

# HAYNES® 718 alloy

## Principal Features

HAYNES® 718 alloy (UNS N07718) is an age-hardenable nickel-iron-chromium-niobium (columbium)-molybdenum-titanium-aluminum alloy designed to combine excellent strength with good fabrication characteristics in the annealed condition. While limited to applications below 1200°F (650°C), it is significantly stronger at these lower temperatures than materials such as Waspaloy alloy, R-41 alloy, or X-750 alloy. It is also much easier to weld than these alloys, and is less susceptible to the strain age cracking problems common for gamma prime strengthened materials. At temperatures greater than 1200°F (650°C), 718 alloy is being replaced by HAYNES® 282® alloy due to the superior strength of 282® alloy at those temperatures as well as its excellent fabricability.

HAYNES® 718 alloy is normally only used for component applications up to 1200°F (650°C); however, its oxidation resistance is comparable to that for other gamma-prime-strengthened superalloys.

## Nominal Composition

### Weight %

|                             |            |
|-----------------------------|------------|
| <b>Nickel:</b>              | 52 Balance |
| <b>Cobalt:</b>              | 1 max.     |
| <b>Iron:</b>                | 19         |
| <b>Chromium:</b>            | 18         |
| <b>Columbium + Tantalum</b> | 5          |
| <b>Molybdenum:</b>          | 3          |
| <b>Manganese:</b>           | 0.35 max.  |
| <b>Silicon:</b>             | 0.35 max.  |
| <b>Titanium:</b>            | 0.9        |
| <b>Aluminum:</b>            | 0.5        |
| <b>Carbon:</b>              | 0.05       |
| <b>Boron:</b>               | 0.004      |

