High-Performance Alloys

For aircraft, land-based & marine gas turbines

The aircraft engines were the first. Their evolution beyond the first prototypes depended on materials becoming available with hitherto unknown resistance to temperature, stress and corrosion by combustion products. In the early 1940s, Special Metals worked with the UK government to create the first of the superalloys to meet those demands. Within a very few years the NIMONIC and INCONEL superalloys had become the cornerstones of jet engine metallurgy; the first, annealed products supplemented by new series of higher strength, age-hardenable alloys.

Gas turbine propulsion is now universal for all but the lowest powered aircraft. New standards of materials performance are being set all the time for aircraft to fly higher, faster, further, more economically, even more quietly. And, for over fifty years, the technology has been spreading into other areas where land-based engines are used for power generation and for such specialist applications as trans-continental pipelines, and for marine applications where gas turbine power acts as an on-demand supplement to more conventional systems.

Special Metals was critically involved at the beginning of gas turbine technology. It remains a world leader in the development and production of the superalloys that support the engines of today and the design demands for the years to come. The following pages offer an introduction to the current level of investment in new and established alloy products, and in melting, remelting and manufacturing facilities.

For compressor blades and vanes

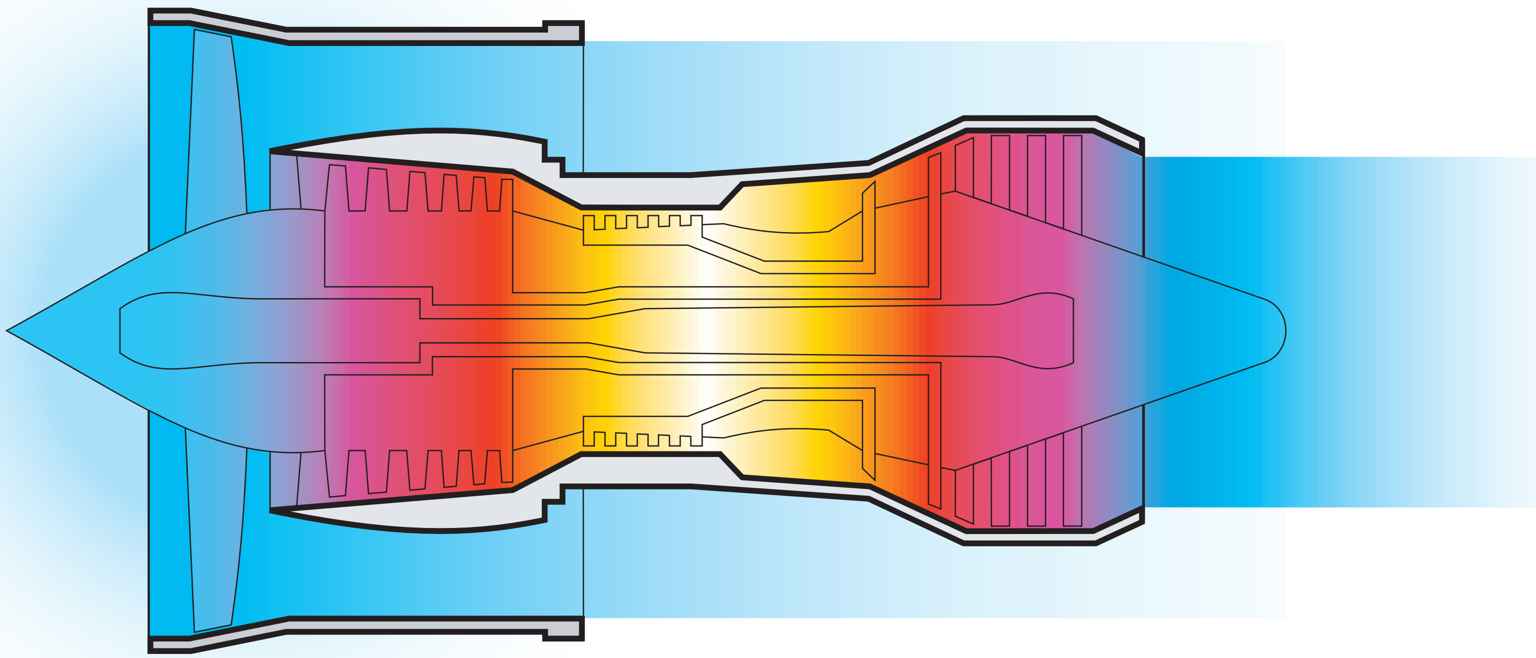
INCONEL® alloy 718
NIMONIC® alloys 90 & 901
INCOLOY® alloy 909

For turbine blades and vanes

INCONEL® alloy MA754
NIMONIC® alloys 80A, 90, 101, 105 & 115

For discs and shafts

INCONEL® alloys 706, 718 & X-750
NIMONIC® alloys 90, 105, & 901
Waspaloy
INCOLOY® alloys 903 & 909
Rene 88, 95
IN 100
UDIMET® alloys 700 & 720
UDIMAR® alloys 250 & 300



For casings, rings, and seals

INCONEL® alloys 600, 617, 625, 718, X-750, 783 & HX
NIMONIC® alloys 75, 80A, 90, 105, 263, 901, PE11, PE16 & PK33
Waspaloy
INCOLOY® alloy 909

For sheet fabrications (combustors, ducting, exhaust systems, thrust reversers, hush kits, afterburners, etc.)

INCONEL® alloys 600, 601, 617, 625, 625LCF®, 718, 718SPF,™ X-750 & HX
NIMONIC® alloys 75, 86, 263, PE11, PE16 & PK 33
INCOLOY® alloy MA956
UDIMET® alloys 188 and L-605

For fasteners and general engine hardware

INCONEL® alloys 600, 625, 718 & X-750
NIMONIC® alloys 80A, 90, 105, 263 & 901
INCOLOY® alloy A-286
Waspaloy

Melting, Remelting & Mechanical Alloying

At the heart of superalloy production, the alloying process itself defines the quality and performance of the alloys that will be called on for operation under extremes of temperature, stress and corrosion-resistance.

In the USA and the UK, Special Metals has invested in the most sophisticated facilities for vacuum induction melting, vacuum arc remelting, electroslag remelting and the mechanical alloying powder metallurgy process. The latest computer technology is applied to all these processes, to help maintain the highest quality standards, and for permanent storage of product and process data from every heat. The industry requires complete superalloy traceability. Special Metals provides such history as an integral part of its world leader quality package.

