

NAS 600 (UNS N06600)

NAS Heat-Resistant Nickel Alloy

NAS 600 (NCF 600, UNS N06600) is a nickel-chromium alloy that provides excellent resistance to oxidation at high temperatures. It is also commonly used as a corrosion resistant alloy due to its resistance against a range of acids and alkalis. Nippon Yakin supplies this product in plate, sheet, and strip forms.

Grade/Standard

NAS	JIS G4902	ASTM B168	EN 10095
NAS 600	NCF 600	UNS N06600	2.4816

Chemical Composition

	C	Si	Mn	P	S	Ni	Cr	Cu	Al	Ti	Fe
Specification (NCF 600)	≤0.15	≤0.50	≤1.00	≤0.030	≤0.015	≥72.00	14.00~17.00	≤0.50	—	—	6.00~10.00
Specification (UNS N06600)	≤0.15	≤0.5	≤1.0	—	≤0.015	≥72.0	14.0~17.0	≤0.5	—	—	6.0~10.0
Specification (EN 2.4816)	0.05~0.10	≤0.50	≤1.00	≤0.020	≤0.015	≥72.00	14.00~17.00	≤0.50	≤0.30	≤0.30	6.00~10.00

Physical Properties

Density	[g/cm ³]	8.51
Specific heat	[J/kg · K]	444
Electrical resistivity	[μΩ · cm]	103
Thermal conductivity	[W/m · K]	15.0
Average coefficient of thermal expansion [10 ⁻⁶ /°C]	25~ 93°C	13.3
	25~316°C	14.2
	25~538°C	15.1
	25~760°C	16.0
	25~982°C	16.7
Young's modulus	[MPa]	21.4 × 10 ⁴
Curie point	[°C]	-124
Magnetism		None
Melting range	[°C]	1370~1410

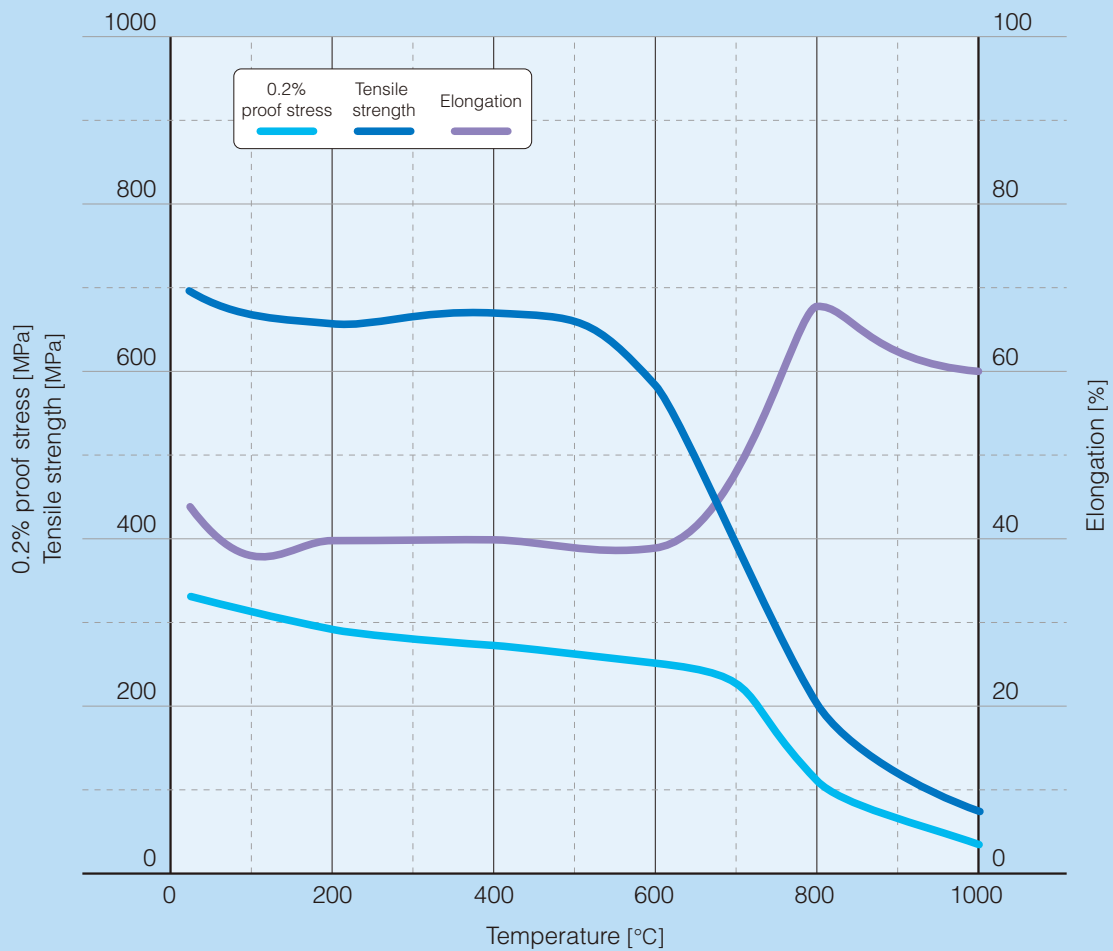
Mechanical Properties

Mechanical Properties at Room Temperature

		0.2% proof stress [MPa]	Tensile strength [MPa]	Elongation [%]	Hardness	
					[Hv]	[HB]
Specification (NCF 600)		≥ 245	≥ 550	≥ 30	≤ 182	≤ 179
Specification (UNS N06600)		≥ 240	≥ 550	≥ 30	—	—
Specification (EN 2.4816)		≥ 240	500~850	≥ 30	—	≤ 200
Example	Hot-rolled plate	321	677	42	—	171
	Cold-rolled sheet	337	704	40	—	84 (HRB)