# Creep and Stress-Rupture Strengths

## HAYNES® 718 Sheet, Age-Hardened\*

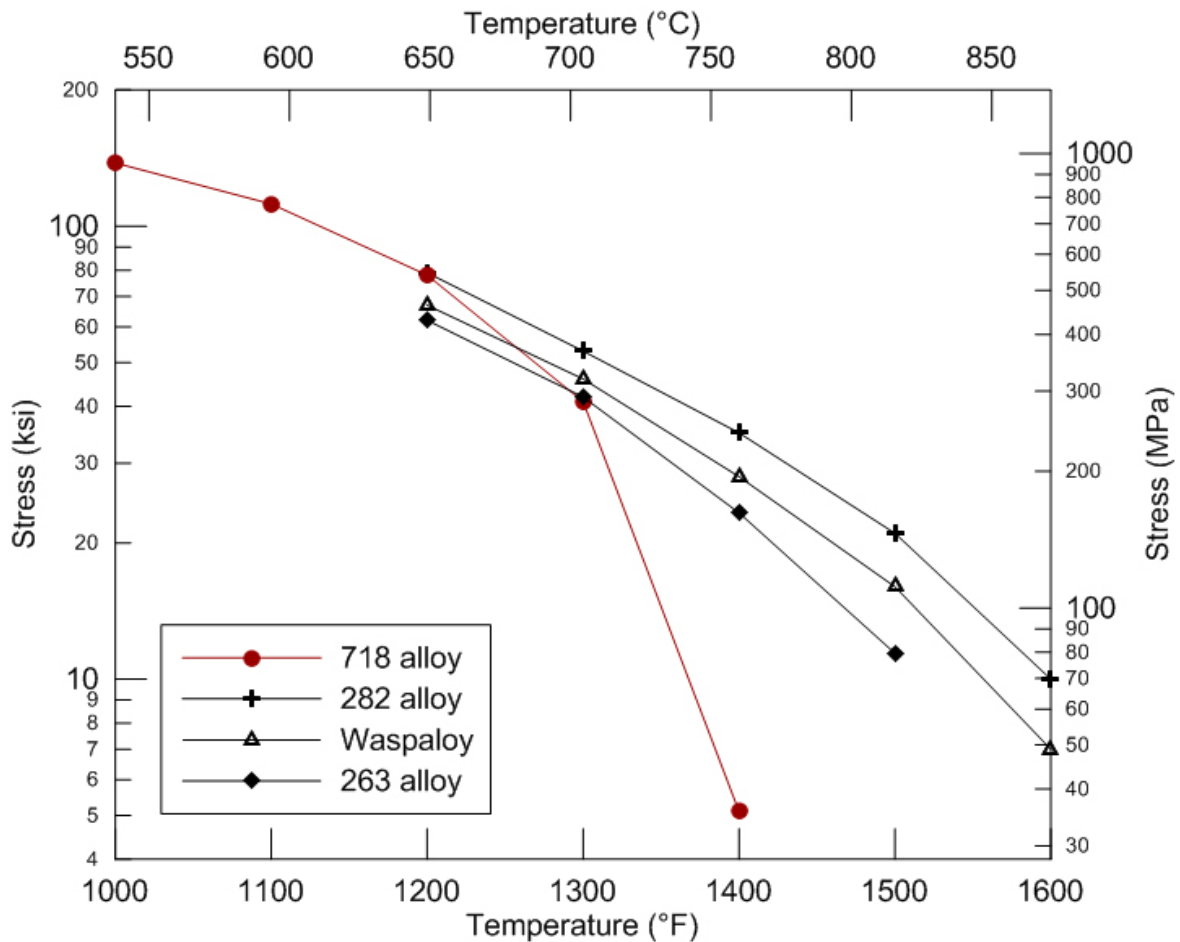
| Temperature |     | Creep | Approximate Initial Stress to Produce Specified Creep in |      |      |      |        |     |
|-------------|-----|-------|--|------|------|------|--------|-----|
|             |     |       | 10h  |      | 100h |      | 1,000h |     |
| °F          | °C  | %     | ksi  | MPa  | ksi  | MPa  | ksi    | MPa |
| 1000        | 538 | 0.5   | 157  | 1083 | 146  | 1007 | 132    | 910 |
|             |     | 1     | 160  | 1103 | 150  | 1034 | 138    | 952 |
|             |     | R     | -  | -    | 165  | 1138 | 144    | 993 |
| 1100        | 593 | 0.5   | 140  | 965  | 126  | 869  | 108    | 745 |
|             |     | 1     | 143  | 986  | 130  | 896  | 112    | 772 |
|             |     | R     | 150  | 1034 | 134  | 924  | 115    | 793 |
| 1200        | 649 | 0.5   | 121  | 834  | 101  | 696  | 75     | 517 |
|             |     | 1     | 124  | 855  | 103  | 710  | 78     | 538 |
|             |     | R     | 130  | 896  | 105  | 724  | 87     | 600 |
| 1300        | 704 | 0.5   | 95   | 655  | 64   | 441  | 35     | 241 |
|             |     | 1     | 98   | 676  | 67   | 462  | 41     | 283 |
|             |     | R     | 106  | 731  | 76   | 524  | 46     | 317 |
| 1400        | 760 | 0.5   | 54   | 372  | 24   | 165  | 3.8    | 26  |
|             |     | 1     | 60   | 414  | 28   | 193  | 5.1    | 35  |
|             |     | R     | 70   | 483  | 37   | 255  | 17     | 117 |

\*Samples were age hardened by treating at 1325°F (718°C)/8h/FC to 1150°F (621°C)/8h/AC

# Creep and Stress-Rupture Strengths Continued

## Comparison of Stress to Produce 1% Creep in 1000 Hours in Sheet

At temperatures below 1200°F (649°C), HAYNES® 718 alloy has creep strength that is superior to most other age-hardenable, wrought nickel-base superalloys. However, starting at temperatures around 1200°F (649°C) and higher, gamma-prime strengthened alloys such as HAYNES® 282® alloy, HAYNES® Waspaloy alloy, and HAYNES® 263 alloy provide higher strength.



