HYDROGENIUS
水素材料先端科学研究センター

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HYDROGENIUS DATABASE

— Fatigue Crack-Growth Properties —

No. A17

Database of Long, Fatigue Crack-Growth Properties of JIS-SNCM439 Low-Alloy Steel for Use in a Storage Cylinder at a 70-MPa-Hydrogen Station

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

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1. MATERIAL

Table 1. Processing details and related properties of SNCM439.

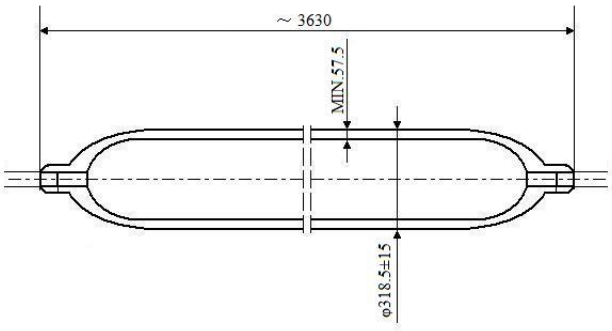


Table 2. Chemical composition of SNCM439.

			Element (mass%, *mass ppm)								
			C	Si	Mn	P	S	Ni	Cr	Mo	H*
Product Analysis[1)]	Inside		0.43	0.28	0.82	0.004	0.002	1.95	0.90	0.23	0.0
	Outside		0.43	0.27	0.82	0.005	0.002	1.95	0.91	0.23	
Ladle Analysis[2)]			0.42	0.26	0.80	0.01	< 0.01	1.91	0.89	0.25	
	Requirements[3)]	Max.	0.43	0.35	0.90	0.030	0.030	2.00	1.00	0.30	
		Min.	0.36	0.15	0.60			1.60	0.60	0.15	

[1)] As performed at HYDROGENIUS.
[2)] After issuance of the inspection certificate.
[3)] According to JIS G 4053:2008, *"Low-Alloyed Steels for Machine Structural Use"*.

Table 3. Heat treatment[1)].

Quenching	Tempering
Barrel furnace	Barrel furnace
860°C, Water-spraying	620°C, Air-cooling
3.30 ～ 3.50 BHD (Target hardness)	

[1)] As reported by the manufacturer.

It should be noted that the following data are identical to those in HYDROGENIUS DATABASE No.8: Tables 1, 2, 3, 4 and 5 and Image 1.

3. MECHANICAL PROPERTIES

Table 4. Tensile properties of SNCM439.

$\sigma_{0.2}$: 0.2% Proof strength
σ_B : Tensile strength
δ : Uniform elongation
φ : Reduction of area

(a) Circumferential direction (Inner)

$\sigma_{0.2}$ (MPa)	σ_B (MPa)	δ (%)	φ (%)
772	910	7.1	49.6

(b) Circumferential direction (Outer)

$\sigma_{0.2}$ (MPa)	σ_B (MPa)	δ (%)	φ (%)
808	927	8.3	55.3

(c) Longitudinal direction (Inner)

$\sigma_{0.2}$ (MPa)	σ_B (MPa)	δ (%)	φ (%)
750	903	8.6	60.1

(d) Longitudinal direction (Outer)

