NIPPON STEEL

NIPPON STEEL Stainless Steel Corporation

NSSC

SOLUTION

DUPLEX
STAINLESS STEEL

EXPERIENCE

KNOWLEDGE

INNOVATION

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NSSC DUPLEX
Stainless Steel

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NSSC™ Duplex series

Real Innovation

New value is added to society by a fusion between cutting edge materials developed entirely from the user perspective and the creativity required to make best use of them.

Tsukishimagawa Terrace Bridge (SUS821L1)

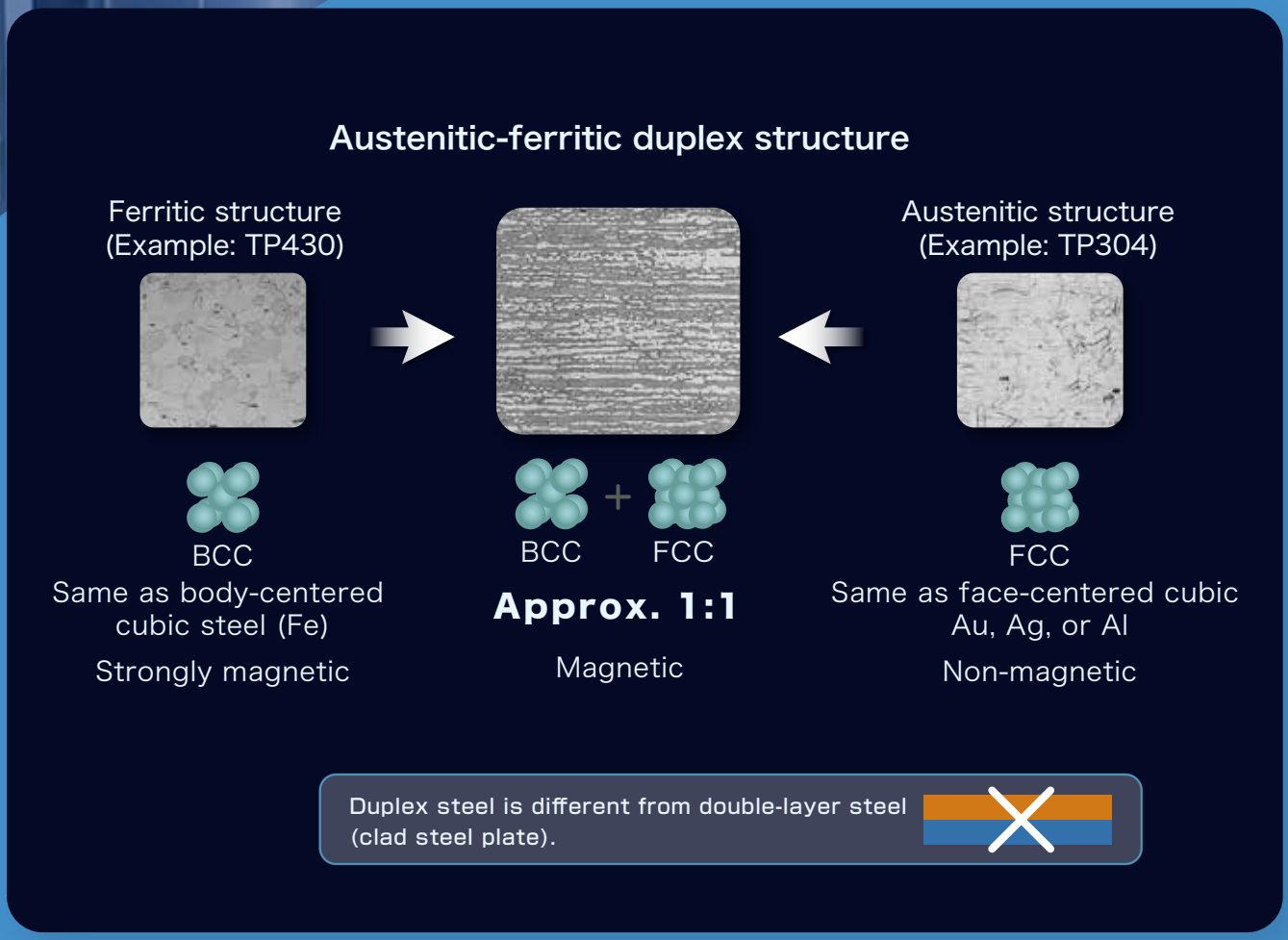
03

Features of NSSC original duplex stainless steel

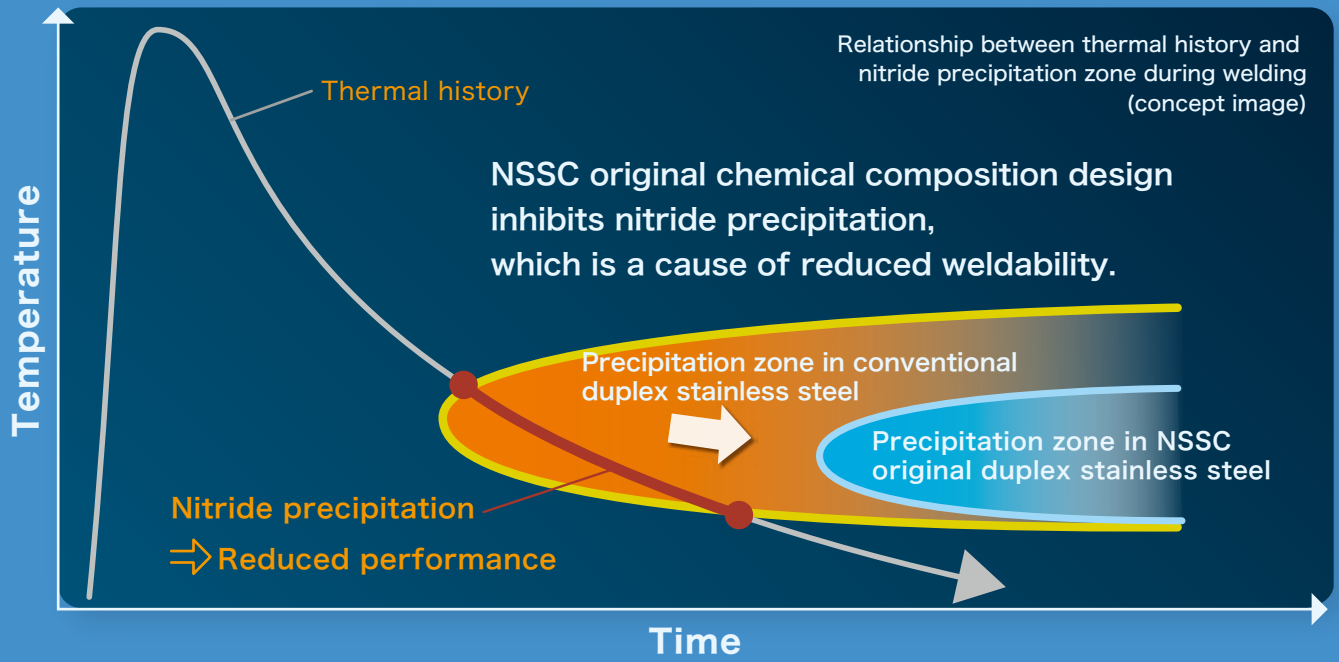
NSSC original duplex stainless steel achieves a large improvement in weldability!※

