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HYDROGENIUS DATABASE

— Mechanical Properties —

No. A8

Database of Mechanical and Hydrogen Transport Properties
of JIS-SNCM439 Low-Alloy Steel for Use in a Storage Cylinder
at a 70-MPa-Hydrogen Station

2012

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

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Low-Alloy Steel for Use in a Storage Cylinder at a 70-MPa-Hydrogen Station

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Kyushu University

HYDROGENIUS

- Fatigue and Fracture Department

MATSUOKA Saburo (Leader)

MATSUNAGA Hisao

YAMABE Junichiro

HAMADA Shigeru

ITOGA Hisatake

AWANE Tohru

YOSHIKAWA Michio

HYDROGENIUS Executive Staff

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KURIYAMA Nobuhiro (Vice-Director)

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

744 Motooka, Nishi-ku, Fukuoka-city, Fukuoka, 819-0395, JAPAN

Tel.: +81-92-802-3921 Fax: +81-92-802-3928

E-mail: db@hydrogenius.kyushu-u.ac.jp

Database of Mechanical and Hydrogen Transport Properties of JIS-SNCM439 Low-Alloy Steel for Use in a Storage Cylinder at a 70-MPa-Hydrogen Station

1. MATERIAL

Table 1. Processing details and related properties of SNCM439.

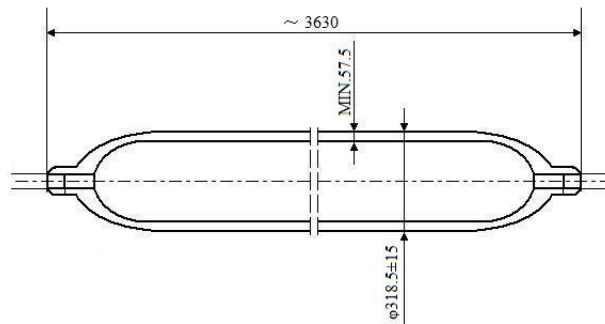


Table 2. Chemical composition of SNCM439.

		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⁾ As per JIS G 4053:2008, "Low-Alloyed Steels for Machine Structural Use".

Table 3. Heat-treatment of SNCM439¹⁾.

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.

2. MICROSTRUCTURES

Table 4. Conditions for microstructural observation.

	Optical	Nital (Nitric acid : 3%, Ethyl alcohol : 97%)
Surface Preparation	EBSD (Electron Backscatter Diffraction)	Colloidal silica solution Acceleration voltage : 25 kV
Sampling ¹⁾	<p>z (L = longitudinal direction)</p> <p>y</p> <p>r (R = radial direction)</p> <p>θ (C = circumferential direction)</p> <p>x</p> <p>Longitudinal direction (z - axis direction)</p> <p>L-R plane (θ - axis direction)</p> <p>R-C plane (z - axis direction)</p> <p>L-C plane (r - axis direction)</p> <p>Longitudinal direction (z - axis direction)</p> <p>Outer diameter : 320 mm</p> <p>Thickness : 60.0 mm</p>	

¹⁾ Specimens for microstructural observation were sampled from a storage cylinder at a hydrogen station.

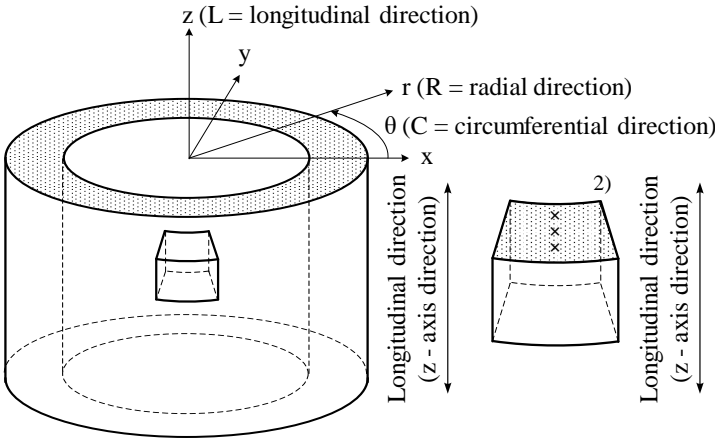
3. HYDROGEN CONTENT

Table 5. Hydrogen-exposure and hydrogen-content measurement conditions.

(a) Hydrogen-exposure conditions	
High-pressure vessel	<p>Gases : Hydrogen, Nitrogen, Argon</p> <p>Maximum pressure : 100 MPa</p> <p>Maximum temperature : 140°C</p> <p>Inner volume : $1.0 \times 10^{-3} \text{ m}^3$</p>
Exposure conditions	100 MPa, 85°C, 200 h
Specimens	<div style="text-align: center;"> <p>Outer diameter : 320 mm Thickness : 60.0 mm</p> <p>(a) Sampling of specimens¹⁾</p> </div> <div style="text-align: center; margin-top: 20px;"> <p>(b) Shape and dimensions of specimens²⁾</p> </div>
<p>¹⁾ Hydrogen-measurement specimens were sampled from a storage cylinder at a hydrogen station.</p> <p>²⁾ Surface-finishing was performed by circumferential-polishing with 600-grade silicon-carbide paper.</p>	
(b) Hydrogen-measurement conditions	
Type of spectroscope	<p>TDA (Thermal Desorption Analysis)</p> <p>Hydrogen detection accuracy : 0.3 Vol. ppm</p> <p>Amount of hydrogen molecule detection : $6.1 \times 10^{-10} \text{ mol/min}$</p>
Measurement conditions	20~520°C, 100°C/h

4. VICKERS HARDNESS

Table 7. Vickers hardness measurement conditions.