# Tensile Properties

## Tensile Data, Plate

| Test Temperature |     | Ultimate Tensile Strength |      | 0.2% Yield Strength |      | Elongation |
|------------------|-----|---------------------------|------|---------------------|------|------------|
| °F               | °C  | ksi                       | MPa  | ksi                 | MPa  | %          |
| RT               | RT  | 200.5                     | 1382 | 167.8               | 1157 | 20.6       |
| 800              | 427 | 173.1                     | 1193 | 149                 | 1027 | 22.6       |
| 1000             | 538 | 170.2                     | 1173 | 145.9               | 1006 | 21.8       |
| 1200             | 649 | 162.5                     | 1120 | 139.9               | 965  | 25.1       |
| 1400             | 760 | 117.3                     | 809  | 104.9               | 723  | 12.1       |
| 1600             | 871 | 42.2                      | 291  | 34.3                | 236  | 68         |
| 1800             | 982 | 14.1                      | 97   | 9.6                 | 66   | 129.9      |

Mill Annealed + 1325°F/8h/Furnace Cool to 1150°F/8h/Air Cool

Total time: 18 hours

RT= Room Temperature

## Tensile Data, Sheet

| Test Temperature |     | Ultimate Tensile Strength |      | 0.2% Yield Strength |      | Elongation |
|------------------|-----|---------------------------|------|---------------------|------|------------|
| °F               | °C  | ksi                       | MPa  | ksi                 | MPa  | %          |
| RT               | RT  | 203.6                     | 1404 | 174.7               | 1205 | 18.4       |
| 800              | 427 | 176.2                     | 1215 | 155.4               | 1071 | 21.3       |
| 1000             | 538 | 172.3                     | 1188 | 150.2               | 1036 | 20.7       |
| 1200             | 649 | 164.1                     | 1131 | 144.3               | 995  | 16.3       |
| 1400             | 760 | 114.8                     | 792  | 103.8               | 716  | 6.9        |
| 1600             | 871 | 39.9                      | 275  | 34                  | 234  | 81.8       |
| 1800             | 982 | 13.7                      | 94   | 9.7                 | 67   | 175.6      |

Mill Annealed + 1325°F/8h/Furnace Cool to 1150°F/8h/Air Cool

Total time: 18 hours

# Physical Properties

| Physical Property                            | British Units |                                  | Metric Units |                         |
|--|---------------|----------------------------------|--------------|-------------------------|
| <b>Density</b>                               | RT            | 0.297 lb/in. <sup>3</sup>        | RT           | 8.23 g/cm. <sup>3</sup> |
| <b>Melting Range</b>                         | 2300-2435°F   | -                                | 1260-1335°C  | -                       |
| <b>Electrical Resistivity</b>                | RT            | 47.5 μohm.in                     | RT           | 121 μohm.cm             |