※ Compared to conventional duplex stainless steel

Metal structure of duplex stainless steel

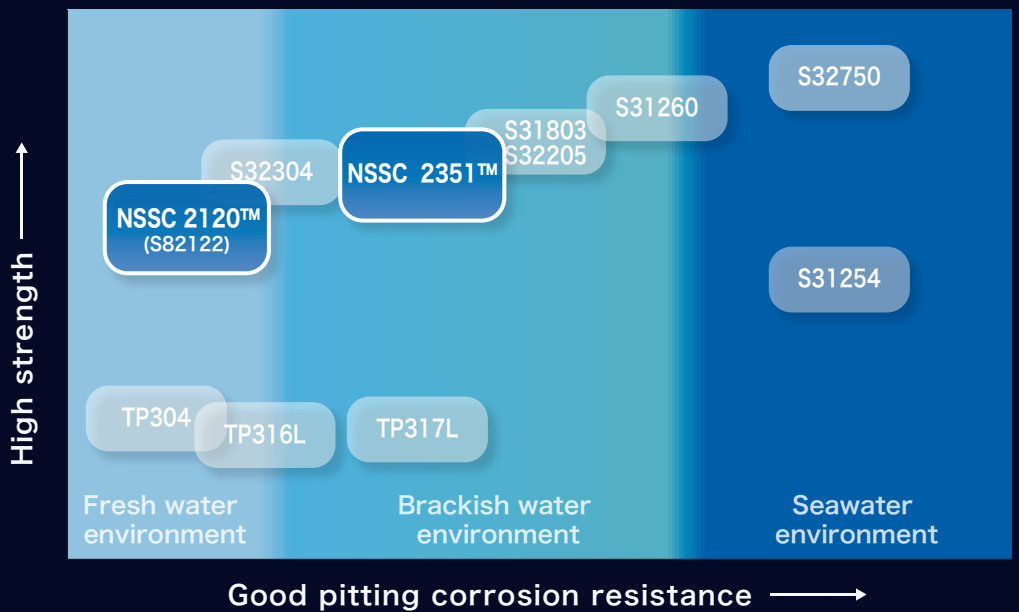


NSSC original stainless duplex stainless steel features greatly improved welding workability.※



Duplex stainless steel lineup

A wide lineup is available ranging from resource-saving Lean grade to the Super grade which can withstand seawater.
Users can choose the steel grade that is most suitable for the service environment.



Classification	NSSC standard/ JIS standard	ASTM standard (UNS)	Main chemical composition (wt%)	PREN *1)	CI *2)	Products that can be provided
Lean Duplex	NSSC 2120™ (SUS821L1)	S82122 *3)	21Cr-2Ni-3Mn-Cu-0.17N	25	26	Coil&Sheets, Plates, rods
	SUS323L	S32304	23Cr-4Ni-0.15N	27	27	Coil&Sheets, Plates, rods
Standard Duplex	NSSC 2351™ (SUS329J1)	—	23Cr-5Ni-1Mo-0.17N	30	32	Coil&Sheets, Plates, rods
	SUS329J3L	S31803 S32205	22Cr-5Ni-3Mo-0.15N	34	38	Coil&Sheets, Plates, rods
	SUS329J4L	S31260	25Cr-6Ni-3Mo-0.15N	36	41	Coil&Sheets, Plates, rods
Super Duplex	SUS327L1	S32750	25Cr-7Ni-4Mo-0.28N	42	49	Coil&Sheets, Plates, rods
Austenitic	SUS304	S30400	18Cr-8Ni-Low N	19	19	Coil&Sheets, Plates, rods
	SUS316L	S31603	18Cr-12Ni-2.5Mo-Low C-N	26	28	Coil&Sheets, Plates, rods
	SUS317L	S31703	18Cr-12Ni-3.5Mo-Low C-N	30	32	Coil&Sheets, Plates, rods
	SUS312L	S31254	20Cr-18Ni-6Mo-0.2N	43	50	Coil&Sheets, Plates

*1) PREN= Cr%+3.3xMo%+16N%(pitting resistance equivalent number)
*2) CI=Cr%+4.1Mo%+27N%(crevice corrosion index)
*3) Flat products

Physical properties (reference values)

Classification	NSSC standard/ JIS standard	Density *1) (g/cm³)	Modulus of longitudinal elasticity (kN/mm²)	Specific heat (kJ/kg/°C)	Specific electric resistivity (10⁻⁸Ωm)	Thermal conductivity (W/m/°C)	Coefficient of linear expansion (×10⁻⁶/°C)
Lean Duplex	NSSC 2120™ (SUS821L1)	7.80	200	0.5	80	16.0	13.7
	SUS323L	7.80	200	0.5	80	16.0	13.0
Standard Duplex	NSSC 2351™ (SUS329J1)	7.80	200	0.5	80	15.2	13.1
	SUS329J3L	7.80	200	0.5	80	12.5	13.7
	SUS329J4L	7.80	200	0.5	80	13.4	13.4
Super Duplex	SUS327L1	7.80	200	0.5	80	14.0	13.0
Austenitic	SUS304	7.93	193	0.5	72	16.3	17.3
	SUS316L	7.98	193	0.5	74	16.3	16.0

*1) Density values reference the JIS standard.

Sources: Duplex Stainless Steel Machining Manual (IMOA)
Best Uses of Duplex Stainless Steel (The Society of Materials Science, Japan)
Information for NSSC 2120™ and NSSC 2351™ are sample measurements by our company.

