HYDROGENIUS
水素材料先端科学研究センター

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HYDROGENIUS DATABASE

— SSRT Properties —

No. A105

Database on Slow Strain Rate Test (SSRT) Properties of cold-rolled JIS-SUS316L (316L Type) Austenitic Stainless Steel in 115 MPa Hydrogen Gas

Data Provider: Kyushu University
Nippon Steel Corporation
The Japan Research and Development Center for Metals

2022

Edited by
Research Center for Hydrogen Industrial Use and Storage (HYDROGENIUS)
Kyushu University

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1. MATERIALS

Table 1　Production process and related data of SUS316L.

Heat	Production process	Product form	Dimensions
Q[1)]	Hot-rolled	Plate	Length: ～650 mm　Width: 90 mm Thickness: 20～70 mm
R[1)]	Hot-rolled	Plate	Length: ～650 mm　Width: 90 mm Thickness: 20～70 mm

1) Laboratory-melted steel.

Table 2　Chemical compositions of SUS316L.

	Heat		Element (mass %)									
			C	Si	Mn	P	S	Ni	Cr	Mo	Cu	N
Product analysis	Q[1)]		0.020	0.36	1.39	0.035	0.001	11.98	16.33	2.11	0.15	0.011
	R[1)]		0.020	0.37	1.72	0.035	0.001	12.65	17.58	2.55	0.15	0.011
Ladle analysis	Q[2)]		0.019	0.38	1.39	0.030	0.001	12.00	16.40	2.13	0.15	0.011
	R[2)]		0.019	0.37	1.71	0.031	0.001	12.39	17.51	2.57	0.15	0.011
	Requirement[3)]	max	0.030	1.00	2.00	0.045	0.030	15.00	18.00	3.00		
		min						12.00	16.00	2.00		

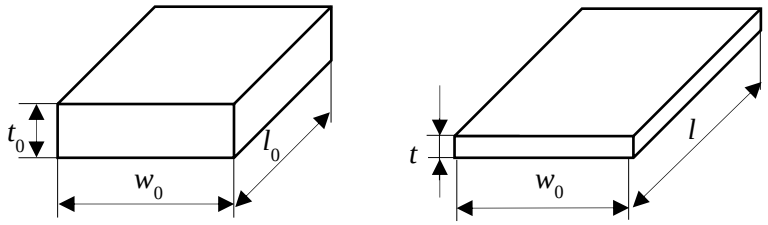
1) Performed by HYDROGENIUS.
2) As reported by Nippon Steel Corp.
3) As per JIS G 4304 (2021), *"Hot-rolled Stainless Steel Plate, Sheet and Strip"*.

Table 3　Heat treatment conditions of SUS316L.

Heat	Heat treatment	Condition
Q[1)]	Solution-treatment	1100°C, 30 min, water quenched
R[1)]	Solution-treatment	1100°C, 30 min, water quenched

1) As reported by Nippon Steel Corp.

Table 4　Cold-rolling process of SUS316L.

<table>
<tr><td>Definition of cold-rolling reduction-ratio, CW (%)</td><td colspan="2">$$CW = \left((t_0 - t) / t_0 \right) \times 100$$
 

Before cold-rolling　　After cold-rolling</td></tr>
<tr><td>True pre-strain, ε_{pre}</td><td colspan="2">$$\varepsilon_{pre} = \ln \frac{A_0}{A} = \ln \frac{1}{1 - (CW / 100)}$$</td></tr>
<tr><td>Heat</td><td>Cold-rolling reduction ratio, CW (%)</td><td>True pre-strain, ε_{pre}</td></tr>
<tr><td rowspan="5">Q</td><td>0</td><td>0</td></tr>
<tr><td>20</td><td>0.22</td></tr>
<tr><td>40</td><td>0.51</td></tr>
<tr><td>50</td><td>0.69</td></tr>
<tr><td>70</td><td>1.20</td></tr>
<tr><td rowspan="5">R</td><td>0</td><td>0</td></tr>
<tr><td>20</td><td>0.22</td></tr>
<tr><td>40</td><td>0.51</td></tr>
<tr><td>50</td><td>0.69</td></tr>
<tr><td>70</td><td>1.20</td></tr>
</table>

2. MECHANICAL PROPERTIES

Table 5 Mechanical properties of SUS316L.

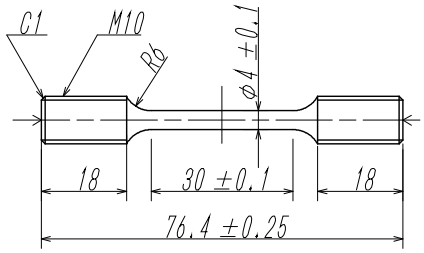
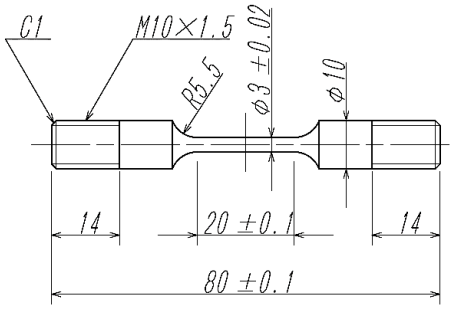
Heat		Cold-Drawing Ratio, *CW* (%)	Tensile Properties				Vickers hardness (*HV*)
			0.2% proof strength $\sigma_{0.2}$ (MPa)	Tensile strength σ_B (MPa)	Elongation ε_f (%)	Reduction of area φ (%)	
Q[1),2)]		0	201	520	81	85	
		20	534	646	49	81	
		40	784	883	20	76	
		50	829	918	20	75	
		70	911	1028	16	72	
R[1),2)]		0	212	523	80	84	
		20	590	661	43	79	
		40	775	870	19	72	
		50	807	922	18	72	
		70	903	1031	14	68	
Requirement[3)]	max						200
	min		175	480	40		

1) As reported by Nippon Steel Corp.
2) Average of 3 times tensile test.
3) As per JIS G 4304 (2021), *"Hot-rolled Stainless Steel Plate, Sheet and Strip"*.