Hot- and Cold-Working

The gas turbine superalloys are, by definition, required to operate without deformation at high service temperatures and yet they have to be worked, hot and cold, to bring them from melting and remelting to the forms the market needs. For the production of its gas turbine quality billet, bar, extruded sections, flat products, tubulars and wire, Special Metals offers an unmatched range of computer supported facilities, quality control procedures and manufacturing experience.

The World's Largest Range of Superalloys for Gas Turbine Applications

	Product designations	Specifications
INCONEL® alloy 600 Ni 76.0, Cr 15.0, Fe 8.0 A general engineering Ni-Cr-Fe alloy with good high-temperature strength and oxidation-resistance. Available as forging billet, bar, extruded section, sheet/strip, plate, tubing and wire.	UNS N06600 Werkstoff Nr 2.4816 DIN NiCr15Fe AFNOR NC 15 Fe ISO NW6600	SAE AMS 5540, 5580, 5665, 5687, 7232 BS 3072-3076 (NA 14) DIN 17742, 17750-54 ISO 4955A, 6207-08, 9723-25
INCONEL® alloy 601 Ni 60.5, Cr 23.0, Fe 14.4, Al 1.4 A Ni-Cr-Fe alloy with outstanding high-temperature strength and oxidation-resistance. Available as bar, sheet/strip, plate, tubing and wire.	UNS N06601 Werkstoff Nr 2.4851 DIN NiCr23Fe AFNOR NC 23 Fe A ISO NW6601	SAE AMS 5715, 5870 ISO 6207-08, 9723-25 DIN 17742, 17750-17754
INCONEL® alloy 617 Ni 52.0, Cr 22.0, Co 12.5, Mo 9.5, Fe 1.5, Al 1.2 A Ni-Cr-Co-Mo alloy with an exceptional combination of high-temperature strength, stability and oxidation-resistance. Available as forging billet, bar, extruded section, sheet/strip, plate, tubing and wire.	UNS N06617 Werkstoff Nr 2.4663a DIN NiCr23Co12Mo ISO NW6617	SAE AMS 5887-89 ISO 6207-08, 9724
INCONEL® alloy 625 Ni 61.0, Cr 21.5, Mo 9.0, Nb 3.6, Fe 2.5 A Ni-Cr-Mo alloy with good strength at up to 1500°F (815°C) and excellent resistance to a wide variety of corrosive media. Available as forging billet, bar, extruded section, sheet/strip, plate, tubing and wire.	UNS N00625 Werkstoff Nr 2.4856 DIN NiCr22Mo9Nb AFNOR NC 22 D NB AICMA NI-P 97 HT ISO NW6625	SAE AMS 5581, 5599, 5666, 5837, 5869 BS 3072, 3074, 3076 (NA21) DIN 17744, 17750-52 ISO 4955A, 6207-08, 9723-25

	Product designations	Specifications
INCONEL® alloy 625LCF® Ni 61.0, Cr 21.5, Mo 9.0, Nb 3.6, Fe 2.5 A development of INCONEL alloy 625 with composition and processing controlled for optimum resistance to mechanical and thermal fatigue at up to 1200°F (650°C). Available as sheet/strip.	UNS N06626	SAE AMS 5879
INCONEL® alloy 706 Ni 41.5, Fe 37.0, Cr 16.0, Nb 2.9, Ti 1.8, Al 0.2 An age-hardenable Ni-Fe-Cr alloy for gas turbine applications particularly for the discs and spacers of large land-based engines. Available as forging billet.	UNS N09706	SAE AMS 5605-06, 5701-03
INCONEL® alloy 718 Ni 54.0, Fe 18.5, Cr 18.0, Nb 5.0, Mo 3.0, Ti 1.0 An age-hardenable Ni-Fe-Cr alloy, possibly the best-known of all the superalloys created by Special Metals, and certainly among the most versatile, combining high strength at up to 1300°F (700°C) with corrosion-resistance and excellent weldability. Available as forging billet, bar, extruded section, sheet/strip, plate, tubing and wire.	UNS N07718 Werkstoff Nr 2.4668 (WL 2.4668) DIN NiCr19NbMo AFNOR NC 19 Fe Nb AICMA NI-P 100 HT ISO NW 7718	SAE AMS 5589-90, 5596-97, 5662-64, 5832, 5962 AECMA PrEN 2404-05, 2407-08, 2952, 2961, 3219, 3666 ISO 6208, 9723-25
INCONEL® alloy 718SPF™ Ni 54.0, Fe 18.5, Cr 18.0, Nb 5.0, Mo 3.0, Ti 1.0 A development of INCONEL alloy 718 with composition and processing controlled to create a high-strength, nickel-base superalloy with exceptional fatigue resistance, amenable to superplastic forming. Available as sheet/strip.	UNS N07719	SAE AMS 5914, 5950
INCONEL® alloy X-750 Ni 73.0, Cr 15.5, Fe 7.0, Ti 2.5, Nb 1.0, Al 0.7 An age-hardenable Ni-Cr alloy with high tensile and creep-rupture properties up to 1300°F (700°C). Available as forging billet, bar, extruded section, sheet/strip, plate, tubing and wire.	UNS N07750 Werkstoff Nr 2.4669 DIN NiCr15Fe7TiAl AFNOR NC 15TNb A ISO NW7750	SAE AMS 5542, 5582-83, 5598, 5667-71, 5698-99, 5747 BS HR 505 ISO 6208, 9723-25
INCONEL® alloy MA754 Ni 77.5, Cr 20.0, Fe 1.0, Y_2O_3 0.6, Ti 0.5, Al 0.3 An oxide-dispersion-strengthened superalloy made by the mechanical alloying powder process, offering exceptional high-temperature strength and oxidation-resistance. Available as bar, sheet/strip and plate.	UNS N07754	