|  | 200°F         | 48.0 μohm.in                     | 100°C        | 122 μohm.cm             |
|  | 400°F         | 49.4 μohm.in                     | 200°C        | 125 μohm.cm             |
|  | 600°F         | 50.3 μohm.in                     | 300°C        | 127 μohm.cm             |
|  | 800°F         | 50.7 μohm.in                     | 400°C        | 129 μohm.cm             |
|  | 1000°F        | 51.6 μohm.in                     | 500°C        | 130 μohm.cm             |
|  | 1200°F        | 52.0 μohm.in                     | 600°C        | 132 μohm.cm             |
|  | 1400°F        | 52.2 μohm.in                     | 700°C        | 132 μohm.cm             |
|  | 1600°F        | 52.1 μohm.in                     | 800°C        | 132 μohm.cm             |
|  | 1800°F        | 52.4 μohm.in                     | 900°C        | 133 μohm.cm             |
|  | -             | -                                | 1000°C       | 133 μohm.cm             |
| <b>Thermal Conductivity</b>                  | RT            | 79 Btu.in/h.ft <sup>2</sup> .°F  | RT           | 11.4 W/m-°C             |
|  | 200°F         | 87 Btu.in/h.ft <sup>2</sup> .°F  | 100°C        | 12.6 W/m-°C             |
|  | 400°F         | 100 Btu.in/h.ft <sup>2</sup> .°F | 200°C        | 14.3 W/m-°C             |
|  | 600°F         | 112 Btu.in/h.ft <sup>2</sup> .°F | 300°C        | 15.9 W/m-°C             |
|  | 800°F         | 124 Btu.in/h.ft <sup>2</sup> .°F | 400°C        | 17.5 W/m-°C             |
|  | 1000°F        | 136 Btu.in/h.ft <sup>2</sup> .°F | 500°C        | 19.0 W/m-°C             |
|  | 1200°F        | 148 Btu.in/h.ft <sup>2</sup> .°F | 600°C        | 20.6 W/m-°C             |
|  | 1400°F        | 161 Btu.in/h.ft <sup>2</sup> .°F | 700°C        | 22.2 W/m-°C             |
|  | 1600°F        | 173 Btu.in/h.ft <sup>2</sup> .°F | 800°C        | 23.8 W/m-°C             |
|  | 1800°F        | 186 Btu.in/h.ft <sup>2</sup> .°F | 900°C        | 25.4 W/m-°C             |
|  | -             | -                                | 1000°C       | 27.1 W/m-°C             |
| <b>Mean Coefficient of Thermal Expansion</b> | 70-200°F      | 7.1 μin/in-°F                    | 25-100°C     | 12.8 μm/m-°C            |
|  | 70-400°F      | 7.5 μin/in-°F                    | 25-200°C     | 13.5 μm/m-°C            |
|  | 70-600°F      | 7.7 μin/in-°F                    | 25-300°C     | 13.8 μm/m-°C            |
|  | 70-800°F      | 7.9 μin/in-°F                    | 25-400°C     | 14.1 μm/m-°C            |
|  | 70-1000°F     | 8.0 μin/in-°F                    | 25-500°C     | 14.3 μm/m-°C            |
|  | 70-1200°F     | 8.4 μin/in-°F                    | 25-600°C     | 14.8 μm/m-°C            |
|  | 70-1400°F     | 8.9 μin/in-°F                    | 25-700°C     | 15.5 μm/m-°C            |
|  | 70-1600°F     | 9.4 μin/in-°F                    | 25-800°C     | 16.3 μm/m-°C            |
|  | -             | -                                | 25-900°C     | 17.2 μm/m-°C            |

