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

### 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 <sup>1)</sup>	Hot-rolled	Plate	45	2011
B <sup>1)</sup>	Hot-rolled	Plate	45	2011
C <sup>1)</sup>	Hot-rolled	Plate	45	2011

<sup>1)</sup> 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 <sup>1)</sup>	0.048	0.39	1.43	0.024	0.002	12.46	17.06	2.33
	B <sup>1)</sup>	0.048	0.39	1.44	0.024	0.002	12.36	16.99	2.32
	C <sup>1)</sup>	0.050	0.42	1.38	0.027	0.002	12.42	16.93	2.27
Ladle Analysis	A <sup>1)</sup>	0.049	0.40	1.40	0.025	0.002	12.38	16.98	2.29
	B <sup>1)</sup>	0.048	0.40	1.39	0.025	0.002	12.39	16.94	2.30
	C <sup>1)</sup>	0.050	0.42	1.37	0.024	0.002	12.45	16.98	2.25
	Requirements <sup>2)</sup>	Max.	0.08	1.00	2.00	0.045	0.030	14.00	18.00
Min.							10.00	16.00	2.00

<sup>1)</sup> As reported by JPEC.

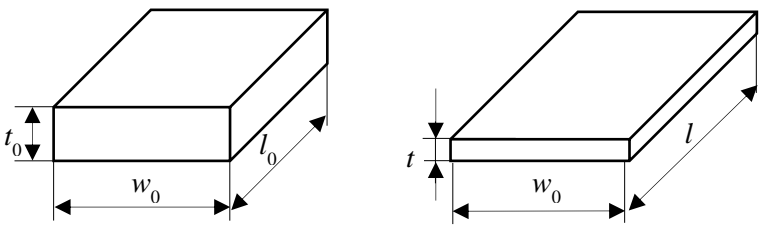
<sup>2)</sup> As per JIS G 4304:2005, "Hot-rolled Stainless Steel Plate, Sheet and Strip".

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

Heat	Heat-Treatment	Conditions
A <sup>1)</sup>	Solution-treatment	1080°C, 1.1 h, water-quenching
B <sup>1)</sup>	Solution-treatment	1080°C, 1.1 h, water-quenching
C <sup>1)</sup>	Solution-treatment	1080°C, 1.1 h, water-quenching

<sup>1)</sup> As reported by JPEC.

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

<p>Definition of cold-rolling reduction ratio, <math>CW</math> (%)</p>	$CW = ((t_0 - t) / t_0) \times 100$  <p>Before cold-rolling                      After cold-rolling</p>	
<p>True pre-strain, <math>\epsilon_{pre}</math></p>	$\epsilon_{pre} = \ln \frac{A_0}{A} = \ln \frac{1}{1 - (CW / 100)}$	
<p>Heat</p>	<p>Cold-rolling reduction ratio, <math>CW</math> (%)</p>	<p>True pre-strain, <math>\epsilon_{pre}</math></p>
<p>A</p>	<p>0</p>	<p>0</p>
	<p>40</p>	<p>0.51</p>
<p>B</p>	<p>20</p>	<p>0.22</p>
<p>C</p>	<p>0</p>	<p>0</p>
	<p>20</p>	<p>0.22</p>
	<p>40</p>	<p>0.51</p>

## 2. MECHANICAL PROPERTIES

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

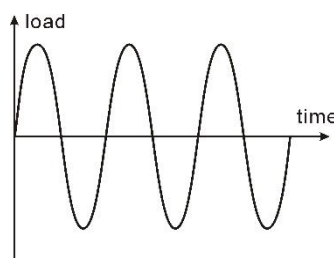
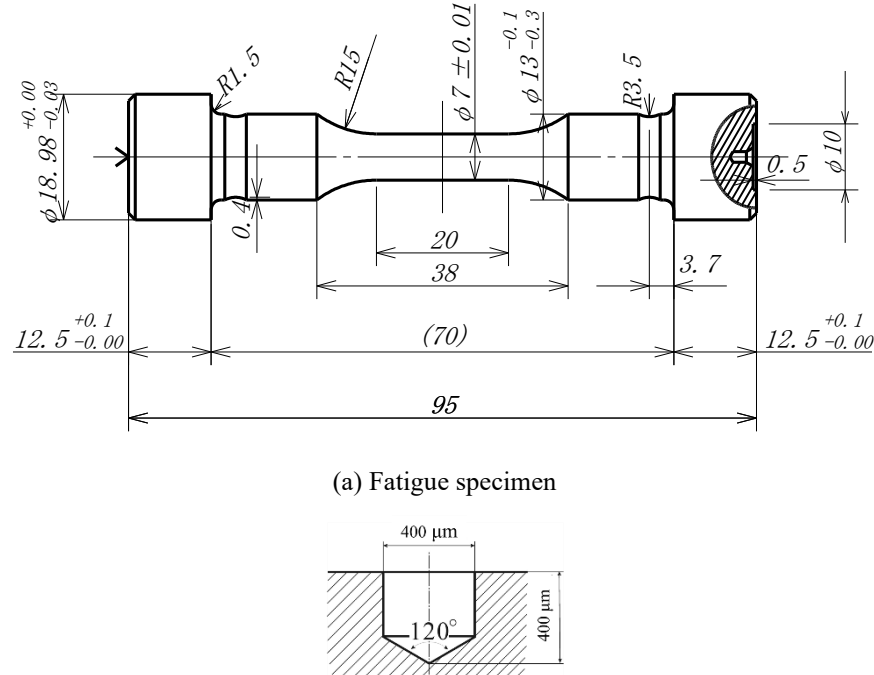
Heat	Cold-rolling reduction ratio, CW (%)	Tensile Properties				Vickers Hardness (HV)
		0.2% Proof Stress, $\sigma_{0.2}$ (MPa)	Tensile Strength, $\sigma_B$ (MPa)	Elongation, $\epsilon_f$ (%)	Reduction of Area, $\phi$ (%)	
A <sup>1)</sup>	0	234	520	74	82	127
		236	522	73	83	
	40					
B <sup>1)</sup>	20	590	670	43	79	238
		596	670	42	75	
C <sup>1)</sup>	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 <sup>2)</sup>	Max.	0				200
	Min.		205	520	40	

<sup>1)</sup> 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.

<sup>2)</sup> 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	<ul style="list-style-type: none"> <li>• 100 kN servo-hydraulic fatigue machine in gaseous hydrogen and nitrogen up to 120 MPa</li> <li>• 50 kN servo-hydraulic fatigue machine in air</li> </ul>
Loading condition	Constant stress amplitude test under zero mean stress ( $R = -1$ )
Waveform	
	Sinusoidal
Frequency	0.0015 ~ 1 Hz
Environment	<ul style="list-style-type: none"> <li>• 115-MPa-hydrogen gas, RT</li> <li>• Laboratory air, RT</li> </ul>
Gas purity	Hydrogen gas: 99.999%
Specimen	 <p>(a) Fatigue specimen</p> <p>(b) Small artificial hole (in mm)</p> <p>Smooth specimen<sup>2)</sup></p> <p>Specimen with a small artificial hole<sup>1), 2)</sup></p>

<sup>1)</sup> Crack length was measured via the replica method.

<sup>2)</sup> The specimen surface was polished by final buffing, using a colloidal SiO<sub>2</sub> (0.04 μm) solution.