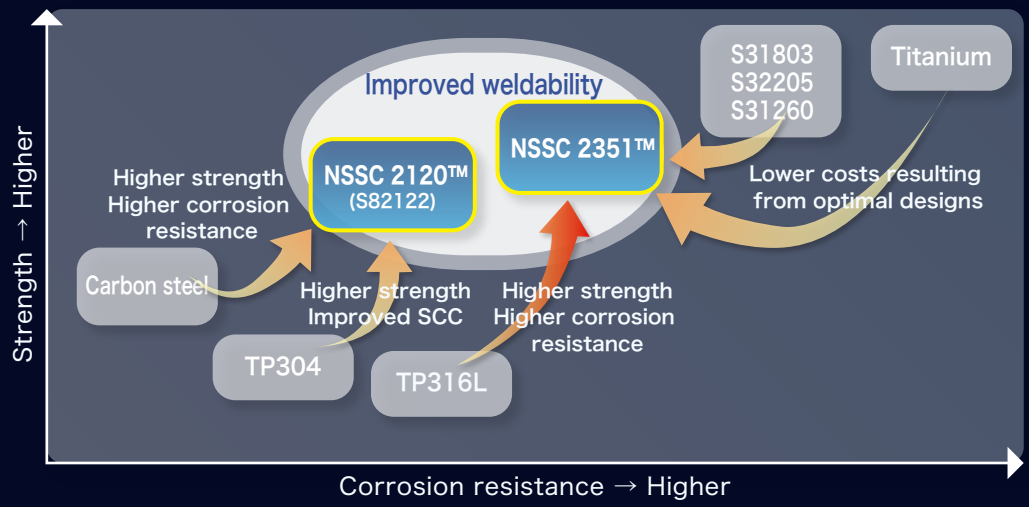
Mechanical properties (reference values)

Classification	NSSC standard/ JIS standard	Finish	Thickness (mm)	0.2% yield strength (MPa)	Tensile strength (MPa)	Elongation (%)	Hardness HV
Lean Duplex	NSSC 2120™ (SUS821L1)	2B 2B	1.5 3.0	570 544	792 759	31 35	256 244
	SUS323L	2B	1.5	580	790	30	253
Standard Duplex	NSSC 2351™ (SUS329J1)	2B 2B	1.5 3.0	613 608	830 809	29 31	264 255
	SUS329J3L	2B	1.5	641	867	28	277
	SUS329J4L	2B	1.5	686	868	25	293
Super Duplex	SUS327L1	2B	1.5	725	955	26	313
Austenitic	SUS304	2B	1.5	300	654	56	170
	SUS316L	2B	1.5	281	561	53	143

NSSC Duplex Series

Utilizing the high strength and high corrosion resistance makes possible VE by changing from regular stainless steel and other materials.

Positioning of NSSC 2120™ and NSSC 2351™

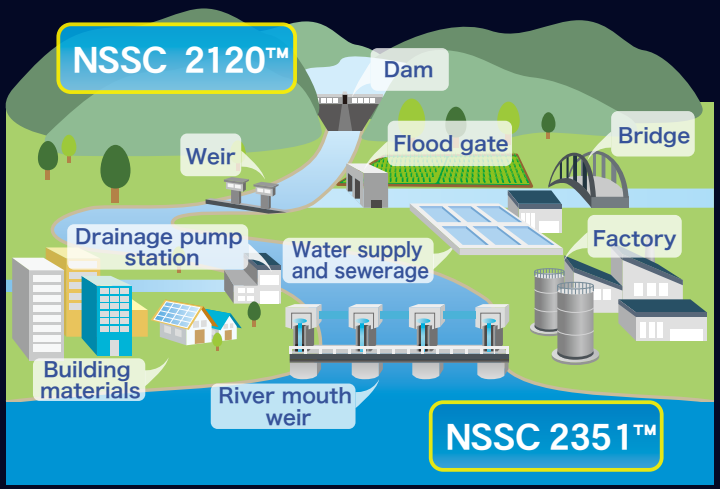


NSSC 2120™

1. Corrosion resistance is equal to or better than TP304.
2. SCC resistance is largely superior to TP304.
3. Utilizing the higher strength makes thinner and lighter-weight designs possible.
4. When switching from carbon steel, there is a limited initial increase in cost, however the overall life cycle costs are reduced.

NSSC 2351™

1. Corrosion resistance is equal to or better than TP316L.
2. SCC resistance is largely superior to TP316L.
3. When used as a replacement for TP316L, thinner and lighter-weight designs are possible and life cycle costs can be reduced.
4. Changing from high-grade materials(avoiding excessively high specifications) can achieve a large reduction in cost.



Possible applications

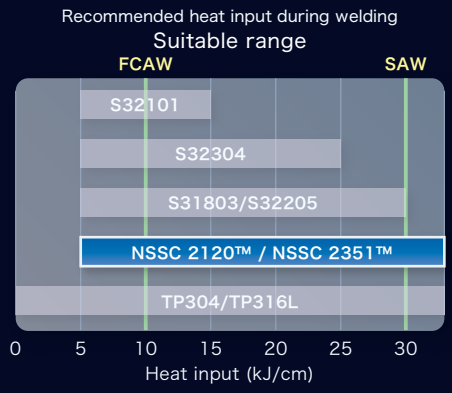
- **River facilities**
  Fresh water environment : NSSC 2120™
  Brackish water environment : NSSC 2351™
- **Buildings and civil engineering**
  Inland environment : NSSC 2120™
  Coastal environment : NSSC 2351™
- **Tanks and other factory equipment**
  Equipment using TP304: NSSC 2120™
  Equipment using TP316L: NSSC 2351™

※For a full seawater environment, S31260 or Super Duplex S32750 is recommended.

NSSC 2120™ and NSSC 2351™ weldability

High heat-input welding is possible.

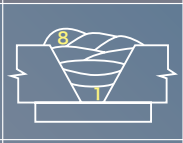
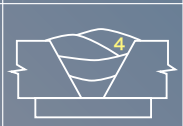
The recommended heat input range for NSSC 2120™ and NSSC 2351™ is larger than conventional duplex stainless steel, allowing high heat-input welding.



Welding efficiency is greatly increased by the use of high heat-input welding.

Weldability NSSC 2120™ NSSC 2351™

Because SAW high heat-input welding can be used, efficient welding is possible (2× or more compared to ordinary welding). It is particularly suitable for construction of large-size structures.

