NIPPON STEEL

www.nipponsteel.com/en/

NIPPON STEEL CORPORATION

Head Office	2-6-1 Marunouchi, Chiyoda-ku, Tokyo, 100-8071, Japan	TEL: +81-3-6867-4111
Kansai Works Amagasaki area	1 Higashimukojima Nishino-cho, Amagasaki City, Hyogo Pref., 660-0856, Japan	TEL: +81-6-6411-7600

NIPPON STEEL Stainless Steel Pipe Co., Ltd.

Head Office	Tokyo-Kandasudacho-Building, 2-5, Kandasudacho, Chiyoda-ku, Tokyo, 101-0041, Japan	TEL: +81-3-3254-2436
Sales Division		
(Tokyo)	Tokyo-Kandasudacho-Building, 2-5, Kandasudacho, Chiyoda-ku, Tokyo, 101-0041, Japan	TEL: +81-3-3254-2431
(Osaka)	Midosuji-SG-Building, 6-1 Bakuromachi, 3 Chome, Chuo-ku, Osaka, 541-0059, Japan	TEL: +81-6-7710-5440
Shonan Works	1-14-1, Kawana, Fujisawa City, Kanagawa Pref., 251-0015, Japan	TEL: +81-466-25-7111

HYDREXEL™

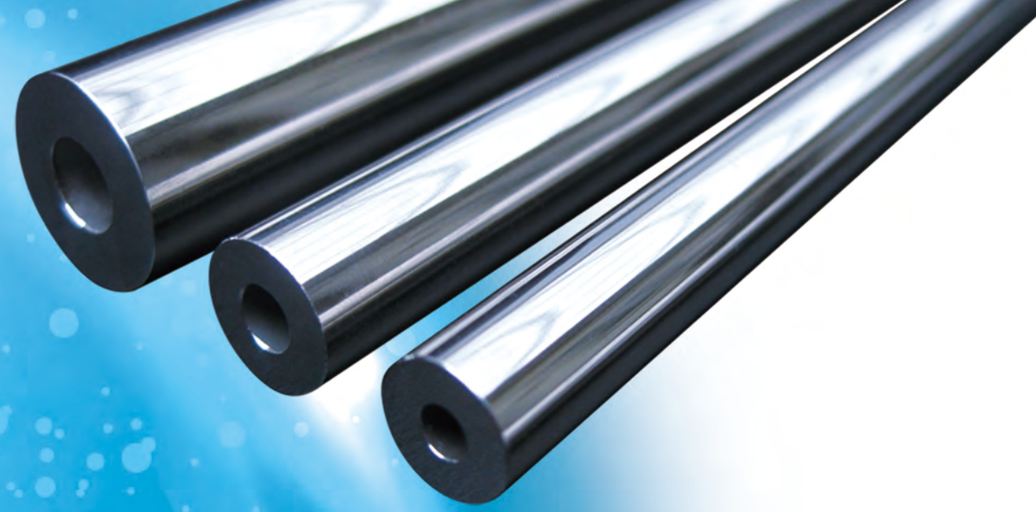
HYDREXEL™ New Specialty Material for High-pressure Gaseous Hydrogen Environments
P106en_03_202503f

NIPPON STEEL

New Specialty Material for High-pressure Hydrogen Environments

HYDREXEL™

NIPPON STEEL CORPORATION
NIPPON STEEL Stainless Steel Pipe Co., Ltd.



HYDREXEL™

Stainless steel for high-pressure hydrogen "HYDREXEL™" will make innovation to the hydrogen-based society.

To supply energy to fuel cell vehicles (FCV), which use hydrogen as the next-generation clean energy, hydrogen stations are being established in the world.
NIPPON STEEL has developed "HYDREXEL™", unique stainless steel with excellent hydrogen embrittlement resistance and high strength for use in high pressure hydrogen environment.
Its features of high strength and welding application availability can be applied most of parts and pipes.
HYDREXEL™, the most suitable material for high-pressure hydrogen environments, makes hydrogen-based society and contributes to zero emission of CO_2.

NIPPON STEEL has utilized its advanced technology to produce high-functionality stainless steel in order to supply high-pressure hydrogen to fuel cell vehicles (FCV).
The color logo uses the beautiful colors of stainless steel (silver gray), a sign of hydrogen and confidence (blue) and thought to the environment at the top right of the "X" (turquoise green).
The colored logo gives the feel of solidity, with shading to show light coming from the left top.
The "HYD" of Hydrogen, "RE" of Revolution, followed by "X" indicate the potential of the coming hydrogen-based society,and the turquoise green suggests the environmental benefits.