	Product designations	Specifications
INCONEL® alloy 783 Co 34.0, Ni 28.5, Fe 26.0, Al 5.4, Nb 3.0, Cr 3.0, Ti 0.1 A cobalt-base superalloy with a low coefficient of thermal expansion, good oxidation- and impact-resistance and metallurgical stability, developed for gas turbine rings, casings and seals. Available as forging billet, bar and extruded section.	UNS R30783	SAE AMS 5940
INCONEL® alloy HX Ni 47.0, Cr 22.0, Fe 18.0, Mo 9.0, Co 1.5, W 0.6 A superalloy with an excellent combination of strength, fabricability and oxidation-resistance up to 2000°F (1100°C). Available as forging billet, bar, extruded section, sheet/strip, plate, tubing and wire.	UNS N06002 Werkstoff Nr 2.4665 DIN NiCr22Fe18Mo AFNOR NC 22 Fe D AICMA NI-P 93 HT ISO NW 6002	SAE AMS 5536, 5587-88, 5754, 5798, 7237 BS HR 6, 204 AECMA PrEN 2182-85 ISO 6207-08, 9723-25
NIMONIC® alloy 75 Ni 76.0, Cr 20.0, Fe 4.0 The first of the superalloys used to make the Whittle engine a practical reality, this Ni-Cr alloy with good high-temperature strength and outstanding oxidation-resistance is still in service for a range of engine applications. Available as forging billet, bar, extruded section, sheet/strip, plate, tubing and wire.	UNS N06075 Werkstoff Nr 2.4951 (WL 2.4630) DIN NiCr20Ti AFNOR NC 20 T AICMA NI-P 91 HT ISO NW6621	BS HR 5, 203, 403, 504 DIN 17742, 17750-52, 17754 AECMA PrEN 2293-94, 2302, 2306-08, 2402, 2411 ISO 4955A, 6207-08, 9723-25
NIMONIC® alloy 80A Ni 76.0, Cr 19.5, Ti 2.4, Al 1.4 An age-hardenable creep-resistant alloy for service at temperatures up to around 1500°F (815°C). Available as forging billet, bar, extruded section, sheet/strip, plate, tubing and wire.	UNS N07080 Werkstoff Nr 2.4952 (WL 2.4631) DIN NiCr20TiAl AFNOR NC 20 TA AICMA NI-P95 HT ISO NW7080	BS 3075-76 (NA20), HR 1, 201, 401, 601 DIN 17742, 17754 AECMA PrEN 2188-91, 2396-97 ISO 6208, 9723-25
NIMONIC® alloy 86 Ni 65.0 Cr 25.0, Mo 10.0, Ce 0.03 A Ni-Cr-Mo superalloy with good ductility, creep strength and cyclic oxidation-resistance up to around 1900°F (1040°C). Readily fabricated and welded. Available as forging billet, bar and sheet/strip.		
NIMONIC® alloy 90 Ni 60.0, Cr 19.5, Co 16.0, Ti 2.5, Al 1.5 An age-hardenable superalloy for service at up to around 1700°F (925°C). Available as forging billet, bar, extruded section, sheet/strip, plate, tubing and wire.	UNS N07090 Werkstoff Nr 2.4632 AFNOR NCK 20 TA AICMA NI-P 96 HT ISO NW 7090	SAE AMS 5829 BS HR 2, 202, 402, 501-03 AECMA PrEN 2295-99, 2400-01, 2412, 2699-70 ISO 6208, 9723-25
NIMONIC® alloy 101 Ni 48.0, Cr 24.2, Co 19.7, Ti 3.0, Mo 1.5, Al 1.4, Nb 1.0 Similar to NIMONIC alloy 105 but with higher chromium to improve resistance to corrosion by the combustion products of low-grade or impure fuels used in some land-based gas turbine engines. Available as bar.		

	Product designations	Specifications
NIMONIC® alloy 105 Ni 54.0, Co 20.0, Cr 15.0, Mo 5.0, Al 4.7, Ti 1.3 An age-hardenable superalloy with increased aluminum for improved oxidation-resistance and strength, and high creep-rupture properties up to around 1740°F (950°C). Available as bar and extruded section..	Werkstoff Nr 2.4634 AFNOR NK 20 CDA ISO NW 3021	BS HR 3 AECMA PrEN 2179-81 ISO 9723, 9725
NIMONIC® alloy 115 Ni 60.0, Cr 14.2, Co 13.2, Al 4.9, Ti 3.8, Mo 3.2 An age-hardenable, creep-resistant superalloy for gas turbine blading in use at up to around 1850°F (1010°C). Available as bar.	Werkstoff Nr 2.4636 AFNOR NCK 15 ATD	BS HR 4 AECMA PrEN 2196-97
NIMONIC® alloy 263 Ni 51.0, Cr 20.0, Co 20.0, Mo 5.8, Ti 2.2, Al 0.5 A readily weldable, age-hardenable superalloy with excellent strength, ductility and corrosion-resistance up to around 1560°F (850°C). Available as forging billet, bar, extruded section, sheet/strip, plate, tubing and wire.	UNS N07263 Werkstoff Nr 2.4650 DIN NiCo20Cr20MoTi AFNOR NCK 20 D AICMA NI-P 105 HT ISO NW 7263	SAE AMS 5872, 5886 BS HR 10, 206, 404 AECMA PrEN 2199-2203 2418 ISO 6207-08, 9723, 9725
NIMONIC® alloy 901 Ni 42.5, Fe 36.0, Cr 12.5, Mo 5.8, Ti 2.9 An age-hardenable superalloy with high yield strength and creep-resistance up to around 1100°F (600°C). Available as forging billet, bar, and extruded section.	UNS N09901 Werkstoff Nr 2.4662 AFNOR Z 8 NCDT 42 AICMA FE-PA 99 HT ISO NW 9911	SAE AMS 5660-61 BS HR 55 AECMA PrEN 2176-78 ISO 9723, 9725
NIMONIC® alloy PE11 Ni 39.0, Fe 34.0, Cr 18.0, Mo 5.2, Ti 2.3, Al 0.8 A readily weldable, age-hardenable alloy with high strength and ductility at service temperatures up to around 1020°F (550°C). Available as bar, extruded section, sheet/strip and plate.	AFNOR Z 8 NCD 38	BS DTD 5037
NIMONIC® alloy PE16 Ni 43.0, Fe 34.0, Cr 16.5, Mo 3.3, Ti 1.2, Al 1.2 An age-hardenable superalloy with good strength and oxidation-resistance up to around 1380°F (750°C). Available as forging billet, bar, extruded section, sheet/strip, tubing and wire.	AFNOR NW 11 AC	BS HR 55, 207
NIMONIC® alloy PK33 Ni 56.0, Cr 18.0, Co 14.0, Mo 7.0, Ti 2.4, Al 2.1 A readily weldable, high creep strength superalloy with good resistance to thermal shock and thermal fatigue. Available as forging billet, bar, extruded section, sheet/strip, plate and wire.	AFNOR NC 19 KDU	BS DTD 5057

