HYDROGENIUS
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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

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

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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

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1. MATERIAL

Table 1. Processing details and related properties of SNCM439.

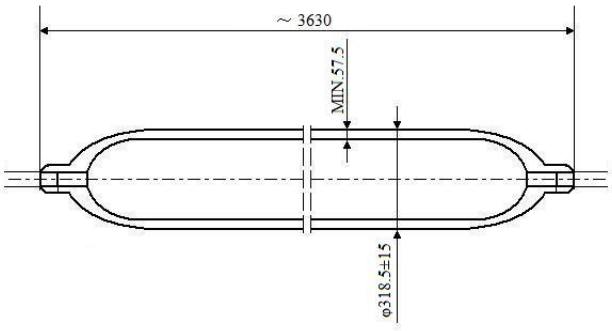


Table 2. Chemical composition of SNCM439.

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

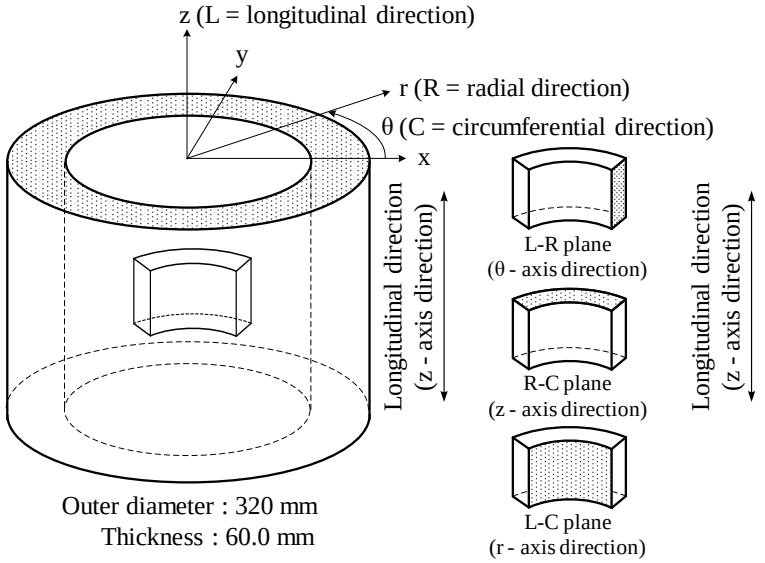
Table 3. Heat-treatment of SNCM439[1)].

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.

2. MICROSTRUCTURES

Table 4. Conditions for microstructural observation.

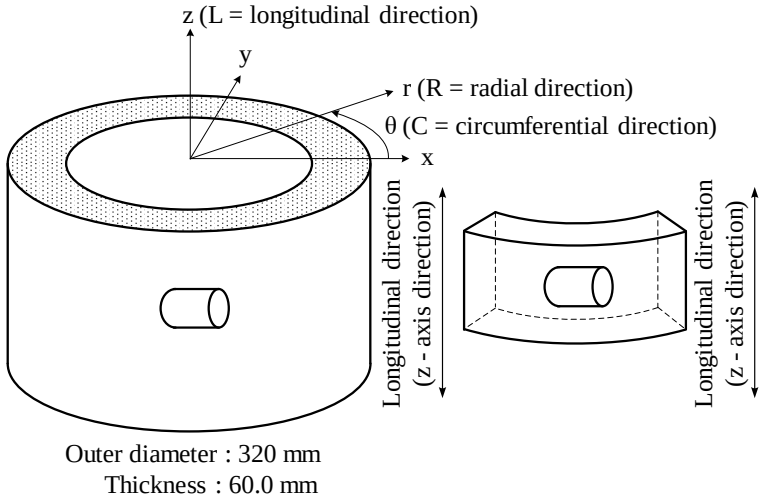
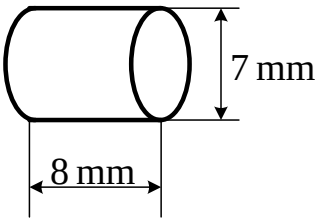
Surface Preparation	Optical	Nital (Nitric acid : 3%, Ethyl alcohol : 97%)
	EBSD (Electron Backscatter Diffraction)	Colloidal silica solution Acceleration voltage : 25 kV
Sampling[1)]		

[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	Gases : Hydrogen, Nitrogen, Argon Maximum pressure : 100 MPa Maximum temperature : 140°C Inner volume : 1.0×10^{-3} m^3
Exposure conditions	100 MPa, 85°C, 200 h
Specimens	 (a) Sampling of specimens[1)]
	 (b) Shape and dimensions of specimens[2)]

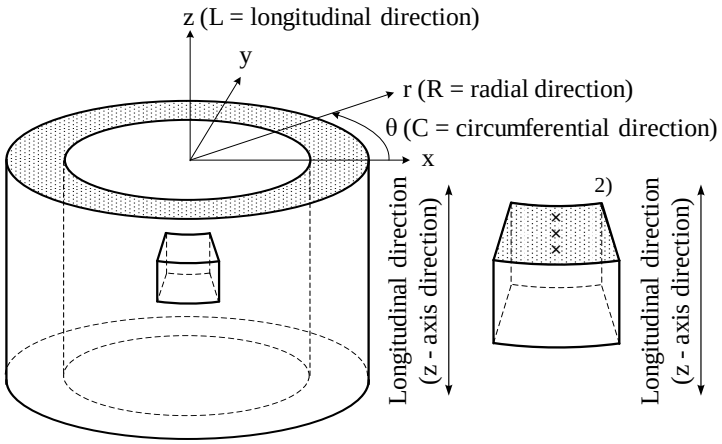
[1)] Hydrogen-measurement specimens were sampled from a storage cylinder at a hydrogen station.
[2)] Surface-finishing was performed by circumferential-polishing with 600-grade silicon-carbide paper.

