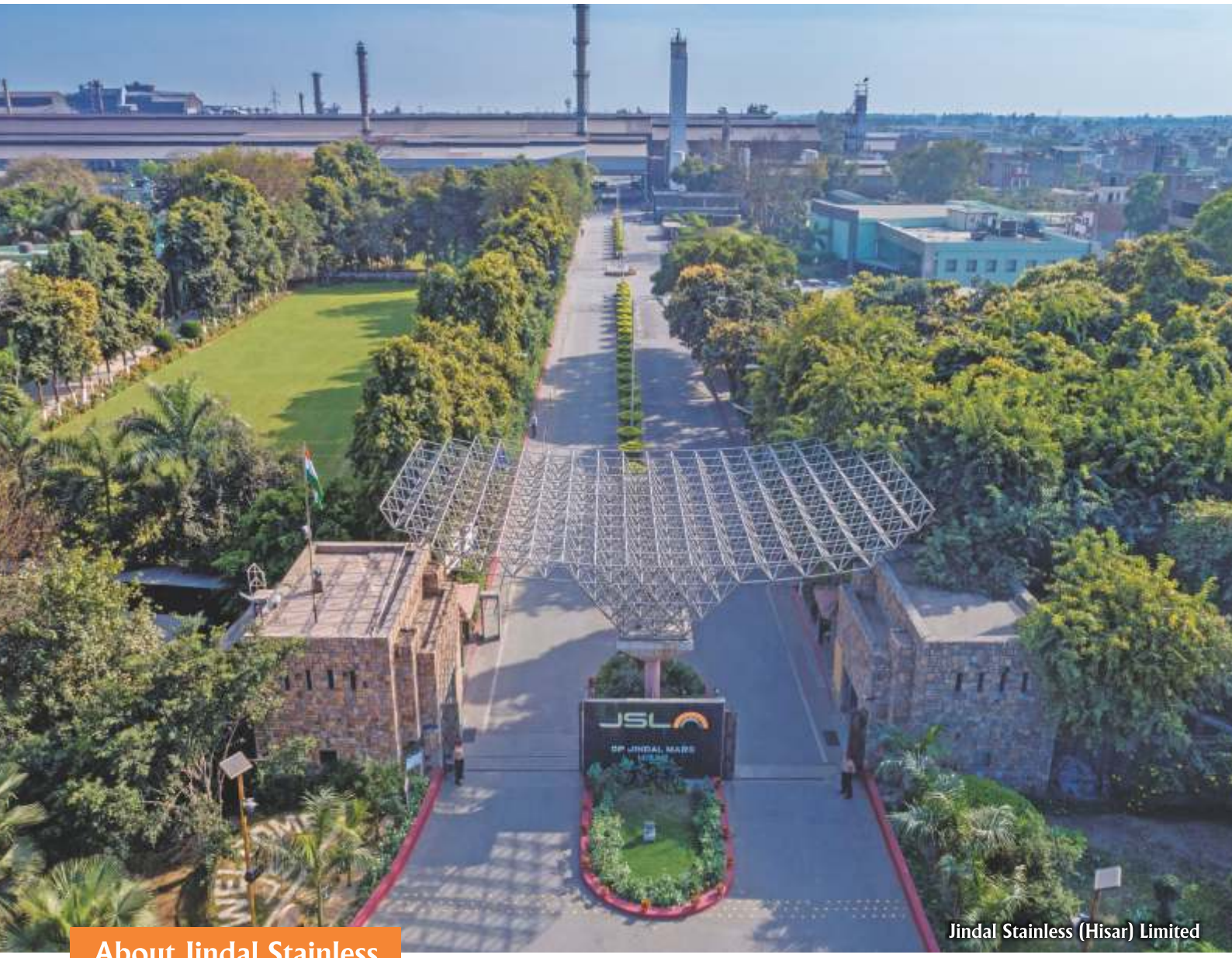
DUPLEX STAINLESS STEEL

THE UNMATCHED STRENGTH

JSL
JINDAL STAINLESS

Shaping a Stainless World



Jindal Stainless (Hisar) Limited

About Jindal Stainless

Founded by Shri OP Jindal in 1970, Jindal Stainless is one of the largest stainless steel conglomerates in India and ranks amongst the top 10 stainless steel conglomerates in the world. Jindal Stainless group has an annual steel melt capacity of 1.6 MTPA with an annual turnover of US $ 3.1 billion*. The group has two stainless steel manufacturing complexes in India, in the state of Haryana and Odisha, with an overseas unit in Indonesia. The Indonesian unit serves in markets of South-East Asia and nearby regions. The integrated operations, from mining to manufacturing of finished products, have given us the edge of cost competitiveness and operational efficiency, making us one of the best stainless steel producers in the world. The group has a country wide network of 14 sales offices in India, with over 13 global offices across the world. It's not only the magnitude of its operations that determines the brand credibility and name, but the group remains inspired by a vision for innovation and enriching lives. The company's growth has been backed by excellence of its people, value driven business operations, customer centricity, adoption of one of the best safety practices in the stainless steel industry, and a commitment for social responsibility.

*(as of March'18)

Jindal Stainless Limited, Jajpur

The guiding vision and mission of Jindal Stainless is to provide trustworthy and innovative stainless steel solutions. Lighter and stronger at the same time, stainless steel is inherently corrosion resistant, durable, recyclable, and beautiful. Unsurprisingly, stainless steel is the preferred choice in industries like nuclear energy, construction & architecture, automotive & transport, oil & gas, desalination processes, fertilizer, storage, chemical processes, dairy, food processing, brewery, sugar, white goods, and of course, kitchenware. The cutting-edge technology in the Special Products Division and state-of-the-art Research & Development wing of Jindal Stainless is complemented by superior knowledge of supply chain systems. At Jindal Stainless, we take pride in being amongst the largest producers of coin blanks and razor blade grade of steel in the world. Strongly rooted in the Indian philosophy of 'Vasudhaiva Kutumbakam', we strive to empower local communities by augmenting their employability. We also provide comprehensive healthcare, education facilities, and vocational training for promoting self-reliance.