■HYDREXEL™ uses different brand names for the domestic trademark (HRX19®) and overseas trademark.

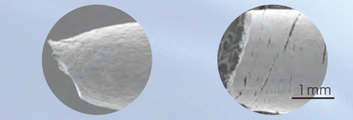
Hydrogen embrittlement resistance

HYDREXEL™ has excellent hydrogen embrittlement resistance even under high pressurized hydrogen gas at low temperature by optimization of chemical compositions.

- Highest hydrogen embrittlement resistance in austenitic stainless steels
- Ni equivalent(*)≧32.09%
- Long term usage under high pressurized hydrogen gas environment
- Free from hydrogen gas leakage and safety improvement of equipment

*Ni equivalent (%) = Ni+0.65Cr+0.98Mo+1.05Mn+0.35Si+12.6C

HYDREXEL™ / Conventional steel



No hydrogen embrittlement / Hydrogen embrittlement

High-strength

HYDREXEL™ can achieve about 1.5 times higher strength than Type 316 (L) . Application of HYDREXEL™ to substitute for Type 316(L) will contribute to increase flow rate of hydrogen gas and decrease filling duration of hydrogen gas by decreasing wall thickness of pipe and expanding inner diameter of pipe.
In addition, it is possible to decrease fabrication cost due to reduce total material weight.

- TS≧800MPa
- About 1.5 times higher strength than Type 316(L)
- Decrease of fabrication cost by weight reduction and filling hydrogen gas with higher flow rate

Conventional steel / New material
Type 316(L) HYDREXEL™

Weldablity

HYDREXEL™ can prevent the leakage of hydrogen gas from fitting portion by applying welding fabrication even high pressurized hydrogen gas environment.

- Similar strength and hydrogen embrittlement resistance of weld to base material.
- Elimination of mechanical fitting by application of welding fabrication.
- Reduction of fabrication cost and maintenance cost
- Improved safety against leakage of hydrogen gas

Chemical Composition

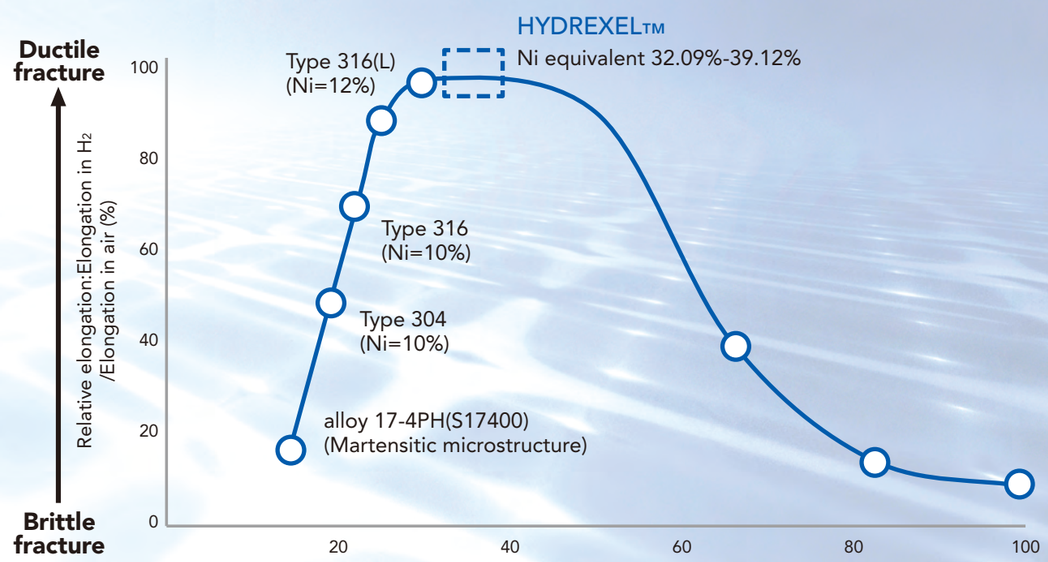
HYDREXEL™ has the optimized chemical composition within the range of XM-19 in ASME/ASTM standards (22%Cr-13%Ni-5%Mn-2%Mo-Nb, V) to improve strength and hydrogen embrittlement resistance.

