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HYDROGENIUS DATABASE
— Fatigue Crack-Growth Properties —

No. B65

Database of Long, Fatigue Crack-Growth Properties of Hydrogen-
Charged JIS-SUS304 (Type 304) Austenitic Stainless Steel
in Air

2017

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

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Database of Long, Fatigue Crack-Growth Properties of Hydrogen-Charged JIS-SUS304 (Type 304) Austenitic Stainless Steel in Air

1. MATERIAL

Table 1. Details of processing and related data of SUS304.

| Heat | Production Process | Product Format | Dimensions (mm) |
|-----------------|--------------------|----------------|---|
| V ¹⁾ | Hot-rolled | Plate | Length: 7000 mm Width: 3100 mm Thickness: 30 mm |

¹⁾ As reported by the manufacturer.

Table 2. Chemical composition of SUS304.

| | Heat | Element (mass%) | | | | | | | |
|------------------|----------------------------|-----------------|------|------|-------|-------|-------|-------|-------|
| | | C | Si | Mn | P | S | Ni | Cr | |
| Product Analysis | V ¹⁾ | 0.04 | 0.53 | 1.32 | 0.025 | 0.002 | 8.15 | 18.70 | |
| Ladle Analysis | V ²⁾ | 0.04 | 0.57 | 1.22 | 0.023 | 0.002 | 8.09 | 18.15 | |
| | Requirements ³⁾ | Max. | 0.08 | 1.00 | 2.00 | 0.045 | 0.030 | 10.50 | 20.00 |
| | | Min. | | | | | | 8.00 | 18.00 |

¹⁾ As performed by NIMS.

²⁾ As reported by the manufacturer.

³⁾ As per JIS G 4304:2005, "Hot-rolled Stainless Steel Plate, Sheet and Strip".

Table 3. Heat-treatment conditions of SUS304.

| Heat | Heat-treatment | Conditions |
|-----------------|--------------------|------------------------------|
| V ¹⁾ | Solution-treatment | 1080°C, 3 min, water-cooling |

¹⁾ As reported by the manufacturer.

It should be noted that the following data are identical to those featured in HYDROGENIUS DATABASE No. 38, Tables 1, 2, 3 and 4.

2. MECHANICAL PROPERTIES

Table 4. Mechanical properties of SUS304.

| Heat | 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 (%) | |
| V ¹⁾ | 276 | 658 | 63 | | |
| Requirements ²⁾ | Max. | | | | 200 |
| | Min. | 205 | 520 | 40 | 60 |

¹⁾ As reported by the manufacturer.

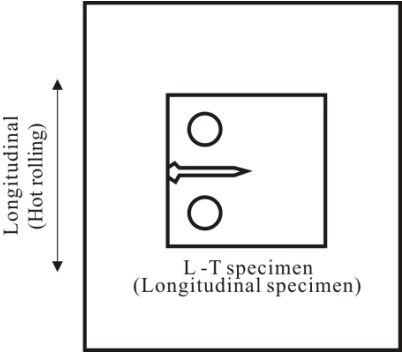
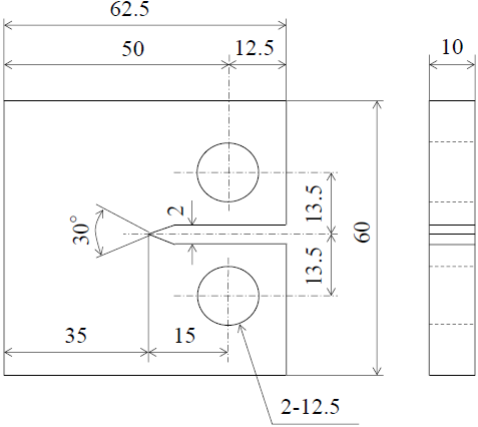
²⁾ As per JIS G 4304:2005, "Hot-rolled Stainless Steel Plate, Sheet and Strip".

It should be noted that the following data are identical to those featured in HYDROGENIUS DATABASE No. 38, Tables 1, 2, 3 and 4.