3. SSRT PROPERTIES

Table 6 SSRT conditions.

(a) Kyushu University (CW = 0%, 20%, 40%)

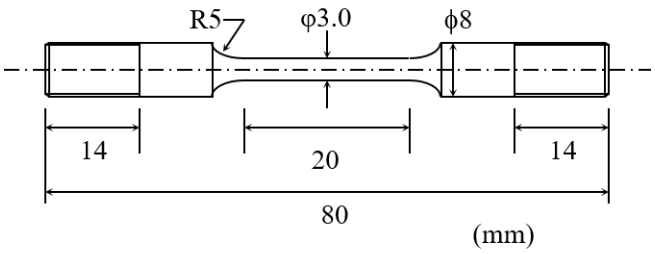
Type and capacity of testing machine	Servo-hydraulic, 50 kN or 100 kN	Screw type, 100 kN
Loading condition	Uniaxial, Monotonic	
Environment	In 115 MPa hydrogen gas at RT and 200°C In 106 MPa hydrogen gas at −45°C In 0.1 MPa nitrogen gas at −45°C In air at 200°C	In air at RT
Gas purity	Hydrogen gas: 99.999% (5N)	
Test speed	1.5×10^{-3} mm/s[2] (5.0×10^{-5} s^{-1})[3] 1.0×10^{-3} mm/s[2] (5.0×10^{-5} s^{-1})[3]	
Specimen[1] (dimensions in mm)	 (a) Type A  (b) Type B	

1) Specimen surface was finished by longitudinal polishing with 600 grade emery paper (LP) or circumferential buffing with a colloidal SiO_2 (0.04 μm) solution (CP).
2) Test speed was determined by crosshead speed.
3) Estimated from crosshead speed divided by the length of parallel section; 30 mm for Type A and 20 mm for Type B. The value of 5.0×10^{-5} s^{-1} is given by 1.5×10^{-3} mm/s / 30 mm or 1.0×10^{-3} mm/s / 20 mm.

(Table continues on the following page)

Table 6　SSRT conditions. (Continued)

(b) Nippon Steel Corporation (*CW* = 0%, 20%, 40%)

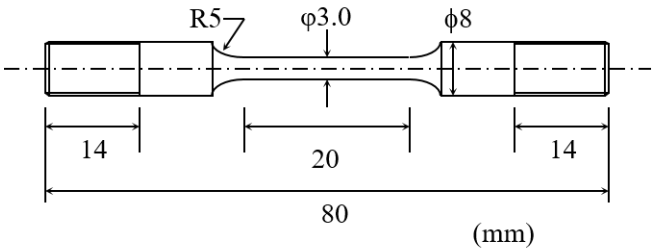
Type and capacity of testing machine	Mechanical-Servo, 10 kN
Loading condition	Uniaxial, Monotonic
Environment	In 90 MPa hydrogen gas at RT In 70 MPa hydrogen gas at −40°C In air at RT In 0.1 MPa nitrogen gas at −40°C
Gas purity	Hydrogen gas: 99.99999% (7N)
Test speed	1.0×10^{-3} mm/s[2] (5.0×10^{-5} s^{-1})[3]
Specimen[1] (dimensions in mm)	

1) Specimen surface was finished by longitudinal polishing with 600 grade emery paper.
2) Test speed was determined by crosshead speed.
3) As determined based on a 20-mm, parallel-length of a specimen. 5.0×10^{-5} s^{-1} is given by (1.0×10^{-3} mm/s) / 20 mm.

(Table continues on the following page)

Table 6　SSRT conditions. (Continued)

(c) The Japan Research and Development Center for Metals (CW = 50%, 70%)

Type and capacity of testing machine	Mechanical-Servo, 10 kN
Loading condition	Uniaxial, Monotonic
Environment	In 90 MPa hydrogen gas at RT In 70 MPa hydrogen gas at −40°C and −50°C In air at RT In 0.1 MPa nitrogen gas at −40°C and −50°C
Gas purity	Hydrogen gas: 99.99999% (7N)
Test speed	1.0×10^{-3} mm/s[2] (5.0×10^{-5} s^{-1})[3] at RT 1.7×10^{-4} mm/s[2] (8.3×10^{-6} s^{-1})[3] at −40°C
Specimen[1] (dimensions in mm)	

1) Specimen surface was finished by longitudinal polishing with 600 grade emery paper.
2) Test speed was determined by crosshead speed.
3) As determined based on a 20-mm, parallel-length of a specimen. 5.0×10^{-5} s^{-1} is given by (1.0×10^{-3} mm/s) / 20 mm.