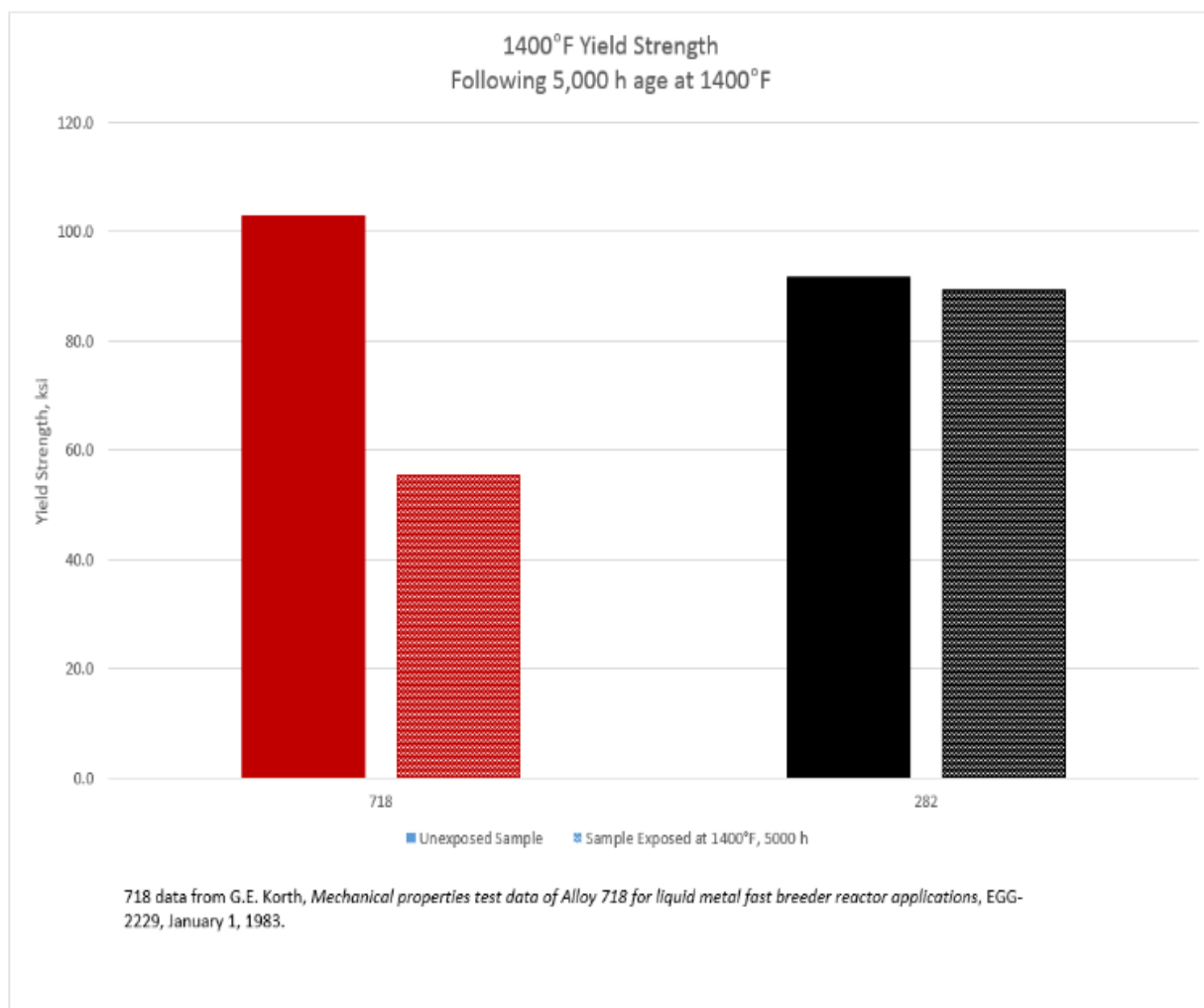
RT= Room Temperature

## Physical Properties Continued

| Physical Property                    | British Units |                            | Metric Units |         |
|--------------------------------------|---------------|----------------------------|--------------|---------|
| <b>Dynamic Modulus of Elasticity</b> | RT            | 29.0 x 10 <sup>6</sup> psi | RT           | 200 GPa |
|                                      | 200°F         | 28.4 x 10 <sup>6</sup> psi | 100°C        | 195 GPa |
|                                      | 400°F         | 27.6 x 10 <sup>6</sup> psi | 200°C        | 191 GPa |
|                                      | 600°F         | 26.7 x 10 <sup>6</sup> psi | 300°C        | 185 GPa |
|                                      | 800°F         | 25.8 x 10 <sup>6</sup> psi | 400°C        | 179 GPa |
|                                      | 1000°F        | 24.8 x 10 <sup>6</sup> psi | 500°C        | 173 GPa |
|                                      | 1200°F        | 23.7 x 10 <sup>6</sup> psi | 600°C        | 167 GPa |
|                                      | 1400°F        | 22.3 x 10 <sup>6</sup> psi | 700°C        | 159 GPa |
|                                      | 1600°F        | 20.2 x 10 <sup>6</sup> psi | 800°C        | 149 GPa |
|                                      | 1800°F        | 17.4 x 10 <sup>6</sup> psi | 900°C        | 134 GPa |

RT= Room Temperature

## Thermal Stability



## Fabrication

HAYNES® 718 alloy has very good forming and welding characteristics. It may be hot-worked at temperatures in the range of about 1700-2100°F (925-1150°C) provided the entire piece is soaked for a time sufficient to bring it uniformly to temperature. Initial break-down is normally performed at the higher end of the range, while finishing is usually done at the lower temperatures to afford grain refinement.

As a consequence of its good ductility, 718 alloy is also readily formed by cold-working. All hot- or cold-worked parts should normally be annealed at 1700 to 1850°F (925 to 1010°C) and cooled by air cool or faster rate before aging in order to develop the best balance of properties.