Chemical Composition (mass %)

Component Range	C	Si	Mn	P	S	Ni	Cr	Mo	V	Nb	N
HYDREXEL™ (Ni equivalent ≧ 32.09%)	0.005 -0.060	0.20 -1.00	4.30 -6.00	0.030 max.	0.001 max.	12.0 -13.5	21.5 -23.5	1.50 -3.00	0.15 -0.30	0.15 -0.30	0.25 -0.40

Hydrogen embrittlement resistance

Hydrogen embrittlement resistance is described by Ni equivalent. HYDREXEL™ has excellent hydrogen embrittlement resistance compared with conventional austenitic stainless steels such as Type 316(L) by higher Ni equivalent than 32.09%.



Ni equivalent(%) = Ni+0.65Cr+0.98Mo+1.05Mn+0.35Si+12.6C

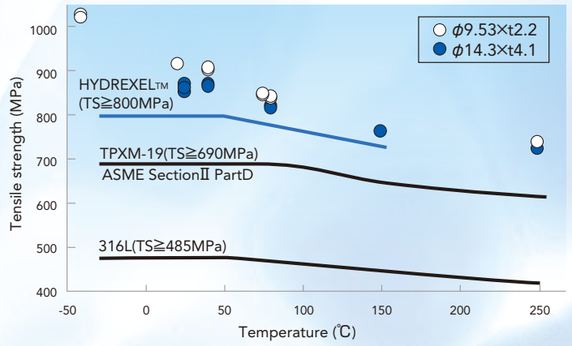
High-strength

- Faster filling duration of hydrogen gas with higher flow rate
- Reduction of material weight by thinner wall thickness of pipe

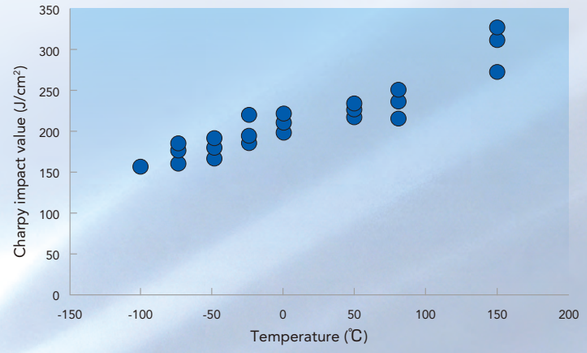
(1) Comparison of mechanical properties

	Yield strength (MPa)	Tensile strength (MPa)	Elongation (%)	Reduction of area (%)
Pipe	≧430	≧800	≧35	–
Rod(≦ϕ100)	≧430	≧800	≧35	≧55
Rod(>ϕ100)	≧380	≧690	≧35	≧55

(2) Tensile strength (TS)



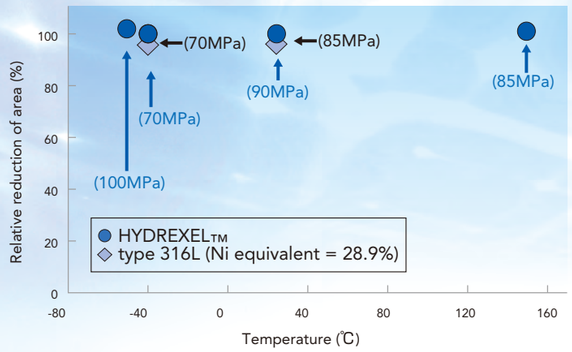
(3) Toughness



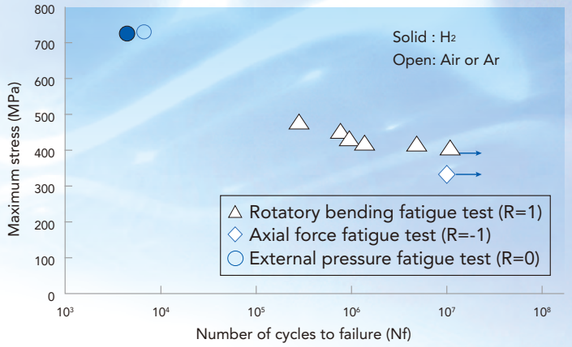
Hydrogen embrittlement resistance

- Excellent hydrogen embrittlement resistance even under high pressurized hydrogen gas at lower temperature
- Reliability for long term operation

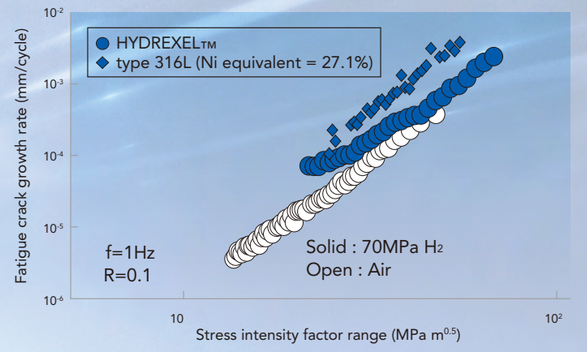
(1) Susceptibility to hydrogen embrittlement (Slow Strain Rate Test)



