

## NICKEL SUPERALLOYS

Where aluminium and steel give out, nickel superalloys keep their strength and resist oxidation and corrosion — the hot section of the gas turbine, and the harshest sour-service oil & gas environments. This family is led by the Inconel grades, complemented by Hastelloy, Waspaloy and Monel. Alloys are either solid-solution strengthened (formable, weldable, corrosion-led) or precipitation/age-hardened (highest strength at temperature).

### Inconel (Ni-Cr-Fe-Nb, age-hardenable)

The dominant aero-engine superalloy family. Inconel 718 is age-hardened for high strength from cryogenic temperatures to ~700 °C, with excellent weldability — turbine discs, casings, fasteners and rocket hardware.

| Grade                                                                     | Nominal composition (wt %)             | UTS / YS / El (MPa, %)                                                               | Key properties & applications                                                                                                                                                                                                                                         |
|---------------------------------------------------------------------------|----------------------------------------|--------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Inconel 718</b><br><i>Alloy 718 / IN718 / Nicrofer 5219</i><br>Day-one | Ni 52, Cr 19, Fe 18, Nb 5, Mo 3, Ti/Al | UTS 1275 / YS 1035 / El 12%<br>$\rho$ 8.19 g/cm <sup>3</sup><br>36 HRC<br>Tmax 700°C | The dominant aero-engine superalloy: high strength -250 C to +700 C, weldable, age-hardenable (site headline grade)<br><b>Forms:</b> Bar, Rod, Plate, Sheet, Forging, Wire, Tube, Powder<br><b>Use:</b> Turbine discs & blades, engine casings, fasteners, rocket, AM |

### Inconel (Ni-Cr-Mo-Nb, solid-solution)

Solid-solution strengthened Inconel 625 combines high strength with outstanding corrosion resistance across acids and seawater, plus superb weldability — exhaust systems, bellows, and oil & gas corrosion-resistant-alloy (CRA) service.

| Grade                                                     | Nominal composition (wt %)       | UTS / YS / El (MPa, %)                                                             | Key properties & applications                                                                                                                                                                                                                         |
|-----------------------------------------------------------|----------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Inconel 625</b><br><i>Alloy 625 / IN625</i><br>Day-one | Ni 61, Cr 21.5, Mo 9, Nb 3.6, Fe | UTS 830 / YS 415 / El 30%<br>$\rho$ 8.44 g/cm <sup>3</sup><br>190 HB<br>Tmax 980°C | Outstanding corrosion resistance across acids & seawater; high fatigue strength; excellent weldability<br><b>Forms:</b> Bar, Rod, Plate, Sheet, Tube, Forging, Wire, Powder<br><b>Use:</b> Exhaust systems, seawater/chemical, oil & gas CRA, bellows |

### Inconel (Ni-Cr, high-temp)

High-chromium Inconel 600/601 for oxidation and carburisation resistance at temperature; X-750 adds age-hardening for springs and high-temperature bolting.

| Grade                                                                      | Nominal composition (wt %)                             | UTS / YS / El (MPa, %)                                                              | Key properties & applications                                                                                                                                                                                               |
|----------------------------------------------------------------------------|--------------------------------------------------------|-------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Inconel 600 / 601 / X-750</b><br><i>Alloy 600/601/X-750</i><br>To-order | Ni 72-76, Cr 15-23, Fe, (X-750: +Ti/Al age-hardenable) | UTS 655 / YS 285 / El 35%<br>$\rho$ 8.42 g/cm <sup>3</sup><br>170 HB<br>Tmax 1090°C | High-temperature oxidation & carburisation resistance; X-750 adds spring/age-hardening capability<br><b>Forms:</b> Bar, Sheet, Plate, Tube, Wire<br><b>Use:</b> Furnace & heat-treat, exhaust, springs (X-750), gas-turbine |

### Hastelloy (Ni-Mo-Cr)

The benchmark for wet-corrosion and sour-service resistance. Hastelloy C-276 handles both reducing and oxidising media — chemical process, flue-gas and the most aggressive sour oil & gas.

| Grade                                                    | Nominal composition (wt %)     | UTS / YS / El (MPa, %)                                                              | Key properties & applications                                                                                                                                                                                                  |
|----------------------------------------------------------|--------------------------------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Hastelloy C-276</b><br><i>Alloy C-276</i><br>To-order | Ni 57, Mo 16, Cr 16, Fe 5, W 4 | UTS 790 / YS 355 / El 40%<br>$\rho$ 8.89 g/cm <sup>3</sup><br>90 HRB<br>Tmax 1090°C | Benchmark for wet-corrosion & sour-service resistance; handles reducing & oxidising media<br><b>Forms:</b> Bar, Plate, Sheet, Tube, Wire, Forging<br><b>Use:</b> Chemical process, sour oil & gas, flue-gas, pollution control |

### Cobalt-strengthened (Ni-Cr-Co-Mo)

Waspaloy is cobalt-strengthened and age-hardened to hold high strength above 718, to ~870 °C — turbine discs, shafts and high-temperature fasteners.

| Grade                                          | Nominal composition (wt %)              | UTS / YS / El (MPa, %)                                                              | Key properties & applications                                                                                                                                                          |
|------------------------------------------------|-----------------------------------------|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Waspaloy</b><br><i>Waspaloy</i><br>To-order | Ni 58, Cr 19, Co 13, Mo 4, Ti 3, Al 1.4 | UTS 1275 / YS 795 / El 25%<br>$\rho$ 8.19 g/cm <sup>3</sup><br>38 HRC<br>Tmax 870°C | Retains high strength to ~870 C - above Inconel 718; premium turbine-disc alloy<br><b>Forms:</b> Bar, Billet, Forging<br><b>Use:</b> Turbine discs, shafts, high-temperature fasteners |

### Nickel-Copper (Monel)

Nickel-copper alloys with excellent seawater and hydrofluoric-acid resistance; non-magnetic. Monel 400 for corrosion service, K-500 age-hardened for strength — marine, pump/valve shafts and downhole tools.

| Grade                                                            | Nominal composition (wt %)                               | UTS / YS / El (MPa, %)                                                             | Key properties & applications                                                                                                                                                                                         |
|------------------------------------------------------------------|----------------------------------------------------------|------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Monel 400 / K-500</b><br><i>Alloy 400 / K-500</i><br>To-order | Ni 63-66, Cu 28-34, Fe 2, (K-500: +Al/Ti age-hardenable) | UTS 550 / YS 240 / El 40%<br>$\rho$ 8.80 g/cm <sup>3</sup><br>130 HB<br>Tmax 540°C | Excellent seawater & HF-acid resistance; K-500 adds high strength via age-hardening; non-magnetic<br><b>Forms:</b> Bar, Rod, Plate, Sheet, Tube, Wire<br><b>Use:</b> Marine, seawater, oil & gas, pump & valve shafts |

#### Forms by industry —

**Aerospace:** Bar, forging, sheet, tube, powder — turbine section, casings, exhaust, AM

**Automotive:** Bar, sheet, tube — turbocharger, exhaust, valves (motorsport)

**Oil & Gas:** Bar, tube, plate, forging — subsea, sour service, valves, cladding (CRA)