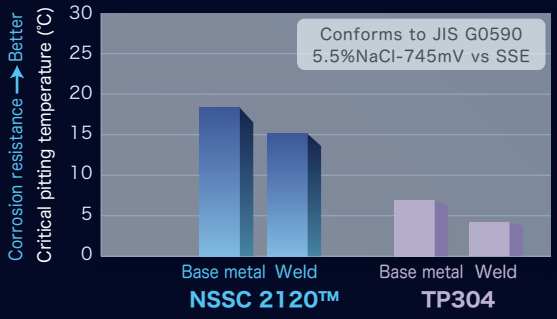
Welding method	Groove shape and laminating procedure	Macroscopic cross-section image	Number of passes	Welding heat input kJ/cm	Applicability NSSC 2120™ NSSC 2351™
Ordinary welding **FCAW** Flux Cored Arc Welding			8	10	○
High heat-input welding **SAW** Submerged Arc Welding			4	35	○

NSSC 2120™ and NSSC 2351™ weld corrosion resistance

NSSC 2120™ weld corrosion resistance is equal to or greater than that of TP304 welds.

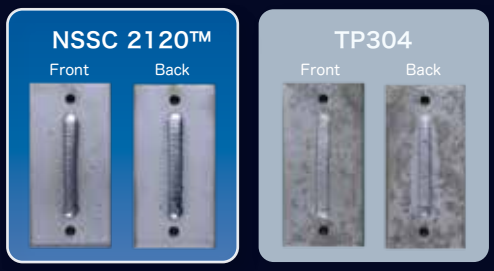
Weldability NSSC 2120™ NSSC 2351™

Corrosion resistance in a neutral high-salinity environment (Critical pitting temperature)



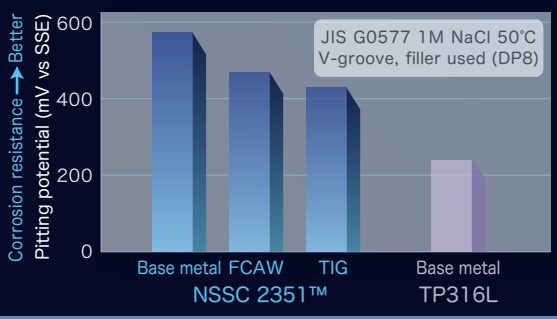
Exposure test results

Exposed for 1 year approximately 30 m from the ocean on the coast of Yamaguchi Prefecture.
TIG welding was performed at the center, followed by pickling.



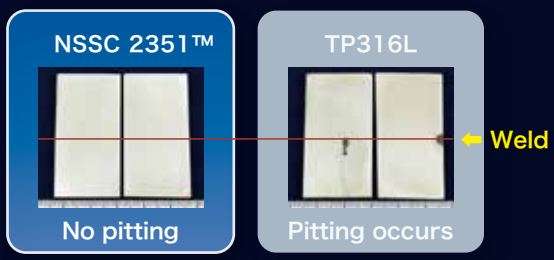
NSSC 2351™ weld corrosion resistance is equal to or greater than that of TP316L welds.

Sample pitting potentials of base metal and welds



Ferric chloride test results

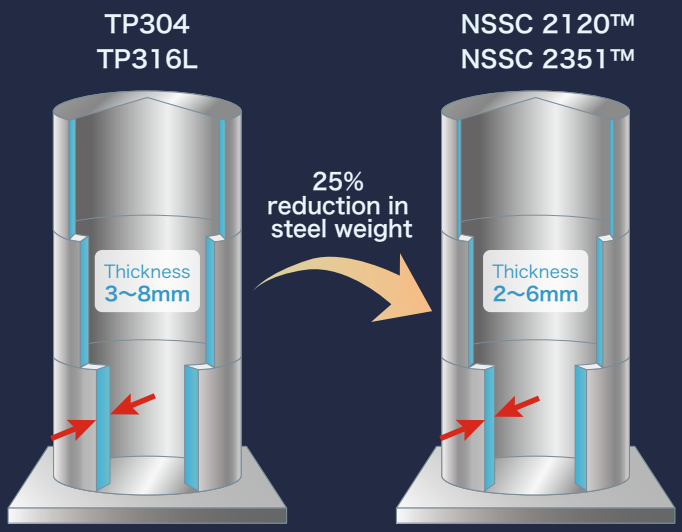
JIS G 0578-B 72 h 15°C TIG welding, 3 mmt, V-groove, 2 passes, Ar shield
Filler used (YM-DP8/2351, YM-316L/316L)

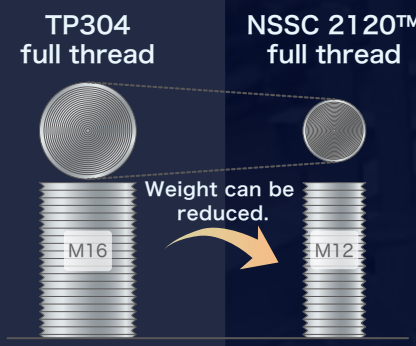


Characteristics of duplex stainless steel

Utilizing the material high strength makes thinner and lighter-weight designs possible. ※Concept image

High strength





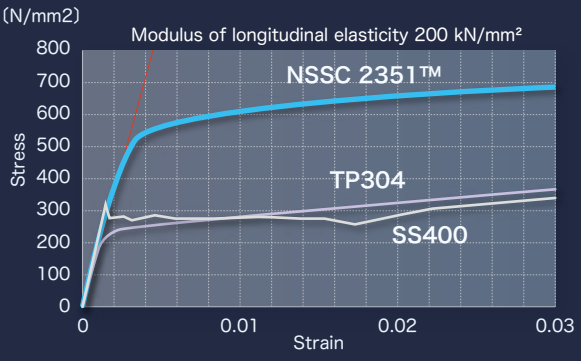
Typical examples of mechanical properties

Product type \ JIS Z 2201(No.14)	0.2% yield strength N/mm²	Tensile strength N/mm²
NSSC 2120™ full thread	600	801
TP304 full thread	486	643

Comparison of design standard strengths

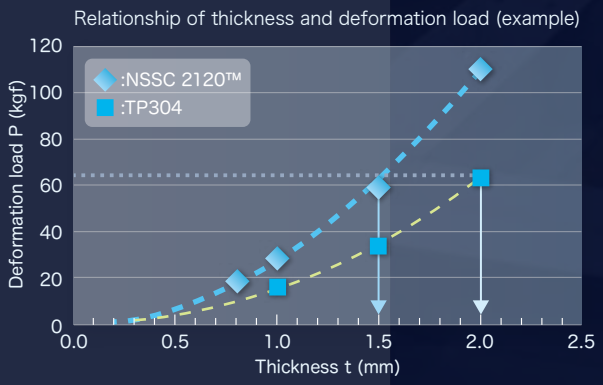
【 Design strength 】 ※When designed for yield strength

【 Stress-strain curve 】

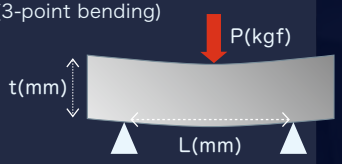


Potential for reduced thickness at bending tests (trial calculations)

Compared with TP304, thickness can be reduced by 25%.