Duplex Stainless Steels

Duplex stainless steels (DSSs), alloys with a mixed micro-structure of about equal proportions of austenite and ferrite, have existed for more than 70 years. The first generation duplexes where 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 development of 'Lean Duplex Grades' containing lower alloy content for less critical applications.

The product range of Jindal Stainless Ltd., encompasses the entire range from Lean duplex to Super-duplex stainless steels.

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 a combination of attractive properties to this family of stainless steel

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

Toughness & Ductility: Duplex Stainless steels have significantly better ductility than ferritic grades, but are inferior to austenitic stainless steels. The toughness of duplex stainless steels is better than both ferritic & austenitic grades.

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

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

Cost: Duplex stainless steels have lower nickel and molybdenum contents than their austenitic counterparts of similar corrosion resistance. Due to the lower alloying content, duplex stainless steels 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 steels, due to their increased yield strength, as compared to austenitic stainless steels. The combination can lead to significant cost and weight savings compared to a solution in austenitic stainless steels.

CATEGORIES OF DUPLEX STAINLESS STEELS

Regular Duplex	Lean Duplex	Super Duplex
• UNS S32205 (EN 1.4462)	• UNS S32101 (EN 1.4162) • UNS S32304 (EN 1.4362)	• UNS S32750 (EN 1.4410) • UNS S32760 (EN 1.4501) • UNS S32550 (EN 1.4507)

Certifications

Moreover, the speciality Product Division of the company gives it the unique distinction of the being the world's largest producer of high quality precision strips and stainless steel strips for razor blades. Apart from these, the company also produces coin blanks, serving the needs of both, Indian and International mints.