Type and capacity of testing machine	Micro-Vickers, 0.01 N~0.50 N
Loading conditions	0.30 N, 15 s
Environment	In air, RT
Sampling ¹⁾	 <p>Outer diameter : 320 mm Thickness : 60.0 mm</p>

¹⁾ Vickers hardness measurement specimens were sampled from a storage cylinder at a hydrogen station. Surface-finishing was conducted via polishing-buffing.

²⁾ Vickers hardness measurements were performed radially from the inner-to-outer surfaces from the surface perpendicular to the loading direction.

5. TENSILE PROPERTIES AND HYDROGEN CONTENT

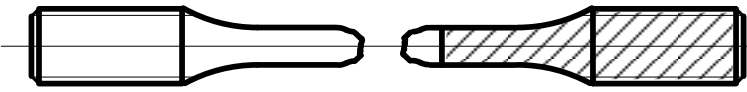
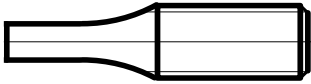
Table 9. Tensile-test, hydrogen-exposure and hydrogen-content measurement conditions.

(a) Tensile-test conditions	
Type and capacity of testing machine	Screw-type, 50 kN
Loading condition	1 mm/min
Environment	In air, RT
Specimens	<div style="text-align: center;"> <p>Outer diameter : 320 mm Thickness : 60.0 mm</p> <p>(a) Sampling of specimens¹⁾</p> </div> <div style="text-align: center; margin-top: 20px;"> <p>(b) Shape and dimensions of specimens²⁾ (in mm)</p> </div>
<p>¹⁾ Tensile specimens were sampled from a storage cylinder at a hydrogen station. ²⁾ Surface-finishing was performed by circumferential-polishing with 600-grade silicon-carbide paper.</p>	
(b) Hydrogen-exposure conditions of tensile specimens	
High-pressure vessel	Gases : Hydrogen, Nitrogen, Argon Maximum pressure : 100 MPa Maximum temperature : 140°C Inner volume : $1.0 \times 10^{-3} \text{ m}^3$
Exposure conditions	100 MPa, 85°C, 200 h

(Table continues on the following page)

Table 9. Tensile-test, hydrogen-exposure and hydrogen-content measurement conditions. (Continued)

(c) Hydrogen-content measurement conditions of specimens fractured by tensile tests

Type of spectroscope	TDA (Thermal Desorption Analysis) Hydrogen detection accuracy : 0.3 Vol. ppm Amount of hydrogen molecule detection : 6.1×10^{-10} mol/min
Measurement conditions	20~520°C, 100°C /h
Specimens	 <p>(a) Sampling of specimens¹⁾</p>
	 <p>(b) Shape of specimens</p>

¹⁾ Hydrogen measurement specimens were sampled from specimens fractured by tensile tests.



6. CHARPY IMPACT PROPERTIES AND HYDROGEN CONTENT

Table 11. Charpy impact test, hydrogen-exposure and hydrogen-content measurement conditions.

(a) Charpy impact test conditions	
Capacity of testing machine	Weight: 252 N, Radius: 0.66 m
Loading condition	Raising angle: 141°
Temperatures	-100°C (173 K) ~ 100°C (373 K)
Environment	In air, RT
Specimens	<p style="text-align: center;">(a) Sampling of specimens¹⁾</p>
	<p style="text-align: center;">(b) Shape and dimensions of specimens (in mm)</p>
¹⁾ Charpy impact specimens were sampled from a storage cylinder at a hydrogen station.	
(b) Hydrogen-exposure conditions of Charpy impact specimens	
High-pressure vessel	Gases : Hydrogen, Nitrogen, Argon Maximum pressure : 100 MPa Maximum temperature : 140°C Inner volume : $1.0 \times 10^{-3} \text{ m}^3$
Exposure conditions	100 MPa, 85°C, 200 h

(Table continues on the following page)

Table 11. Charpy impact test, hydrogen-exposure and hydrogen-content measurement conditions.
(Continued)

(c) Hydrogen-content measurement conditions of specimens fractured by Charpy impact tests	
Type of spectroscope	TDA (Thermal Desorption Analysis) Hydrogen detection accuracy : 0.3 Vol. ppm Amount of hydrogen molecule detection : 6.1×10^{-10} mol/min
Measurement conditions	20~520°C, 100°C /h
Specimens	 <p style="text-align: center;">(a) Sampling of specimens¹⁾</p>
	 <p style="text-align: center;">(b) Shape of specimens</p>

¹⁾ Hydrogen-measurement specimens were sampled from specimens fractured by Charpy impact tests.