Waspaloy (UNS N07001/W. Nr. 2.4654) is a nickel-base, age hardenable superalloy with excellent high-temperature strength and good corrosion resistance, notably to oxidation, at service temperatures up to 1200°F (650°C) for critical rotating applications, and up to 1600°F (870°C) for other, less demanding, applications. The alloy's high-temperature strength is derived from its solid solution strengthening elements, molybdenum, cobalt and chromium, and its age-hardening elements, aluminum and titanium. Its strength and stability ranges are higher than those typically available for alloy 718.

Special Metals offers Waspaloy made by vacuum induction melting and vacuum arc refining (VIM/VAR) or by vacuum induction melting and electroslag refining (VIM/ESR). The manufacturing process is selected to meet specific customer requirements and final service applications. An even higher strength "super Waspaloy" chemistry is available, a unique composition to provide higher strength properties for more demanding applications.

Special Metals Waspaloy is used for gas turbine engine components that call for considerable strength and corrosion resistance at high operating temperatures. Current and potential applications include compressor and rotor discs, shafts, spacers, seals, rings and casings, fasteners and other miscellaneous engine hardware, airframe assemblies and missile systems.

The alloy's oxidation resistance is good under conditions of frequent thermal cycling, and in continuous exposure to temperatures up to 1900°F (1038°C). It has performed well in atmospheres found in gas turbine engine service and in salt spray environments. Solution-treated material offers the best levels of corrosion resistance.

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Table 1 - Limiting Chemical Composition[a], %[b]

Chromium	18.00-21.00
Boron	0.003-0.01
Zirconium	0.02-0.12
Aluminum	1.20-1.60
Titanium	2.75-3.25
Molybdenum	3.50-5.00
Cobalt	12.00-15.00
Copper	0.50 max.
Iron	2.00 max.
Sulfur	0.030 max.
Silicon	0.75 max.
Manganese	1.00 max.
Carbon	0.02-0.10 max.
Phosphorus	0.030 max.
Nickel	Balance[c]

[a]Commercial chemistries for specific applications are usually much tighter and defined to meet customer requirements on individual orders.
[b]In compliance with UNS N07001.
[c]Reference to the balance of the alloy's composition does not guarantee this is exclusively of the element mentioned but that it predominates and others are present only in minimal quantities.

Table 2 - Some Physical Constants

Density	8.19 g/cm^3 (0.296 lb/in^3)
Melting Range	1330-1360°C (2425-2475°F)
Coefficient of Thermal Expansion	
At 70-200°F (21-93°C)	6.8 x 10^{-6} in/in/°F
At 70-1000°F (21-538°C)	7.7 x 10^{-6} in/in/°F
At 70-2000°F (21-1093°C)	10.4 x 10^{-6} in/in/°F
Electrical Resistivity	
Solution treated at	
1080°C (1975°F)/4h/AC	1.24 microhm•m (0.38 microhm•ft)
Fully age hardened,	
i.e. solution treated + 845°C (1550°F)/24h/AC + 760°C (1400°F)/16h/AC	1.20 microhm•m (0.37 microhm•ft)
Modulus of Elasticity (Dynamic)	
At 70°F (21°C)	30.3 x 10^3 ksi (211 GPa)
At 1000°F (538°C)	26.7 x 10^3 ksi (184 GPa)
At 1600°F (871°C)	22.7 x 10^3 ksi (157 GPa)
Magnetic Permeability	
H = 200 oersteds (solution treated + aged)	1.004

Waspaloy

Heat Treatment

Special Metals Waspaloy is heat treated in a three-step sequence encompassing solution treatment, stabilization and age-hardening.

A. *For optimum high-temperature creep and stress-rupture properties.*
Solution treatment - heat at 1080°C (1975°F)/4h/AC to produce hardness of 20-25 Rockwell C.
Stabilization - reheat to 845°C (1550°F)/24h/AC.
Age harden - reheat to 760°C (1400°F)/16h/AC to produce hardness of 34-40 Rockwell C.