REGULAR DUPLEX - UNS S32205

The 2205 is the most widely used duplex 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 shipped product is free from presence of detrimental phases such as sigma.

It is often used in 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.

Chemistry

UNS	C%	Cr%	Ni%	Mo%	N%	Mn%
S31803	≤0.03	21.0-23.0	4.5-6.5	2.5-3.5	0.08-0.2	≤ 2.0
S32205	≤0.03	22.0-23.0	4.5-6.5	3.0-3.5	0.14-0.20	≤ 2.0

Specification Equivalents

- UNS S31803, UNS S32205, EN1.4462
- ASTM: A182, A240, A276, A789, A790, and A815

Mechanical Properties (as per ASTM 240)

Grade	YS (MPa)	UTS (MPa)	% Elongation	Hardness (BHN)
S31803	450 min.	620 min.	25 min.	293 max.
S32205	450 min.	655 min.	25 min.	293 max.

Typical Values of Mechanical Properties

Grade	YS (MPa)	UTS (MPa)	% Elongation	Hardness (BHN)
S31803	550	750	30	228
S32205	530	720	30	220

General Characteristics

- PREN value 34 (Pitting Resistance Equivalent Number: %Cr+3.3*%Mo+ 16*%N)
- It is an extra low carbon duplex stainless steel.
- Its yield strength is nearly twice as that of the austenitic stainless steel.
- It has good weldability with minimal inter-granual corrosion in as welded condition.
- It has high resistance to SCC in chloride and in hydrogen sulfide containing environments.
- It exhibits high resistance to corrosion fatigue, pitting and crevice corrosion, and erosion-corrosion.

Machinability

- Cutting procedures with high speed steel tools are same as 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 that 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°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 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), or Gas Metal Arc Welding (GMAW).
- Heat input should be in the range of 0.5-2.5 KJ/mm
- Inter-pass temperature should be held to 150°C max.
- Pre-heat or post-weld heat treatment is normally not required.
- Typical filler metals are over alloyed with nickel like E2209.
- Welding with carbon steels, other stainless steels, and nickel alloys is readily achieved.

Corrosion Resistance

- It 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.
- It has 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 2205 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 lines
- Petrochemical Industries
- Power Generation Industries
- Oil & Gas Industries
- Desalination
- Architecture and Construction
- Food Processing Equipments
- Bio-fuels Plants
- Cargo Tanks for Ships and Trucks

LEAN DUPLEX - UNS S32101

Lean duplex stainless steels processes high strength coupled with corrosion resistance, as compared to austenitic grades like 316L. This grade has stable cost owing to low nickel and molybdenum content. This 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

UNS S32304

Chemistry

UNS	EN	C%	Cr%	Ni%	Mo%	N%	Mn%	Cu%
S32304	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 and 2304 have a PREN value around 24.
- These lean duplex alloys provide good strength, formability, and economy with slightly less corrosion resistance than reference duplex alloy 2205 in various acidic environments.
- They possess good drawing and welding characteristics.
- They have excellent chloride SCC resistance and high oxidation resistance upto 970°C.
- They exhibit high ductility (superplasticity) at high temperatures (above 920°C), making them readily formable (formability is better than the ferritic grades but not as good as the austenitics).
- They have considerably higher resistance to sigma formation as compared to duplex stainless steels and some heat resistant steels.
- They are optimised with respect to strength, maintenance, ductility, and long term cost efficiency.

Fabricability

Lean duplex stainless steel (LDSS) can be successfully cold-bent and expanded to the same extent as other duplex stainless steels. Because of the higher strength and lower ductility of duplex grades, greater loads and more generous bend radii are required for forming as 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 steels. Allowances will also need to be made for a larger spring back than seen with lower strength materials.