	Product designations	Specifications
Waspaloy Ni 58.0, Cr 19.5, Co 13.5, Mo 4.25, Ti 3.0, Al 1.4 A high-strength, creep-resistant superalloy used for critical gas turbine engine components. This alloy is made by Special Metals as a VIM melted and ESR remelted product offering improved cleanness as well as by conventional VIM/VAR routes. Available as forging billet, bar, extruded section and wire.	UNS N07001 Werkstoff Nr 2.4654 AFNOR NC 20 K 14 AICMA NI-P 101 HT ISO NW7001	SAE AMS 5544, 5704, 5706-09, 5828 AECMA PrEN 2193-95, 2406, 2958-2960, 3220 ISO 9723-25
INCOLOY® alloy 903 Fe 42.0, Ni 38.0, Co 15.0, Nb 3.0, Ti 1.4, Al 0.9 An age-hardenable alloy with a low and constant coefficient of thermal expansion up to 800°F (430°C), high strength, a constant modulus of elasticity and resistance to thermal shock. Available as forging billet, bar and wire.	UNS N19903 AFNOR Z 3 NK 38	
INCOLOY® alloy 909 Fe 42.0, Ni 38.0, Co 13.0, Nb 4.7, Ti 1.5, Si 0.4, Al 0.03 Similar to INCOLOY alloy 903 but with improved notch-rupture and high-temperature tensile properties and improved processing characteristics. Available as forging billet, bar, sheet/strip and wire.	UNS N19909	SAE AMS 5884, 5892-93
INCOLOY® alloy MA956 Fe 74.0, Cr 20.0, Al 4.5, Ti 0.5, Y_2O_3 0.5 An oxide-dispersion-strengthened Fe-Cr-Al alloy, made by the mechanical alloying powder process, with exceptional strength and oxidation-, sulfidation- and carburization-resistance at up to around 2300°F (1250°C). Available as bar, sheet/strip, tubing and wire.	UNS S67956	
INCOLOY® alloy A-286 Fe 56.5, Ni 25.5, Cr 15.0, Ti 2.1, Mo 1.25 An age-hardenable Fe-Ni-Cr alloy with good strength and oxidation-resistance up to around 1300°F (700°C). Available as forging billet, bar, sheet/strip, plate and wire.	UNS S66286 Werkstoff Nr 1.4980 AFNOR Z 3 NCT 25	SAE AMS 5525, 5726, 5731-32, 5734, 5737, 5858, 5895, 7235 BS HR 51-2, 650 AECMA PrEN 2119, 2171-75, 2303-04, 2398-99, 2417, 3510
UDIMET® alloy 188 Co 38.0, Ni 22.0, Cr 22.0, W 14.0, Fe 3.0, Mn 1.25 A cobalt-base alloy with good high temperature strength, and oxidation/sulfidation resistance for applications as gas turbine combustors and other key components. Available as forging billet, bar, plate and sheet.	UNS R30188	SAE AMS 5772

	Product designations	Specifications
UDIMET® alloy 500 Ni 53.0, Co 18.5, Cr 18.0, Mo 4.0, Ti 3.0, Al 3.0 A high strength, creep-resistant superalloy used for critical gas turbine blading components. Available as forging bar.	UNS N07500	SAE AMS 5751, 5753
UDIMET® alloy 520 Ni 56.0, Cr 19.0, Co 12.0, Mo 6.0, Ti 3.0, Al 2.0, W 1.0 A nickel-base alloy with good high temperature strength and structural stability for application as gas turbine blading material. Available as forging bar.		
UDIMET® alloy L-605 Co 50.0, Cr 20.5, W 15.0, Ni 10.0, Fe 3.0, Mn 1.5 A cobalt-base alloy with high strength, good oxidation resistance to 1800°F (980°C), good sulfidation resistance and resistance to wear and galling. Applications include gas turbine components and bearings. Available as forging billet, bar, sheet and plate.	UNS R30605	SAE AMS 5759
UDIMET® alloy 700 Ni 53.0, Cr 15.0, Co 18.5, Ti 3.5, Mo 5.2, Al 4.3 A nickel-base alloy used in gas turbine blading and disc applications requiring high strength at elevated temperatures. Available as forging billet and bar.	SAE AMS 5846	
UDIMET® alloy 720 Ni 56.0, Cr 16.0, Co 14.7, Ti 5.0, Mo 3.0, Al 2.5, W 1.25 A nickel-base alloy used in gas turbine blading and disc applications requiring high strength at elevated temperatures and good corrosion resistance. Available as forging billet and bar.		
UDIMET® alloy D-979 Ni 45.0, Fe 27.0, Cr 15.0, Mo 4.0, W 4.0, Ti 3.0, Al 1.0 An age hardenable nickel-base alloy exhibiting good strength and corrosion resistance at moderate temperatures. Normally used in gas turbine disc applications. Available as forging billet and bar.	UNS N09979	SAE AMS 5746
UDIMET® alloy R41 Ni 55.0, Cr 19.0, Co 11.0, Mo 10.0, Ti 3.1, Al 1.5 An age hardenable nickel-base alloy exhibiting excellent strength at elevated temperatures. Normally used in gas turbine rings and fabricated assemblies. Available as forging billet, bar, sheet and plate.	UNS N07041	SAE AMS 5712-13

	Product designations	Specifications
UDIMAR® alloy 250 Fe 68.0, Ni 18.0, Co 8.0, Mo 5.0, Ti 0.4, Al 0.1 An age hardenable martensitic (maraging) steel combining ultra-high strength, toughness and resistance to crack propagation. Available as forging billet and bar.	UNS K92890 UNS K92940	SAE AMS 6512
UDIMAR® alloy 300 Fe 66.0, Ni 18.5, Co 9.0, Mo 5.0, Ti 0.7, Al 0.1 An age hardenable martensitic (maraging) steel combining ultra-high strength and resistance to crack propagation. Available as forging billet and bar.	UNS K93120	SAE AMS 6514

Powder alloys

For discs and shafts

Product section 1

Material selection for these critical rotating applications is dictated by the operating temperatures and by physical and mechanical property requirements including high proof strength, tensile ductility, low creep extension, fracture toughness, resistance to crack propagation, and high- and low- cycle fatigue strength.

