved resistance to SCC (in NaCl, sea water and many other environments), crevice corrosion and pitting when compared to austenitics like Types 304, 316, 317L and even 20Cr-25Ni grades

APPLICATIONS:

- Equipment in chemical process industry,
- H₂SO₄ production
- Oil and gas industry
- Petro-chemical industry
- Equipment in pollution control
- Pulp and paper industry
- Wet phosphoric acid production
- Equipment in urea production



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