Calculation basis conditions
(3-point bending)



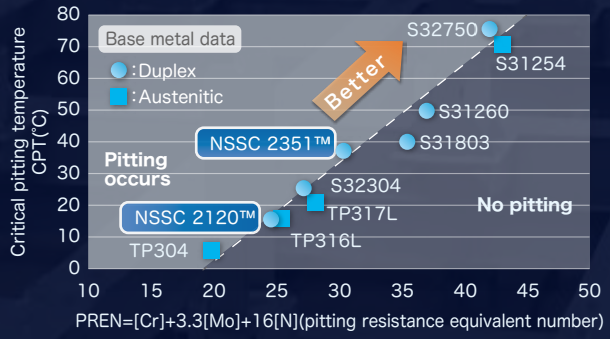
$$P = \frac{2b\sigma y}{3L} t^2$$

Deformation load : P (kgf)
Distance between support points : L (mm)
Thickness : t (mm)
Width : b (mm)

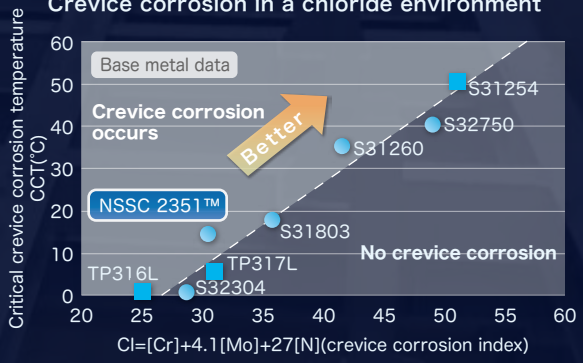
Wide range of steel grade variations

High corrosion resistance

Pitting resistance in a chloride environment

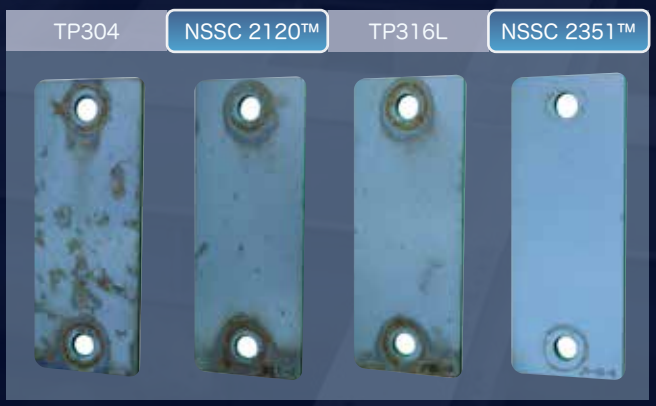


Crevice corrosion in a chloride environment

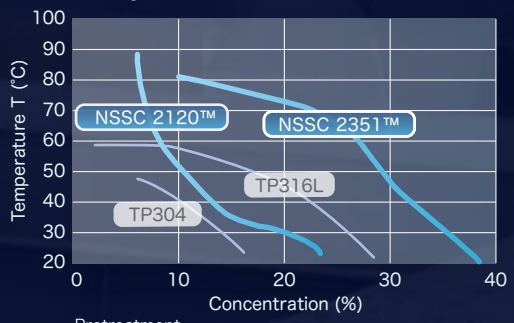


Exposure test

Results from exposure for 1 year in SE Asia ocean



Sulfuric acid resistance limit of application (≦0.1mm/y)



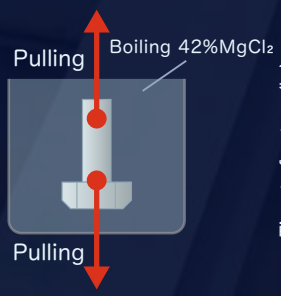
Pretreatment
After #600 chemical polishing, exposed for 24 hours in 40 – 45% RH desiccator.
Test condition: 24 hour immersion

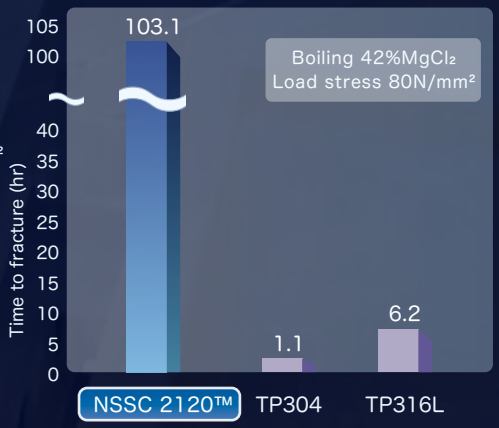
Excellent stress corrosion cracking resistance (SCC resistance)

High corrosion resistance

Compared to austenitic stainless steel in the same class, duplex stainless steel has superior stress corrosion cracking resistance (SCC resistance) in a chloride environment.

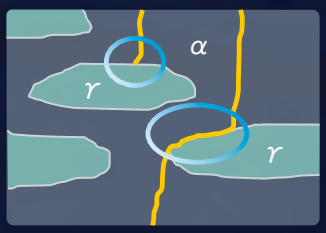
※Schematic





SCC resistance improvement mechanism

It was confirmed that the crack end branches at the $\alpha\gamma$ interface.



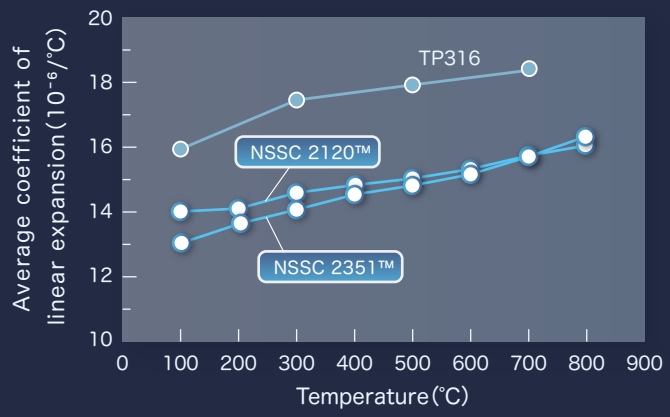
α=Ferrite phase
γ=Austenite phase

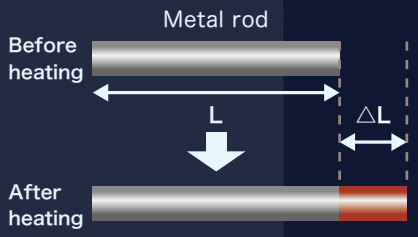
Characteristics of duplex stainless steel

Relaxing of thermal strain

Low thermal expansion

Compared to austenitic stainless steel, the coefficient of linear expansion is lower.
This can be expected to produce longer lifetimes in equipment where thermal strain is a problem.