High Temperature Strength

Results of high-temperature tensile test



Creep Properties

Heat treatment	Temperature [°C]	Creep rupture strength [MPa]		
		10hr	100hr	1000hr
Annealing (Cold-rolled sheet)	538	511	345	234
	649	234	158	100
	760	89	58	38
	871	52	33	21

Corrosion Resistance

The composition of NAS 600 provides corrosion resistance in a remarkably large number of corrosive environments. The addition of chromium content provides superior corrosion resistance in acidic environments over pure nickel. Furthermore, the high nickel content maintains the corrosion resistance in a reducing state and exhibits superior corrosion resistance to alkaline solutions. Another feature of this product is the high level of resistance against stress corrosion cracking.

Comparison of Alloys in Stress Corrosion Cracking Test

Test condition: U-shaped test piece in boiling MgCl₂ aqueous solution for 300hr

Alloy	Main chemical composition (wt %)	45% (154°C)	42% (142°C)	40% (138°C)	38% (134°C)	35% (126°C)	30% (115°C)	25% (110°C)	20% (108°C)
Type 304	18Cr-8Ni	x	x	x	x	x	x	x	x
Type 316L	17Cr-12Ni-2Mo	x	x	x	x	x	x	x	○
NAS 64	25Cr-6Ni-3.3Mo-0.16N	x	x	x	x	x	x	○	○
NAS 155N	18Cr-15Ni-4Mo-3Cu-0.15N	x	x	x	x	x	○	○	○
NAS 185N	20Cr-18Ni-6Mo-0.8Cu-0.2N	x	x	x	x	○	○	○	○
NAS 254N	23Cr-25Ni-5.5Mo-0.2N	x	x	x	○	○	○	○	○
NAS 255NM	20Cr-25Ni-6Mo-1Cu-0.2N	x	x	x	○	○	○	○	○
NAS 354N	23Cr-35Ni-7.5Mo-0.2N	x	○	○	○	○	○	○	○
NAS 600	Ni-17Cr	○	○	○	○	○	○	○	○
NAS NW276	Ni-15Cr-16Mo-4W-5Fe	○	○	○	○	○	○	○	○
NAS NW22	Ni-21Cr-13Mo-3W-4Fe	○	○	○	○	○	○	○	○

○: No cracking x: Cracking present

Workability

Hot working is relatively easy with NAS 600. For hot working, temperature should be between 1000 and 1180°C, although light work may be done at temperature as low as 850°C. The range between 650 and 850°C should be avoided as cracking may occur. Cold workability is easier than austenitic stainless steels, similar to Monel.

Weldability

As with standard austenitic stainless steels, NAS 600 may be welded using techniques such as TIG, MIG, and shield metal arc welding. For edge preparation, mechanical cutting is desirable. Wide U- and V-groove angles should be used. Care should be taken to ensure its welding portion is clean as NAS 600 is sensitive to surface contamination.

Heat Treatment

The following heat treatment may be used:

Annealing: 800~1150°C; Air or water cooling

Care should be taken at temperatures exceeding 1050°C as there is a strong tendency for the crystal grains to become coarse.

Machinability

As a high-nickel alloy, NAS 600 is not as machinable as an austenitic stainless steel. A high-speed steel cutting tool may be used, though a sintered carbide tool is recommended. Also, the feed speed should be somewhat reduced, aiming for deep cutting. The recommended lathe feed speeds are as follows:

High-speed steel tool: 1050~1350mm/min

Sintered carbide tool: 3000~5250mm/min

After machine work, lubricants should be completely removed before welding or heat treating.

Properties at High Temperatures

Exhibiting particularly superior oxidation resistance at high temperatures, NAS 600 can be used in air as well as other environments continuously for long periods of time. Because it has excellent resistance to nitrogen, hydrogen and carburization, NAS 600 can be used in heat treatment furnaces. Care is needed with wet chlorine and bromide, however, as they will cause damage.

The maximum temperatures that NAS 600 may be used in different environments are as follows:

Long-term continuous use in air oxidizing environment: 1100°C

Reducing environment of H₂ or CO not containing sulfur: 1150°C

Oxidizing sulfur environment (in air containing sulfurous acid): 815°C

Reducing environment containing hydrogen sulfide: 535°C

Hydrogen chloride: 540°C

Chlorine gas: 510°C

Applications

Nuclear power plants, heat exchangers, industrial chemical evaporators, industrial acid and alkali equipments, heat treatment furnace parts, afterburner parts and other components used at high temperatures.

For more information, please contact:

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