

NAS 660 (UNS S66286)

NAS Heat-Resistant Stainless Steel

A precipitation hardening stainless steel, NAS 660 (SUH 660, UNS S66286) maintains superior strength at high temperatures up to 700°C, surpassing austenitic stainless steels. With a higher nickel content than Type 304, NAS 660 also includes such elements as titanium and aluminum for hardening. Age hardening is used to precipitate γ' phase [Ni₃(Al, Ti)] making this an extraordinarily strong metal at high temperatures. Nippon Yakin supplies this product in plate, sheet, and strip forms.

Steel Grade/Standard

NAS	JIS G4312	AMS 5525
NAS 660	SUH 660	UNS S66286

Chemical Composition

	C	Si	Mn	P	S	Ni	Cr	Mo	Al	Ti	B	V	Co	[wt %]
Specification (SUH 660)	≤0.08	≤1.00	≤2.00	≤0.040	≤0.030	24.00~27.00	13.50~16.00	1.00~1.50	≤0.35	1.90~2.35	0.001~0.010	0.10~0.50	—	
Specification (UNS S66286)	≤0.08	≤1.00	≤2.00	≤0.025	≤0.025	24.00~27.00	13.50~16.00	1.00~1.50	≤0.35	1.90~2.35	0.003~0.010	0.10~0.50	≤1.00	

Physical Properties

Density	[g/cm ³]	7.98
Specific heat	[J/kg · K]	460
Electrical resistivity	[μΩ · cm]	91
Thermal conductivity	[W/m · K] 150°C	12.2
Average coefficient of thermal expansion [10 ⁻⁶ /°C]	20~100°C	16.8
	20~500°C	17.7
	20~650°C	17.4
	20~750°C	18.5
	20~950°C	19.4
Young's modulus	[MPa]	20.1 × 10 ⁴
Magnetism		None
Melting range	[°C]	1340~1400

*All of the above values were measured after aging.

Mechanical Properties

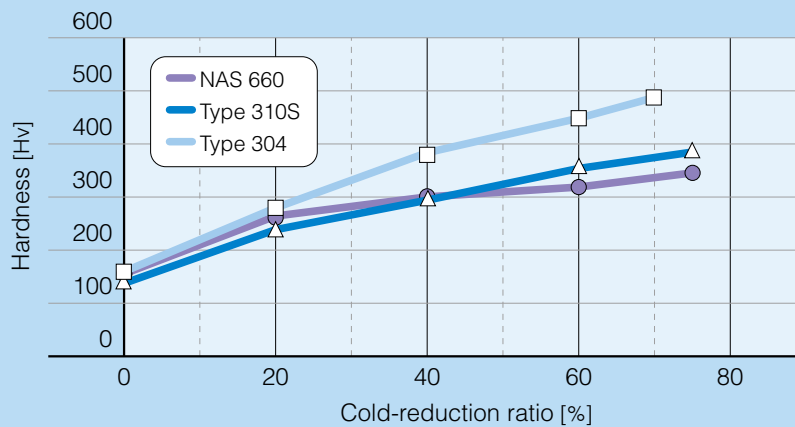
Mechanical Properties at Room Temperature

Solution treatment		0.2% proof stress [MPa]	Tensile strength [MPa]	Elongation [%]	Hardness [HRB]	Special notes
Specification (SUH 660)		—	≤ 730	≥ 25	≤ 91	
Specification (UNS S66286)		—	≤ 724	≥ 25	≤ 90	At least 1mm thick
Example	Cold-rolled sheet	344	665	40	86	0.2% proof stress for reference

Solution treatment and aging		0.2% proof stress [MPa]	Tensile strength [MPa]	Elongation [%]	Hardness [HRC]	Special notes
Specification (SUH 660)		≥ 590	≥ 900	≥ 15	≥ 24	
Specification (UNS S66286)		≥ 655	≥ 965	≥ 15	24~35	At least 1mm thick
Example	Cold-rolled sheet	774	1099	25	32	

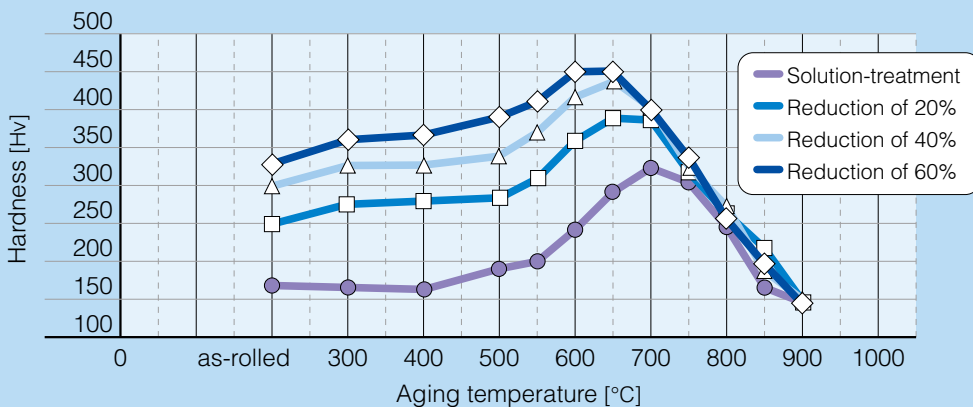
Work Hardening

The work hardening of NAS 660 is equivalent to Type 310S, and cold working is possible on the same level.