B. *For optimum room- and high-temperature tensile properties.*
Solution treatment - heat at 995-1035°C (1825-1895°F)/4h/oil quench.
Stabilization - reheat to 845°C (1550°F)/4h/AC.
Age harden - reheat to 760°C (1400°F)/16h/AC to produce hardness of 34-44 Rockwell C.

Scale formed during heat-treatment in oxidizing atmospheres may be removed by acid pickling or by mechanical means.

Creep Rupture Properties

Table 3 - Typical Properties (Heat Treatment A)

Temperature		Rupture Strength (1000 h)	
°F	°C	ksi	MPa
1200	649	89	615
1300	704	65	450
1400	760	42	290
1500	816	26	180
1600	870	16	110

Mechanical Properties

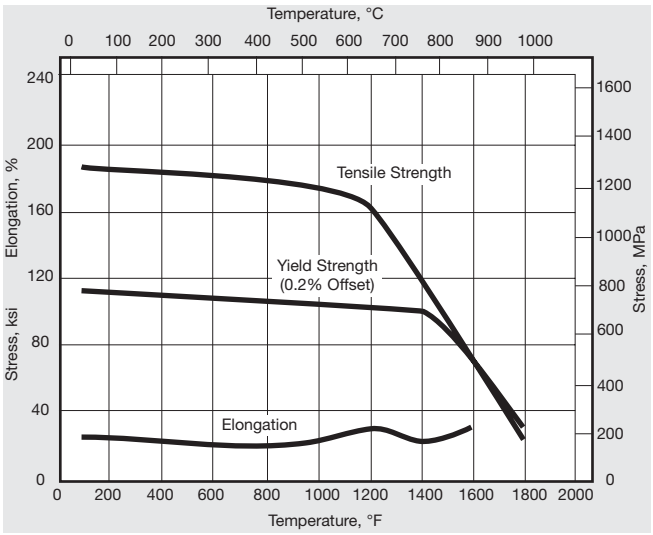

Figure 1.- Typical Mechanical Properties (Heat Treatment A)

Hot and Cold Working

Special Metals Waspaloy may be hot worked in the 1170-980°C (2140-1800°F) range. This avoids rapid work hardening, possible cracking below 980°C (1800°F), and hot shortness above 1180°C (2150°F). The alloy may be cold worked by hydroforming, drawing, spinning, bending, roll forming, etc. It is considerably stronger than the AISI 300 series stainless steels at room temperature. Annealed alloy bar has also been successfully cold-headed into fastener configurations. Intermediate annealing is normally required because the alloy work hardens very rapidly.

Machining

Waspaloy is among the more difficult of the superalloys to machine. General guidance can be found in the Special Metals publication "Machining" on the website www.specialmetals.com.

Joining

Waspaloy, generally regarded as a material that is not readily weldable outside very carefully controlled circumstances, can be fusion welded by argon-arc methods using a matched composition filler metal. Heavy sections, thin sheet and tubing joints can all be made using non-consumable arc welding with a gas shield. The high-temperature strength of welds, after heat treatment, is lower than that of heat-treated, wrought material. Therefore, welds should be avoided at high-stress locations. The alloy may display "hot short" characteristics and show some sensitivity to strain cracking. It is recommended that material to be welded is in only the solution-treated condition before welding and that all welded components are re-solution treated before being put into service.

Information on joining is available in the Special Metals publication "Joining" on the website, www.specialmetals.com.

Available Products and Specifications

Waspaloy is designated as UNS N07001 and Werkstoff Number 2.4654. Waspaloy is available as round bar, forging stock, extruded section and wire.

Rod, Bar, Wire and Forging Stock - ASTM B 637, ISO 9723, ISO 9724, ISO 9725, SAE AMS 5704, SAE AMS 5706, SAE AMS 5707, SAE AMS 5708, SAE AMS 5709, SAE AMS 5828, SAE MAM 5706, AECMA PrEN 2193, AECMA PrEN 2194, AECMA PrEN 2406, AECMA PrEN 2958, AECMA PrEN 2959, AECMA PrEN 2960, AECMA PrEN 3220

Plate, Sheet and Strip - SAE AMS 5544, AECMA PrEN 2195

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