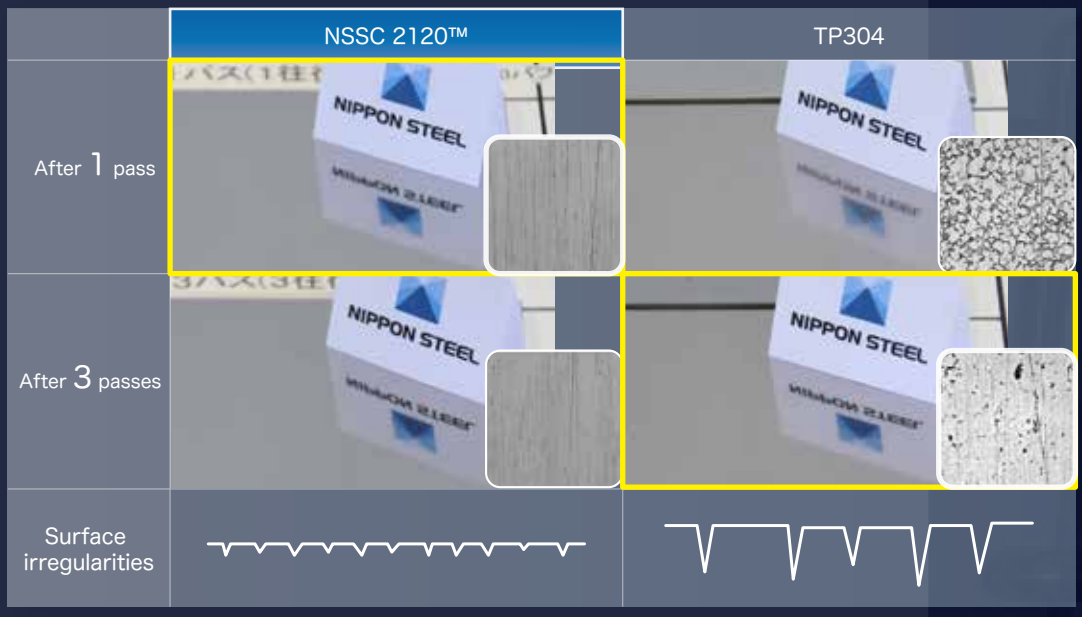
Coefficient of linear expansion = ΔL/L (per 1°C)

Excellent polishing property

Good polishing property

NSSC 2120™ provides superior polishing property, with the finish (yellow box) after 1 pass equivalent to the finish after 3 passes with TP304, making it possible to reduce the man-hours required for polishing.

Polishing conditions
Material before polishing: Cold-rolled 3.0 mm, No. 2B finish
Polishing powder: #400 alumina based powder
Polishing conditions: Buff diameter 400 mm, speed 2000 rpm, material movement speed 286 mm/s



It is thought that buffing performance is affected by the differences in the grain boundary depth that can be seen in the material surface after pickling.

Price stability

Uses much smaller amounts of Ni and Mo – expensive materials that are subject to price fluctuations.

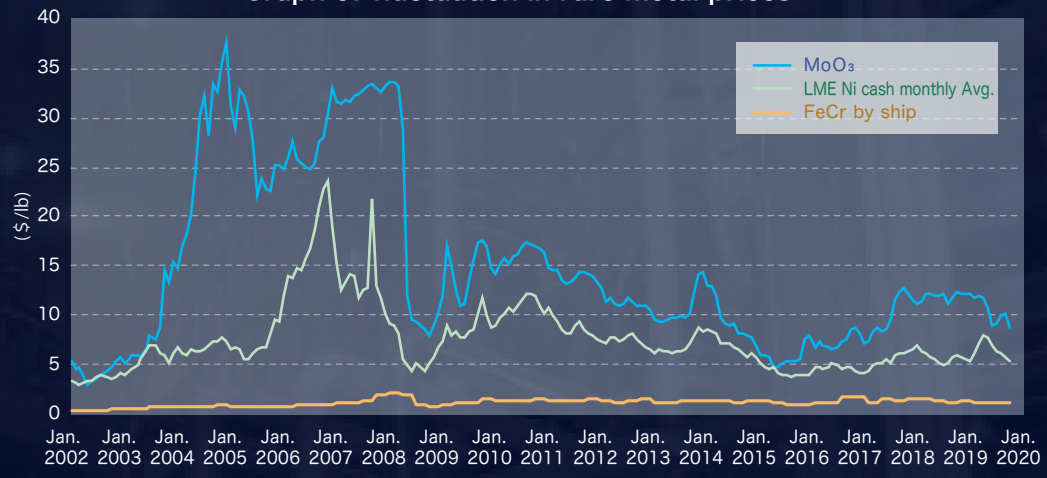
Resource conservation

Comparison of main components

	TP304	NSSC 2120™
Ni	8%	2%
Mo	0%	0%
Cr	18%	21%

	TP316L	NSSC 2351™
Ni	12%	5%
Mo	2.5%	1%
Cr	18%	23%

Graph of fluctuation in rare metal prices



NSSC™ Duplex series

Examples of Applications

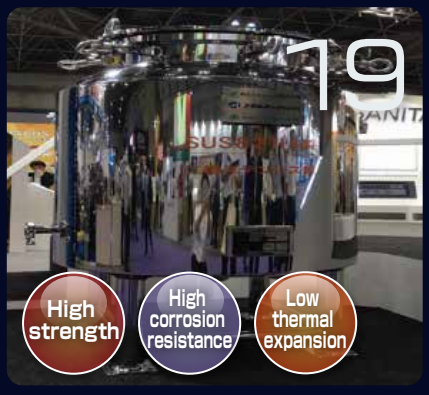
01. Pedestrian overpass (SUS821L1)
02. NS Smart Inspection Walkway (SUS821L1)
NETIS registration No. HK-200018-A
03. Underwater beam (SUS821L1)
Duplex stainless steel, full-thread bolts (NSSC 2120™)
NETIC registration No. CG-200011-A
04. Dam selective water intake equipment (SUS821L1)
05. Drain sluice (SUS323L)