Comparing candidate disc materials, titanium and its alloys are the strongest available, but offer poor oxidation-resistance above 900F (480C), and are the most expensive. The Ni-Cr-Fe alloys (Waspaloy, INCONEL alloy 718 and NIMONIC alloy 901) offer the most cost-effective range of selection for aircraft engines. Steels are cheaper and are used where power-to-weight ratios are less important, such as in heavy-duty, land-based engines. Even in that market, the trend is to the higher performance nickel-base alloys such as INCONEL alloy 706 *(see Figure 1)* and INCONEL alloy 718.

Stress-rupture, yield strength and tensile strength properties of some of the disc alloys offered by Special Metals are illustrated in *Figures 2, 3 and 4*. To achieve these and other critical property levels, Special Metals facilities on both sides of the Atlantic are able to offer combinations of vacuum induction melting and the vacuum arc and electroslag remelting process. For the most demanding operating conditions, Special Metals produces powder metal superalloys for forging and as-hot isostatically pressed components.

In some gas turbine engines the shafts are integrally bonded with the discs. High-performance superalloys are required. Where the length of the shaft also introduces problems of differential expansion, which can lead to difficulties in achieving gas-tight seals, the controlled, low, thermal expansion alloys - INCOLOY alloys 903 and 909, and INCONEL alloy 783 should be considered.

NIMONIC and Waspaloy turbine discs, as displayed at the Farnborough International and Paris, Le Bourget, air shows

Fig. 1: Progress in superalloy development for industrial gas turbine rotor wheels.

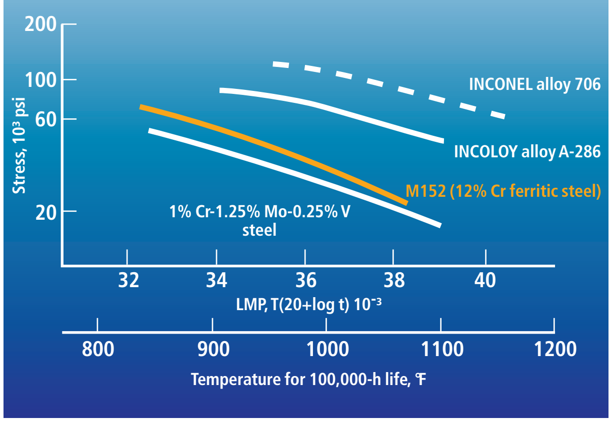


Fig. 2: Stress to produce rupture in disc alloys in 1000 hours.

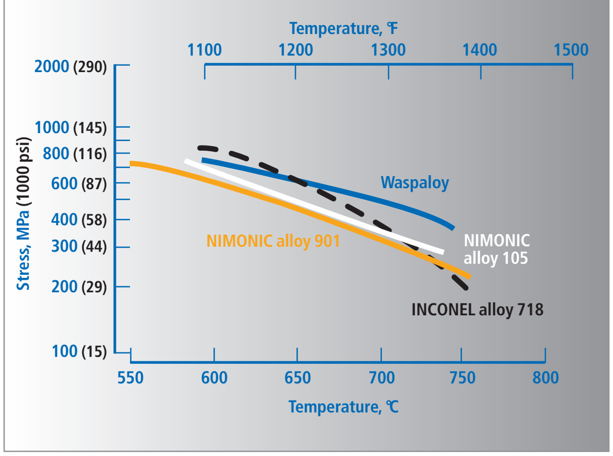


Fig. 3: 0.2% yield strength at 1200°F (650°C) of disc alloys made by Special Metals

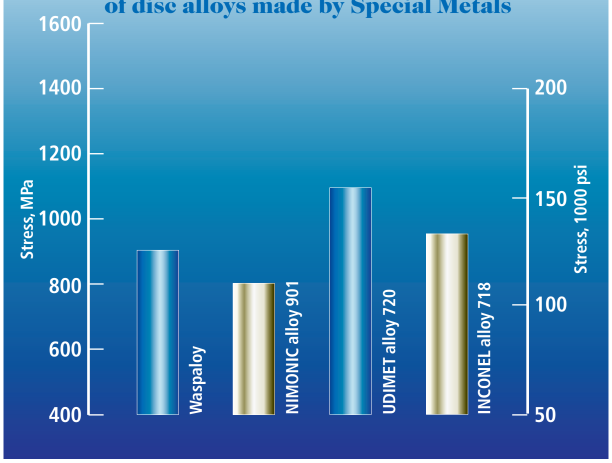
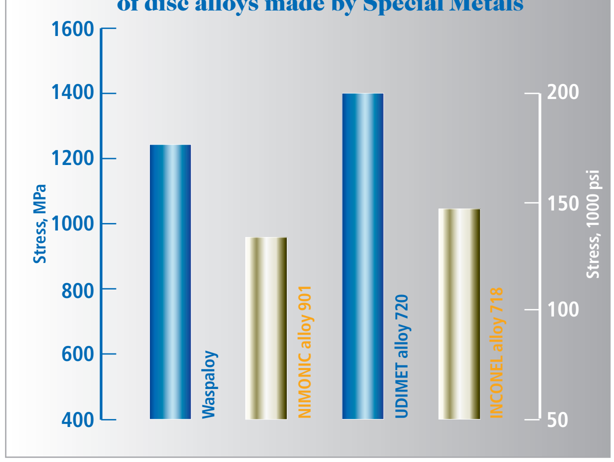


Fig. 4: Tensile strength at 1200°F (650°C) of disc alloys made by Special Metals



For blades and vanes

Product section 2

The rotor blades of gas turbine engines operate under more rigorous conditions of stress and temperature than any other components. Blade tip speeds can be as high as 1280 ft (390 m) per second. Gas temperatures can be up to 2200°F (1200°C), and gas velocity can reach 1970 ft (600 m) per second.