Weldability

Commercially available filler metals, which are over alloyed with nickel, are suggested for welding 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), Flux Cored Arc Welding (FCAW) and Plasma Arc Welding (PAW). Root treatment can be given using Gas Tungsten Arc Welding (GTAW) for welding thickness sections. Heat input should be in the range of 0.3-1.5KJ/mm for UNS S32101 & 0.5-2.5KJ/2.5KJ/mm for UNS S32304 grade.

Corrosion Resistance

- Plain and welded samples of lean duplex alloys were exposed for over 1000 hours in a salt fog cabinet as per ASTM: B 177 and no signs of rust or pitting were observed.
- 2101 and 2304 show more resistance to SCC than austenitic grades like 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: Pre-heater shell and tube plates, Evaporator chambers
- Pulp & Paper: Storage tanks
- Oil and Gas: Pressure vessels, flue gas cleaner, heat exchangers
- Food and Beverage Industry: Storage containers for wine, fruit juices, ethanol, silos
- Potash Industry: Chutes, bins, fans, blowers
- Construction: Bridges
- Tanker truck hot cargo containers
- Waste water treatment systems

SUPER DUPLEX - UNS S32750/32760

Super duplex stainless steels, which combine high and excellent corrosion resistance in many environments, have found applications in chemical and process industries, pulp mills, offshore systems, and flue gas desulphurization units. Localized corrosion resistance of super duplex steels is close to what is achieved with 6% Mo super austenitic grades.

Chemistry

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 Value 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 steels exhibit PREN value higher than 40.
- They combine most desirable characteristics of both super-ferritic and super-austenitic steels.
- They have excellent resistance to chloride SCC, pitting, crevice and general corrosion, and carbide related inter-granular corrosion.
- They possesses high strength & impact strength.
- They have high thermal conductivity and a lower coefficient of thermal expansion compared to super austenitic steels.

Fabricability

- They should be hot worked in the range of 1000-1250°C, followed by a solution anneal at 1100°C and rapid quench.
- They 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

- They possesses good weldability and can be welded to themselves 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 0.3-1.5KJ/mm
- The interpass temperature should not exceed 150°C.
- The root should be shielded with commercial Ar or 90%N_2 / 10%H_2 purging gas for maximum corrosion resistance.

Corrosion Resistance

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

Applications

- Oil and Gas Industry.
- Petrochemical Industry (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-plants and sea-water piping)
- Fertilizers (re-circulation tanks, sedimentation tanks, phosphate reactor re-circulation 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

Chemistry

Elements	%C	%Mn	%S	%P	%Si	%Ni	%Cr	%Mo	%N	Cu
Min	-	-	-	-	-	4.5	24.0	2.9	0.10	1.5
Mix	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 steels under extreme 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

Typical Values of Mechanical Properties

UNS32550	YS (MPa)	TS (MPa)	% Elongation	Hardness (BHN)
ASTM 240 UN S32550 min.	550	760	15	302 Max.
Typical values	605	835	23	242

Fabricability

- It can be readily machined using conventional techniques. Inspite of being considerably harder than austenities, 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, nitiric, hydrochloric, and other severely reducing acids and chemicals.
- It is highly resistance to acetic, formic, and other organic acids and compounds.
- It is particularly suitable for 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. It has improved resistance to SCC (in NaCl, sea water and many other environments), crevice corrosion, and pitting, when compared to austenitics like 304, 316, 317L, and even 20Cr-25Ni grades.