### Tensile Properties of Solution-annealed 718 at Room Temperature

| Form  | Ultimate Tensile Strength |     | Yield Strength |     | Elongation |
|-------|---------------------------|-----|----------------|-----|------------|
|       | ksi                       | MPa | ksi            | MPa | %          |
| Sheet | 126.3                     | 871 | 60.7           | 419 | 46.7       |
| Plate | 124.3                     | 857 | 57.3           | 395 | 49         |

### Cold-work Hardness

| % Cold-work | Average Hardness HRB/ C |
|-------------|-------------------------|
| 0           | 92.4 HRB                |
| 10          | 27.2 HRC                |
| 20          | 33.6 HRC                |
| 30          | 36.9 HRC                |
| 40          | 38.3 HRC                |
| 50          | 39.2 HRC                |

HRB= Hardness Rockwell "B"

HRC= Hardness Rockwell "C"

### Hardness and Grain Size

| Form  | Hardness, HRB | Typical ASTM Grain Size |
|-------|---------------|-------------------------|
| Sheet | 94            | 6-8                     |
| Plate | 93            | 5-8                     |

All samples tested in solution-annealed condition

# Welding

HAYNES® 718 alloy is readily welded by Gas Tungsten Arc Welding (GTAW), Gas Metal Arc Welding (GMAW), Shielded Metal Arc Welding (SMAW), Electron Beam (EB) and resistance welding techniques. Its welding characteristics are similar to those for HASTELLOY® X alloy. Submerged Arc Welding (SAW) and oxyacetylene are not recommended as these processes are characterized by high heat input to the base metal and slow cooling of the weld. These factors can increase weld restraint and promote cracking.

## Base Metal Preparation

The welding surface and adjacent regions should be thoroughly cleaned with an appropriate solvent prior to any welding operation. All greases, oils, cutting oils, crayon marks, machining solutions, corrosion products, paint, scale, dye penetrant solutions, and other foreign matter should be completely removed.

## Filler Metal Selection

HAYNES® 718 alloy should be joined using matching filler metal (AWS A5.14 ERNiFeCr-2, AMS5832). For welding 718 alloy to other alloys, HASTELLOY® S (AMS 5838) or W (AWS A5.14 ERNiMo-3, AMS 5786) filler wires are suggested. Please see the “Welding and Fabrication” brochure or the Haynes Welding SmartGuide for more information.

## Preheating and Interpass Temperatures

Preheat is not required. Preheat is generally specified as room temperature (typical shop conditions). Interpass temperature should be maintained below 200°F (93°C). Auxiliary cooling methods may be used between weld passes, as needed, providing that such methods do not introduce contaminants. For further information, please refer to the “Welding and Joining” brochure.

## Post-Weld Heat-treatment

HAYNES® 718 alloy is normally used in the fully-aged condition. Following forming and welding, a full solution anneal prior to aging is often employed in order to develop the best joint and overall fabrication properties. The best practice is dependent upon the specific condition of the fabrication prior to aging. Contact Haynes International, Inc. for further information.

## Nominal Welding Parameters

Details for GTAW, GMAW and SMAW welding are given in the “Welding and Fabrication” brochure. Nominal welding parameters are provided as a guide for performing typical operations and are based upon welding conditions used in our laboratories.



# Specifications and Codes

## Specifications

| <b>HAYNES® 718 alloy<br/>(N07718)</b> |   |
|---------------------------------------|---|
| <b>Sheet, Plate &amp; Strip</b>       | AMS 5596<br>AMS 5597  |
| <b>Billet, Rod &amp; Bar</b>          | AMS 5662<br>AMS 5663<br>AMS 5664<br>SB 637/B 637                      |
| <b>Coated Electrodes</b>              | -   |
| <b>Bare Welding Rods &amp; Wire</b>   | A 5.14 (ERNiFeCr-2)<br>AMS 5832                                       |
| <b>Seamless Pipe &amp; Tube</b>       | AMS 5589<br>AMS 5590<br>B 983   |
| <b>Welded Pipe &amp; Tube</b>         | -   |
| <b>Fittings</b>                       | -   |
| <b>Forgings</b>                       | AMS 5662<br>AMS 5663<br>AMS 5664<br>SB 637/B 637                      |
| <b>DIN</b>                            | 17742 No. 2.4668<br>NiCr19Fe19NbMo3                                   |
| <b>Others</b>                         | ASME Code Case No. 1993-6<br>Case No. 2221-1<br>NACE MR0175 ISO 15156 |

## Codes

| <b>HAYNES® 718 alloy<br/>(N07718)</b> |       |
|---------------------------------------|-------|
| <b>MMPDS</b>                          | 6.3.5 |

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