(b) Hydrogen-measurement conditions

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

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)]	 Outer diameter : 320 mm Thickness : 60.0 mm

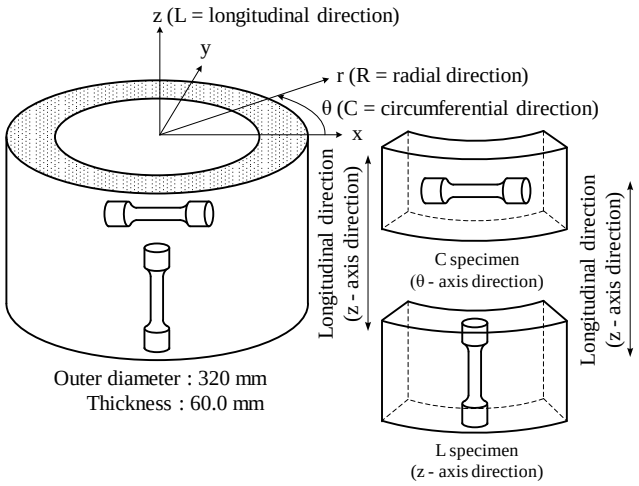
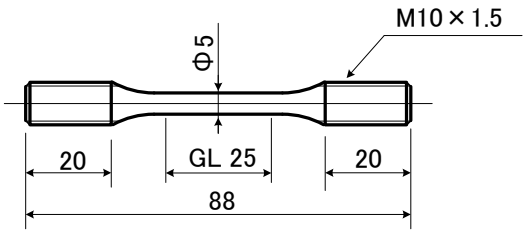
[1)] Vickers hardness measurement specimens were sampled from a storage cylinder at a hydrogen station. Surface-finishing was conducted via polishing-buffing.

[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	 (a) Sampling of specimens[1)]
	 (b) Shape and dimensions of specimens[2)] (in mm)

[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.

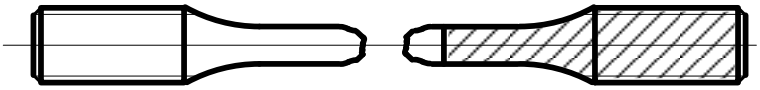
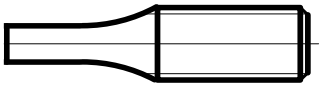
(b) Hydrogen-exposure conditions of tensile specimens

High-pressure vessel	Gases : Hydrogen, Nitrogen, Argon Maximum pressure : 100 MPa Maximum temperature : 140°C Inner volume : 1.0×10^{-3} 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

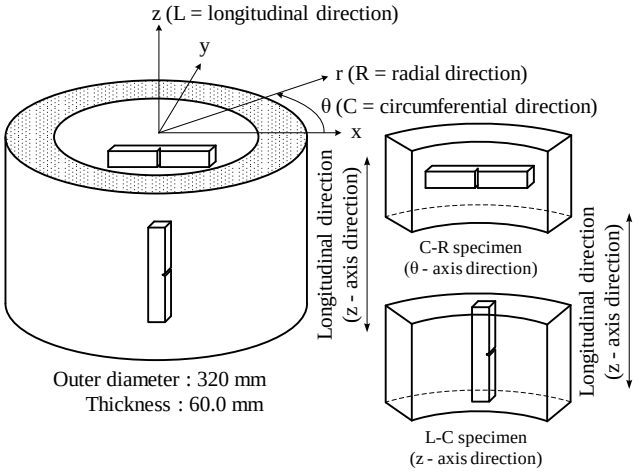
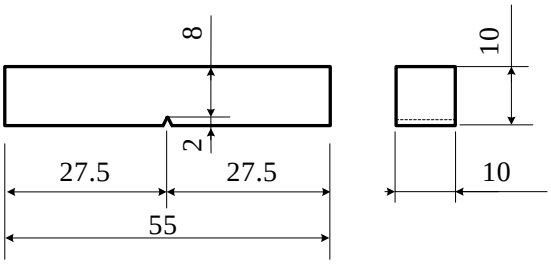
Type of spectroscope	TDA (Thermal Desorption Analysis) Hydrogen detection accuracy : 0.3 Vol. ppm Amount of hydrogen molecule detection : 6.1×10^{-10} mol/min
Measurement conditions	20～520°C, 100°C /h
Specimens	 (a) Sampling of specimens[1)]
	 (b) Shape of specimens

[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	 (a) Sampling of specimens[1)]  (b) Shape and dimensions of specimens (in mm)

[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 : 1.0×10^{-3} 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	 (a) Sampling of specimens[1)]
	 (b) Shape of specimens

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