NSSC™ Duplex series

06. Dust remover (SUS821L1)
07. Seawater-resistant screen (SUS327L1)
08. Spray dryer (SUS821L1)
09. PCI coal storage tank (SUS821L1)
10. Tide embankment floodwall gate (SUS821L1)
11. Mega-scale solar panel frame (SUS821L1)
12. Storm surge gate (SUS323L)

Examples of Applications

13. Seawater desalinization equipment (SUS329J3L or other)
14. Chemical tanker (SUS329J3L or other)
15. Vacuum chamber (SUS821L1)
16. Steelmaking service reservoir (SUS329J4L or other)
17. Cylindrical tank (SUS821L1)
18. Food product tank (SUS329J1)
19. Sanitary tank (SUS821L1, SUS329J1, or other)



20. Sterile tray (SUS821L1)
21. Home door frame (SUS821L1)
22. Disaster supply storage facility (SUS821L1 or other)
(Including bolts, nuts, and washers)Duplex stainless steel, full-thread bolts (NSSC 2120™)
NETIS registration No. CG-200011-A
23. Truck cargo bed (SUS821L1, SUS329J1)
24. Balcony railings for high-rise apartment building "Skyplex" (SUS821L1)
25. Factory floor material (SUS821L1)
26. Light suspension bolt (NSSC 2120™)
27. Swimming pool (SUS821L1)

NSSC™Duplex series

Precautions for Use

(1)Forming

- Because these are high-strength stainless steels, formability is not the same as austenitic stainless steel .
- Although drawing is possible to the same shape as austenitic stainless steel , because the deformation load is approximately 10% higher, check the equipment capacity. It may be necessary to adjust dies, lubricating conditions, or other factors.
- Adjustment is necessary when bending due to the large spring-back.
- Cutting performance and drilling performance are equal to or better than austenitic stainless steel .

(2)Welding

- NSSC original duplex stainless steel features greatly improved weldability and allows welding under approximately the same conditions as austenitic stainless steel.
- However special welding material is recommended. Although welding without welding material is possible, it is necessary to check the weld characteristics in advance.

(3)Recommended service temperature

- The recommended service temperature range is -50 to 300°C, narrower than that of austenitic stainless steel (-196 to 850°C).

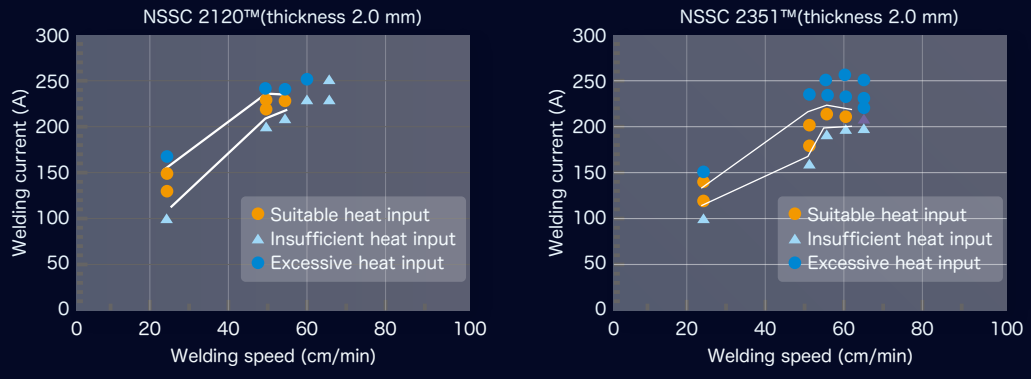
Precautions when welding duplex stainless steel

1. In order to suppress the precipitation of carbonitrides and structural changes, avoid excessive or insufficient welding heat input.
2. Limit the interpass temperature to 100 to 150°C.
3. Because low-temperature cracking caused by hydrogen is possible, avoid the use of H2 in the shield gas.
4. Be sure to fully remove the welding scale.

Welding materials for carbon steel and different stainless steels

		Lean Duplex	Standard Duplex		Super Duplex
		NSSC 2120™ S82122 S32304	NSSC 2351™ S31803 S32205	S31260	S32750
Lean Duplex	NSSC 2120™ S82122 S32304	Similar metal (lean duplex steel) Type2209	Type2209	Type2209	Type2209
Standard Duplex	NSSC 2351™ S31803 S32205	Type2209	Type2209	Type2594	Similar metal (super duplex steel)
	S31260	Type2209	Type2594	Type2594	Similar metal (super duplex steel)
Super Duplex	S32750	Type2209	Similar metal (super duplex steel)	Similar metal (super duplex steel)	Similar metal (super duplex steel)
Austenitic stainless steel	TP304	Type2209 309L/309 309LMo/309Mo	Type2209 309LMo/309Mo	Type2209 309LMo/309Mo	Type2209 309LMo/309Mo
	TP316L	Type2209 309LMo	Type2209 309LMo	Type2209 309LMo	Type2209 309LMo
Carbon steel Low-alloy steel	SS400 SM490 Others	Type2209 309L/309 309LMo/309Mo	Type2209 309L/309 309LMo/309Mo	Type2209 309L/309 309LMo/309Mo	Type2209 309L/309 309LMo/309Mo

Example of suitable TIG welding conditions



Applicable Standards and Other Official Standards

NETIS registration No. QS-120023-VE

NSSC 2120™ registration in NETIS

NSSC 2120™ and S32304 (SUS323L) are the first stainless steel materials to be registered in the New Technology Information System (NETIS) operated by the Ministry of Land, Infrastructure, Transport and Tourism.

QS-120023-VE Lean duplex stainless steel (NSSC 2120™, S32304 (SUS323L))

M-650 ED.4

NORSOK certification

The following duplex stainless steels have been certified as steel suitable for marine structures.

