HYDROGENIUS
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HYDROGENIUS DATABASE

— Fatigue Properties —

No. B36

Database of Fatigue-Strength Properties of
SUS316 (Type 316, over 12 mass% Ni) Austenitic Stainless Steel
in 115-MPa-Hydrogen Gas

2012

Research Center for Hydrogen Industrial Use and Storage (HYDROGENIUS)
Kyushu University - JAPAN

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1. MATERIAL

Table 1. Details of processing and related data of SUS316 (over 12 mass% Ni).

Heat	Production Process	Product Format	Thickness (mm)	Date of Issue
A[1)]	Hot-rolled	Plate	45	2011
B[1)]	Hot-rolled	Plate	45	2011
C[1)]	Hot-rolled	Plate	45	2011

[1)] As reported by JPEC.

Table 2. Chemical composition of SUS316 (over 12 mass% Ni).

	Heat		Element (mass%)							
			C	Si	Mn	P	S	Ni	Cr	Mo
Product Analysis	A[1)]		0.048	0.39	1.43	0.024	0.002	12.46	17.06	2.33
	B[1)]		0.048	0.39	1.44	0.024	0.002	12.36	16.99	2.32
	C[1)]		0.050	0.42	1.38	0.027	0.002	12.42	16.93	2.27
Ladle Analysis	A[1)]		0.049	0.40	1.40	0.025	0.002	12.38	16.98	2.29
	B[1)]		0.048	0.40	1.39	0.025	0.002	12.39	16.94	2.30
	C[1)]		0.050	0.42	1.37	0.024	0.002	12.45	16.98	2.25
	Requirements[2)]	Max.	0.08	1.00	2.00	0.045	0.030	14.00	18.00	3.00
		Min.						10.00	16.00	2.00

[1)] As reported by JPEC.
[2)] As per JIS G 4304:2005, *"Hot-rolled Stainless Steel Plate, Sheet and Strip"*.

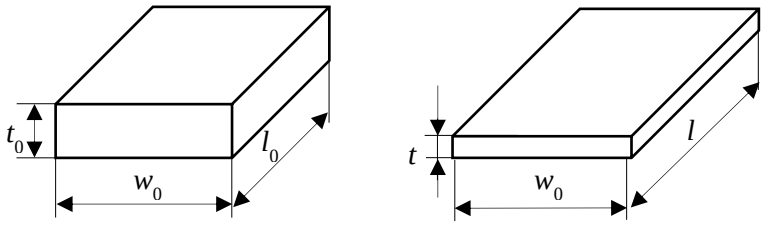
Table 3. Heat-treatment conditions of SUS316 (over 12 mass% Ni).

Heat	Heat-Treatment	Conditions
A[1)]	Solution-treatment	1080°C, 1.1 h, water-quenching
B[1)]	Solution-treatment	1080°C, 1.1 h, water-quenching
C[1)]	Solution-treatment	1080°C, 1.1 h, water-quenching

[1)] As reported by JPEC.

The data on this page are identical to those featured in HYDROGENIUS DATABASE No. 34.

Table 4. Cold-rolling process of SUS316 (over 12 mass% Ni).

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

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="2">A</td><td>0</td><td>0</td></tr>
<tr><td>40</td><td>0.51</td></tr>
<tr><td>B</td><td>20</td><td>0.22</td></tr>
<tr><td rowspan="3">C</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>
</table>

2. MECHANICAL PROPERTIES

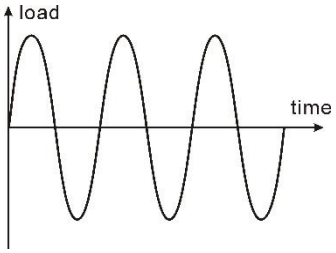
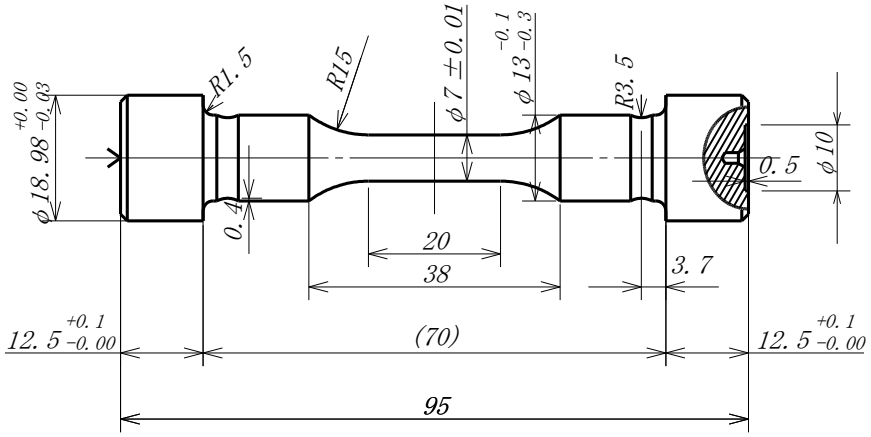
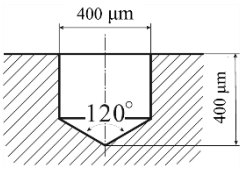
Table 5. Mechanical properties of SUS316 (over 12 mass% Ni).

Heat		Cold-rolling reduction ratio, *CW* (%)	Tensile Properties				Vickers Hardness (*HV*)
			0.2% Proof Stress, $\sigma_{0.2}$ (MPa)	Tensile Strength, σ_B (MPa)	Elongation, ε_f (%)	Reduction of Area, φ (%)	
A[1)]		0	234	520	74	82	127
			236	522	73	83	
		40					
B[1)]		20	590	670	43	79	238
			596	670	42	75	
C[1)]		0	230	541	63	84	134
			234	540	62	84	
		20	653	710	28	80	243
			624	719	25	78	
		40	798	945	16	70	307
			893	936	15	71	
Requirements[2)]	Max.	0					200
	Min.		205	520	40		

[1)] As reported by JPEC and according to JIS Z 2241:2011, *"Metallic materials – Tensile testing – Method of test at room temperature (Foreign Standard)"*, using a No. 14A-type specimen.
[2)] As per JIS G 4304:2005, *"Hot-Rolled Stainless Steel Plates, Sheets and Strip"*.

3. FATIGUE-STRENGTH PROPERTIES

Table 6. Fatigue-test conditions.

Type of test	Uniaxial
Testing machines	• 100 kN servo-hydraulic fatigue machine in gaseous hydrogen and nitrogen up to 120 MPa • 50 kN servo-hydraulic fatigue machine in air
Loading condition	Constant stress amplitude test under zero mean stress ($R = -1$)
Waveform	
	Sinusoidal
Frequency	0.0015 ~ 1 Hz
Environment	• 115-MPa-hydrogen gas, RT • Laboratory air, RT
Gas purity	Hydrogen gas: 99.999%
Specimen	 (a) Fatigue specimen  (b) Small artificial hole (in mm)
	Smooth specimen[2)] Specimen with a small artificial hole[1), 2)]

[1)] Crack length was measured via the replica method.
[2)] The specimen surface was polished by final buffing, using a colloidal SiO_2 (0.04 µm) solution.