

# In718-0405 powder for additive manufacturing

## Process specification

|                                      |                     |
|--------------------------------------|---------------------|
| <b>Powder description</b>            | Nickel alloy powder |
| <b>Layer thickness</b>               | 30 µm and 60 µm     |
| <b>Laser power</b>                   | 200 W               |
| <b>Additive manufacturing system</b> | AM250               |

## Material description

In718-0405 alloy comprises nickel mass fraction up to 55% alloyed with iron up to 21% and chromium up to 21%, along with other minor elements. Properties include high strength, excellent corrosion resistance and a working temperature range between -250 °C and 650 °C (-418 °F to 1200 °F). It is also age-hardenable.

In718-0405 has a wide range of applications within industry and is particularly suitable for applications where good tensile, creep, and rupture strength is required. Similar to In625-0402 which is suitable for applications where corrosion and oxidation resistance at high temperatures is required. Its excellent welding characteristics and resistance to cracking makes it an ideal material for additive manufacturing.

## Material properties

- Retains strength up to 650 °C
- High creep resistance
- High corrosion resistance
- Solidification properties suit additive manufacture

## Applications

- Aerospace and defence
- Gas turbine blades
- Exhaust manifolds
- Rocket motors
- Heat exchangers
- Nuclear

## Generic data - wrought material

|                                                      |                        |
|------------------------------------------------------|------------------------|
| <b>Density</b>                                       | 8.19 g/cm <sup>3</sup> |
| <b>Thermal conductivity</b>                          | 6 W/mK to 12 W/mK      |
| <b>Melting range</b>                                 | 1260 °C to 1336 °C     |
| <b>Coefficient of thermal expansion (see note 1)</b> | 12 µm/mK to 16 µm/mK   |

Note 1 In the range of 25 °C to 760 °C.

Note 2 Heat treated conditions: 1. Solution treated at 980 °C ± 10 °C for 1 hr 2. Aged at 720 °C ± 10 °C for 8 hr, and further aged at 620 °C ± 10 °C for 8 hr.

Note 3 Hot Isostatically pressed.

Note 4 Tested at ambient temperature to ASTM E8. Machined before testing. Values based on a sample size of 6.

Note 5 Tested to ASTM E384-11, after polishing.

Note 6 Tested to JIS B 0601-2001 (ISO 97), after bead blasting.

## Composition of powder

| Element              | Mass (%)       |
|----------------------|----------------|
| Nickel               | 50.00 to 55.00 |
| Chromium             | 17.00 to 21.00 |
| Iron                 | Balance        |
| Niobium and Tantalum | 4.75 to 5.5    |
| Molybdenum           | 2.80 to 3.30   |
| Titanium             | 0.65 to 1.15   |
| Cobalt               | ≤ 1.00         |
| Aluminium            | 0.20 to 0.80   |
| Manganese            | ≤ 0.35         |
| Silicon              | ≤ 0.35         |
| Copper               | ≤ 0.30         |
| Carbon               | 0.02 to 0.05   |
| Nitrogen             | ≤ 0.03         |
| Oxygen               | ≤ 0.03         |
| Phosphorus           | ≤ 0.015        |
| Sulphur              | ≤ 0.015        |
| Calcium              | ≤ 0.01         |
| Magnesium            | ≤ 0.01         |
| Selenium             | ≤ 0.005        |
| Boron                | ≤ 0.005        |

\*ASTM standard composition powder. Renishaw powders are supplied to a tighter specification to minimise batch-to-batch variations. Results quoted in this data sheet are from samples produced using Renishaw's tighter specification powder. Please contact Renishaw for further information about specifications or if you require support in qualifying non-Renishaw powders.