$\sigma_{0.2}$ (MPa)	σ_B (MPa)	δ (%)	φ (%)
801	933	8.2	60.4

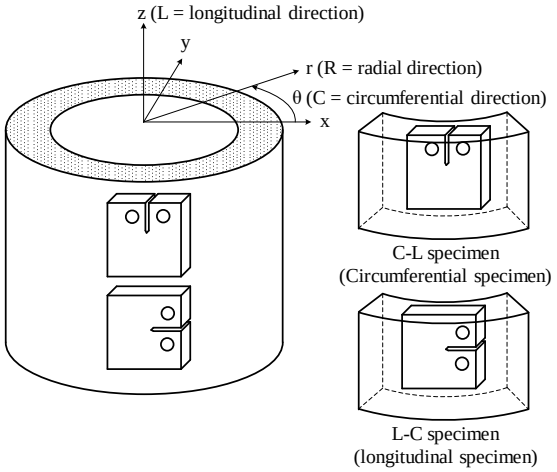
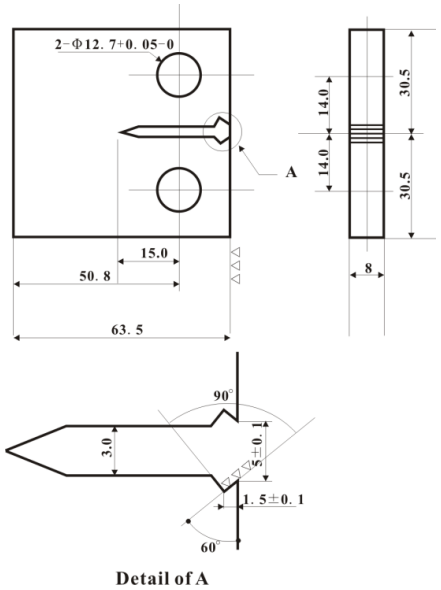
Table 5. Average Vickers hardness value of SNCM439.

$\overline{HV}$
292

It should be noted that the following data are identical to those in HYDROGENIUS DATABASE No.8: Tables 1, 2, 3, 4 and 5 and Image 1.

4. LONG, FATIGUE CRACK-GROWTH PROPERTIES

Table 6. Fatigue crack-growth test conditions.

Type and capacity of testing machine	100 kN servo-hydraulic fatigue machine in 120-MPa-hydrogen and 120-MPa-nitrogen gas 50 kN servo-hydraulic fatigue machine in 0.1-MPa-hydrogen and 0.1-MPa-nitrogen gas 30 kN servo-hydraulic fatigue machine in air
Loading conditions	Uniaxial, Sinusoidal
Environment	Room temperature, 0.6 ~ 90-MPa-hydrogen gas (absolute pressure) Room temperature, laboratory air
Frequency	0.01 ~ 20 Hz
Specimens[1)]	 (a) Sampling of CT specimens  (b) Shape and dimensions of CT specimens (in mm)

(Table continues on the following page)

Table 6. Fatigue crack-growth test conditions. (Continued)

Loading conditions[2)]	① ΔK - decreasing / ΔK decreasing rate : $d\Delta K/da = -2$ GPa·m$^{-1/2}$ ② ΔK - increasing / ΔK increasing rate : $d\Delta K/da = 2$ GPa·m$^{-1/2}$ ③ ΔK - constant ④ ΔP - constant / ΔK - increasing $\Delta K = \frac{\Delta P}{B\sqrt{W}} \frac{(2+\alpha)}{(1-\alpha)^{3/2}} (0.886 + 4.64\alpha - 13.32\alpha^2 + 14.72\alpha^3 - 5.6\alpha^4)$ (1) ΔP: Force range W: Width B: Thickness a: Crack size $\alpha = a/W$
Crack-length measurement[2)]	Compliance method with clip-on gage $a = W\left(C_0 + C_1 u_x + C_2 u_x^{\ 2} + C_3 u_x^{\ 3} + C_4 u_x^{\ 4} + C_5 u_x^{\ 5}\right)$ (2) $u_x = \left\{ \left[\frac{EvB}{P} \right]^{\frac{1}{2}} + 1 \right\}^{-1}$ (3) W: Width E: Elastic modulus v: Displacement between measurement points B: Thickness P: Force $C_0 = 1.0010$ $C_1 = -4.6695$ $C_2 = 18.460$ $C_3 = -236.82$ $C_4 = 1214.9$ $C_5 = -2143.6$

[1)] The specimen surface was polished by final buffing using a colloidal SiO_2 (0.04 μm) solution.
[2)] As per ASTM E647 - 08e1, *"Standard test method for measurement of fatigue crack growth rates"*.