DOI: 10.48708/4756014

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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Year of publication: 2010

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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.

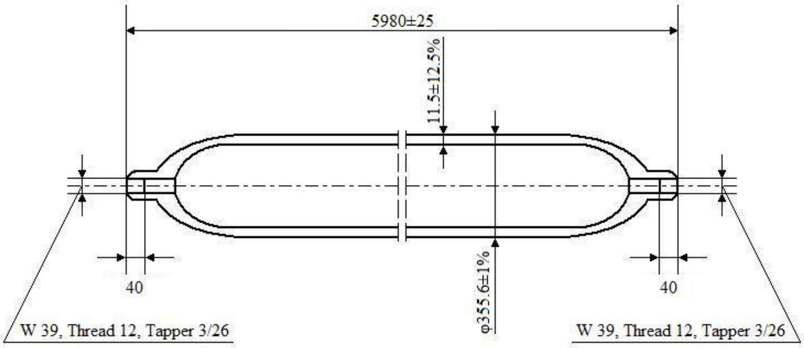


Table 2. Chemical composition of SCM435.

			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

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

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

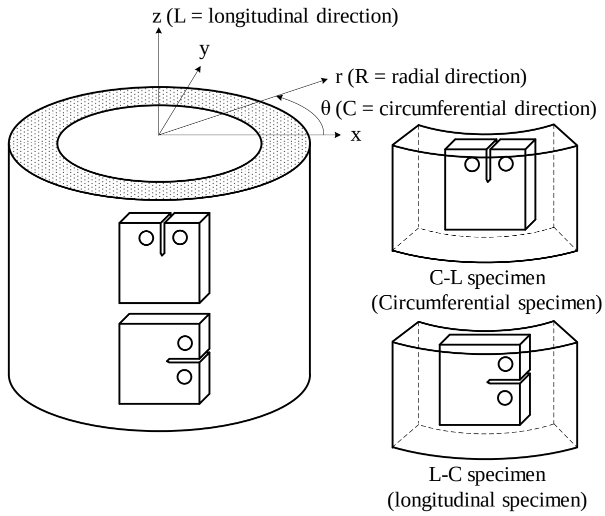
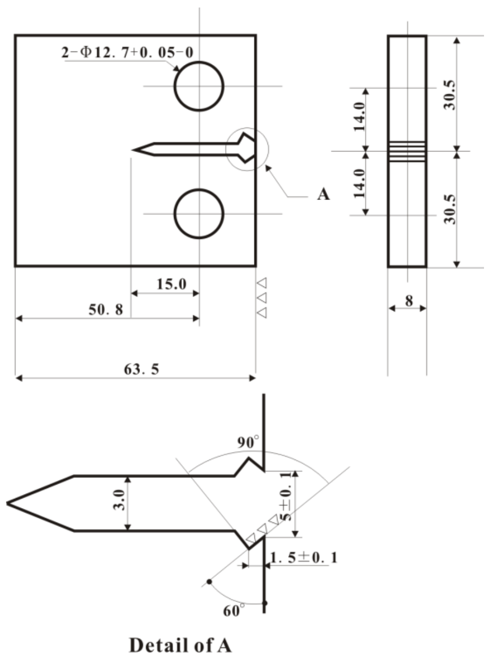
(b) Longitudinal direction (L-specimens)

	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
Specimens	 (a) Sampling of CT specimens  (b) Shape and dimensions of CT specimens (in mm)

(Table continues on the following page)

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

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