(2) Fatigue strength



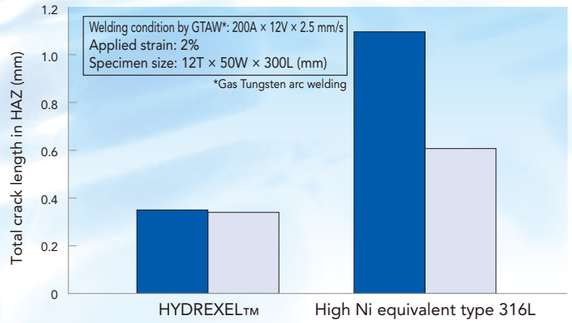
(3) Fatigue crack growth rate



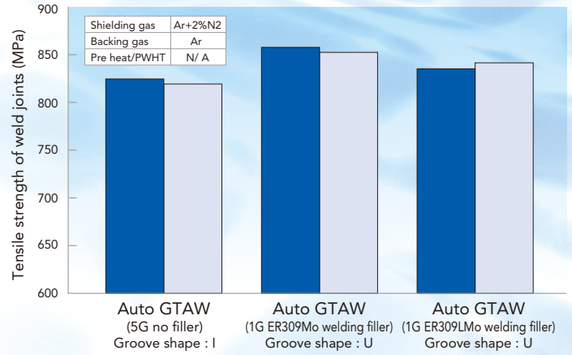
Weldablity

- Dramatic decrease of number of mechanical fittings
- Not required additional wall thickness for machining screw
- Improvement of productivity
  ⇒Fabrication cost saving
- Reliabiity for no leakage of hydrogen gas
  ⇒Maintenance cost saving

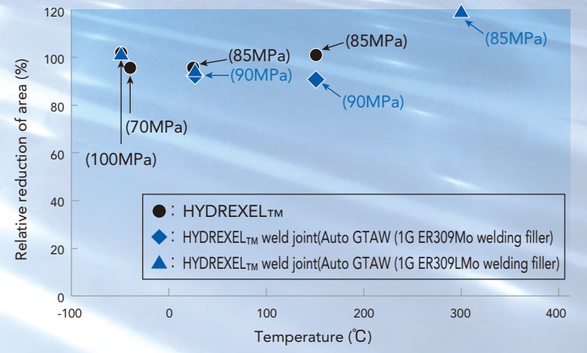
(1) Resistance to weld cracking (longitudinal varestraint test)



(2) Welded joint strength

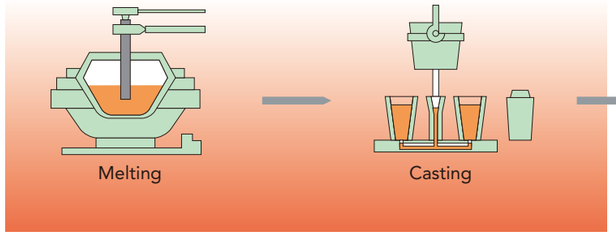


(3) Susceptibility to hydrogen embrittlement for HYDREXEL™ weldment (Slow Strain Rate Test)