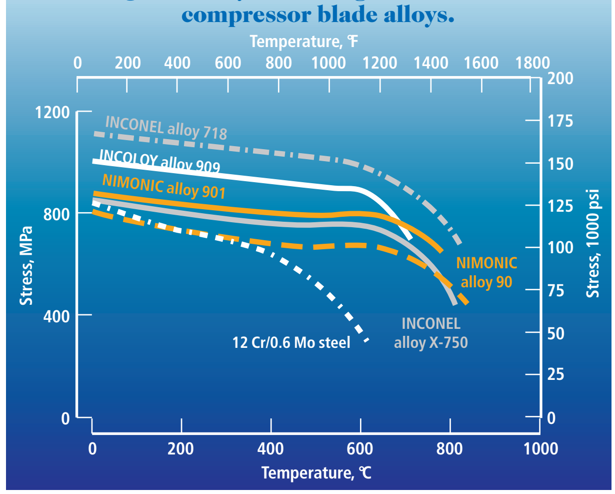
A blade material must resist corrosion and erosion, superimposed fatigue stresses, and impact loadings. It must meet requirements for service life between overhauls. Material density is important; affecting centrifugal loading and the weight of the disc necessary to support the blades.

Compressor blades, though not subject to temperatures and stresses as high as in the turbine rotor stages, present increasingly complex material selection problems. For the current generation of aircraft engines, for example, compressor blade alloys need high yield and tensile strengths up to 1110°F (600°C), low density, high impact strength and good fatigue strength.

Special Metals products have been used for turbine rotor blades and vanes since the early 1940s. Most recently, INCONEL alloy MA754, an oxide dispersion strengthened superalloy made by the mechanical alloying powder metallurgy process, has established an application for stator assemblies in military aircraft.

As performance requirements have increased in the "cooler" sectors of engines, so the nickel-base superalloys are increasingly used in the compressor stages.

Fig. 5: 0.2% yield strength of candidate compressor blade alloys.



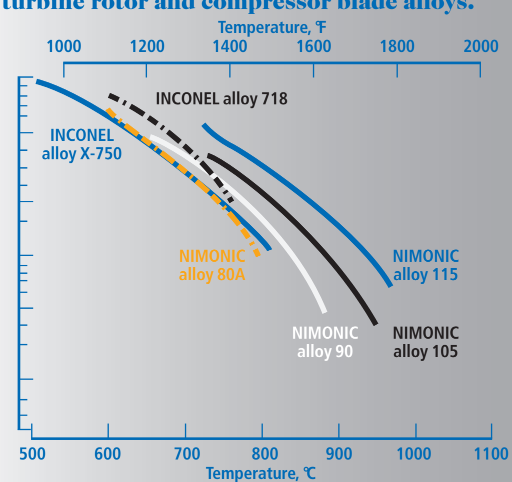


Fig. 6: 1000-hour creep-rupture strength of turbine rotor and compressor blade alloys.

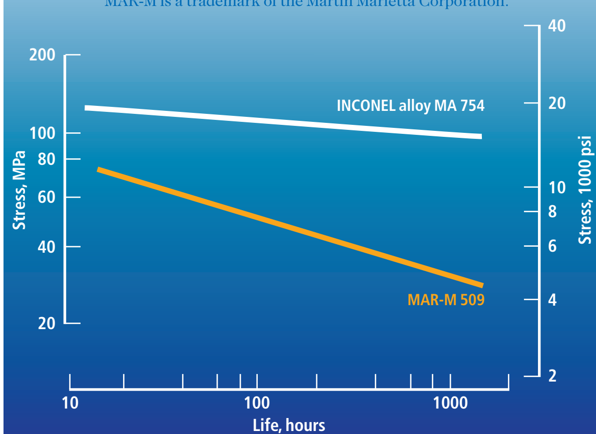


Fig. 7: Operating life for INCONEL alloy MA754 compared with that of a conventional superalloy used for nozzle guide vanes.

MAR-M is a trademark of the Martin Marietta Corporation.

For casings, rings and seals

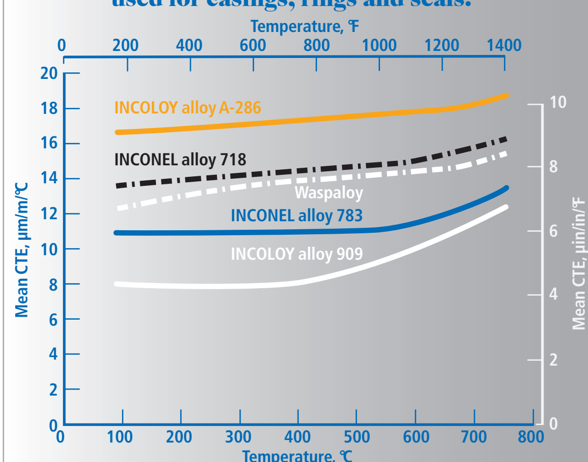
Product section 3

The term "casings, rings, and seals" covers a wide variety of circular forms used, from the compressor intake through to the exhaust system, to contain the rotating components. They vary in configuration according to their location in the engine, and in materials according to the operating temperatures and the corrosive environments. They can be made by casting, ring rolling, and forming and welding from extruded and welded sections. Special Metals supplies superalloys for all these processes, except casting.

At Special Metals Wiggin Ltd., Hereford, UK, the focus is on extruded, near-net profile section for rolled and welded rings, offering cost-effective profiles with minimum machining envelopes, to create complex casings.

Maintaining its leadership in superalloy development, Special Metals has also introduced a new controlled expansion superalloy, INCONEL alloy 783, specifically for this type of application.

Fig. 8: Controlled thermal expansion properties of some of the Special Metals superalloys used for casings, rings and seals.



Extruded sections in nickel-base superalloys for casings, rings and seals.

Fig. 9: INCONEL alloy 783 - room-temperature mechanical properties.

