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HYDROGENIUS DATABASE
— Fatigue Crack-Growth Properties —

No. B16

Database of Long, Fatigue Crack-Growth Properties of JIS-SCM435
Low-Alloy Rolled Steel for Use in a 20-MPa-Hydrogen Storage Cylinder

April 2010

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

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Database of Long, Fatigue Crack-Growth Properties of JIS-SCM435 Low-Alloy Rolled Steel for Use in a 20-MPa-Hydrogen Storage Cylinder

1. MATERIAL

Table 1. Related properties of SCM435.

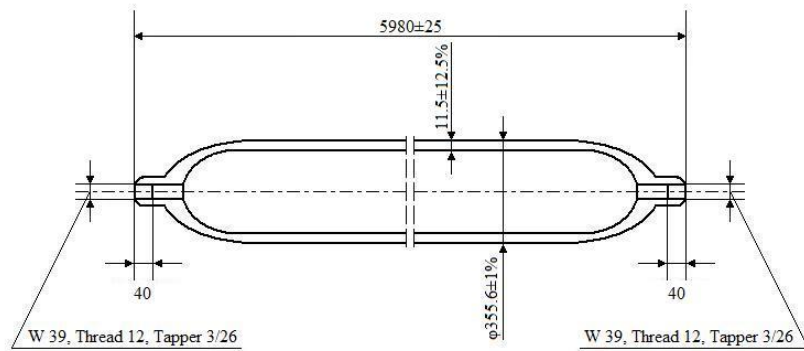


Table 2. Chemical composition of SCM435.

		Element (mass%)							
		C	Si	Mn	P	S	Cr	Mo	
Product Analysis	Present Material ¹⁾	0.30	0.32	0.62	0.029	0.011	0.91	0.19	
Ladle Analysis	Requirements ²⁾	Max.	0.38	0.35	0.85	0.030	0.030	1.20	0.30
		Min.	0.33	0.15	0.60			0.90	0.15

¹⁾ As performed at HYDROGENIUS.

²⁾ According to JIS G 3441:1988, "Alloy Steel Tubes for Machine Purpose".

Table 3. Heat-treatment conditions.

Quenching	Tempering

2. MECHANICAL PROPERTIES

Table 4. Mechanical properties and hydrogen content of SCM435.

$\sigma_{0.2}$: 0.2% Proof strength
 σ_B : Tensile strength
 ε_u : Uniform elongation
 ε_f : Total elongation
 φ : Reduction of area
 C_H : Hydrogen content

(a) Circumferential direction (C-specimens)

	Tensile properties					Hydrogen content
	$\sigma_{0.2}$ (MPa)	σ_B (MPa)	ε_u (%)	ε_f (%)	φ (%)	C_H (mass ppm)
Uncharged	650	807	7.1	17.3	60.9	0.0

(b) Longitudinal direction (L-specimens)

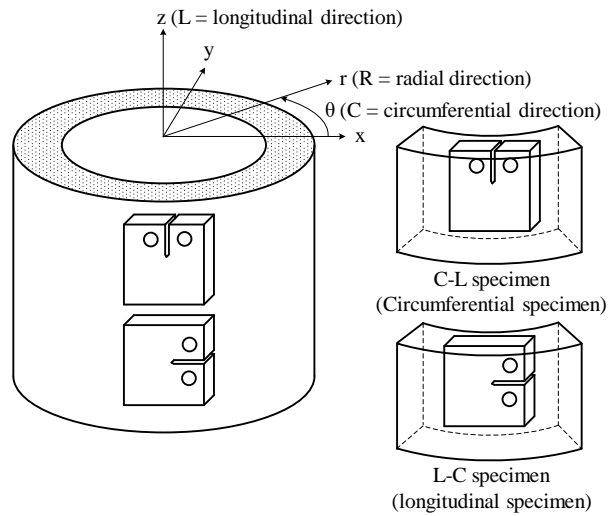
	Tensile properties					Hydrogen content
	$\sigma_{0.2}$ (MPa)	σ_B (MPa)	ε_u (%)	ε_f (%)	φ (%)	C_H (mass ppm)
Uncharged	655	801	6.5	17.1	66.1	0.0

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

3. FATIGUE CRACK-GROWTH PROPERTIES

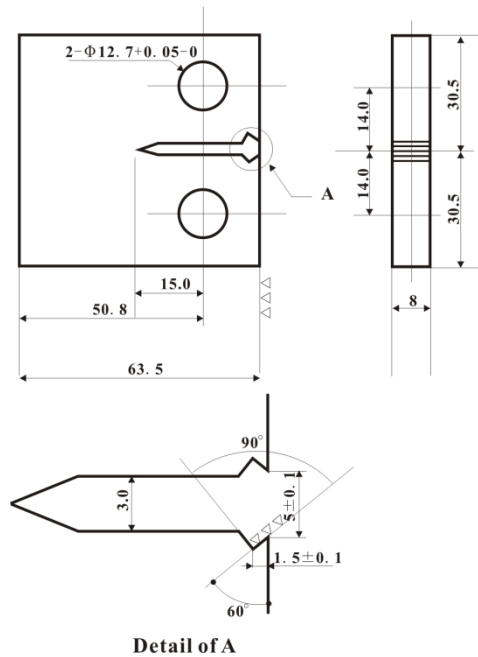
Table 5. Fatigue crack-growth test conditions.

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	1 ~ 20 Hz



(a) Sampling of CT specimens

Specimens



(b) Shape and dimensions of CT specimens (in mm)

(Table continues on the following page)

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

<p>Loading conditions</p>	<p>① ΔK - decreasing , ΔK decreasing rate : $d\Delta K/da = -2 \text{ GPa} \cdot \text{m}^{-1/2}$</p> <p>② ΔK - constant</p> <p>③ ΔP - constant</p> $\Delta K = \frac{\Delta P}{B\sqrt{W}} \frac{(2 + \alpha)}{(1 - \alpha)^{3/2}} (0.886 + 4.64\alpha - 13.32\alpha^2 + 14.72\alpha^3 - 5.6\alpha^4) \quad (1)$ <p>ΔP: Force range</p> <p>W: Width</p> <p>B: Thickness</p> <p>a: Crack size</p> <p>$\alpha = a/W$</p>
<p>Crack-length measurement</p>	<p>Compliance method with clip-on gage</p> $a = W(C_0 + C_1u_x + C_2u_x^2 + C_3u_x^3 + C_4u_x^4 + C_5u_x^5) \quad (2)$ $u_x = \left\{ \left[\frac{EvB}{P} \right]^{\frac{1}{2}} + 1 \right\}^{-1} \quad (3)$ <p>W: Width</p> <p>E: Elastic modulus</p> <p>v: Displacement between measurement points</p> <p>B: Thickness</p> <p>P: Force</p> <p>$C_0 = 1.0010$</p> <p>$C_1 = -4.6695$</p> <p>$C_2 = 18.460$</p> <p>$C_3 = -236.82$</p> <p>$C_4 = 1214.9$</p> <p>$C_5 = -2143.6$</p>