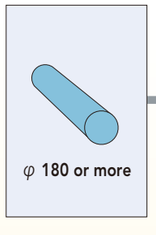


Manufacturing Process of HYDREXEL™

NIPPON STEEL CORPORATION

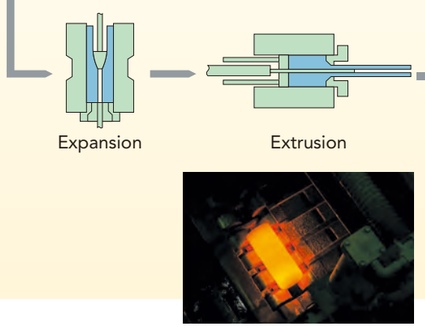


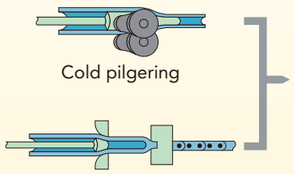
Forging

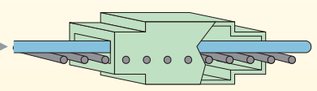


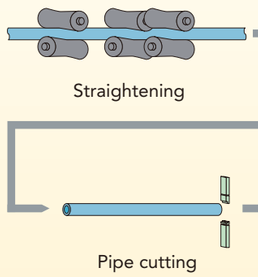
Forging

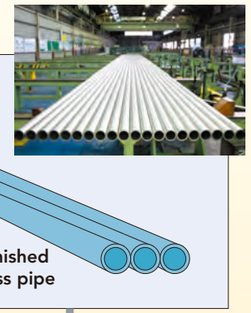
Heat treatment



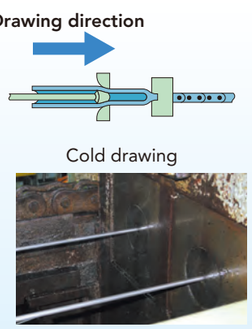


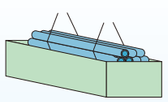


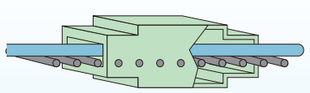


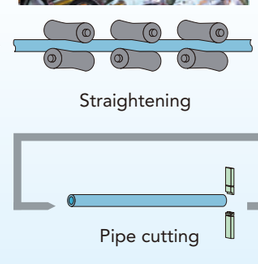


NIPPON STEEL Stainless Steel Pipe Co., Ltd. (Shonan Works)









Feasible Manufacturing Range of HYDREXEL™

NIPPON STEEL CORPORATION

Cold-finished seamless pipe

Nominal diameter (A)	Nominal diameter (B)	Outer diameter (mm)	Wall thickness (mm) 1.2	1.6	2	2.6	3.2	4	4.5	5	5.5	6	7	8	9	10	11	12	13	14	15	17	20	25	30	35	Outer diameter (mm)
		6.0																									6.0
		8.0																									8.0
6	1/8	10.5																									10.5
10	3/8	17.3																									17.3
15	1/2	21.7																									21.7
20	3/4	27.2																									27.2
25	1	34.0																									34.0
	1 1/4	38.1																									38.1
32	1 1/2	42.7																									42.7
40	1 1/4	48.6																									48.6
50	2	60.5																									60.5
65	2 1/2	76.3																									76.3
		82.6																									82.6
80	3	89.1																									89.1
90	3 1/2	101.6																									101.6
100	4	114.3																									114.3
		120.0																									120.0
		130.0																									130.0
125	5	139.8																									139.8
		150.0																									150.0
150	6	165.2																									165.2
		170.0																									170.0
	7	190.7																									190.7
200	8	216.3																									216.3
250	10	267.4																									267.4
300	12	318.5																									318.5
350	14	355.6																									355.6
400	16	406.4																									406.4
(A)	(B)	(mm)	1.2	1.6	2	2.6	3.2	4	4.5	5	5.5	6	7	8	9	10	11	12	13	14	15	17	20	25	30	35	(mm)
Nominal diameter		Outer diameter	Wall thickness (mm)																								Outer diameter

Standard dimensions

Please consult with us

Remarks: Please contact us for details about dimensions not shown on these charts.

NIPPON STEEL Stainless Steel Pipe Co., Ltd.

Cold-finished seamless pipe

Outer diameter (mm)	Wall thickness (mm) 0.1	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	Outer diameter (mm)
1.0																														1.0
2.0																														2.0
3.0																														3.0
4.0																														4.0
5.0																														5.0
6.0																														6.0
7.0																														7.0
8.0																														8.0
9.0																														9.0
10.0																														10.0
11.0																														11.0
12.0																														12.0
13.0																														13.0
14.0																														14.0
15.0																														15.0
16.0																														16.0
17.0																														17.0
18.0																														18.0
19.0																														19.0
20.0																														20.0
21.0																														21.0
22.0																														22.0
23.0																														23.0
24.0																														24.0
25.0																														25.0
26.0																														26.0
27.0																														27.0
28.0																														28.0
29.0																														29.0
30.0																														30.0
31.0																														31.0
32.0																														32.0
33.0																														33.0
34.0																														34.0
(mm)	0.1	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	(mm)
Outer diameter	Wall thickness (mm)																													Outer diameter

Standard dimensions

Please consult with us

Remarks: The strength of steel pipes with an outer diameter of 34 mm or more and round bars with an outer diameter that exceed 100 mm requires separate consultation in accordance with ASME Sec. II-Part D SA-312 TPXM-19 and SA-479 XM-19 (1998).

Rod

Outer diameter and length: upon request
*Results obtained for provision of rods with outer diameter 25 mm to 200 mm.