Applications

- Equipments in Chemical Process Industry
- H_2SO_4 Production
- Oil and Gas Industry
- Petrochemical Industry
- Equipments in Pollution Control
- Pulp and Paper Industry
- Wet Phosphoric Acid Production
- Equipments in Urea Production

Applications


Cargo Tanks

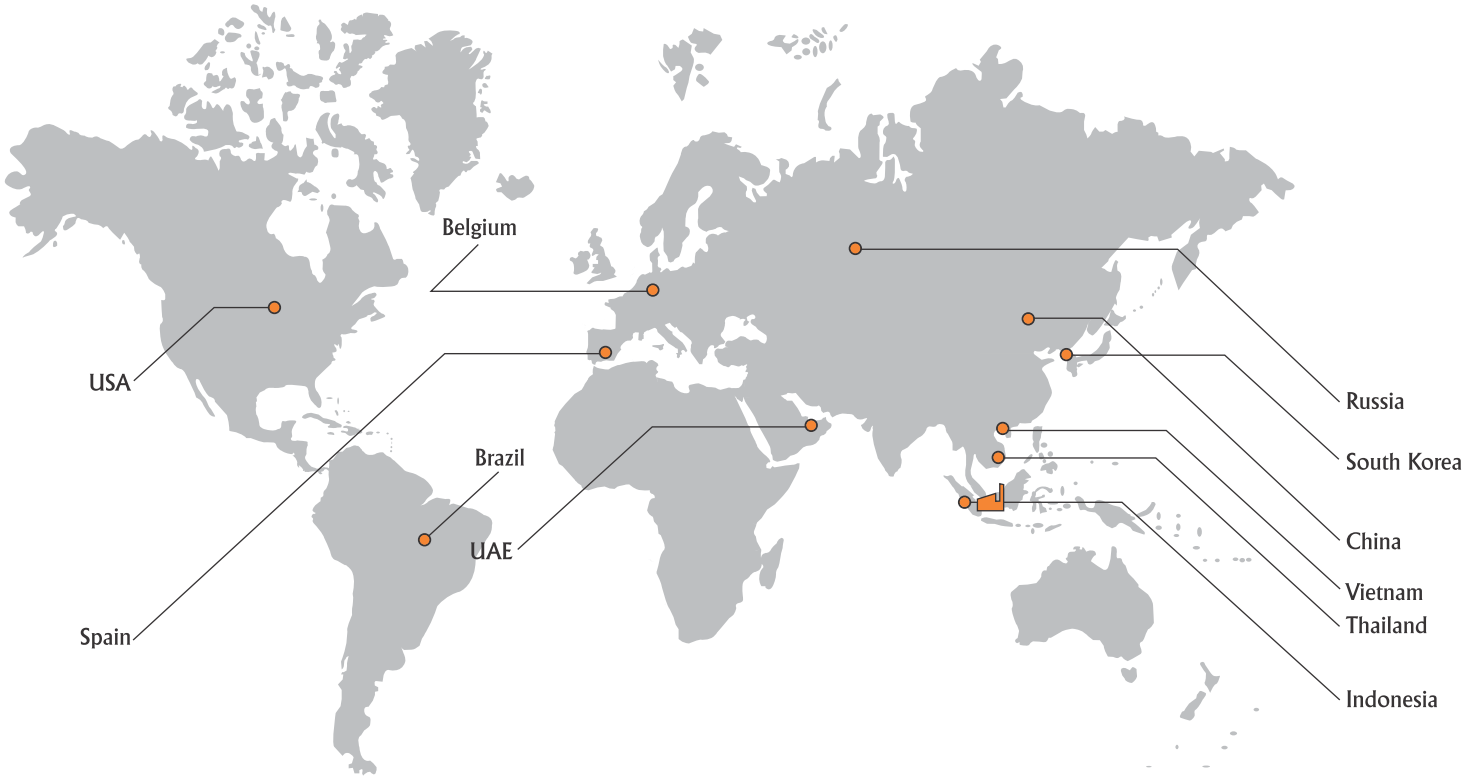

Fertiliser Industry


Desalination Plants


Offshore Plants


Petrochemical Industry