3. FATIGUE CRACK-GROWTH PROPERTIES

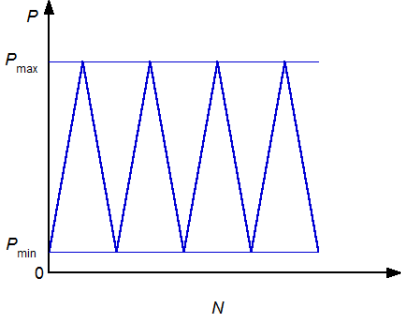
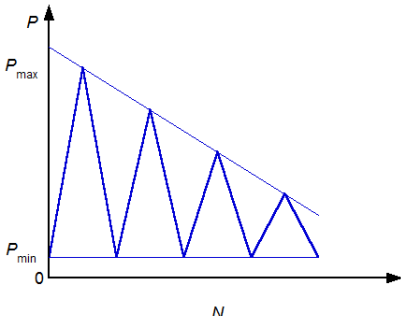
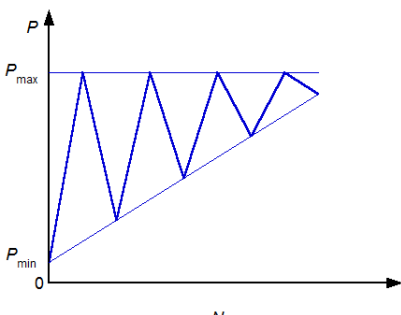
Table 5. Fatigue crack-growth test-conditions.

| | |
|---------------------------------------|--|
| Type and capacity of testing machines | 50 kN, servo-hydraulic fatigue machine 10 kN, servo-hydraulic fatigue machine |
| Loading conditions | Uniaxial, Sinusoidal |
| Environment | Laboratory air, RT |
| Frequency | 0.1 ~ 30 Hz |

| | |
|-----------------------------|--|
| Specimens ^{1), 2)} |  <p>(a) Sampling of CT specimens</p> |
| |  <p>(b) Shape and dimensions of CT specimens (in mm)</p> |

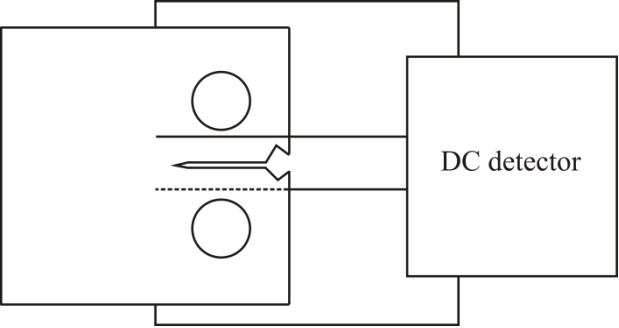
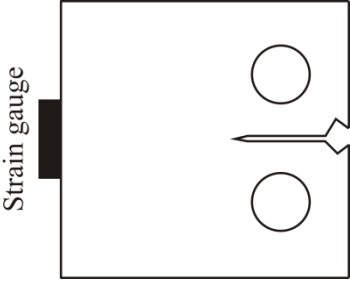
(Table continues on the following page)

Table 5. Fatigue crack-growth test-conditions. (Continued)

| | | |
|-----------------------|--|--|
| ΔK conditions |  | $\Delta P = P_{\max} - P_{\min}$ $R = P_{\min} / P_{\max}$ |
| | (a) ΔP -constant ΔK -increasing | |
| |  | $\Delta P = P_{\max} - P_{\min}$ $R = P_{\min} / P_{\max}$ |
| | (b) R -constant ΔK -decreasing | |
| |  | $\Delta P = P_{\max} - P_{\min}$ $R = P_{\min} / P_{\max}$ |
| | (c) P_{\max} -constant ΔK -decreasing | |
| | $\Delta K = \frac{\Delta P}{B\sqrt{W}} \frac{(2 + \alpha)}{(1 - \alpha)^{3/2}} (0.886 + 4.64\alpha - 13.32\alpha^2 + 14.72\alpha^3 - 5.6\alpha^4) \quad (1)^2$ | |
| | ΔP : Force range W : Width B : Thickness a : Crack size $\alpha = a/W$ | |

(Table continues on the following page)

Table 5. Fatigue crack-growth test-conditions. (Continued)

| | |
|--------------------------|---|
| Crack-length measurement |  <p>(a-1) 10 kN, servo-hydraulic fatigue machine</p>  <p>(a-2) 50 kN, servo-hydraulic fatigue machine</p> <p>(a) Potential-drop method</p> |
|--------------------------|---|

¹⁾ The specimen surface was finished by buffing, using a colloidal SiO₂ (0.04 μm) solution.

²⁾ According to ASTM E647 - 08e1, "Standard test method for measurement of fatigue crack growth rates".

Table 6. Hydrogen-charging conditions of CT specimens.

| | |
|---------------------|---|
| Hydrogen exposure | 68-MPa-hydrogen gas at a temperature of 300°C |
| Hydrogen-gas purity | 99.999% (5N) |
| Holding time | 245 h |

Table 7. Hydrogen-measurement conditions of fractured CT specimens.

| | |
|------------------------------|---|
| Specimen shape | Plate with a length of 15 mm, a width of 10 mm and a thickness of 10 mm, cut from a fractured CT specimen |
| Type of hydrogen measurement | Thermal desorption analysis, TDA |
| Heating rate | 100°C/h |
| Hydrogen-detection accuracy | 0.3 Vol. ppm |