S31803 (MDS D45)
S32205 (MDS D45)
S32750 (MDS D55)

Public standards that can be provided

	NSSC 2120™	SUS323L	NSSC 2351™	SUS329J3L	SUS329J4L	SUS327L1
JIS G 4304: Hot-rolled stainless steel plate, sheet and strip JIS G 4305: Cold-rolled stainless steel plate, sheet and strip	○ SUS821L1	○	○ SUS329J1 (≥2mm thickness)	○	○	○
JIS G 4303: Stainless steel bars JIS G 4308: Stainless steel wire rods	○ SUS821L1 (JIS G 4303)	○ (JIS G 4303)	○ SUS329J1	○	○	○ (JIS G 4303)
JIS B 8265: Construction of pressure vessel – General principles (safety factor 4) JIS B 8267: Construction of pressure vessel (safety factor 3.5)	○ (JIS B 8267)	○ (JIS B 8267)	○ SUS329J1 (≥2mm thickness)	○	○	○ (JIS B 8267)
NK ship class	○ KSUS821L1		○ KSUS329J1	○ KSUS329J3L		
ASTM A240/240M: Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications	○ S82122	○ S32304		○ S31803 S32205	○ S31260	○ S32750

Awards

NSSC 2120™

6th Monodzukuri Nippon Grand Awards
Received the Minister of Economy, Trade and Industry Award.

Monodzukuri
Nippon Grand Awards
Minister of Economy,
Trade and Industry Award

Specifications

Hot-rolled plate (4Hi)

Classification	Grade	0.2% yield strength (MPa)	Tensile strength (MPa)	Elongation (%)	Hardness	
					HB	HRC
Lean Duplex	NSSC 2120™	≧400	≧600	≧30	≦290	≦32
	S82122	≧400	≧600	≧30	≦290	≦32
	S32304	≧400	≧600	≧25	≦290	≦32
Standard Duplex	NSSC 2351™	≧400	≧600	≧25	≦277	≦29
	S31803	≧450	≧620	≧25	≦293	≦31
	S32205	≧450	≧655	≧25	≦293	≦31
Super Duplex	S32750	≧550	≧795	≧15	≦310	≦32
Austenitic	TYPE304	≧205	≧515	≧40	≦201	–
	TYPE316L	≧170	≧485	≧40	≦217	–
	TYPE317L	≧205	≧515	≧40	≦217	–
	S31254	≧310	≧655	≧35	≦223	–

(1MPa=1N/mm²)

Cold-rolled sheet and strip

Classification	Grade	Thickness (mm)	0.2% yield strength (MPa)	Tensile strength (MPa)	Elongation (%)	Hardness		
						HB	HRC	HV
Lean Duplex	NSSC 2120™	<3.0	≧500	≧700	≧25	≦290	≦32	≦320
		≧3.0	≧400	≧600	≧30	≦290	≦32	≦320
	S82122	<3.0	≧500	≧700	≧25	≦290	≦32	-
		≧3.0	≧400	≧600	≧30	≦290	≦32	-
	S32304	-	≧400	≧600	≧25	≦290	≦32	-
Standard Duplex	NSSC 2351™	<2.0	≧400	≧600	≧20	≦302	≦32	≦320
		≧2.0	≧400	≧600	≧20	≦277	≦29	≦292
	S31803		≧450	≧620	≧25	≦293	≦31	-
	S32205	-	≧450	≧655	≧25	≦293	≦31	-
Super Duplex	S32750	-	≧550	≧795	≧15	≦310	≦32	-
Austenitic	TYPE304	-	≧205	≧515	≧40	≦201	-	-
	TYPE316L	-	≧170	≧485	≧40	≦217	-	-
	TYPE317L	-	≧175	≧480	≧40	≦187	-	-
	S31254	<5.0	≧310	≧690	≧35	≦223	-	-

(1MPa=1N/mm²)

Hot-rolled sheet and strip

Classification	Grade	Thickness (mm)	0.2% yield strength (MPa)	Tensile strength (MPa)	Elongation (%)	Hardness		
						HB	HRC	HV
Lean Duplex	NSSC 2120™	>2.0	≧400	≧600	≧25	≦290	≦32	≦320
	S82122	≧3.0	≧400	≧600	≧30	≦290	≦32	-
	S32304	-	≧400	≧600	≧25	≦290	≦32	-
Standard Duplex	NSSC 2351™	<6.0	≧400	≧600	≧20	≦277	≦29	≦292
		≧6.0	≧400	≧600	≧25	≦277	≦29	≦292
	S31803	-	≧450	≧620	≧25	≦293	≦31	-
	S32205	-	≧450	≧655	≧25	≦293	≦31	-
Super Duplex	S32750	-	≧550	≧795	≧15	≦310	≦32	-
Austenitic	TYPE304	-	≧205	≧515	≧40	≦201	-	-
	TYPE316L	-	≧170	≧485	≧40	≦217	-	-
	TYPE317L	-	≧175	≧480	≧40	≦187	-	-
	S31254	<5.0	≧310	≧690	≧35	≦223	-	-

(1MPa=1N/mm²)

Wires and rods

Classification	Grade/UNS	Diameter (mm)	0.2% yield strength (N/mm²)	Tensile strength (N/mm²)	Elongation (%)	Reduction of area(%)	Hardness		
							HB	HRC	HV
Lean Duplex	NSSC 2120™	≦ϕ75	≧400	≧600	≧25	≧40	≦290	≦32	≦310
	SUS821L1	≦ϕ75	≧400	≧600	≧25	≧40	≦290	≦32	≦310
	SUS323L	-	≧400	≧600	≧25	≧40	≦290	≦32	≦310
Standard Duplex	SUS329J1	-	≧390	≧590	≧18	≧40	≦277	≦29	≦292
	SUS329J3L	-	≧450	≧620	≧18	≧40	≦302	≦32	≦320
	TYPE31803	-	≧450	≧620	≧18	≧40	≦302	≦32	≦320
	TYPE32205	-	≧450	≧620	≧18	≧40	≦302	≦32	≦320
	SUS329J4L	-	≧450	≧620	≧18	≧40	≦302	≦32	≦320
Super Duplex	SUS327L1	≦ϕ50.8	≧550	≧800	≧15	≧40	≦310	≦32	≦330
		>ϕ50.8	≧515	≧760	≧15	≧40	≦310	≦32	≦330
Steel for welding	ER2209	-	-	-	-	-	-	-	-
Austenitic	TP304	-	≧205	≧520	≧40	≧60	≦187	-	≦200
	TP316L	-	≧175	≧480	≧40	≧60	≦187	-	≦200
	TP317L	-	≧175	≧480	≧40	≧60	≦187	-	≦200

(1MPa=1N/mm²)

NSSC™ Duplex series

NSSC SOLUTION

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stainless.nipponsteel.com

NSSC SOLUTION

Creating the future one step ahead

NSSC Duplex WEB

NSSC Duplex Search

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+81-3-6841-5290

Biratori Dam sand discharge facility (SUS821L1)

TECHNOLOGY
DEVELOPMENT
QUALITY

Achieve reductions in total costs with NSSC original duplex stainless steel!

Head Office Products Development Division

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