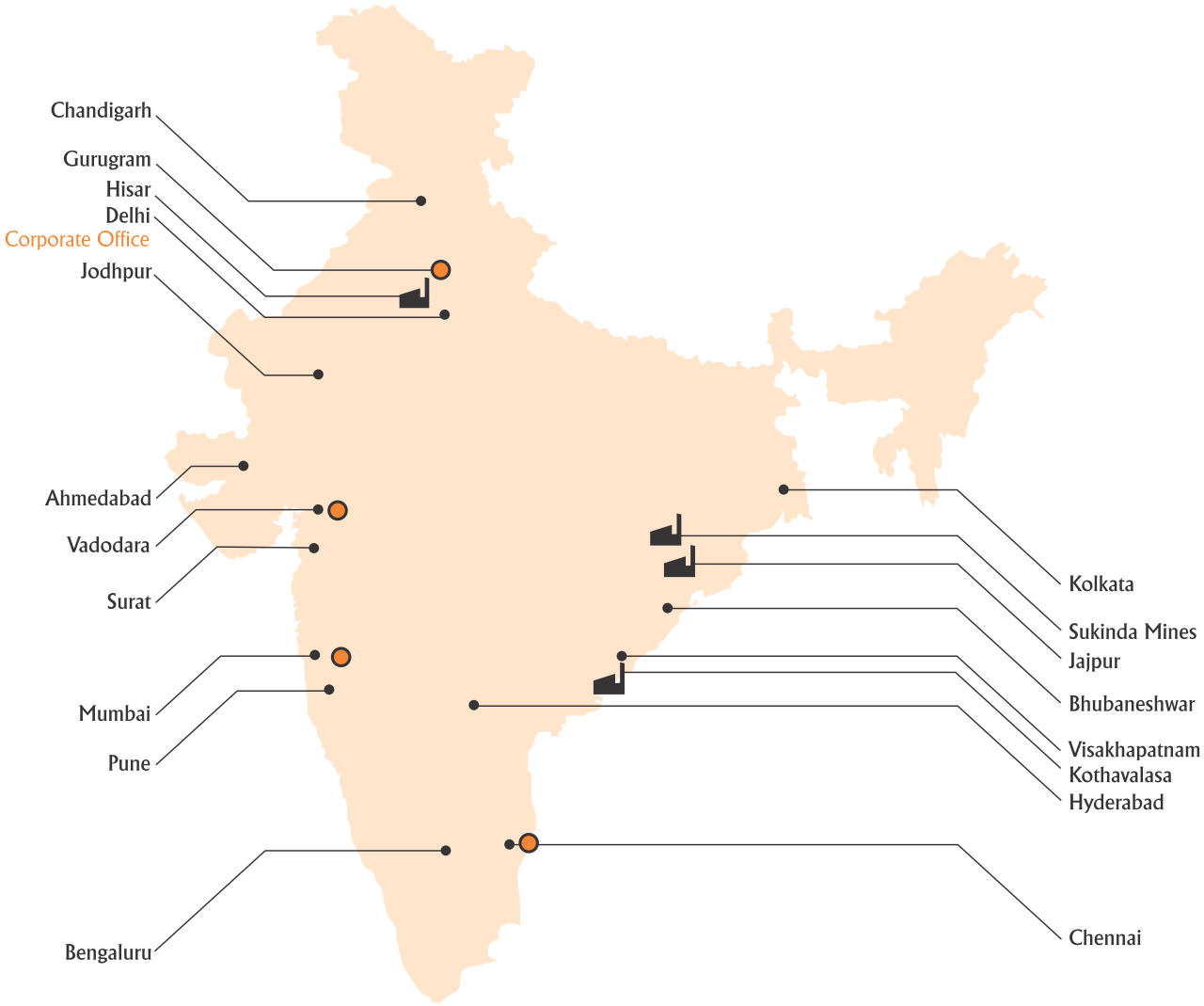
Overseas Network



Manufacturing Facilities

International Sales Offices

Domestic Network



- Manufacturing Facilities
- Domestic Sales Offices
- Service Centers

Jindal Stainless Locations

DOMESTIC OFFICES

Ahmedabad
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Shaping a Stainless World

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