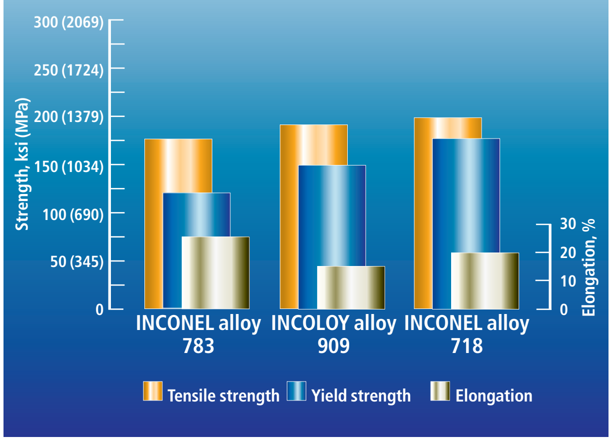


Fig. 10: INCONEL alloy 783 - stress-rupture properties at 1200°F (650°C)

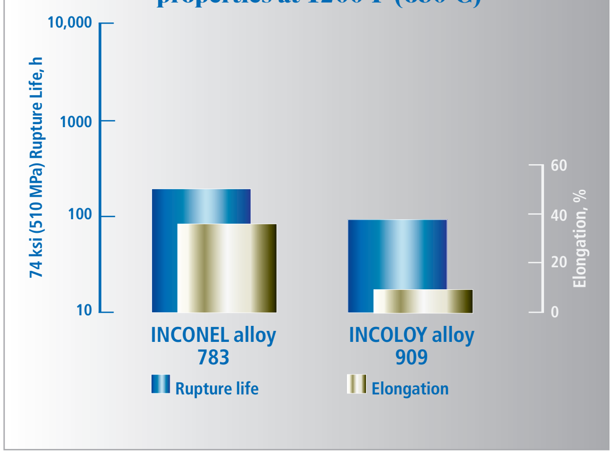


Fig. 11. Cyclic oxidation-resistance at 1300 °F (704°C). Cycle of 15 minutes heating/5 minutes cooling.

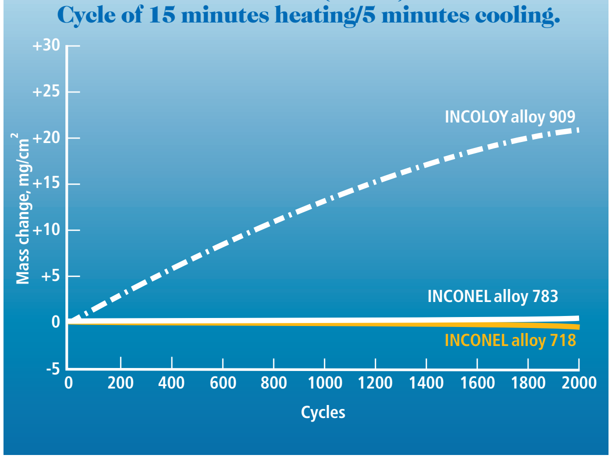
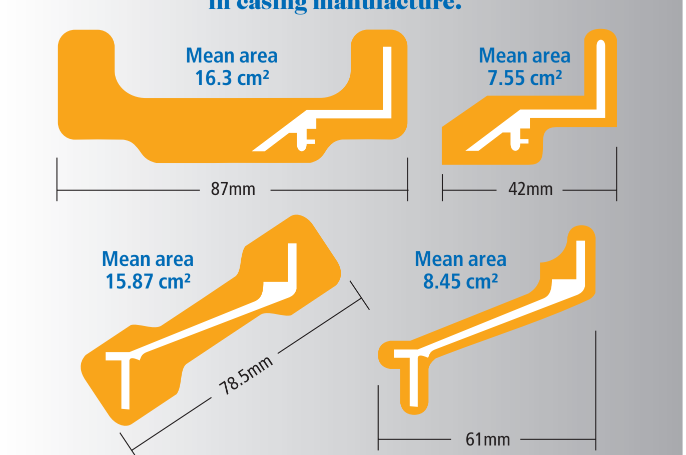


Fig. 12: These two examples illustrate how close tolerance, near-net profile sections (on the right), with small machining envelopes, save time and money in casing manufacture.



For sheet alloy fabrications

Product section 4

Many gas turbine components, most of which are used for containing or directing gases at high temperatures and pressures, are made from high-performance alloy sheet. Although performance demands are not as high as those for critical rotating components, the materials selection criteria are still specialized. Gas temperatures can be as high as 2000°F (1100°C). The need for light-weight sheet creates a demand for high-strength, oxidation-resistant superalloys. Complex component designs require excellent ductility and ease of fabrication.

In brief, the materials selection criteria can be defined as high thermal and mechanical fatigue strength, creep strength, oxidation-resistance, ease of fabrication and joining and, where appropriate, the availability of matched composition welding products. The INCONEL, NIMONIC, and INCOLOY alloys from Special Metals meet all these demands and are being further developed to respond to design needs.

INCONEL alloy 625LCF *(UNS N06626)* is a premium, bellows quality, development of INCONEL alloy 625, itself a Special Metals invention. It offers outstanding low-cycle fatigue strength which can be as much as a hundred times better than that of conventional alloy 625 at stresses around 100,000 psi (690 MPa). The new alloy offers a combination of low-cycle fatigue life, good weldability and consistent formability. Its composition meets standard specifications for alloy 625, with carbon, silicon, and nitrogen controlled to low and more precise levels. With closely controlled processing, the new product has a microstructure that improves the low-cycle fatigue strength. Composition, processing, VIM melting and ESR remelting combine to offer dramatic improvements in low-cycle and thermal fatigue compared with alloy 625 produced with conventional chemistry and processing.

INCONEL alloy 718SPF *(UNS N07719)* was developed from INCONEL alloy 718 (yet another

Transition ducts and combustion liners fabricated from superalloy sheet for GE land-based turbine applications.
(Courtesy of GE Power Systems.)

Special Metals invention) to meet the need for a nickel-base alloy suitable for the use of superplastic forming technologies to manufacture complex components subject to high-temperature stress and corrosion-resistance in service. Optimized for the fabrication process by rigorous controls of composition, melt practices and rolling conditions, INCONEL alloy 718SPF meets all the property requirements of AMS 5596G, as annealed plus aged, as well as all the requirements of AMS 5950, specific to the new alloy.

INCONEL alloy MA754, an oxide-dispersion-strengthened superalloy made by the mechanical alloying powder process, has a twenty year history of gas turbine use as a bar product. Today it is being re-evaluated for a new series of applications as a fabricated sheet alloy involving spin forming, brazing, expanding cylinders and honeycomb fabrication.

Fig. 13: Cyclic oxidation-resistance of some superalloys. Thermal cycle between room temperature and 1000°C (1830°F), except as noted, 15 minutes heating/ 5 minutes cooling.