## Mechanical properties of additively manufactured components using 30 µm layers

|                                                          | As built           |                                      | Solution treated and aged (See note 2) |                                      | HIP treated (See note 3) |                                      |
|----------------------------------------------------------|--------------------|--------------------------------------|----------------------------------------|--------------------------------------|--------------------------|--------------------------------------|
|                                                          | Mean               | Standard deviation ( $\pm 1\sigma$ ) | Mean                                   | Standard deviation ( $\pm 1\sigma$ ) | Mean                     | Standard deviation ( $\pm 1\sigma$ ) |
| <b>Ultimate tensile strength (UTS)</b> (See note 4)      |                    |                                      |                                        |                                      |                          |                                      |
| Horizontal direction (XY)                                | 1040 MPa           | 7 MPa                                | 1467 MPa                               | 6 MPa                                | 1379 MPa                 | 3 MPa                                |
| Vertical direction (Z)                                   | 971 MPa            | 3 MPa                                | 1391 MPa                               | 9 MPa                                | 1346 MPa                 | 5 MPa                                |
| <b>Yield strength</b> (see note 4)                       |                    |                                      |                                        |                                      |                          |                                      |
| Horizontal direction (XY)                                | 758 MPa            | 4 MPa                                | 1259 MPa                               | 5 MPa                                | 1088 MPa                 | 26 MPa                               |
| Vertical direction (Z)                                   | 636 MPa            | 19 MPa                               | 1202 MPa                               | 15 MPa                               | 1052 MPa                 | 4 MPa                                |
| <b>Elongation at break</b> (see note 4)                  |                    |                                      |                                        |                                      |                          |                                      |
| Horizontal direction (XY)                                | 30%                | 1%                                   | 17%                                    | 1%                                   | 25%                      | 1%                                   |
| Vertical direction (Z)                                   | 36%                | 1%                                   | 17%                                    | 1%                                   | 24%                      | 1%                                   |
| <b>Modulus of elasticity</b> (see note 4)                |                    |                                      |                                        |                                      |                          |                                      |
| Horizontal direction (XY)                                | 186 GPa            | 5 GPa                                | 195 GPa                                | 13 GPa                               | 207 GPa                  | 4 GPa                                |
| Vertical direction (Z)                                   | 158 GPa            | 18 GPa                               | 186 GPa                                | 15 GPa                               | 201 GPa                  | 3 GPa                                |
| <b>Hardness (Vickers)</b> (see note 5)                   |                    |                                      |                                        |                                      |                          |                                      |
| Horizontal direction (XY)                                | 277 HV0.5          | 9 HV0.5                              | 418 HV0.5                              | 9 HV0.5                              | 456 HV0.5                | 11 HV0.5                             |
| Vertical direction (Z)                                   | 302 HV0.5          | 8 HV0.5                              | 488 HV0.5                              | 11 HV0.5                             | 463 HV0.5                | 7 HV0.5                              |
| <b>Surface roughness (<math>R_a</math>)</b> (See note 6) |                    |                                      |                                        |                                      |                          |                                      |
| Horizontal direction (XY)                                | 1.28 µm to 1.36 µm |                                      |                                        |                                      |                          |                                      |
| Vertical direction (Z)                                   | 1.72 µm to 1.96 µm |                                      |                                        |                                      |                          |                                      |

Density of additively manufactured In718 is typically 99.8%, measured optically on a 10 mm × 10 mm × 10 mm sample at 75× magnification.

## Mechanical properties of additively manufactured components using 60 µm layers

|                                                          | As built           |                                      | Solution treated and aged (See note 2) |                                      | HIP treated (See note 3) |                                      |
|----------------------------------------------------------|--------------------|--------------------------------------|----------------------------------------|--------------------------------------|--------------------------|--------------------------------------|
|                                                          | Mean               | Standard deviation ( $\pm 1\sigma$ ) | Mean                                   | Standard deviation ( $\pm 1\sigma$ ) | Mean                     | Standard deviation ( $\pm 1\sigma$ ) |
| <b>Ultimate tensile strength (UTS)</b> (See note 4)      |                    |                                      |                                        |                                      |                          |                                      |
| Horizontal direction (XY)                                | 1057 MPa           | 11 MPa                               | 1504 MPa                               | 3 MPa                                | 1289 MPa                 | 4 MPa                                |
| Vertical direction (Z)                                   | 943 MPa            | 38 MPa                               | 1439 MPa                               | 11 MPa                               | 1228 MPa                 | 24 MPa                               |
| <b>Yield strength</b> (see note 4)                       |                    |                                      |                                        |                                      |                          |                                      |
| Horizontal direction (XY)                                | 753 MPa            | 8 MPa                                | 1306 MPa                               | 10 MPa                               | 958 MPa                  | 8 MPa                                |
| Vertical direction (Z)                                   | 639 MPa            | 13 MPa                               | 1231 MPa                               | 10 MPa                               | 929 MPa                  | 10 MPa                               |
| <b>Elongation at break</b> (see note 4)                  |                    |                                      |                                        |                                      |                          |                                      |
| Horizontal direction (XY)                                | 25%                | 3%                                   | 16%                                    | 2%                                   | 23%                      | 2 %                                  |
| Vertical direction (Z)                                   | 19%                | 8%                                   | 16%                                    | 2%                                   | 17%                      | 4%                                   |
| <b>Modulus of elasticity</b> (see note 4)                |                    |                                      |                                        |                                      |                          |                                      |
| Horizontal direction (XY)                                | 203 GPa            | 10 GPa                               | 202 GPa                                | 4 GPa                                | 219 GPa                  | 6 GPa                                |
| Vertical direction (Z)                                   | 191 GPa            | 9 GPa                                | 198 GPa                                | 11 GPa                               | 214 GPa                  | 7 GPa                                |
| <b>Hardness (Vickers)</b> (see note 5)                   |                    |                                      |                                        |                                      |                          |                                      |
| Horizontal direction (XY)                                | 275 HV0.5          | 14 HV0.5                             | 465 HV0.5                              | 28 HV0.5                             | 408 HV0.5                | 11 HV0.5                             |
| Vertical direction (Z)                                   | 295 HV0.5          | 11 HV0.5                             | 467 HV0.5                              | 20 HV0.5                             | 418 HV0.5                | 16 HV0.5                             |
| <b>Surface roughness (<math>R_a</math>)</b> (See note 6) |                    |                                      |                                        |                                      |                          |                                      |
| Horizontal direction (XY)                                | 1.14 µm to 1.70 µm |                                      |                                        |                                      |                          |                                      |
| Vertical direction (Z)                                   | 2.36 µm to 3.0 µm  |                                      |                                        |                                      |                          |                                      |

Density of additively manufactured In718 is typically 99.8%, measured optically on a 10 mm x 10 mm x 10 mm sample at 75x magnification.

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