Age Hardening Behavior

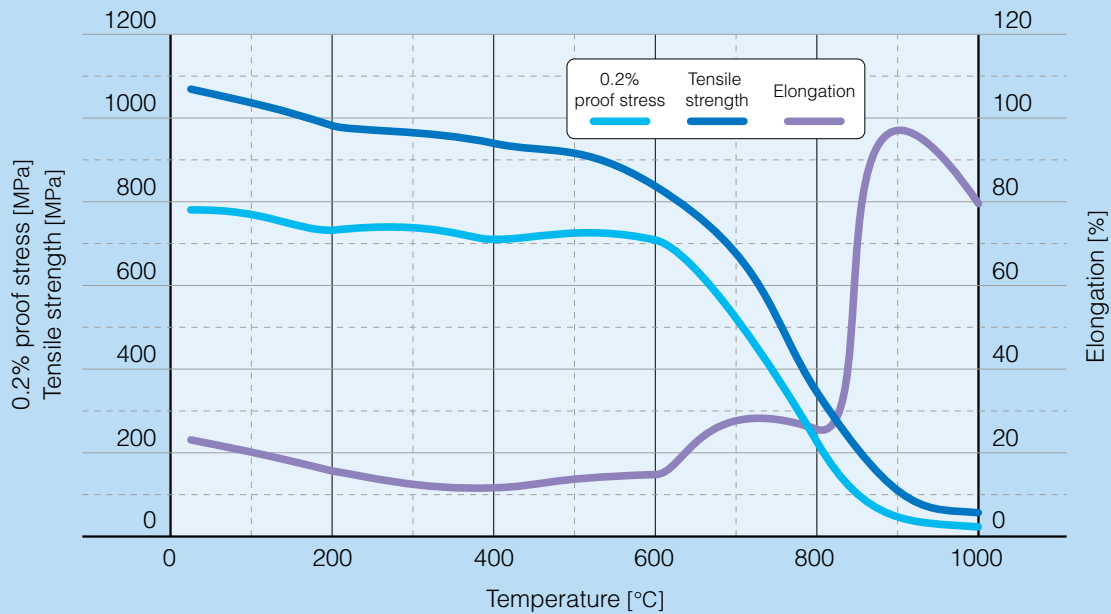
NAS 660 was held at various temperatures for 16 hours to investigate its age hardening behavior. Solution-treated NAS 660 reaches its maximum hardness at 16 hours of heat treatment around 700°C, though this temperature can be lowered if the NAS 660 is cold rolled.



High Temperatures Strength

An example of test values for Solution-treated NAS 660 that is aged for 16 hours at 720°C

Results of high-temperature tensile test



Creep Properties

An example of test values for solution-treated NAS 660 that is aged for 16 hours at 720°C

	Test temperature [°C]	Rupture strength [MPa]	Elongation [%]	Creep strength [MPa]	
				0.5% total strain	1.0% total strain
100hr Strength properties	538	689	3	559	634
	593	562	3	525	551
	649	434	5	365	414
	704	304	12	207	244
	732	241	28	—	—
	816	90	55	—	—
1000hr Strength properties	538	599	3	537	585
	593	490	3	469	482
	649	317	9	241	282
	704	207	24	—	155
	732	148	35	—	—
	816	58	—	—	—

Corrosion Resistance

NAS 660 provides superior corrosion resistance beyond the standard austenitic stainless steel Type 304, and this does not vary even after aging.

Evaluation of Pitting Corrosion Resistance

Test condition: 5% NaCl, 30°C

NAS 660	Solution treatment	0.37V
	Age hardening	0.38V
Type 304	Solution treatment	0.28V

Weldability

Spot, TIG, MIG and shield metal arc welding can be used on thin NAS 660 sheets under similar conditions to austenitic stainless steels.

Heat Treatment

NAS 660 is a precipitation hardening alloy. Its strength is increased through aging after solution heat treatment. Two stages of heat treatment are generally carried out, as follows:

Solution heat treatment: 980°C; oil or water cooling

Age hardening: 720°C × 16hr; air cooling

After solution heat treatment, either oil or water cooling is required, though air cooling is better for thinner metal. Note that it is important to use a suitable temperature and holding time for aging to obtain the target strength.

Machinability

Compared to standard austenitic stainless steels, NAS 660 has somewhat superior machining properties. Although a high-speed steel tool can be used, we recommend the use of a sintered carbide tool, and suggest combining a slower feed rate with a greater cutting depth.

Applications

NAS 660 is an excellent choice when high-temperature strength is required such as jet engines, gas turbines and turbo charger components.

For more information, please contact:

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