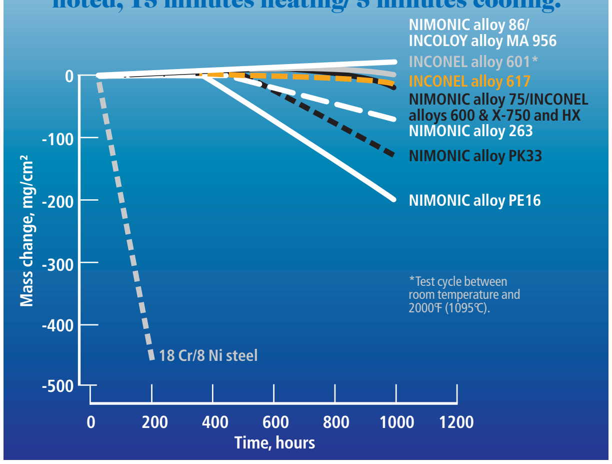


Fig. 14: 1000-hour creep-rupture data for some of the alloys used for sheet metal applications.

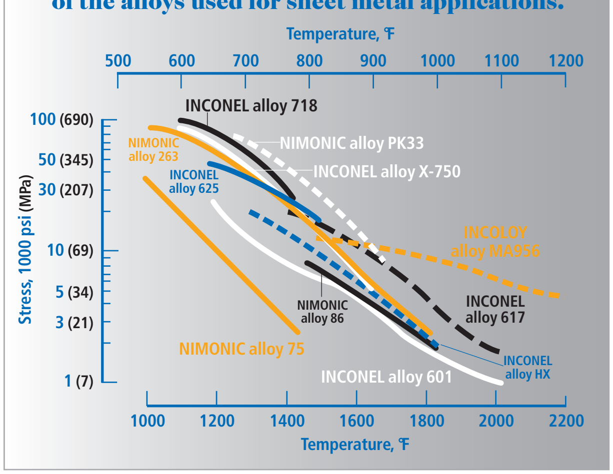
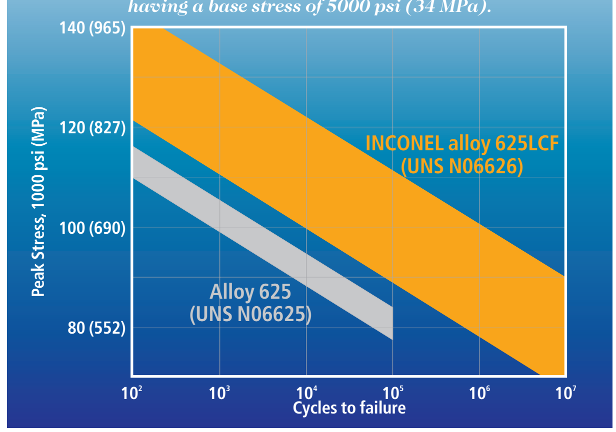


Fig. 15: Low-cycle fatigue strength comparison between INCONEL alloy 625LCF and conventional alloy 625 at 900-1200°F (480-750°C).
All data determined from axial load (pull/pull) tests having a base stress of 5000 psi (34 MPa).



SPECIAL METALS

www.specialmetals.com

U.S.A.
Special Metals Corporation
Billet, rod & bar, flat & tubular products
3200 Riverside Drive
Huntington, WV 25705-1771
Phone +1 (304) 526-5100
+1 (800) 334-4626
Fax +1 (304) 526-5643

Billet & bar products
4317 Middle Settlement Road
New Hartford, NY 13413 5392
Phone +1 (315) 798-2900
+1 (800) 334-8351
Fax +1 (315) 798-2016

Atomized powder products
100 Industry Lane
Princeton, KY 42445
Phone +1 (270) 365-9551
Fax +1 (270) 365-5910

United Kingdom
Special Metals Wiggin Ltd.
Holmer Road
Hereford HR4 9SL
Phone +44 (0)1432 382200
Fax +44 (0)1432 264030

France
Special Metals Services SA
17 rue des Frères Lumière
69680 Chassieu (Lyon)
Phone +33 (0)4 72 47 46 46
Fax +33 (0)4 72 47 46 59

Germany
Special Metals Deutschland Ltd.
Postfach 20 04 09
40102 Düsseldorf
Phone +49 (0)211 38 63 40
Fax +49 (0)211 37 98 64

Hong Kong
Special Metals Pacific Pte. Ltd.
Room 1110, 11th Floor
Tsuen Wan Industrial Centre
220-248 Texaco Road, Tsuen Wan
Phone +852 2439 9336
Fax +852 2530 4511

India
Special Metals Services Ltd.
520, 46th Cross, V Block
Jayanagar, Bangalore 560 041
Phone +91 (0)80 664 6521
Fax +91 (0)80 664 2773

Italy
Special Metals Services SpA
Via Assunta 59
20054 Nova Milanese (MI)
Phone +390 (0)362 4941
Fax +390 (0)362 494224

The Netherlands
Special Metals Services BV
Postbus 8681
3009 AR Rotterdam
Phone +31 (0)10 451 44 55
Fax +31 (0)10 450 05 39

Singapore
Special Metals Pacific Pte. Ltd.
50 Robinson Road
06-00 MNB Building, Singapore 06888
Phone +65 222 3988
Fax +65 221 4298

Affiliated Companies

Special Metals Welding Products
1401 Burris Road
Newton, NC 28658, U.S.A.
Phone +1 (828) 465 0352
+1 (800) 624 3411
Fax +1 (828) 464 8993

Regal Road
Stratford-upon-Avon
Warwickshire CV37 0AZ, U.K.
Phone +44 (0)1789 268017
Fax +44 (0)1789 269681

Controlled Products Group
590 Seaman Street, Stoney Creek
Ontario L8E 4H1, Canada
Phone +1 (905) 643 6555
Fax +1(905) 643 6614

A-1 Wire Tech, Inc.
A Special Metals Company
840 39th Avenue
Rockford, IL 61109, U.S.A.
Phone +1 (815) 226 0477
+1 (800) 426 6380
Fax +1 (815) 226 0537

Reseal SA
A Special Metals Company
200 rue de la Couronne des Prés
78681 Epône Cédex, France
Phone +33 (0)1 30 90 04 00
Fax +33 (0) 30 90 02 11

DAIDO-*SPECIAL METALS* Ltd.
A Joint Venture Company
Daido Building
7-13, Nishi-shinbashi 1-chome
Minato-ku, Tokyo 105, Japan
Phone +81 (0)3 3504 0921
Fax +81 (0)3 3504 0939

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